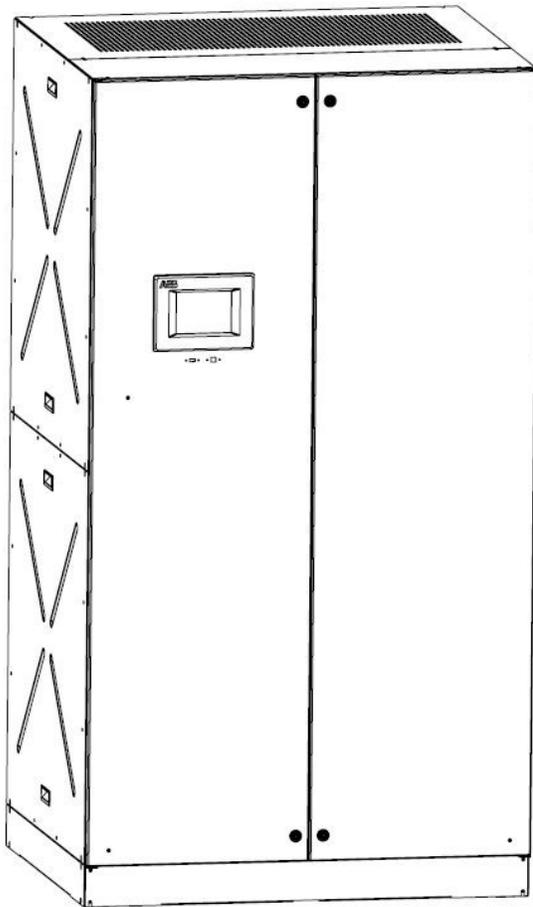


94-1100-00002874 A0

USER MANUAL

# TruFit™ Power Distribution Unit

## 50-300 kVA



The ABB TruFit™ PDU offers the most reliable and flexible power distribution product on the market today with almost unlimited configurations of panelboards and sub-feed breakers to meet every load requirement. One cabinet design supports ratings up to 300kVA.

For a comprehensive overview of publications available for the ABB TruFit™ PDU product line, refer to the inside cover of this publication. Web link and QR code references are also included.



## The Company

We are an established world force in the design and manufacture of power electronics and power protection equipment.

As a part of ABB, a world leader in electrical technology, we offer customers application expertise, service and support worldwide. We are committed to teamwork, high quality manufacturing, advanced technology and unrivalled service and support.

The quality, accuracy and performance ABB's products result from over 100 years of experience, combined with a continuous program of innovative design and development to incorporate the latest technology.



### Quality control

To ensure that we meet our responsibilities and obligations to our customers, our people, our partners, our suppliers and to our shareholders, we are committed to deliver on-time and on-quality products, systems and services that meet or exceed our customers' expectations.



### For more information

Further publications for the TruFit™ Power Distribution Unit and accessories are available for download from <http://new.abb.com/ups/power-distribution> or by scanning the QR code below.



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## Contacting ABB for support

To contact ABB for general information call 800-238-5000 or preventative and remedial services in the United States, call 800-292-3739. ABB offers a complete range of start-up services, repair services, preventive maintenance plans and service contracts.

For repair or maintenance service outside the 48 contiguous United States, contact ABB, if available in your area.

Please provide the following information for customer service when you contact the ABB service center:

Equipment
Part number
Serial number
Voltage rating
Current rating
Purchase date
Installation date
Location

To get important information on all equipment warranties, please contact the ABB service center or request service follow-up or by scanning the QR code below.



# 1 Important safety instructions

## 1.1 Using this manual

TruFit™ Power Distribution Unit, henceforth referred as PDU, is a high-energy device. The following safety instructions must be observed when working with the device. Refer to the unit's nameplate for the specific model designation and operating parameters.

This manual is provided to aid the user in the installation, operation, and maintenance of the PDU, manufactured by ABB. Read and understand the procedures described to ensure trouble-free installation and operation. Read through each procedure before beginning the procedure. Perform only those procedures that apply to the PDU cabinet being installed or operated.

**Read all safety and operating instructions before operating the PDU. Adhere to all warnings on the unit and in this manual.**

### 1.1.1 List of symbols

These symbols may appear on your PDU or on labels inside the PDU. Most international safety agents accept them. Everyone in your organization who works with your system should understand the meaning of these symbols:

	<b>SAFETY ALERT SYMBOL</b> This is the safety alert symbol. It is used to alert you to potential physical injury hazards. Obey all safety messages that follow this symbol to avoid possible injury or death.
	<b>DANGER</b> Indicates a hazardous situation which, if not avoided, will result in death or serious injury.
	<b>WARNING</b> Indicates a hazardous situation which, if not avoided, could result in death or serious injury.
	<b>CAUTION</b> Indicates a hazardous situation which, if not avoided, could result in minor or moderate injury.
	<b>NOTICE</b> Is used to address situations not related to physical injury but could result in property damage.
	<b>ELECTRICAL HAZARD SYMBOL</b> Indicates the presence of an electrical hazard.

	<p><b>ARC FLASH HAZARD SYMBOL</b></p> <p>Indicates the presence of an arc flash hazard.</p>
	<p><b>IMPORTANT INFORMATION SYMBOL</b></p> <p>This symbol indicates operator tips and/or important information for the use of the product. This symbol is not used to indicate information regarding potential hazards or property damage.</p>
	<p><b>RECYCLE SYMBOL</b></p>
	<p><b>DO NOT DISCARD SYMBOL</b></p> <p>Indicates that you should not discard waste electrical or electronic equipment (WEEE) in the trash. For proper disposal, contact your local recycling/reuse or hazardous waste center.</p>

## 1.2 Safety rules

### Save these instructions!

The power distribution unit operates with high currents and voltages. The properly installed system is grounded to earth and IP 20 rated against electrical shock and foreign objects when all dead fronts are in place. Installation and service must be performed by a manufacturer's qualified technicians or a certified service partner.

#### General

- Move the PDU in an upright position in its original package to the final destination room.  
To lift the cabinets, use a forklift or lifting belts with spreader bars.
- Check for sufficient floor and elevator loading capacity.
- Check the integrity of the PDU equipment carefully.  
If you notice visible damage, do not install or start the PDU.  
Contact your ABB Service Center immediately.
- **WARNING! RISK OF ELECTRICAL SHOCK!**  
Do not remove covers, there are no user serviceable parts inside.  
This should be performed by qualified service personnel.
- This PDU contains potentially hazardous voltages.
- End user must follow applicable regional occupational safety codes/regulations during installation, operation and equipment maintenance. This may require additional field marking or labelling defining appropriate level of PPE (Personal Protection Equipment) to reduce the risk of Arc-flash related injuries.  
Contact our ABB Service Center for product specific information.

## Installation

- This PDU must be installed and connected only by trained personnel.
- Verify accurately during Commissioning and Maintenance of the PDU, for the following:  
Damaged components, squeezed wires and cables, or not correctly inserted plugs.
- After removing the sidewalls of the PDU, make sure that all earth connections when reassembling, are correctly reattached.
- This PDU is intended for use in a controlled indoor environment free of conductive contaminants and protected against animal intrusion.
- **WARNING! HIGH LEAKAGE CURRENT TO GROUND:**  
Ground connection is essential before connecting to AC input!
- Switching OFF the Unit does not isolate the PDU from the Utility.
- Do not install the PDU in an excessively humid environment or near water.
- Avoid spilling liquids on or dropping any foreign object into the PDU.
- The Unit must be placed in a sufficiently ventilated area; the ambient temperature should not exceed 104°F (40°C).
- It is important that air can move freely around and through the Unit. Do not block the air vents.
- Avoid locations in direct sunlight or near heat sources.

## Storage

- Store the PDU in a dry location; storage temperature must be within -13°F (-25°C) to 131°F (+55°C).

### 1.3 Safety precautions

The PDU contains hazardous voltages, and hazardous voltages are present regardless of the mode of operation. Before making any connection(s) to the PDU, ensure that any/all power sources are de-energized and locked out.

As lethal voltages are present within the PDU during all modes of operation, maintenance shall only be performed by authorized service personnel.

ABB neither recommends nor knowingly sells this product for use with life support applications or other FDA designed critical applications.

All wiring should be performed by qualified electricians and in the accordance with local and national electrical safety codes. Before placing the unit into service, a thorough inspection and supervised start-up should be performed by a qualified service technician.

This PDU is designed for operation from a three (3) phase, three (3) wire power source. Refer to the unit's nameplate for the specific model designation, operating voltage, and input power configuration. Input over-current protection is to be supplied by the user in accordance with nameplate ratings, in applications where the PDU has no main breaker.

### 1.4 Safety considerations

The TruFit™ PDU is designed for commercial applications and should be handled with appropriate care, following these guidelines:

- Keep surroundings clean and free from excess moisture.
- Do not operate the PDU system close to gas or electric heat sources.
- The system is not intended for outdoor use.
- The operating environment should be maintained within the parameters stated in the manual.
- Keep the cabinet doors closed and locked to ensure proper cooling airflow and to protect personnel from dangerous voltages inside the unit.

---

#### CAUTION

Only authorized service personnel should perform maintenance on or service the PDU system.

---

If service or routine maintenance is required:

- Ensure all power is disconnected before performing maintenance.
- Ensure the area around the PDU is clean and uncluttered.
- Observe all DANGER, CAUTION and WARNING notices affixed to the inside and outside of the equipment.

---

#### WARNING

To provide sufficient isolation protection when working upstream of the PDU, open the respective source feeder breakers contained within the PDU. Prescribing to this maintenance method reduces the risk of electric shock due to backfeed.

# Table of contents

1	Important safety instructions .....	4
1.1	Using this manual .....	4
1.1.1	List of symbols .....	4
1.2	Safety rules.....	5
1.3	Safety precautions .....	7
1.4	Safety considerations .....	7
2	General .....	12
2.1	Cybersecurity .....	12
2.1.1	Disclaimer.....	12
2.1.2	Ports used by this product.....	12
3	Startup .....	13
3.1	Powerup .....	13
3.1.1	Safety checks before energizing system.....	13
3.1.2	Energizing the system .....	13
3.2	Graphical user interface .....	14
3.2.1	Display module.....	15
3.2.2	Menu tree .....	17
3.3	Security .....	18
3.3.1	Login and logout.....	18
3.4	System setup .....	20
3.4.1	Network Settings screen .....	20
3.4.2	Protocol Settings screen .....	21
3.4.3	Email Settings screen .....	23
3.4.4	General Settings screen.....	24
3.4.5	Display Settings screen .....	25
3.4.6	Information screen.....	26
3.4.7	User-Interface Board (UIB) .....	27
4	Alarms and Events.....	28
4.1	Overview .....	28
4.2	Product description .....	28
4.3	Event Log and alarm/warning .....	28
4.3.1	Overview .....	28
4.3.2	Viewing events .....	28
4.3.3	Acknowledging events .....	29
4.3.4	Event filtering.....	31
4.3.5	Alarm/warning annunciation (Local) .....	32
4.3.6	Alarm/warning annunciation (Remote) .....	33
4.3.7	Group Fault.....	33
5	Metering and Monitoring.....	34
5.1	Overview .....	34
5.2	Product description .....	34
5.3	Features .....	34
5.4	Modbus.....	34
5.5	Metering screens.....	35

5.5.1	Metering Overview screen .....	35
5.5.2	PDU metering .....	35
5.5.3	Panel and Branch Metering screens .....	39
5.5.4	Sub-feed Metering screens .....	48
5.5.5	Custom Groups .....	51
5.5.6	Input status screens .....	54
5.6	Setting alarm/warning limits and ratings .....	56
5.6.1	PDU configuration settings .....	57
5.6.2	Panel configuration settings .....	60
5.6.3	Branch configuration settings .....	63
5.6.4	Sub-feed configuration settings .....	67
5.6.5	Thermocouple configuration settings .....	69
6	Specifications .....	70
6.1	Standards .....	70
6.2	Electrical characteristics .....	71
6.3	Environmental characteristics .....	71
7	System maintenance .....	72
7.1	Tightening torques .....	72

# Figures

Figure 3-1: Home screen with ABB bar highlighted .....	14
Figure 3-2: Display module - Front view as mounted on door .....	15
Figure 3-3: Display module - Rear view .....	16
Figure 3-4: Security Login screen .....	18
Figure 3-5: Password Keyboard.....	18
Figure 3-6: The "Settings" submenu .....	20
Figure 3-7: Network Settings screen (Dynamic) .....	20
Figure 3-8: Network Settings screen (Static) .....	20
Figure 3-9: Protocol Settings screen .....	21
Figure 3-10: Modbus TCP configuration .....	21
Figure 3-11: Modbus RTU configuration .....	22
Figure 3-12: Secure Shell configuration card .....	22
Figure 3-13: TFTP Server configuration tile.....	22
Figure 3-14: Email Settings screen .....	23
Figure 3-15: General Settings screen.....	24
Figure 3-16: Display Settings screen .....	25
Figure 3-17: System Information screen .....	26
Figure 3-18: System Software screen .....	26
Figure 3-19: Slot Information screen .....	27
Figure 4-1: Events log .....	29
Figure 4-2: Event Log with active warning .....	29
Figure 4-3: Event Log with active alarm & un-acknowledged .....	30
Figure 4-4: Event 'Ack all' is pressed .....	30
Figure 4-5: Event Filters window .....	31
Figure 4-6: Event screen with "Alarm' and 'Warning' filters enabled.....	31
Figure 4-7: Event screen showing the filter criteria .....	32
Figure 5-1: Metering Overview screen.....	35
Figure 5-2: PDU Graphical screen - Output side .....	36
Figure 5-3: PDU Graphical screen - Input side .....	36
Figure 5-4: PDU Tabular screens .....	37
Figure 5-5: PDU Thermal screen .....	38
Figure 5-6: PDU Waveform Capture screen.....	38
Figure 5-7: PDU Waveform Capture Save screen.....	39
Figure 5-8: Panel and Branch Main screen .....	39
Figure 5-9: Panel Graphical screen .....	40
Figure 5-10: Panel Tabular screens.....	41
Figure 5-11: Panel Waveform Capture screen .....	42
Figure 5-12: Panel Waveform Capture Save screen .....	42
Figure 5-13: Branch Status screen, 1-pole breaker.....	43
Figure 5-14: Branch status screens, 2-pole breaker .....	44
Figure 5-15: Branch status screens, 3-pole breaker .....	45
Figure 5-16: Branch Waveform Capture screen 1-pole breaker .....	46
Figure 5-17: Branch Waveform Capture screen 2-pole breaker .....	46
Figure 5-18: Branch Waveform Capture screen 3-pole breaker .....	47
Figure 5-19: Branch Waveform Capture Save screen .....	47
Figure 5-20: Sub-feed Graphical screen .....	48
Figure 5-21: Sub-feed Tabular screens .....	49
Figure 5-22: Sub-feed Waveform Capture screen .....	50
Figure 5-23: Sub-feed Waveform Capture Save screen .....	50
Figure 5-24: Metering Overview screen with groups .....	51
Figure 5-25: Groups of Meters screen .....	51
Figure 5-26: Custom Group screen – Branches and Panels .....	52

Figure 5-27: Custom Group screen - Sub-feeds.....	52
Figure 5-28: Meters in a Custom Group screen .....	53
Figure 5-29: Input Status screen.....	54
Figure 5-30: Thermocouple Input Screen .....	55
Figure 5-31: Input Register screen .....	55
Figure 5-32: Edit Settings keyboard .....	56
Figure 5-33: PDU's submenu options with 'Settings' icon.....	57
Figure 5-34: PDU Limits Settings screens .....	57
Figure 5-35: PDU Duration Settings screen.....	59
Figure 5-36: PDU Ratings Settings screen .....	59
Figure 5-37: PDU Reset screen .....	60
Figure 5-38: Panel submenu options with 'Settings' icon .....	60
Figure 5-39: Panel Alarm Limits screens.....	61
Figure 5-40: Panel Duration Settings screen .....	61
Figure 5-41: Panel Ratings screen .....	62
Figure 5-42: Panel Parameter Reset screen .....	62
Figure 5-43: PDU's submenu options with 'Settings' icon.....	63
Figure 5-44: Branch Alarm Limits screen – 1-pole .....	63
Figure 5-45: Branch Alarm Limits screen – 2 or 3-pole.....	63
Figure 5-46: Branch Duration Settings screen – 1-pole .....	64
Figure 5-47: Branch Duration Settings screen – 2 or 3-pole.....	64
Figure 5-48: Branch Ratings screen – 1-pole .....	65
Figure 5-49: Branch Ratings screen – 2 or 3-pole.....	65
Figure 5-50: Branch Parameter Reset screen- 1-pole.....	66
Figure 5-51: Branch Parameter Reset screen – 2 or 3-pole.....	66
Figure 5-52: Sub-feed's submenu options with 'Settings' icon .....	67
Figure 5-53: Sub-feed Alarm Limits Settings screens .....	67
Figure 5-54: Sub-feed Duration Settings screen .....	68
Figure 5-55: Sub-feed Ratings screen .....	68
Figure 5-56: Sub-feed Parameter Reset screen .....	69
Figure 5-57: Thermocouple configuration screen .....	69

---

## Tables

Table 3-1: Default login passwords.....	19
Table 4-1: Group Fault slot assignment.....	33
Table 5-1: PDU alarm/warning limit settings.....	58
Table 6-1: Electrical characteristics .....	71
Table 7-1: Recommended tightening torque .....	72

## 2 General

### 2.1 Cybersecurity

#### 2.1.1 Disclaimer

This product is designed to be connected to and to communicate information and data via a network interface. It is the Customer's sole responsibility to provide and continuously ensure a secure connection between the product and Customer network or any other network (as the case may be). The customer shall establish and maintain any appropriate measures (such as but not limited to the installation of firewalls, application of authentication measures, encryption of data, installation of anti-virus programs, etc.) to protect the product, the network, its system and the interface against any kind of security breaches, unauthorized access, interference, intrusion, leakage and/or theft of data or information. ABB Ltd and its affiliates are not liable for damages and/or losses related to such security breaches, any unauthorized access, interference, intrusion, leakage and/or theft of data or information.

We recommend connecting the system in private network, if not the case additional hardware that provide increased security controls/measures such as firewalls should be implemented.

#### 2.1.2 Ports used by this product

Port	Service	Purpose
22/tcp	SSH	Valid for SSH
502/tcp	Modbus/TCP	Valid for Modbus TCP
25/tcp	Email	Valid of Email
110/tcp	Email	Valid of Email
143/tcp	Email	Valid of Email
465/tcp	Email	Valid of Email
587/tcp	Email	Valid of Email
993/tcp	Email	Valid of Email
995/tcp	Email	Valid of Email
69/udp	TFTP	Valid for Software Upgrade
123/udp	NTP	Valid for Network Time Products

---

## 3 Startup

### 3.1 Powerup

#### 3.1.1 Safety checks before energizing system

Prior to energizing the system, the installing electrical contractor should verify the following:

1. Proper phase rotation and safe grounding practices have been exercised.
2. All conductor sizing meets or exceeds conductor sizes as detailed in the guidelines of the current National Electric Code.
3. All building interface points are terminated onto the system's interface board (see Section 3.4.6.3).
4. The TruFit™ system's main input circuit breaker and all subsequent circuit breakers are all in the "OFF" position.

\*\* DOUBLE CHECK ITEMS 1-4 AFTER THE STEPS ABOVE HAVE BEEN PERFORMED \*\*

#### 3.1.2 Energizing the system

1. The installing electrical contractor should now verify that the input voltage to the unit properly matches the input voltage rating of the unit as reflected on the system's identification label (affixed to the inside of the front door of the unit) and as indicated on the transformer label located on the top of the high isolation transformer positioned in the rear of the unit.
2. Turn the building's circuit breaker feeding the TruFit™ product to the "ON" position. The system's red **Emergency Power Off** (EPO) pushbutton should now be illuminated as well as display LCD screen indicating power is present at the line side of the TruFit™ system main circuit breaker.
3. Energize the TruFit™ product by turning the system's main input circuit breaker to the "ON" position.
4. Next, the output voltages from the system should be verified. Identify the output voltage of the transformer by using a true RMS digital volt-meter. If the output voltage of the transformer is not the desired voltage, access the system's 2 1/2% compensation taps. Compensation tap configurations are clearly marked on the label affixed to the top of the high isolation transformer itself. The contractor should re-verify the output voltage to determine that the optimum compensation tap combination is used to achieve an output voltage as close to your output voltage as possible.
5. The installing contractor should now verify that the Emergency Power Off (EPO) circuit and the Remote Emergency Power OFF (REPO) circuit (if applicable) are connected and working properly.
6. Now that the emergency power off circuit has been verified and input/output voltages are adjusted properly, energize the system's secondary main circuit breakers (if purchased). Next, sequentially energize the branch circuit breakers to distribute power to your critical load.



- Per NEC Article 645.10, an Emergency Power Off button (EPO) is required. If this option is not installed on the PDU, a remote EPO must be installed. See Section 3.4.6.3 for location of connection.
- 

Your TruFit™ system is now distributing power to your connected load. The next sections are dedicated to assisting you in operating your display/monitoring system. Please take a moment to familiarize yourself with your TruFit™ product.

### 3.2 Graphical user interface

The user interface is a touchscreen LCD. It shows all system status as well as providing a means to set the unit up and control it. This is done through buttons, checkboxes, radio buttons, pull-down menus, and text entry screens.

The GUI display/control panel displays system status as monitored by the PowerView metering system. Monitoring details can be found in Section 5.

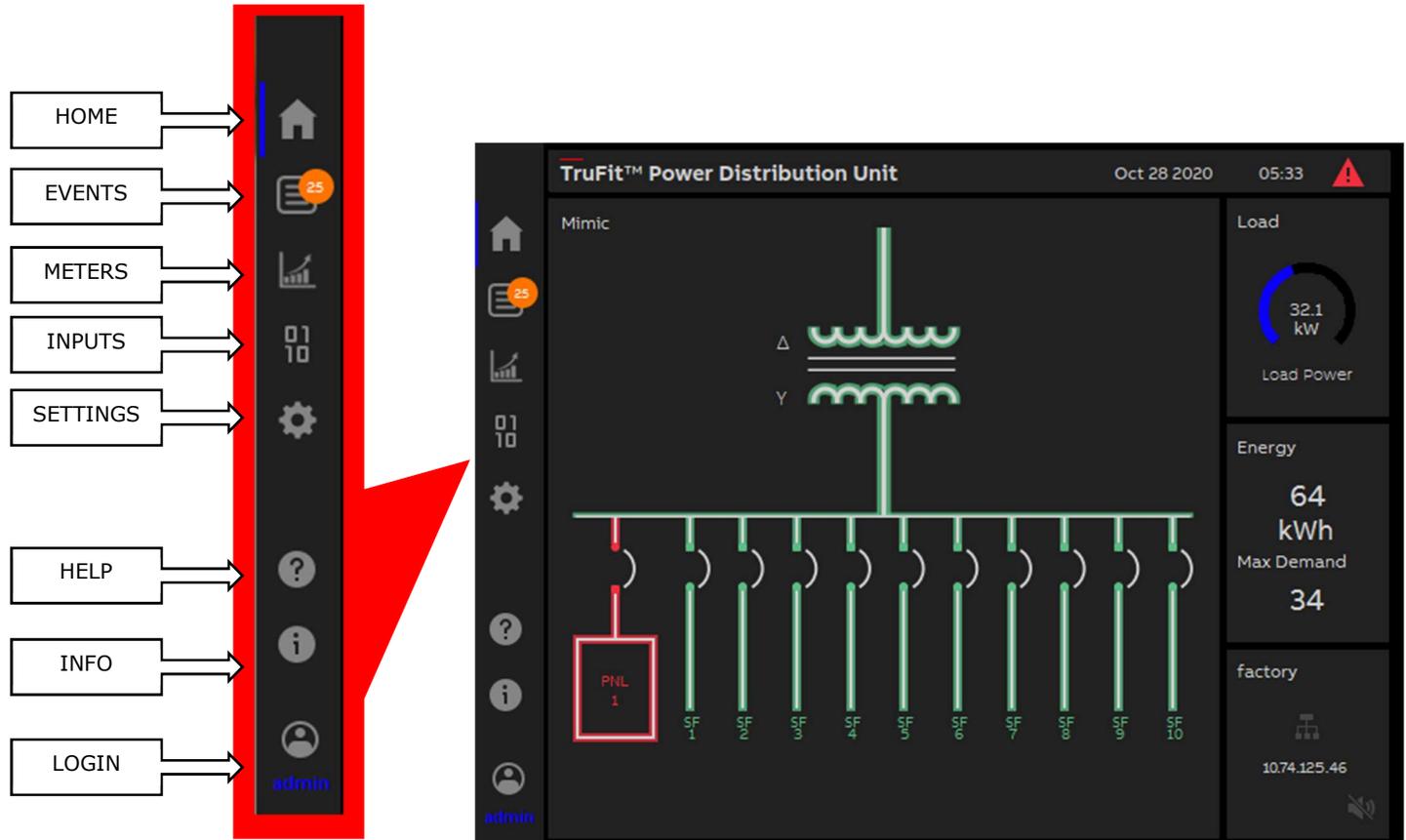
The GUI display/control panel is surrounded by a ring light, which displays green, yellow or red, depending on operating status and active alarms, as described in Section 4.3.

Each PDU unit has a User Interface Board (UIB), which is provided for the user's connections.

External monitoring systems, e.g., Building Management Systems, can be used to poll the PDU units using Modbus RTU (on an RS-485 bus) or Modbus/TCP. Each unit connected in the Modbus network shall be configured with a unique Modbus ID.

The operation of the display module is based on the Navigation Bar.

**Figure 3-1: Home screen with ABB bar highlighted**

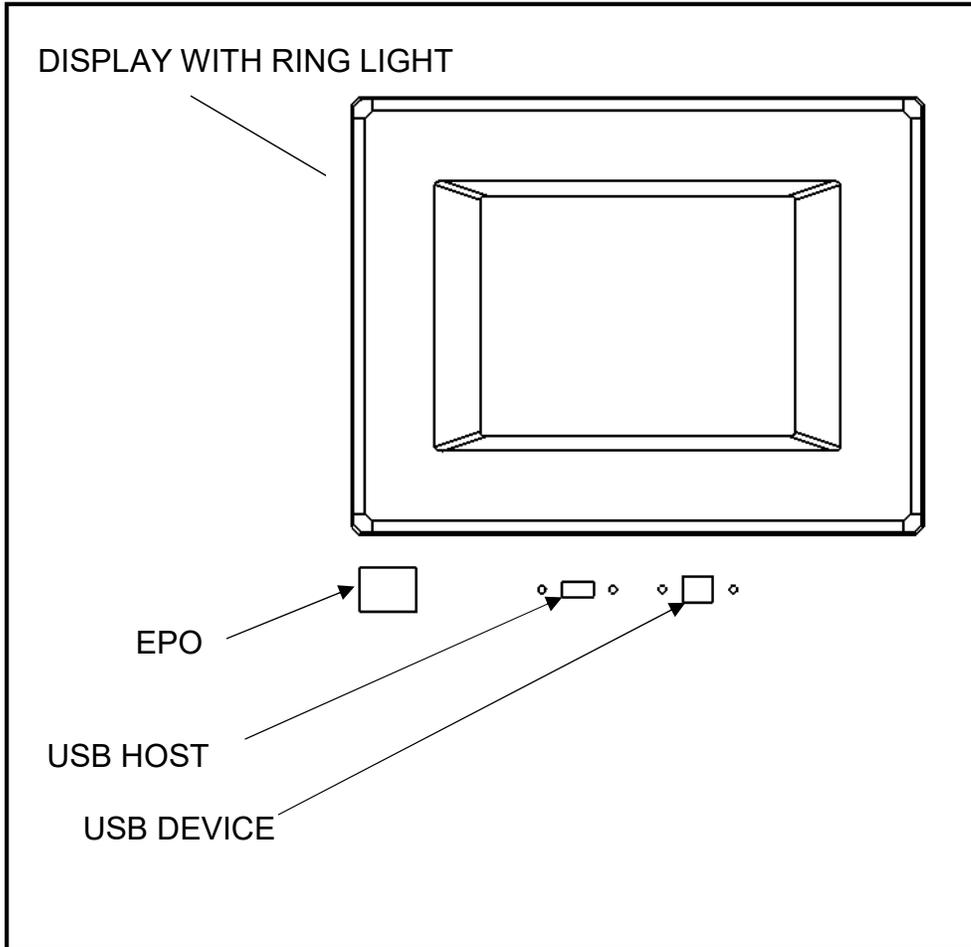


### 3.2.1 Display module

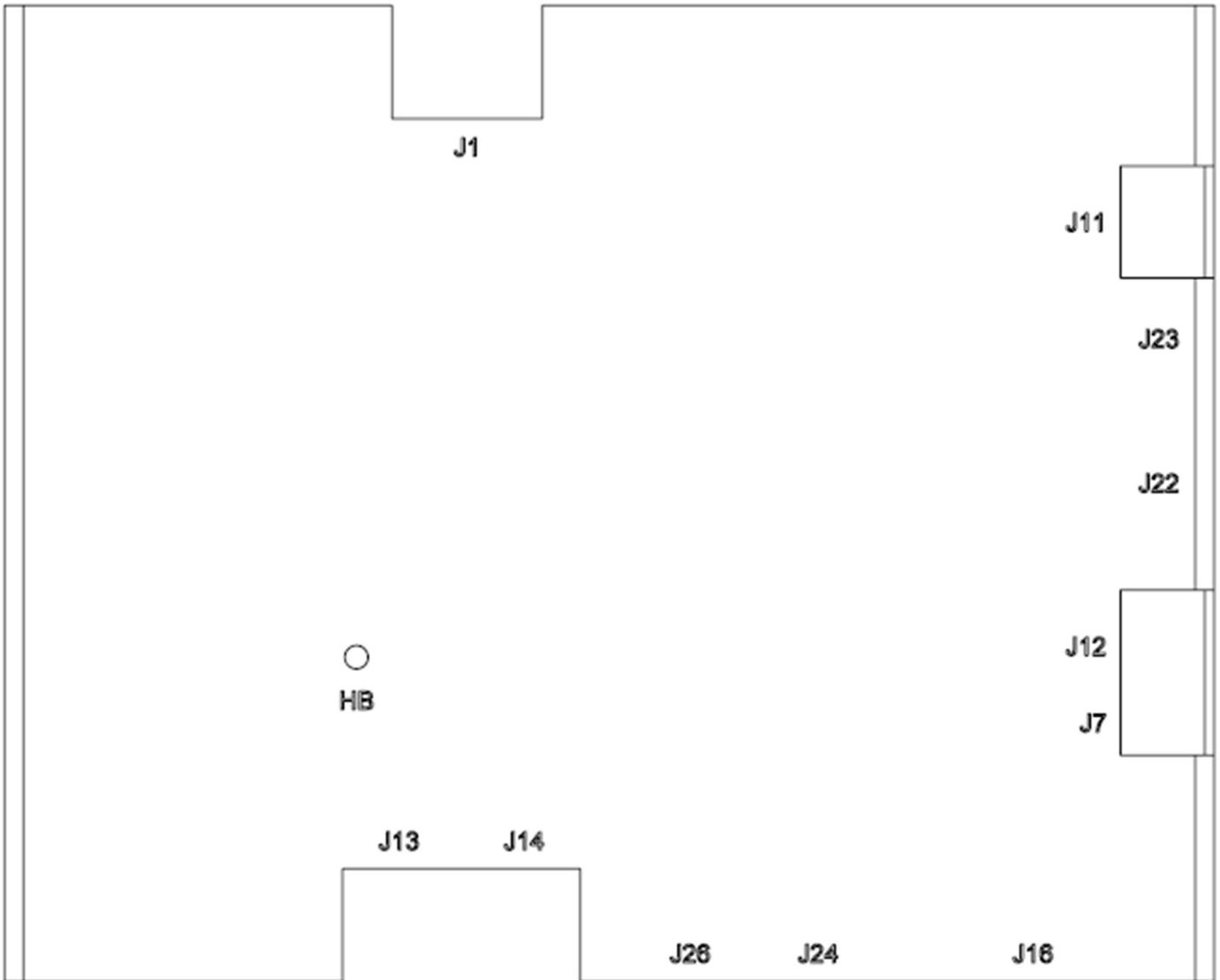
The graphic user interface is shown on the Display Module. The Display Module is also surrounded by a ring light, whose color will change depending on the alarm or warning that is currently in need of attention. Details on alarms and warning are described in Section 4.

USB DEVICE is configured as the Service Port.

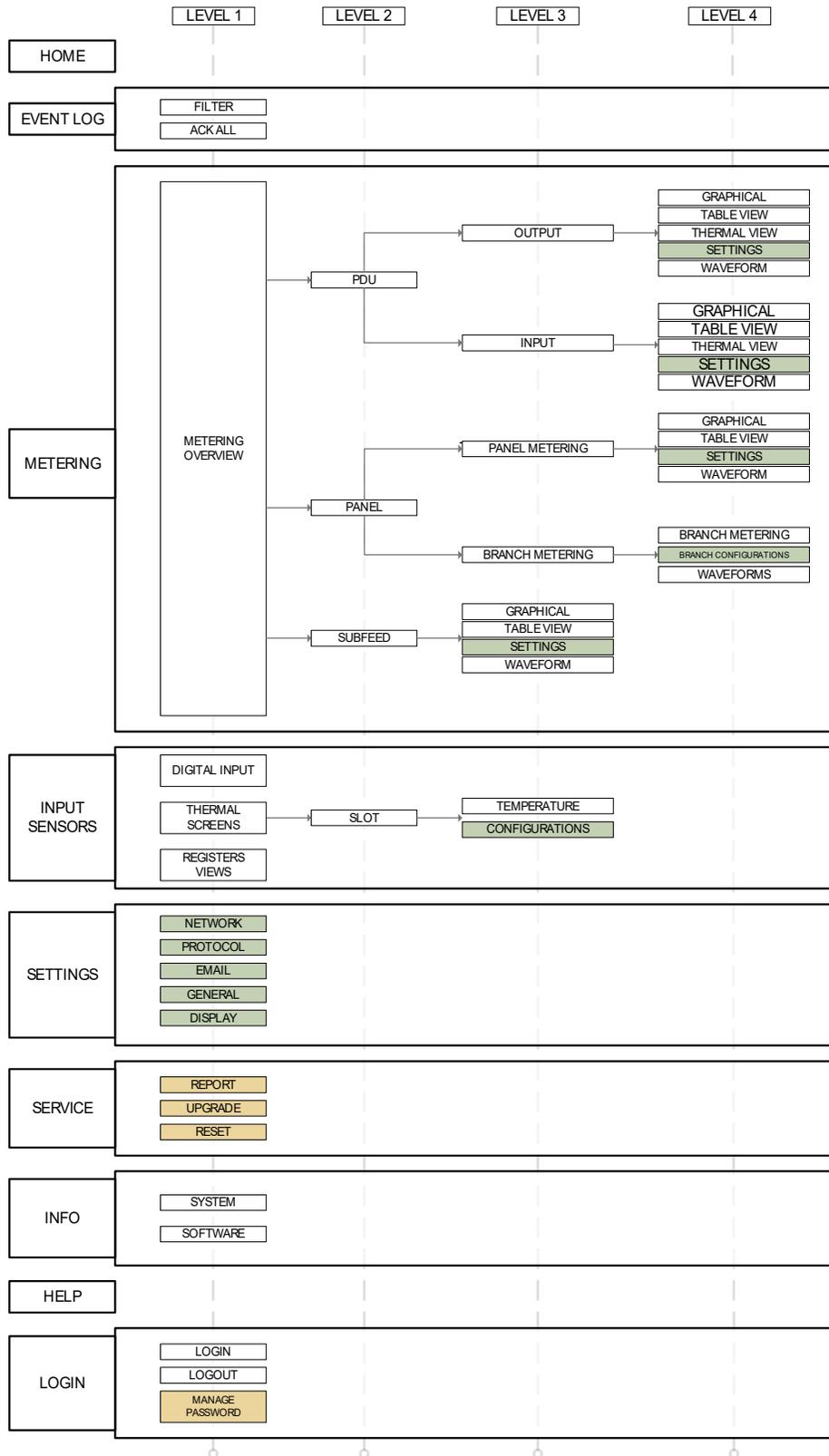
**Figure 3-2: Display module - Front view as mounted on door**



**Figure 3-3: Display module - Rear view**



### 3.2.2 Menu tree



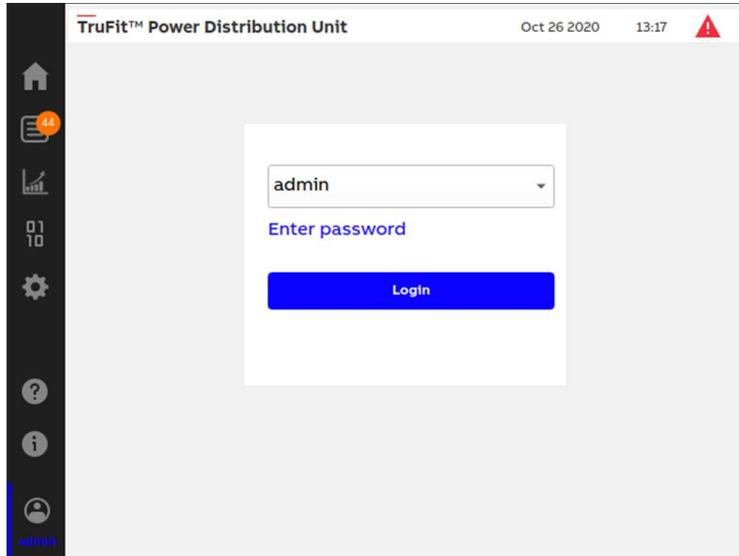
- - DEFAULT, USER
- - ADMIN & Above
- - SERVICE & Above

### 3.3 Security

#### 3.3.1 Login and logout

To login in to a security level, select User icon . The below screen should appear.

**Figure 3-4: Security Login screen**

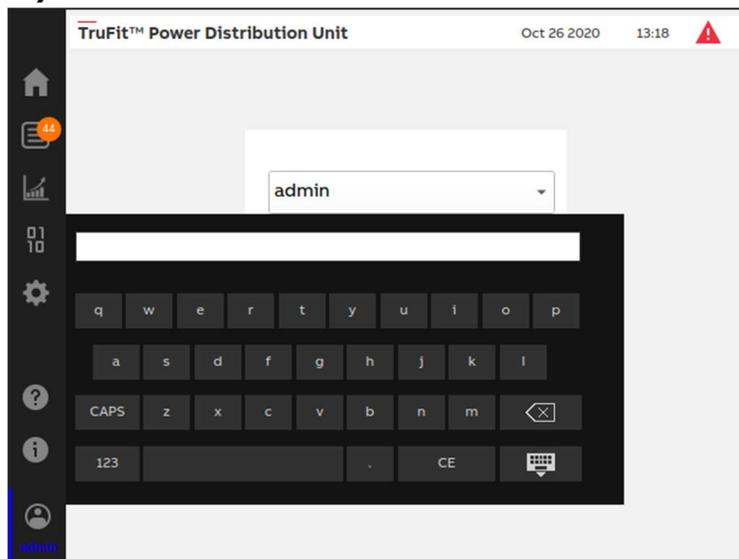


Select the proper "User Name" from the pull-down list.

Click "Enter Password" for the keyboard to appear, as shown below. Click the letters to enter the password, then click the keyboard icon in the lower right to close the keyboard.

Click the blue "Login" button to complete login.

**Figure 3-5: Password Keyboard**



This will login the user to the appropriate security level.



### 3.4 System setup

Under the Settings icon  on the menu bar, the user can configure the unit as shown below. The user must be logged in as 'admin' (or higher) to access the items under "Settings".

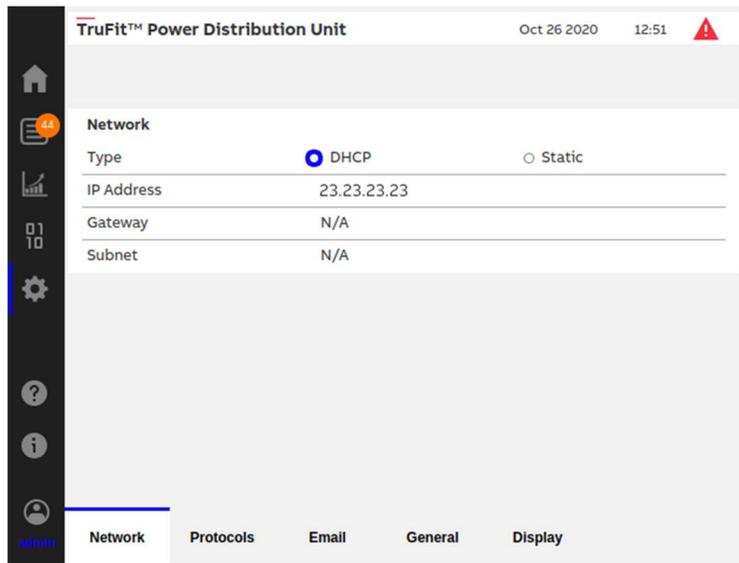
**Figure 3-6: The "Settings" submenu**



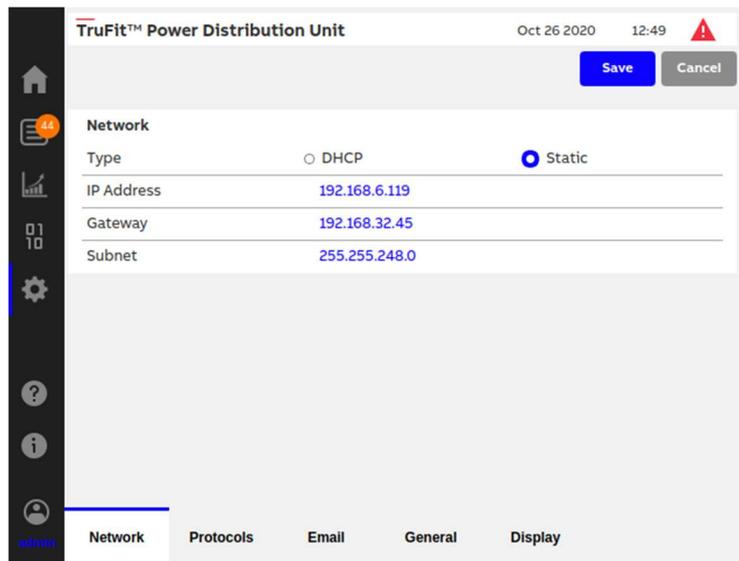
#### 3.4.1 Network Settings screen

The Network Settings screen is used to configure the IP, gateways & subnet address of the system.

**Figure 3-7: Network Settings screen (Dynamic)**



**Figure 3-8: Network Settings screen (Static)**

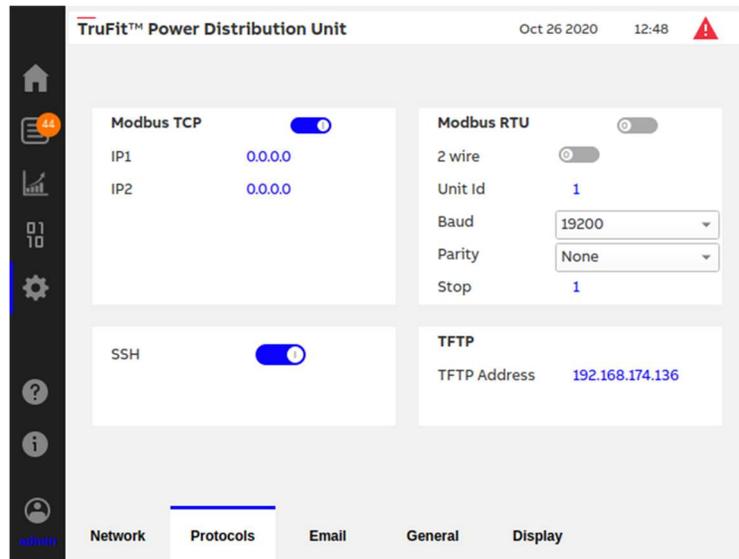


### 3.4.2 Protocol Settings screen

The Protocol Settings screen is used to configure the upstream access parameters.

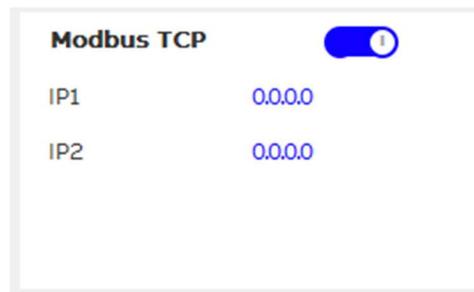
E.g.: SSH (Secured Shell), Modbus TCP, Modbus RTU & TFTP settings.

**Figure 3-9: Protocol Settings screen**



#### 3.4.2.1 Modbus TCP configuration:

**Figure 3-10: Modbus TCP configuration**

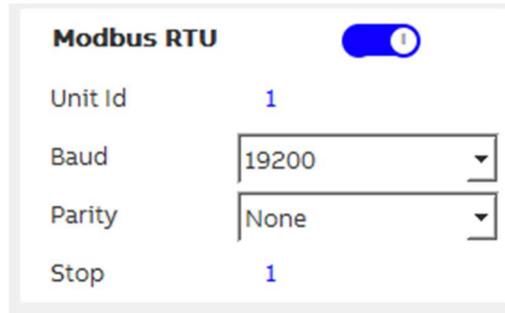


Modbus TCP can be configured from this tile.

- The on/off toggle slider is used to enable/disable this feature.
- IP1 & IP2 are the IP address of the polling device.
  - If IP1 & IP2 are 0.0.0.0 any device can poll
  - If either IP1/IP2 is set, only the IP address that is entered can poll the unit.  
ego: If IP1 is 192.168.5.4 & IP2 is 0.0.0.0 only IP1 can poll the device.

### 3.4.2.2 Modbus RTU configuration

**Figure 3-11: Modbus RTU configuration**



The image shows a configuration card for Modbus RTU. At the top, the title "Modbus RTU" is followed by a blue toggle switch that is turned on. Below the title, there are four configuration fields: "Unit Id" with the value "1", "Baud" with a dropdown menu showing "19200", "Parity" with a dropdown menu showing "None", and "Stop" with the value "1".

The Modbus RTU feature can be configured from this:

- The ON/OFF toggle switch is used to enable/disable the feature.
- Unit id can be configured from 1-250
- Baud rates can be configured as 9600,19200,38400 & 57600
- Parity can be configured as None, Even & Odd
- Stop bit can be set to 1 or 2.

### 3.4.2.3 Secured Shell

**Figure 3-12: Secure Shell configuration card**

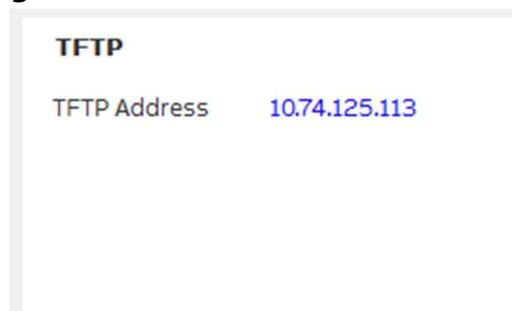


The image shows a configuration card for Secure Shell (SSH). At the top, the title "SSH" is followed by a blue toggle switch that is turned on.

The Secure Shell (SSH) service can be enabled/disabled via the toggle button.

### 3.4.2.4 TFTP Server Address:

**Figure 3-13: TFTP Server configuration tile**



The image shows a configuration tile for TFTP. At the top, the title "TFTP" is displayed. Below the title, there is a field for "TFTP Address" with the value "1074.125.113".

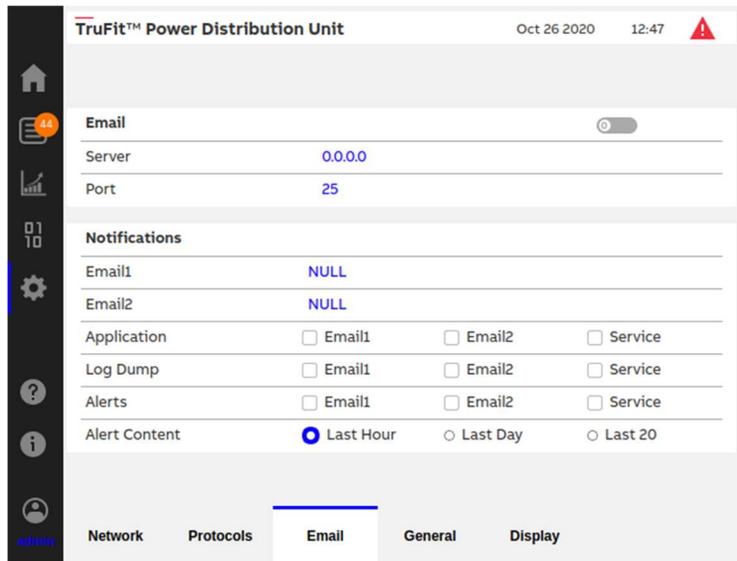
The TFTP server can be configured in the above tile. This TFTP server is used for upgrade & report generation.

### 3.4.3 Email Settings screen

The Email Settings screen is used to configure the system email parameters.

e.g.: Email server, Port, Email address & Content.

**Figure 3-14: Email Settings screen**



### 3.4.4 General Settings screen

The following parameters can be configured in this screen. They can be changed by clicking on the parameter to enable editing.

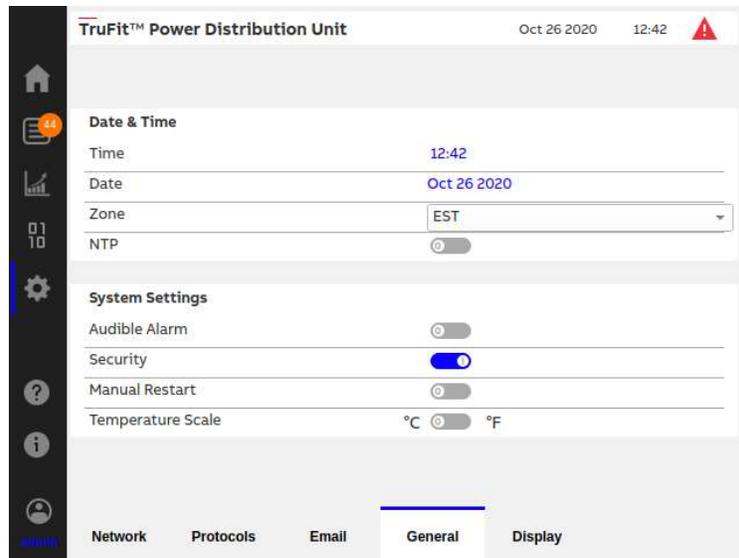
#### Date & Time

1. Time
2. Date
3. Time Zone
4. NTP

#### System Settings

1. Audible Alarm
2. Security
3. Manual Restart
4. Temperature Scale

**Figure 3-15: General Settings screen**



### 3.4.5 Display Settings screen

The System Display screen helps the user to configure the screen saver and display contrast.

The screen saver can be enabled or disabled by the on/off toggle button.

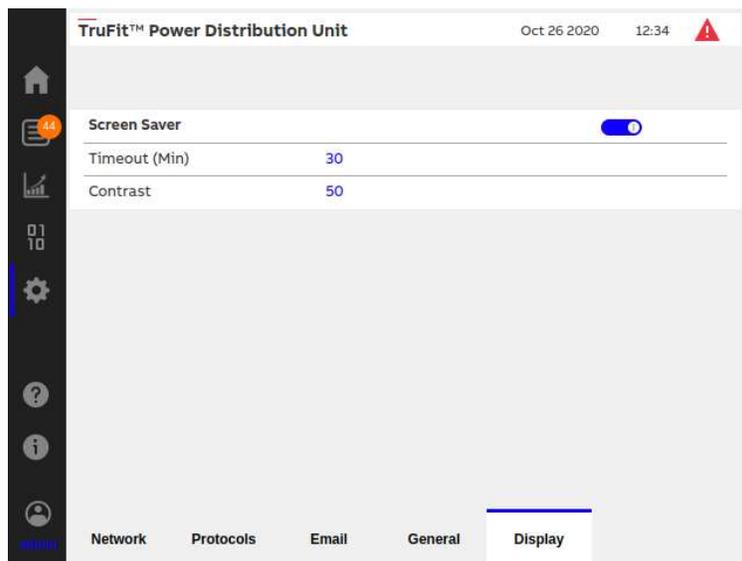
When screen saver is enabled, the system turns off the backlight and logs off the user after the number of minutes entered for Timeout.

When the screen saver is disabled, the user will not be automatically logged out of the system.

The screen saver setting is retained through power down /up cycles.

The screen contrast is also set via this screen.

**Figure 3-16: Display Settings screen**

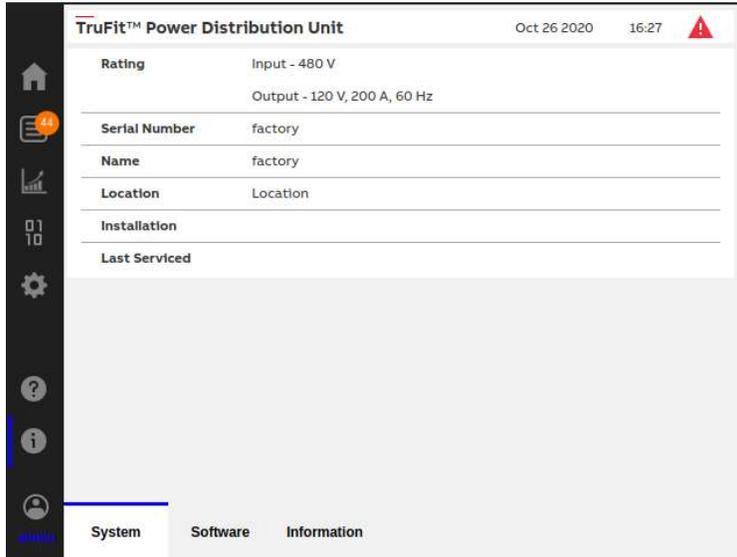


### 3.4.6 Information screen

The system information screen can be viewed from the About Icon 

#### 3.4.6.1 System information

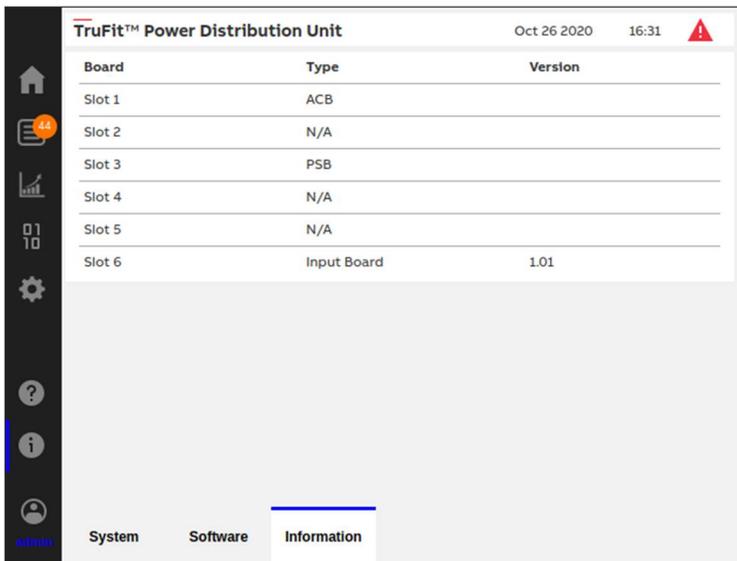
**Figure 3-17: System Information screen**



The System Information screen is shown above. This screen contains the rating, serial number, name, location, installation & last serviced information.

#### 3.4.6.2 System software information

**Figure 3-18: System Software screen**



The System software information is shown above. This screen contains all the software versions of the meter modules & display modules. Note that the versions shown in Figure 3-18 may not be the most recent or what is loaded on your unit. Software upgrades can only be performed by authorized ABB service personnel. Contact ABB if there is interest in upgrading to the latest software revision.

### 3.4.6.3 Slot Information

**Figure 3-19: Slot Information screen**

Board	Type	Version
Slot 1	ACB	
Slot 2	N/A	
Slot 3	PSB	
Slot 4	N/A	
Slot 5	N/A	
Slot 6	Input Board	1.01

The System slot information is shown above. This screen contains information on the type of daughter card installed in each PowerView slot. The number of slots displayed will depend on whether the unit has a 2 slot or 6 slot PowerView system. Daughter card additions or changes can only be performed by authorized ABB service personnel. Contact ABB if there is interest in upgrading the PowerView system.

### 3.4.7 User-Interface Board (UIB)

The User-Interface Board (UIB) provides an interface for connecting the PDU to external monitoring and control equipment. See **TruFit Installation Guide** for more details.

## 4 Alarms and Events

All referenced voltages and currents are based on the standard 480 -208/120V units. See as built documents and/or unit nameplate for unit specific voltages.

### 4.1 Overview

Alarms and events are conveyed to the user through the Display Module's graphical user interface and audible alarm. Alarm and warning threshold levels are configured in the installed PowerView metering module. PowerView will monitor various voltages & currents in a power distribution panel, will also compute various other parameters such as power, energy, demand, frequency, power factor, etc. Finally, PowerView provides the Modbus connection to interface with a building management system.

### 4.2 Product description

The PowerView metering module will acquire the voltage & current signals from an analog signal conditioning board. It will calculate energy and power quality parameters. These parameters are passed to the display board/PC for display and data logging. It will also receive control/command/system parameter data from display board or a third-party display module.

### 4.3 Event Log and alarm/warning

#### 4.3.1 Overview

System events are logged in the Event Log. Each event contains the following attributes:

1. Timestamp
2. Severity of event (▲ Information, ▲ Warning, ▲ Alarm).
3. Active state (🔒)
4. Acknowledgement state ( ! )
5. Event description

Some events remain active in the Event Log if the event status is true. The event becomes inactive only when the condition is cleared. For example, an event triggered by a metered value that exceeds a high limit will remain active until that metered value falls back below the high limit.

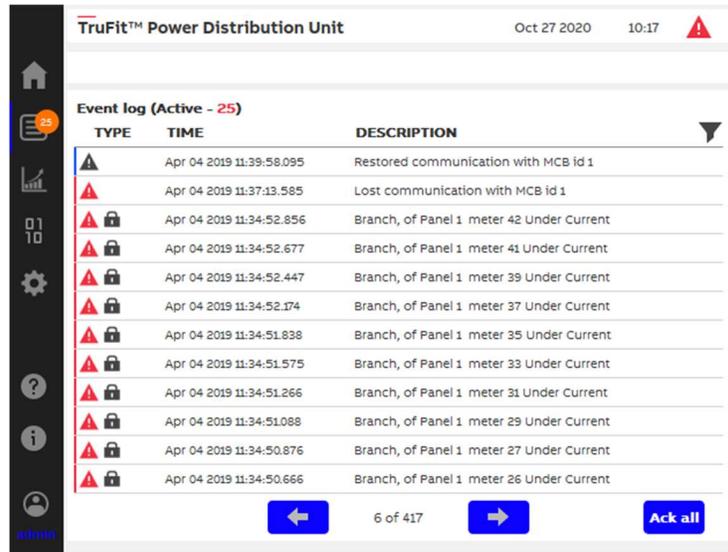
Some alarm/warning events also require acknowledgement from the user after they become inactive. This will be discussed below. Other types of alarm/warning events do not require acknowledgement.

#### 4.3.2 Viewing events

The events can be viewed in the Event Log by clicking the Event icon  .

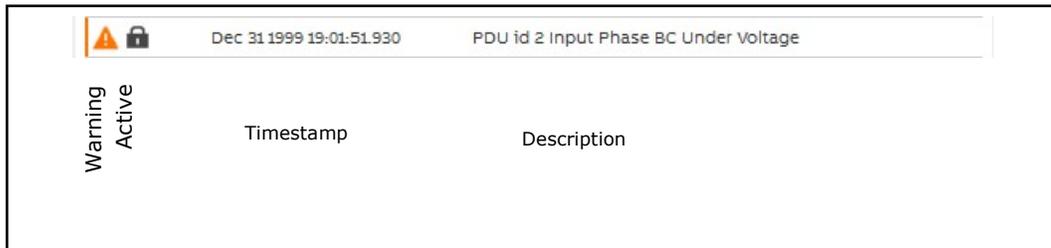
The Event Log displays the number of active events.

**Figure 4-1: Events log**



By clicking the back  and next  buttons the user can navigate to next page of the events.

**Figure 4-2: Event Log with active warning**



### 4.3.3 Acknowledging events

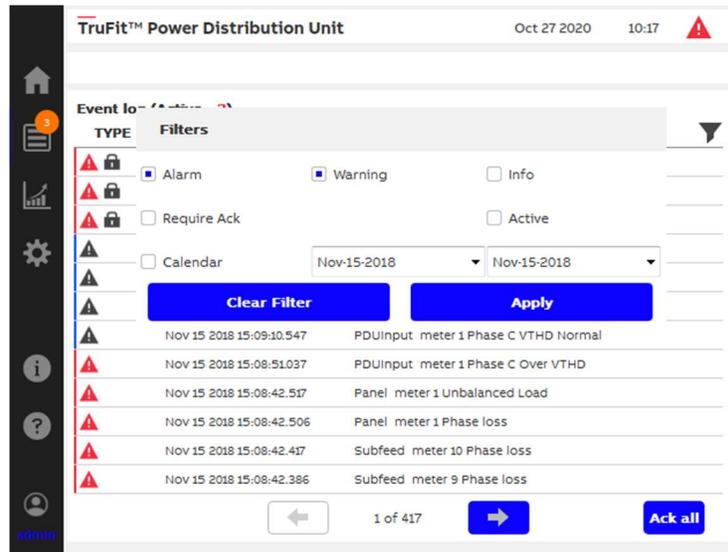
The 'Ack all' button is to acknowledge all the events in the Event Log. An example screenshot of the Event Log, when 'Ack all' is clicked, is shown below. Once the 'Ack all' event is pressed, the buzzer stops, and unacknowledged event sign goes away.



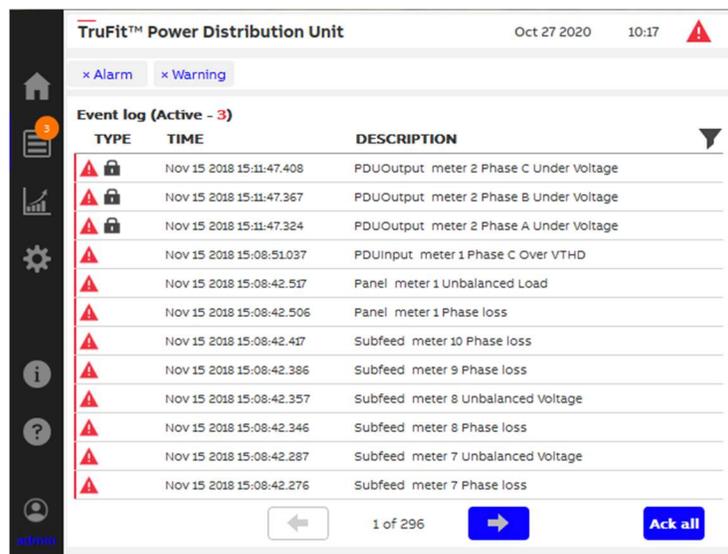
### 4.3.4 Event filtering

The events displayed in the Event Log can be filtered via the 'Filters' window as shown below. This feature is activated by selecting Filter icon  in the Event Log. After selecting the filter criteria and clicking the "Apply" button, the filtered list of events will appear in the Event Log and the filter criteria will appear at the top of the Event Log. The filters can be cleared by clicking on the filter criteria on the top of the Events Log or by clicking the "Clear Filter" button in the 'Filters' window.

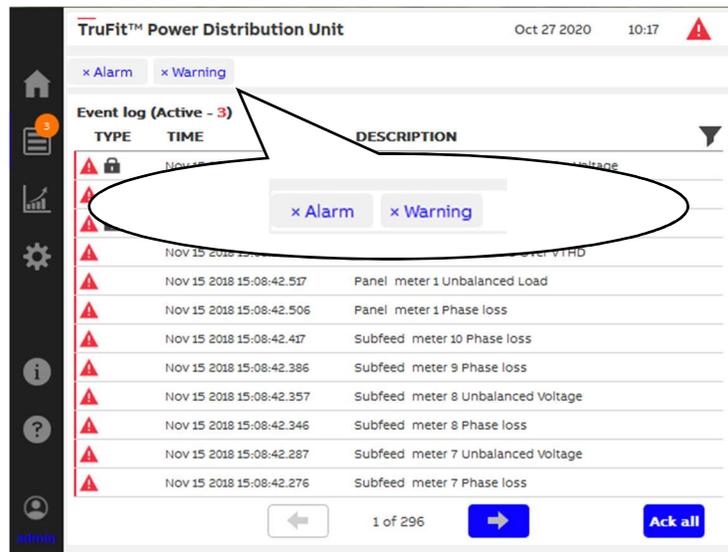
**Figure 4-5: Event Filters window**



**Figure 4-6: Event screen with "Alarm" and "Warning" filters enabled**



**Figure 4-7: Event screen showing the filter criteria**



#### 4.3.5 Alarm/warning annunciation (Local)

The PDU display unit annunciates alarms/warnings locally by the following two different means.

- Alarm/warning ring light
- Audible alarm

##### 4.3.5.1 The alarm/warning ring light:

The alarm/warning ring light, which is located under the LCD display, can be in any of the following three states:

Ring light state	Description
Green (Solid)	Normal operating condition. No active alarms or warnings are present.
Yellow (Solid)	One or more active warnings are present.
Red (Blinking)	One or more active alarms are present.

The alarm/warning ring light states (above) are non-latching. For example, the ring light will automatically change from red to green if a warning condition disappears and there are no other active alarms or warnings present.

See **Display Module** section for detailed location of ring light.

##### 4.3.5.2 The audible alarm:

When logged in as 'admin' (or higher), the user can enable or disable the audible alarm as mentioned in Section 3.4.4. When using this method, the new setting is permanently saved in flash memory.

The audible alarm operates independently of the alarm/warning ring light. The audible alarm sounds only if there is one or more alarm/warning event(s) in the log that require(s) acknowledgement, in addition to the other caveats mentioned below. (Note that not all alarm/warning events require acknowledgement.) Therefore, it is possible for the audible alarm to be sounding while the alarm/warning ring light is green and for the audible alarm to be silent while the alarm/warning ring light is red.

Note that alarm and warning events from the PowerView do not require acknowledgement and will not cause the audible alarm to sound.

#### 4.3.6 Alarm/warning annunciation (Remote)

The PDU can annunciate alarms/warning remotely via two sets of Form-C alarm relay contacts. (See Section 3.4.6.3 for the wiring details.) These relay contacts are designated as follows:

- Summary Alarm Contacts
- Unacknowledged Events Contacts

##### 4.3.6.1 The Summary Alarm contacts:

The Summary Alarm contacts will be in the alarm state if there are one or more active warnings or alarms present. The Summary Alarm contact follows the state of the alarm/warning ring light, i.e., they should be in the alarm state when the alarm/warning ring light is red (solid or blinking) and should be in the normal state when the alarm/warning ring light is green.

##### 4.3.6.2 The Unacknowledged Events contacts:

The Unacknowledged Events contacts will be in the alarm state only when there are one or more alarm/warning events in the log that require acknowledgement. The Unacknowledged Events contacts should be in the alarm state when the audible alarm is sounding. See the caveats about the audible alarm above in Section 4.3.5. Also note that disabling the audible alarm does not disable the Unacknowledged Events contacts.

Note that both sets of alarm contacts will be in the normal state if power is lost to the equipment.

#### 4.3.7 Group Fault

The Group Fault occurs when there are connectivity problems in a daughter board. Connectivity is monitored in two groups of daughter boards, assigned by slot depending on chassis type.

**Table 4-1: Group Fault slot assignment**

Chassis	Group 1	Group 2
6 slots	Slots 1,2 and 3	Slots 4,5 and 6
2 slots	Slot 1	Slot 2

Users are alerted to Group Fault in the following ways:

- Alerted with both the ring light and buzzer, as described in Section 4.3.5.
- Noted in the event log with the description "MCB [ID] ACB Group [ID] Fault, with the ID's related to the MCB or ACB Group where the fault occurs
- Meter readings on the GUI will stop updating

The Group Fault needs to be resolved by ABB Service. If this fault occurs, please contact ABB Service for resolution.

## 5 Metering and Monitoring

### 5.1 Overview

The PowerView metering module will be used to monitor various voltages & currents in a power distribution panel or remote power panel. The meter will also compute various other parameters such as power, energy, demand, frequency, power factor, etc. Specific parameters for transformers, branches and sub-feeds are shown in Section 5.5.



This unit is equipped with ABB's PowerView monitoring system. Instructions regarding monitoring can be found in **PowerView Manual 94-1100-00002861**. The reader is expected to know the fundamentals of electricity, wiring, electrical components and electrical schematic symbols.

### 5.2 Product description

The Metering module board will acquire the voltage & current signals from an analog signal conditioning board. It will calculate energy and power quality parameters. PowerView can also monitor discrete or thermocouple inputs, if so equipped. These parameters are passed to the display board/PC for display and data logging. It will also receive control/command/system parameter data from display board or a third-party display module.

### 5.3 Features

The following are standard features of distribution products equipped with PowerView:

1. Thermal shutdown (shunts trip input breaker when goes past acceptable thermal levels).
2. TVSS or surge arrestor fault indication. This indication could mean that there is a fault with the TVSS or the surge arrestor (if applicable).
3. Over temperature warning.
4. Manual restart (requires a "manual restart" of the input breaker when there is a power outage).
5. Local Emergency Power Off button (EPO).
6. Remote Emergency Power Off contacts (REPO).

### 5.4 Modbus

The PowerView with HMI acts as a Modbus slave, and can be accessed by the Modbus master using either Modbus RTU (via RS-485) or Modbus TCP through customer connection on the UIB Modbus port. The PowerView with HMI is identified by a unique slave ID=1 by the master. The default Modbus RTU settings are as follows.

Baud rate: 19200  
Parity: None  
Stop bits: 1

## 5.5 Metering screens

### 5.5.1 Metering Overview screen

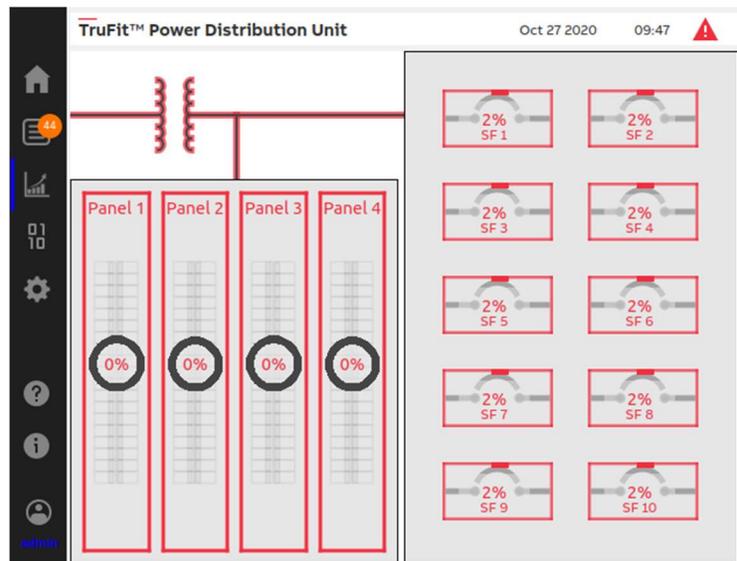
By clicking on the Meters icon , the Metering Overview screen will be shown, with a graphic showing the monitored system components. The user clicks the icon of a component to open screens with further monitoring information on that component.

Users with ADMIN access need to click the specific panel, branch or sub-feed to change settings or parameters for that component. For more details on changing parameters and settings, see Section 5.65.5.6.1.

RPPs do not have transformers, so that that icon will not be available.

Events associated with the displayed screen are shown with triangles (▲ Information, ▲ Warning, ▲ Alarm). Event details can be accessed by clicking on the triangle icons. For more information on events and alarms, see Section 4.

**Figure 5-1: Metering Overview screen**

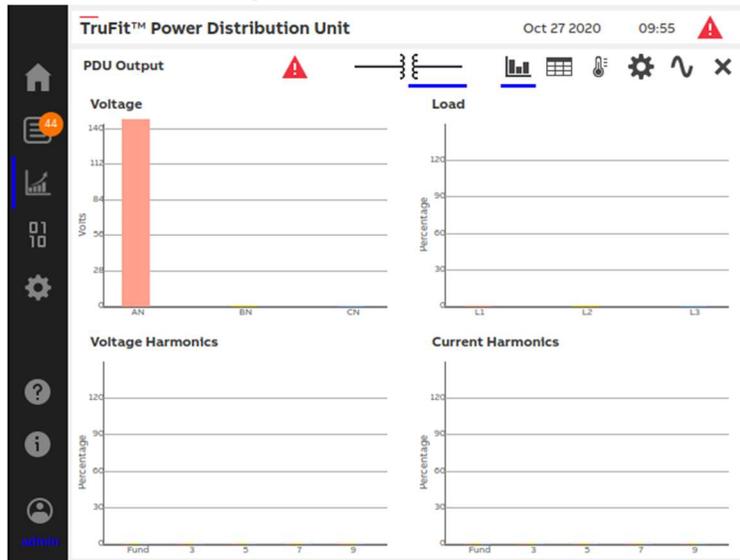


### 5.5.2 PDU metering

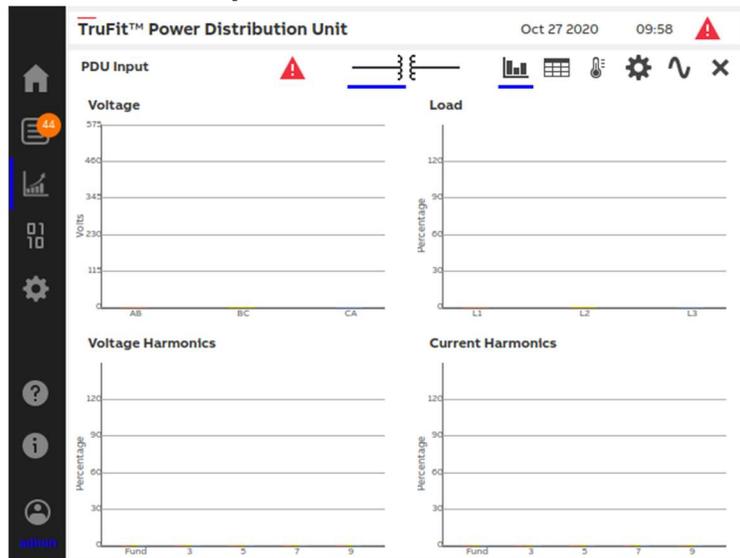
#### 5.5.2.1 PDU graphical view

When the user clicks the Metering Overview screen's transformer icon, the PDU Graphical screen opens, showing metering in bar graph format. By default, the metering shown is from the transformer's output side, as noted by the blue bar under the small transformer icon shown in Figure 5-2. To switch to metering on the input side, the user will click that transformer icon, and results will be as shown in Figure 5-3.

**Figure 5-2: PDU Graphical screen - Output side**



**Figure 5-3: PDU Graphical screen - Input side**



### 5.5.2.2 PDU Meter Tabular View

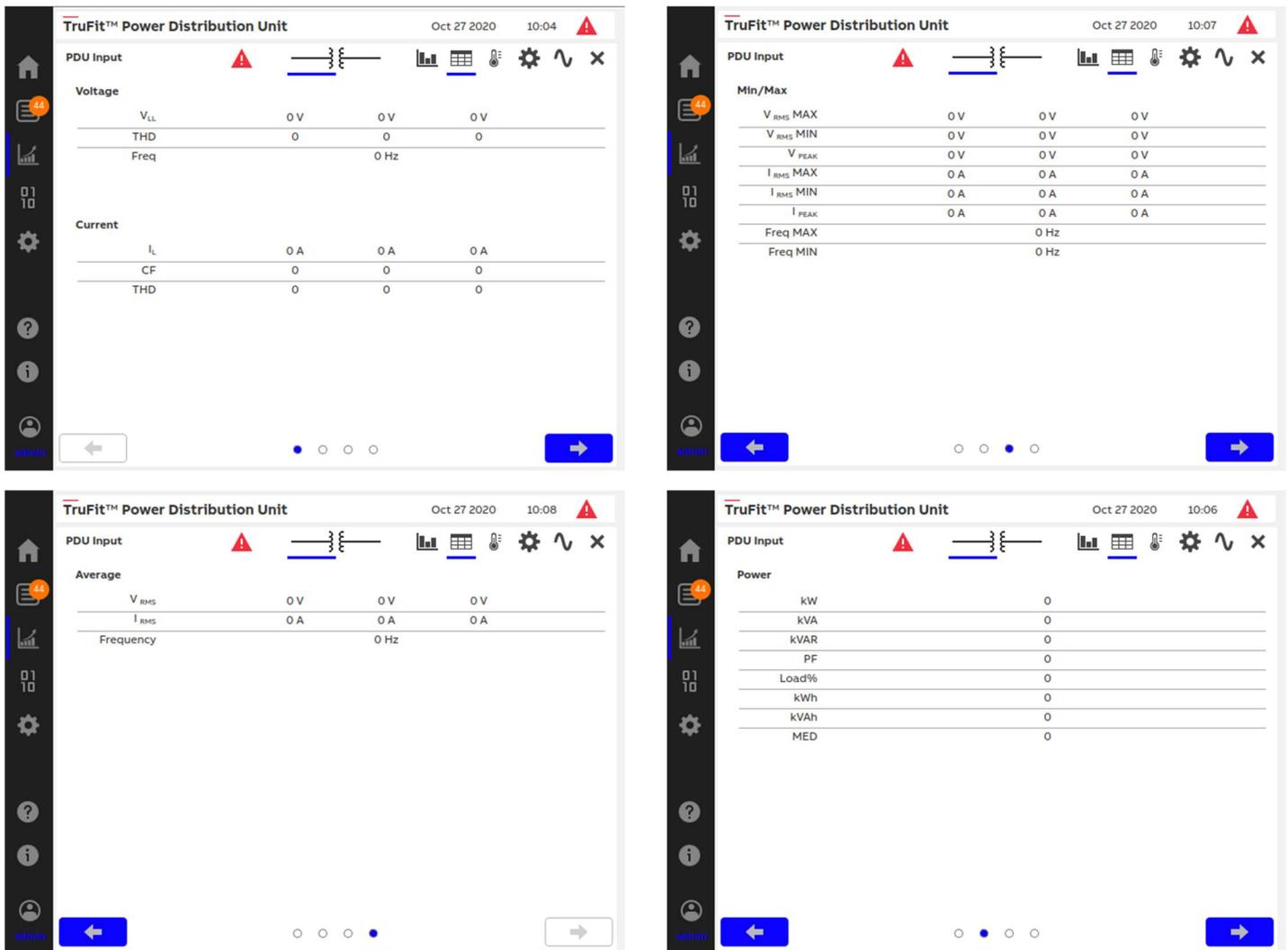
When the user clicks the tabular icon , even more detailed meters in a tabular structure will be shown. Four screens show prevailing metering information regarding voltage, current, frequency and power.

Click the blue arrows   to move through the screens.

The transformer icon continues to identify whether the metering information is from the input or output side.

Min and Max values are since the last reset. Averages are over the duration noted in the settings. Changing settings and resetting values requires ADMIN access.

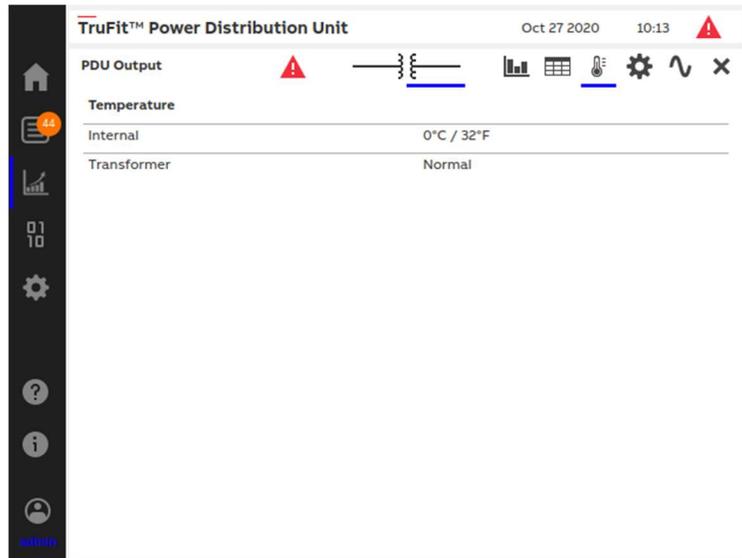
**Figure 5-4: PDU Tabular screens**



### 5.5.2.3 PDU Thermal View

Select the thermometer icon to view temperature information regarding the internal PCA's and the main transformer.

**Figure 5-5: PDU Thermal screen**

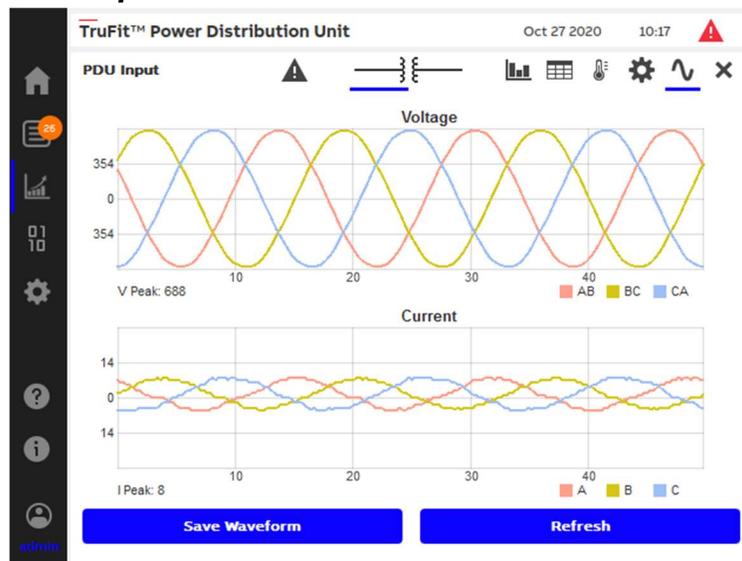


### 5.5.2.4 PDU Waveform screen

Select the waveform icon to view waveform from the main transformer's primary or secondary side, captured at the instant of selection.

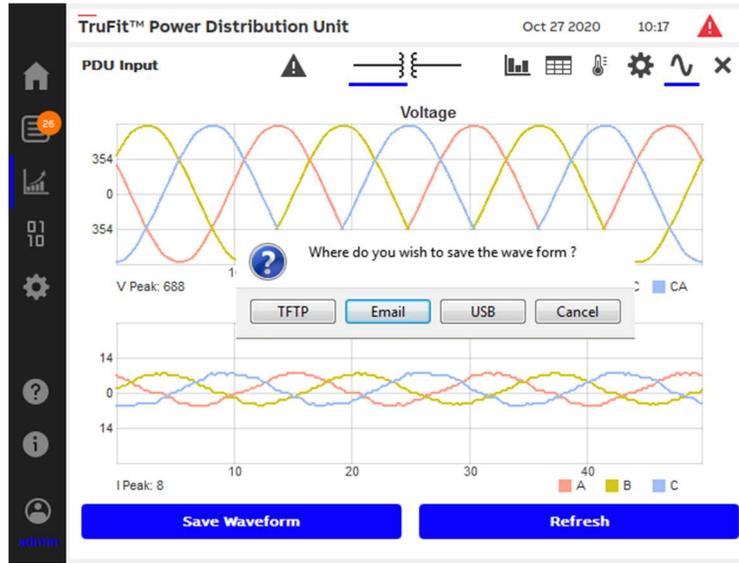
Pressing the  will update to a new waveform capture.

**Figure 5-6: PDU Waveform Capture screen**



A waveform capture can be saved to an output drive, by pressing **Save Waveform** and selecting as shown below. Output file is in .csv format.

**Figure 5-7: PDU Waveform Capture Save screen**

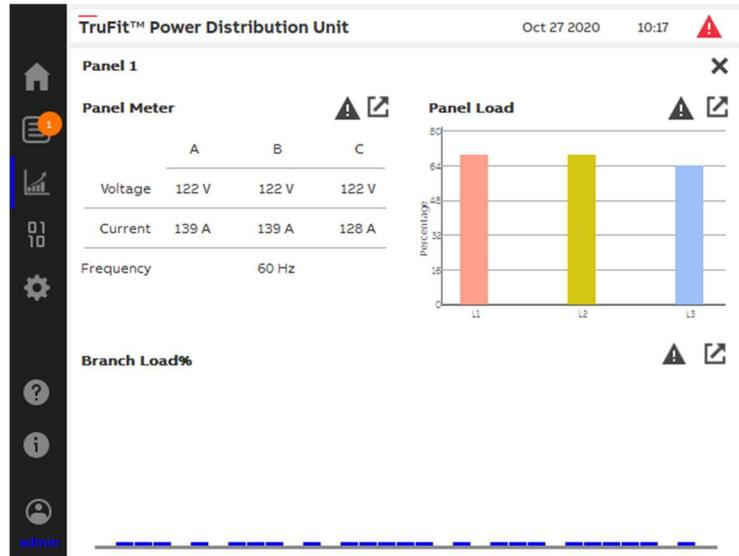


### 5.5.3 Panel and Branch Metering screens

#### 5.5.3.1 Panel and Branch Main screens

When the user clicks one of the Overview screen’s panel icons, the Panel Main screen for that panel opens. The Panel Mains screen shows an overview of the prevailing voltage, current and load conditions for that panel as noted in the upper left corner.

**Figure 5-8: Panel and Branch Main screen**

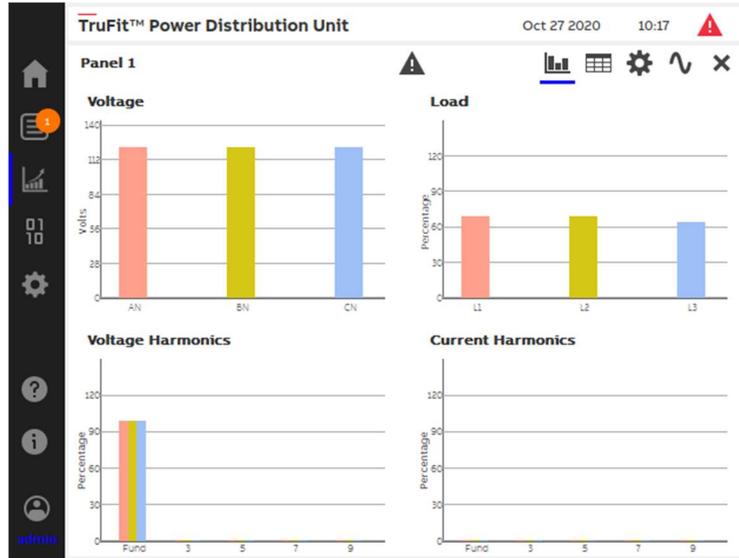


### 5.5.3.1.1 Panel Graphical View

Clicking the Panel Meter or Panel Load information on the Main screen takes the user to the Panel Graphical screen. Prevailing voltage, load and harmonics information for that panel is displayed in bar graphs.

Clicking the  icon on the Panel Tabular view returns the user to this screen.

**Figure 5-9: Panel Graphical screen**



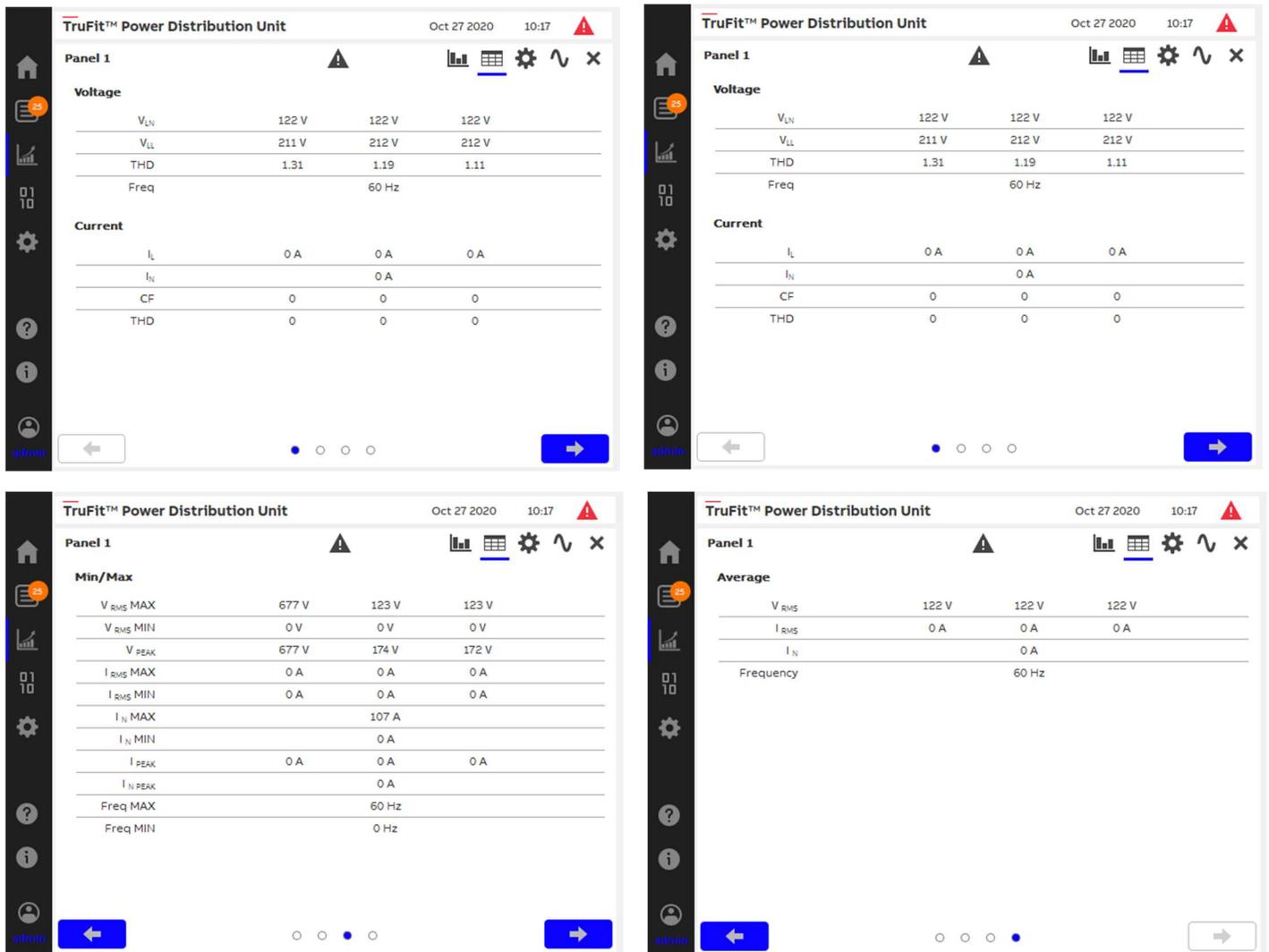
### 5.5.3.1.2 Panel Tabular View

Four screens show present metering information regarding voltage, current, frequency and power for the panel noted in the upper left corner.

Click the blue arrows   to move through the screens.

Min and Max values are since the last reset. Averages are over the duration noted in the settings. Changing settings and resetting values requires ADMIN access.

**Figure 5-10: Panel Tabular screens**

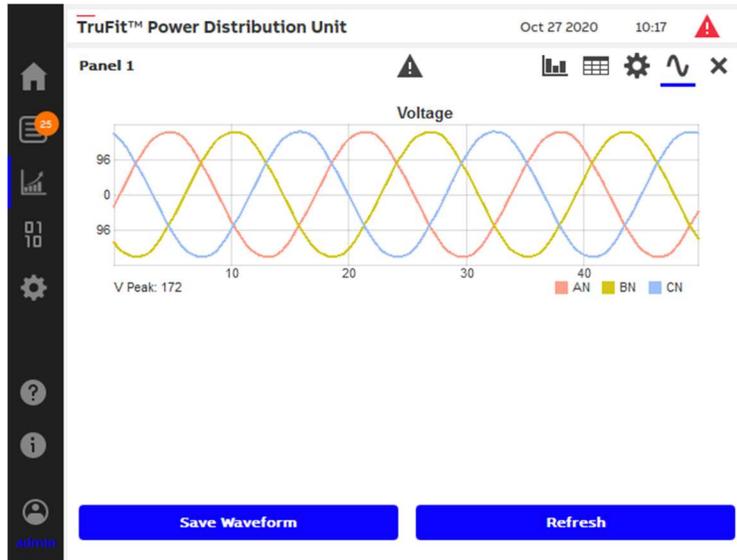


### 5.5.3.1.3 Panel Waveform view

Select the waveform icon to view waveform from the noted panel, captured at the instant of selection.

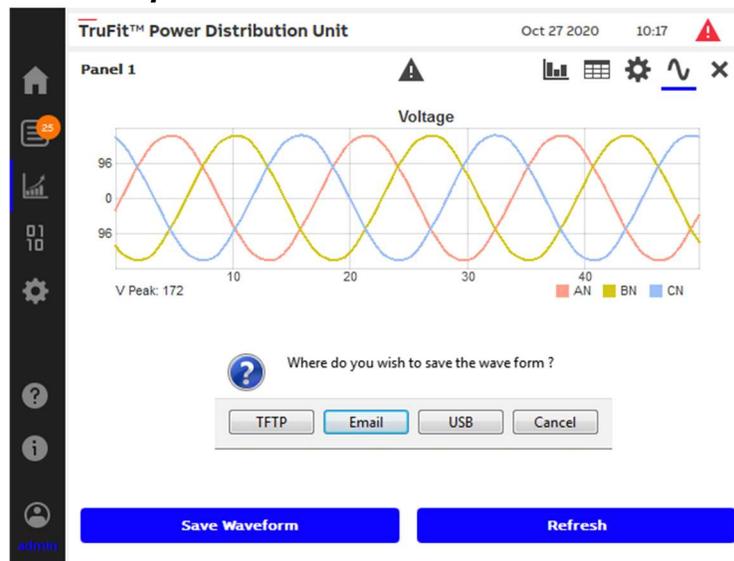
Pressing the  will update to a new waveform capture.

**Figure 5-11: Panel Waveform Capture screen**



A waveform capture can be saved to an output drive, by pressing  and selecting as shown below. Output file is in .csv format.

**Figure 5-12: Panel Waveform Capture Save screen**



### 5.5.3.2 Branch screens

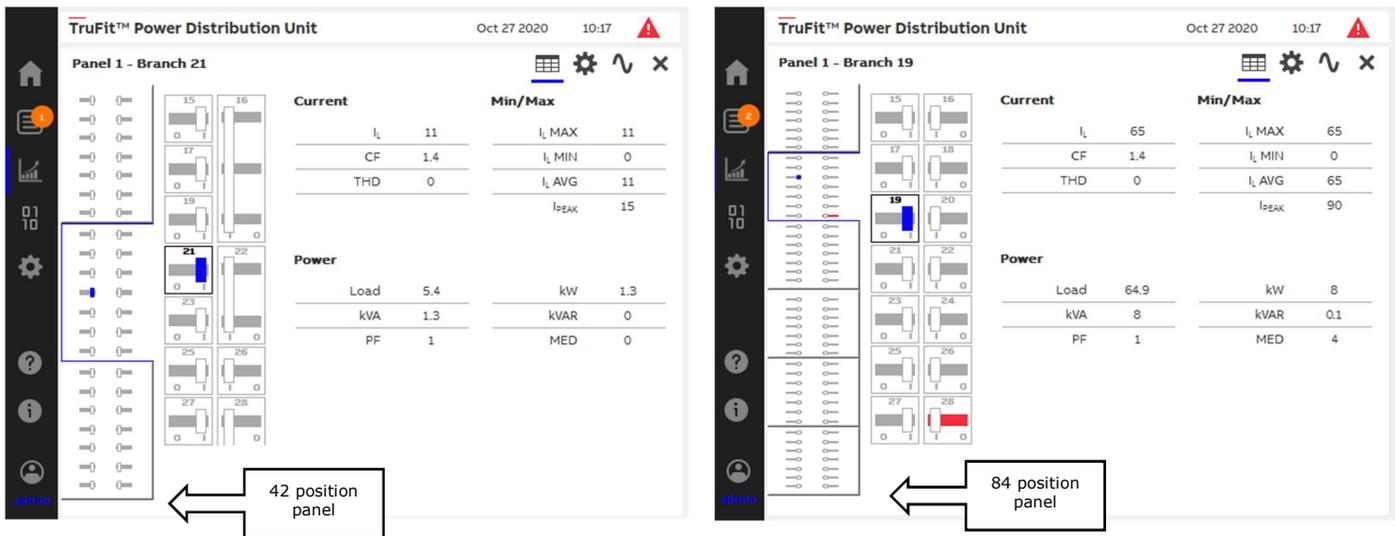
Clicking the Branch Load information on the Panel and Branch Main screen takes the user to the Branch Status screen. The screen shows icons for each branch on that panel.

The selected branch icon is noted in blue and identified in the upper left corner, as shown by Branch 1 in Figure 5-13. Prevailing current and power information for that branch is shown.

#### 5.5.3.2.1 Branches with 1-pole breakers

PowerView can display 42 or 84 position panels, as shown in Figure 5-13. Branches are displayed in groups of 14. To select another group, click on that group along the left part of the screen. To select another branch, click on the breaker icon for that branch, whether 1-pole, 2-pole or 3-pole breakers.

**Figure 5-13: Branch Status screen, 1-pole breaker**

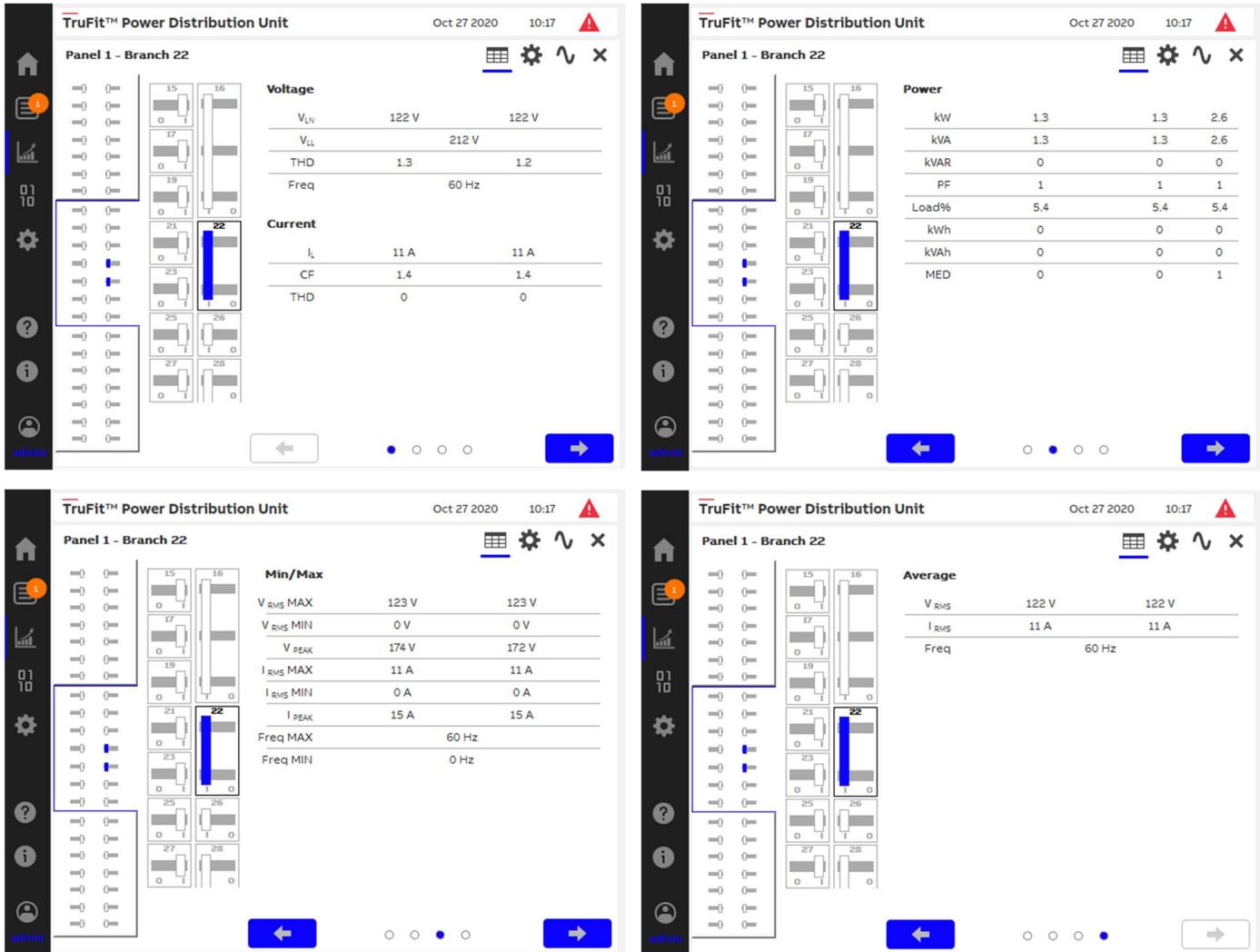


### 5.5.3.2.2 Branches with 2-pole breakers

Four screens show present metering information regarding voltage, current, frequency and power for the branch with 2-pole breaker noted in the upper left corner.

Click the blue arrows   to move through the screens.

**Figure 5-14: Branch status screens, 2-pole breaker**

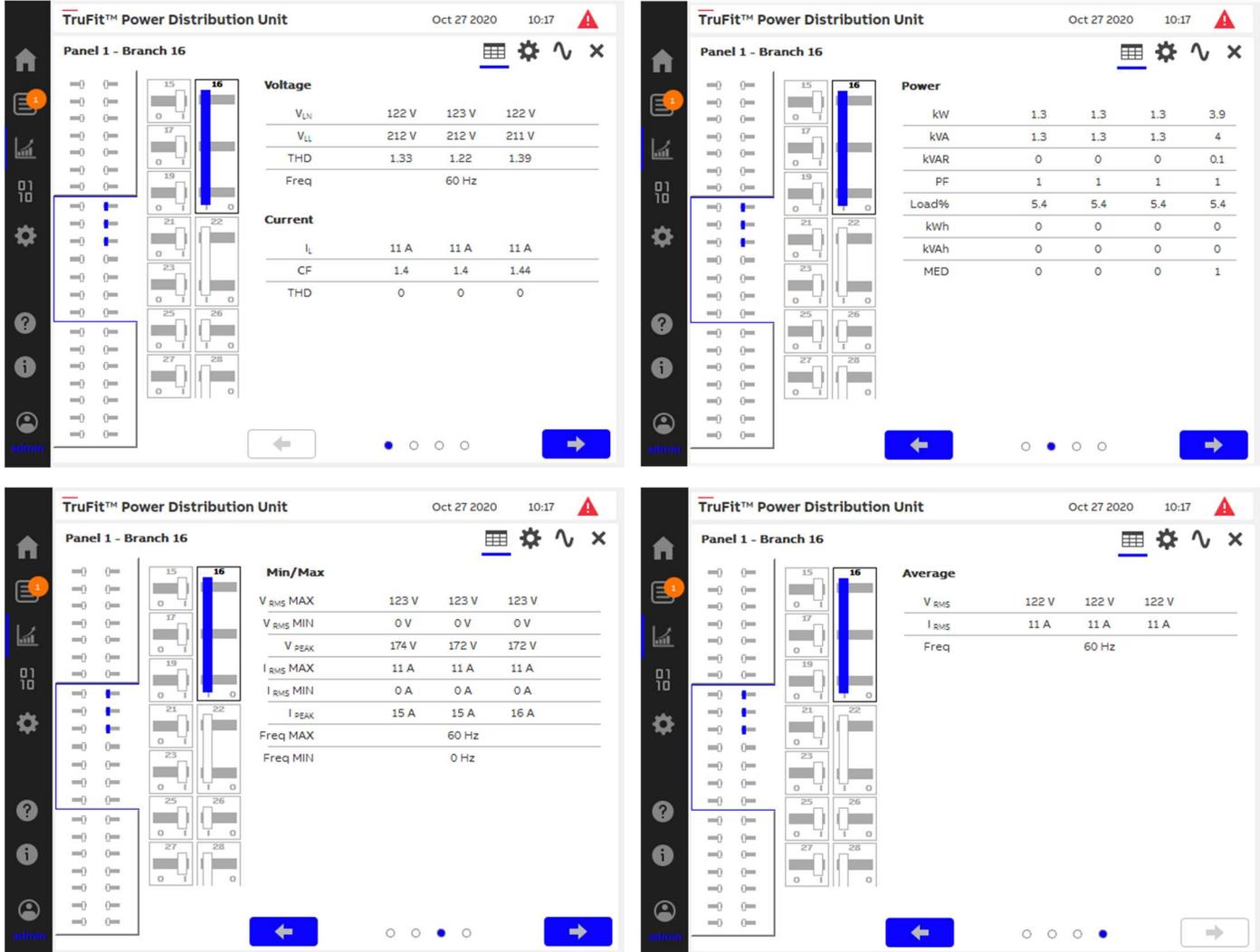


### 5.5.3.2.3 Branches with 3-pole breakers

Four screens show present metering information regarding voltage, current, frequency and power for the branch with 3-pole breaker noted in the upper left corner.

Click the blue arrows   to move through the screens.

**Figure 5-15: Branch status screens, 3-pole breaker**

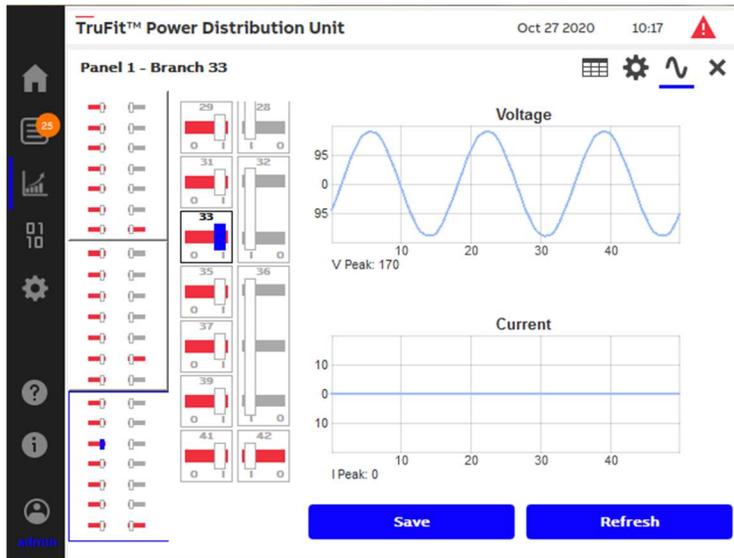


### 5.5.3.2.4 Branch Waveform screens

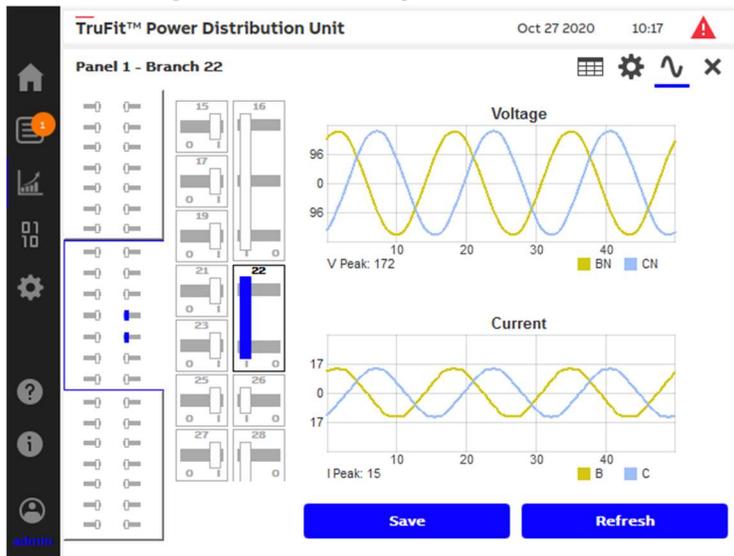
Select the waveform icon to view waveform from the noted branch, captured at the instant of selection.

Pressing the **Refresh** will update to a new waveform capture.

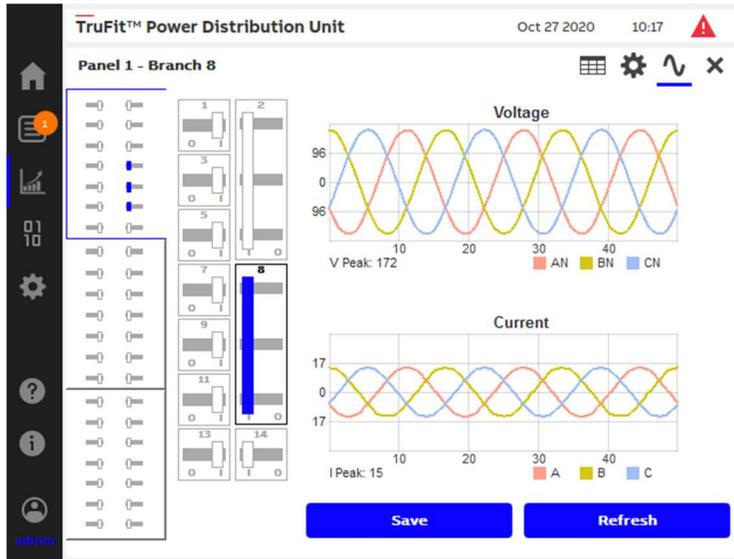
**Figure 5-16: Branch Waveform Capture screen 1-pole breaker**



**Figure 5-17: Branch Waveform Capture screen 2-pole breaker**

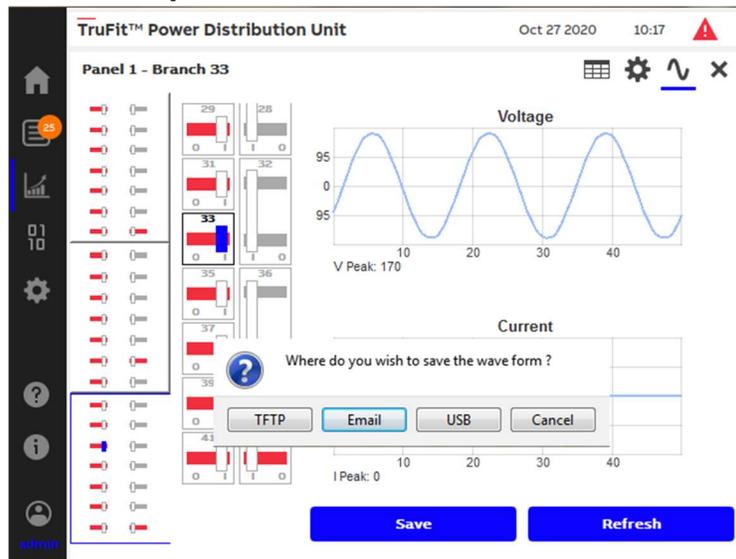


**Figure 5-18: Branch Waveform Capture screen 3-pole breaker**



A waveform capture can be saved to an output drive, by pressing **Save Waveform** and selecting as shown below. Output file is in .csv format.

**Figure 5-19: Branch Waveform Capture Save screen**

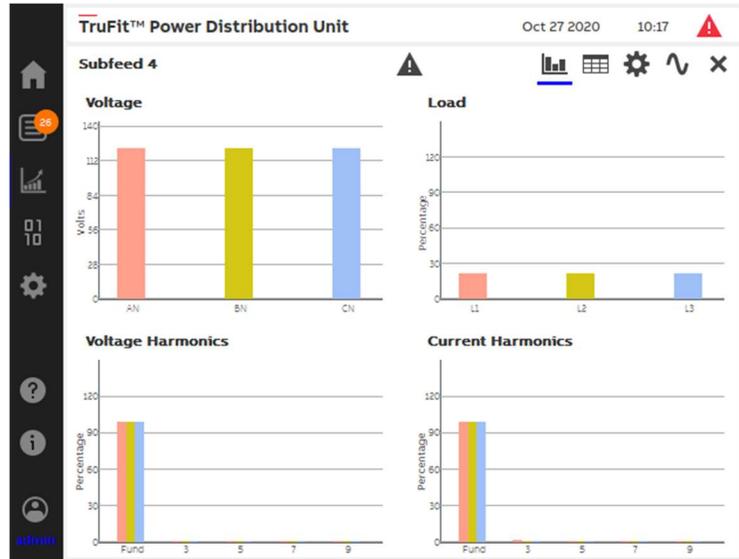


## 5.5.4 Sub-feed Metering screens

### 5.5.4.1 Sub-feed Graphical View

When the user clicks one of the sub-feed icons on the Metering Overview screen, the Sub-feed Graphical screen for that sub-feed opens, showing metering in bar graph format.

**Figure 5-20: Sub-feed Graphical screen**



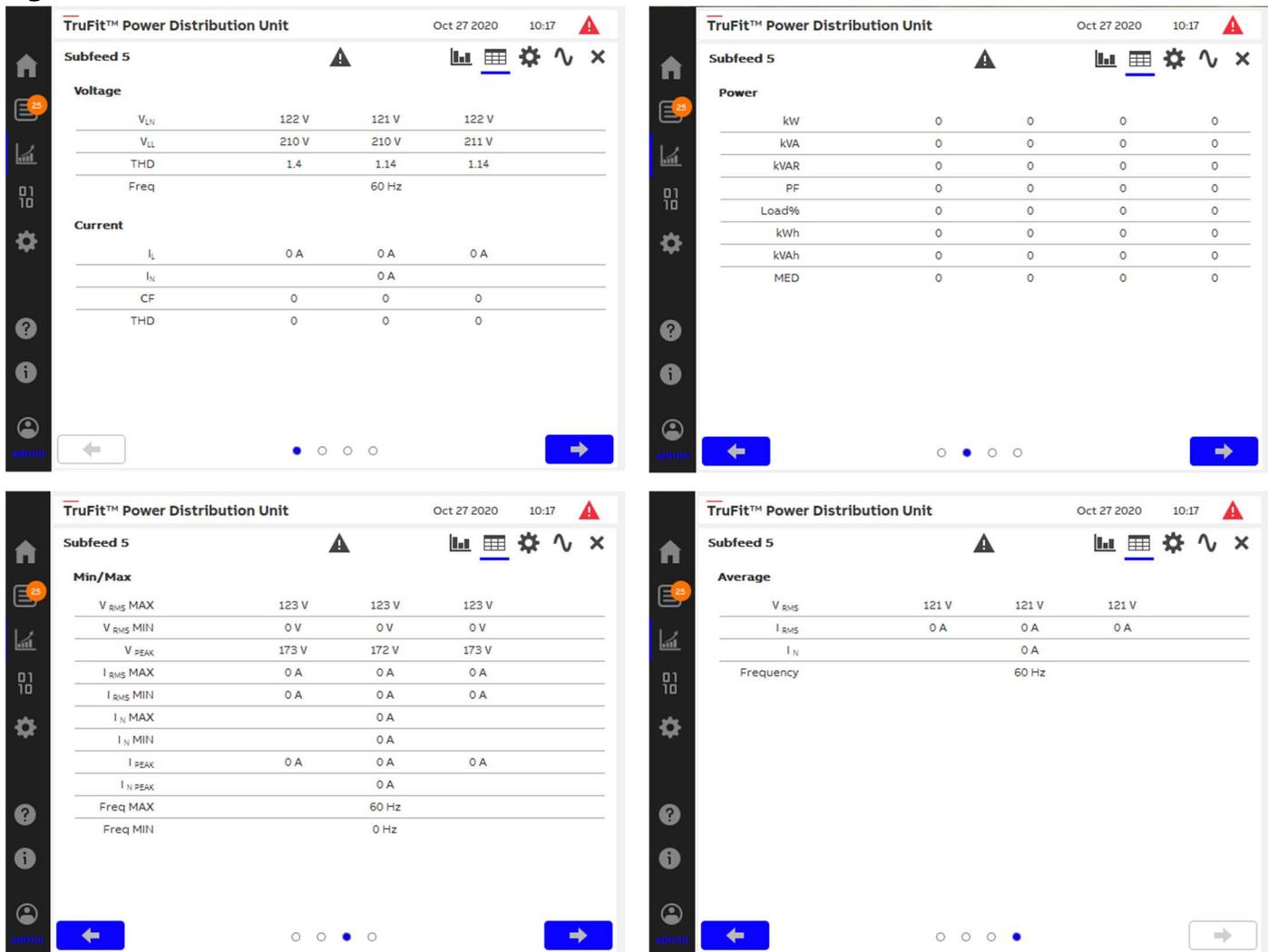
### 5.5.4.2 Sub-feed Tabular View

Four screens show present metering information regarding voltage, current, frequency and power for the panel noted in the upper left corner.

Click the blue arrows   to move through the screens.

Min and Max values are since the last reset. Averages are over the duration noted in the settings. Changing settings and resetting values requires ADMIN access.

**Figure 5-21: Sub-feed Tabular screens**

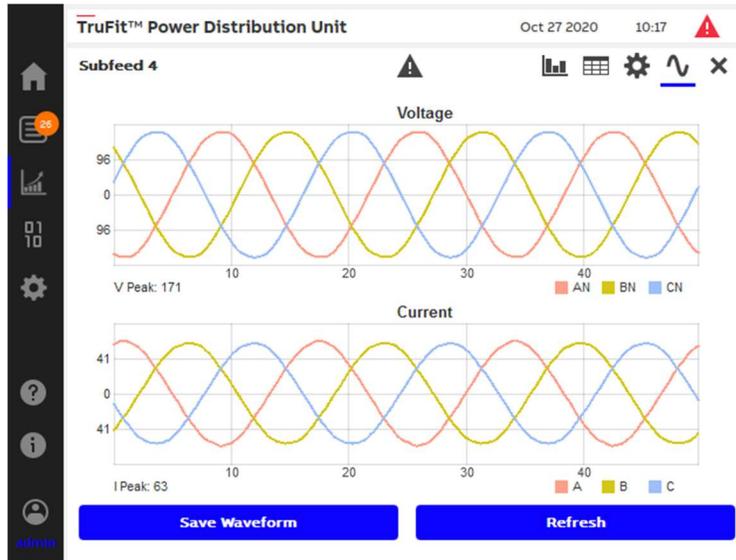


### 5.5.4.3 Sub-feed Waveform view

Select the waveform icon to view waveform from the noted sub-feed, captured at the instant of selection.

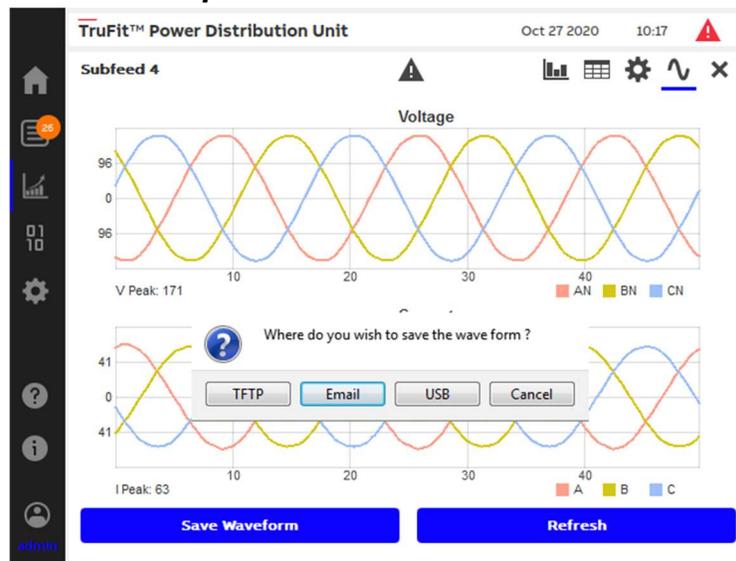
Pressing the  will update to a new waveform capture.

**Figure 5-22: Sub-feed Waveform Capture screen**



A waveform capture can be saved to an output drive, by pressing  and selecting as shown below. Output file is in .csv format.

**Figure 5-23: Sub-feed Waveform Capture Save screen**

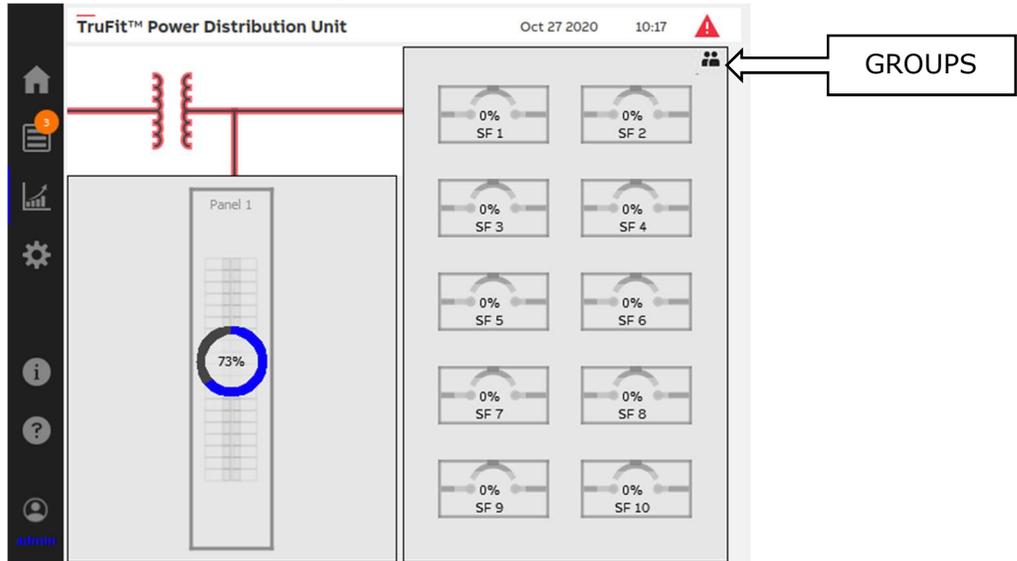


### 5.5.5 Custom Groups

PowerView allows the users to create up to 50 custom groups of sub-feeds, panels or branches. Groups are created during configuration.

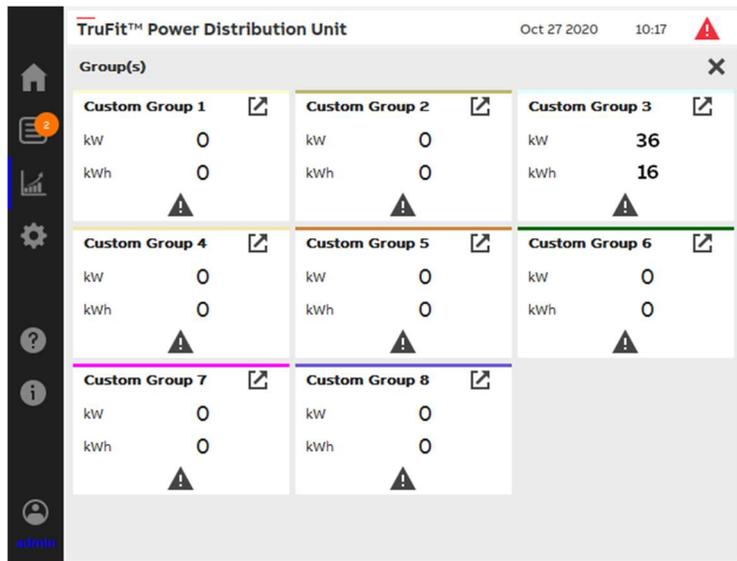
When custom groups have been configured the Metering Overview screen has the Groups icon shown below in Figure 5-24.

**Figure 5-24: Metering Overview screen with groups**



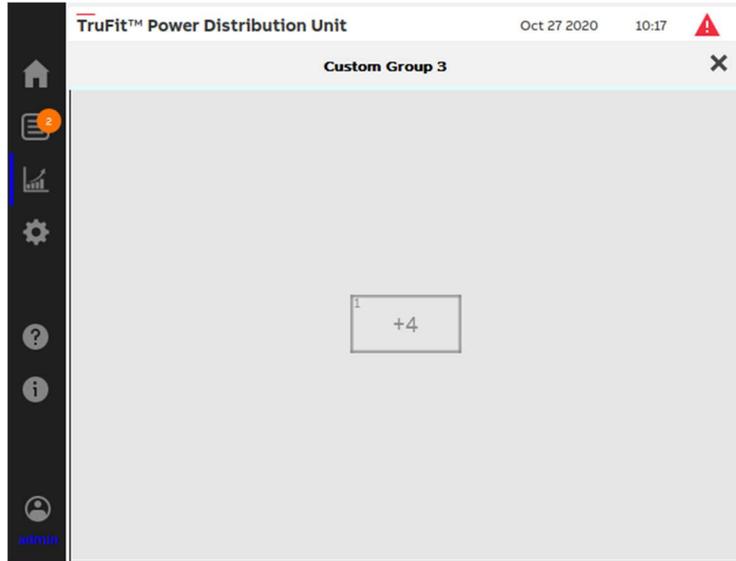
Clicking on the icon opens the screen with all custom groups as shown in Figure 5-25.

**Figure 5-25: Groups of Meters screen**

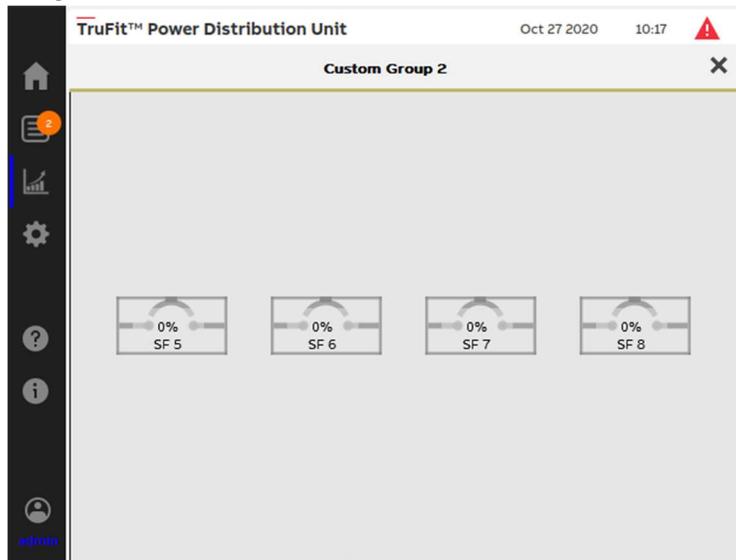


Clicking on a specific group opens the custom group screen. This screen displays a view of the group, showing number of included meters, as shown in Figure 5-26 or Figure 5-27.

**Figure 5-26: Custom Group screen – Branches and Panels**

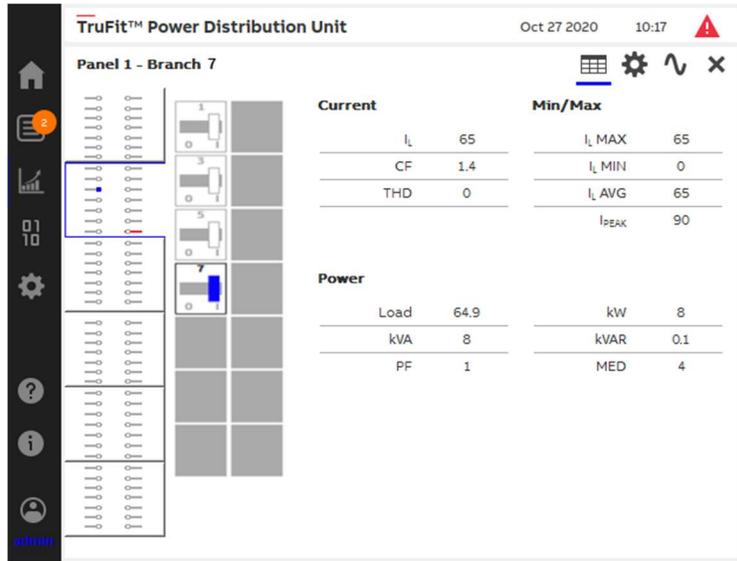


**Figure 5-27: Custom Group screen - Sub-feeds**



Clicking on an icon takes the operator to a view of the included sub-feed, branches or panels. Click on a specific branch or panel to display the metering information as described in Section 5.5.2, 5.5.3, or 5.5.4

**Figure 5-28: Meters in a Custom Group screen**



## 5.5.6 Input status screens

When a Discrete Input Board (DIB) or Thermocouple Input Board (TIB) are installed in PowerView, the Input Icon  will display in the main menu. By clicking on the Input icon, the Input Status screen will be shown.

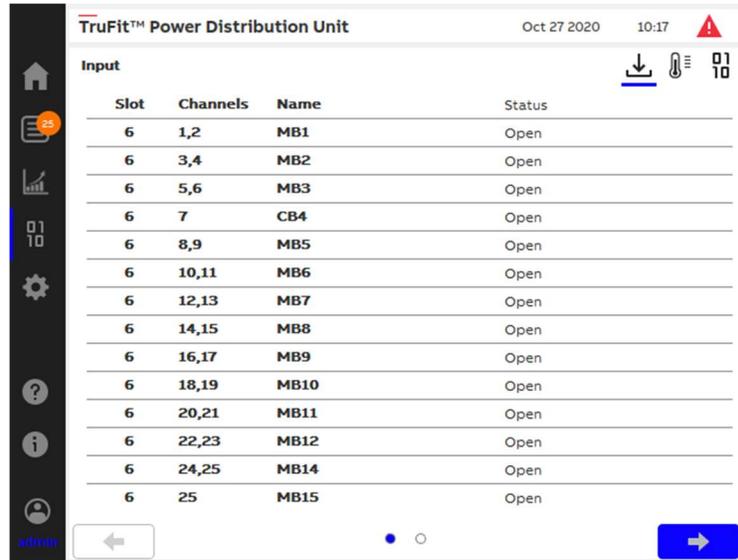
### 5.5.6.1 Input screen

This screen displays a table of each input sensor, and its status. Status is typically open or closed.

Clicking on the  icon returns to the input sensor screen

Click the blue arrows   to move through the screens.

**Figure 5-29: Input Status screen**



Slot	Channels	Name	Status
6	1,2	MB1	Open
6	3,4	MB2	Open
6	5,6	MB3	Open
6	7	CB4	Open
6	8,9	MB5	Open
6	10,11	MB6	Open
6	12,13	MB7	Open
6	14,15	MB8	Open
6	16,17	MB9	Open
6	18,19	MB10	Open
6	20,21	MB11	Open
6	22,23	MB12	Open
6	24,25	MB14	Open
6	25	MB15	Open

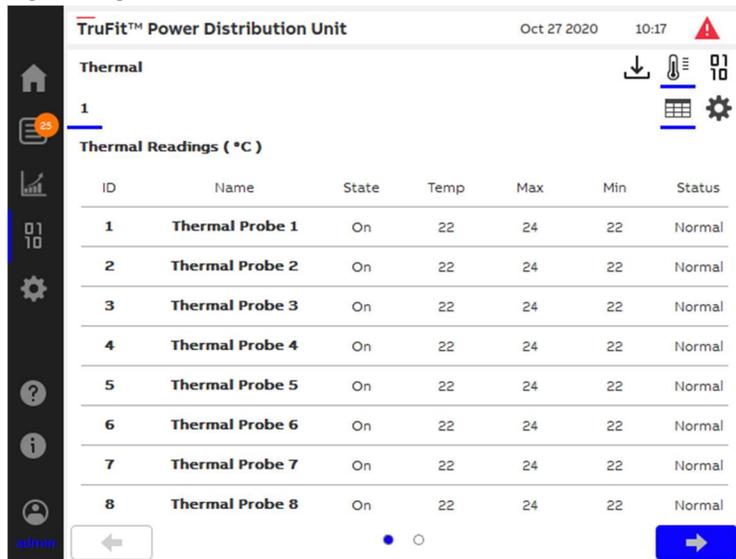
### 5.5.6.2 Thermocouple screens

A TIB icon  will be displayed when a Thermocouple Input Board is installed in PowerView. Click on the icon to go to the thermocouple screen. This screen displays a table of each thermal sensor's current temperature, the maximum and minimum temperature since the last system reset, and its status. Status is compared to the alert and warning temperatures from the settings discussed in Section 5.6.5.

Please contact ABB service for more information regarding system reset.

Click the blue arrows   to move through the screens.

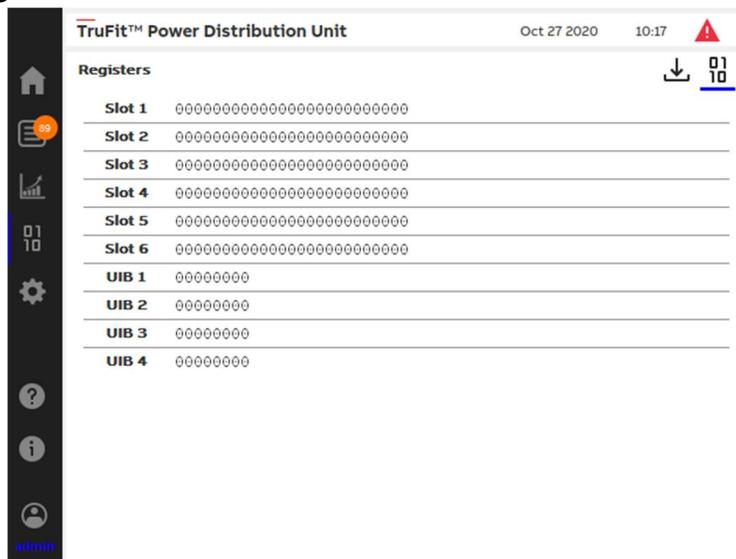
**Figure 5-30: Thermocouple Input Screen**



### 5.5.6.3 Registers screen

By clicking on the Register icon , the Input Register screen will be shown. This screen displays a table of each input sensor, and the register status.

**Figure 5-31: Input Register screen**



## 5.6 Setting alarm/warning limits and ratings

This section shows the PowerView configuration screens for the PDU, panel, branch and sub-feed circuits and shows the range of adjustments that are possible using these screens.

**Note:** Only 'ADMIN' or higher can access these screens. The changes made are not saved until you select the "Save" option.

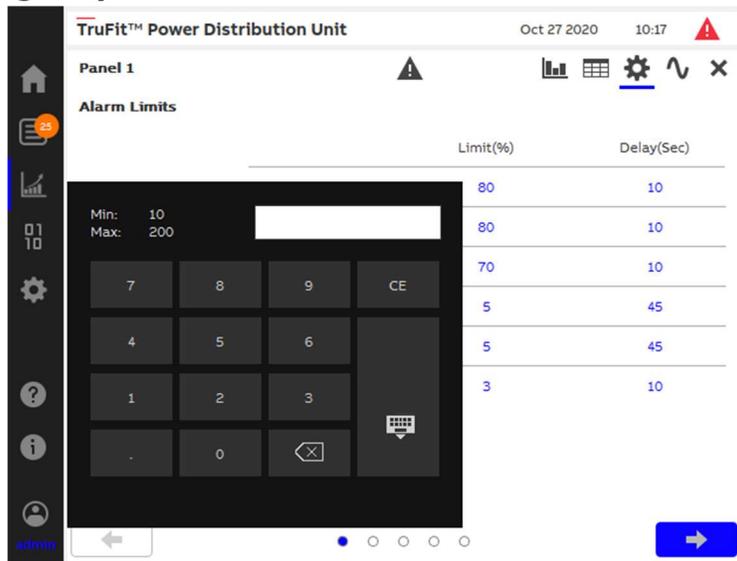
### **CAUTION**

Use caution when making configuration changes. In some cases, the GUI may not limit you from making unwise changes that could cause the equipment to malfunction.

The settings pages can be configured/viewed by navigating to the panel through the settings icon (⚙️).

Any value on a settings screen that is blue can be changed. To change a value, click on that value. A keyboard sub-window will open, as shown in Figure 5-32. Click on the numerals or letters to enter the new value. Click on the keyboard icon the sub-window's lower right to close the window and set the new value.

**Figure 5-32: Edit Settings keyboard**



Click  to save changes.

Click  to exit the screen without changes being implemented.

### 5.6.1 PDU configuration settings

The PDU's ratings and limits for voltage and current can be viewed or changed on the PDU's Settings screens, which are opened by selecting the setting icon (⚙️) under the PDU's submenu. The user needs to be logged in as ADMIN to change values in these screens. The values can be viewed with USER access.

**Figure 5-33: PDU's submenu options with 'Settings' icon**



Click the blue arrows   to move through the screens.

By default, the configurations shown is from the transformer's output side, as noted by the blue bar under the small transformer icon shown in Figure 5-34. To switch to configuration on the input side, the user will click that transformer icon.

#### 5.6.1.1 PDU Alarm Limits Settings screens

The over/under voltage and over-current alarm /warning limit settings can set in the PDU Limits Configuration screen (shown below).

**Figure 5-34: PDU Limits Settings screens**

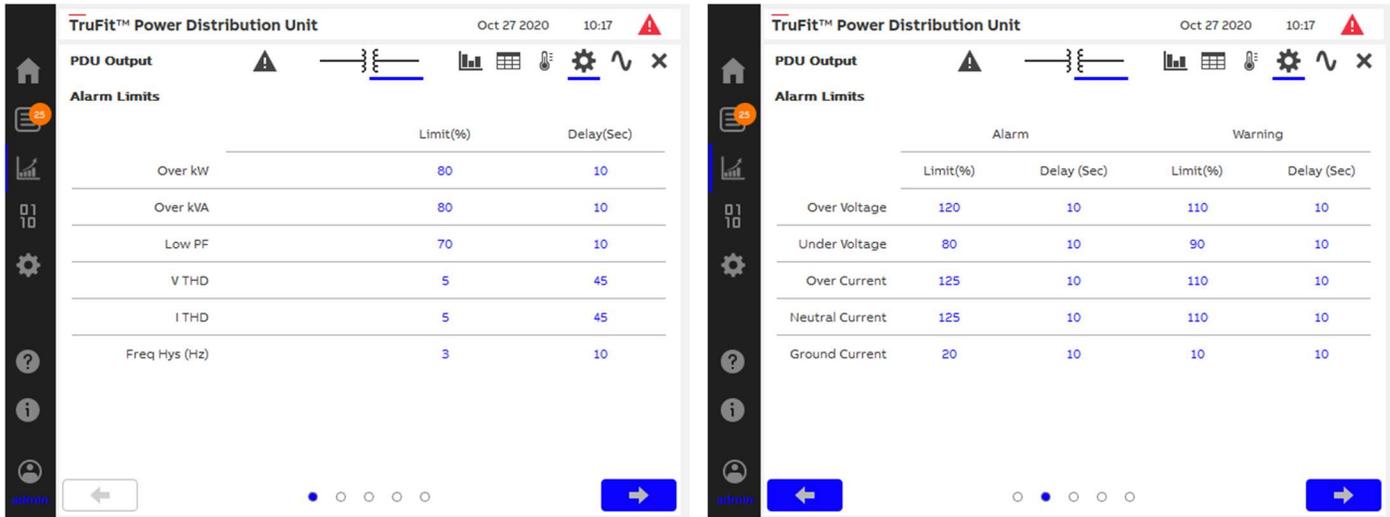


Table 5-1 shows the defaults and the minimum and maximum set point values that can be set using the PDU Configuration Limit screen above.

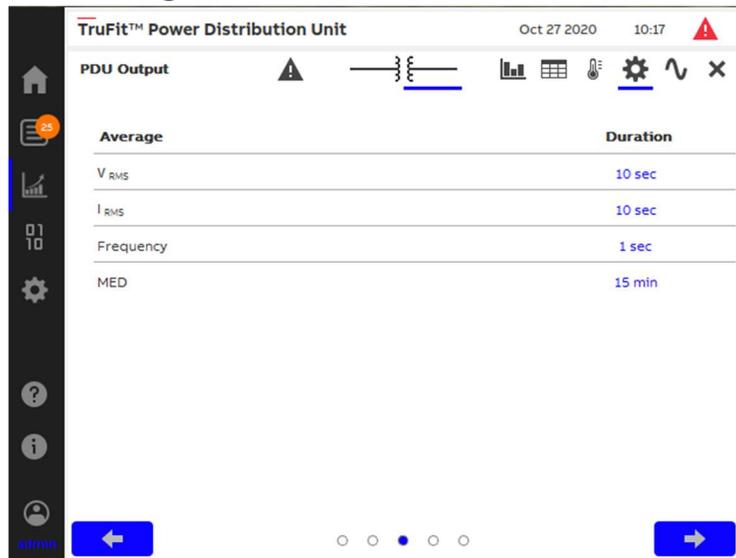
**Table 5-1: PDU alarm/warning limit settings**

Description	Min	Default	Max	Units
Input OV Alarm Limit	115	115	125	%
Input OV Warning Limit	105	110	115	%
Input UV Warning Limit	85	95	95	%
Input UV Alarm Limit	75	85	85	%
Output OV Alarm Limit	115	115	125	%
Output OV Warning Limit	105	110	115	%
Output UV Warning Limit	85	95	95	%
Output UV Alarm Limit	75	85	85	%
Output OC Alarm Limit	125	125	150	%
Output OC Warning Limit	100	115	125	%
Neutral Current Limit	0.1	125	150	%
Ground Current Limit	5	20	50	A
Frequency	0.1	0.5	4	Hz

### 5.6.1.2 PDU Duration Settings screen

Some metering parameters for the PDU are averaged over time. The duration for averaging these parameters is set on the duration screen, shown below.

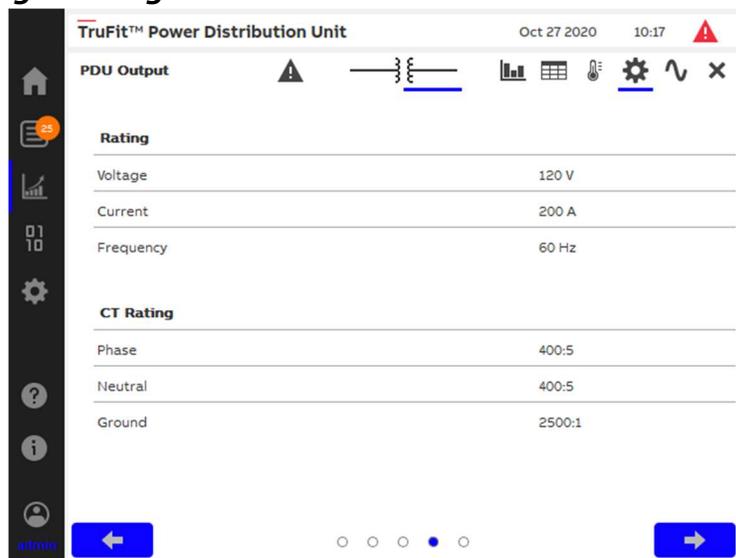
**Figure 5-35: PDU Duration Settings screen**



### 5.6.1.3 PDU Ratings screen

The PDU's voltage, current, and frequency ratings and CT information are shown in this screen. These settings cannot be configured; they are set by the factory and are read only.

**Figure 5-36: PDU Ratings Settings screen**

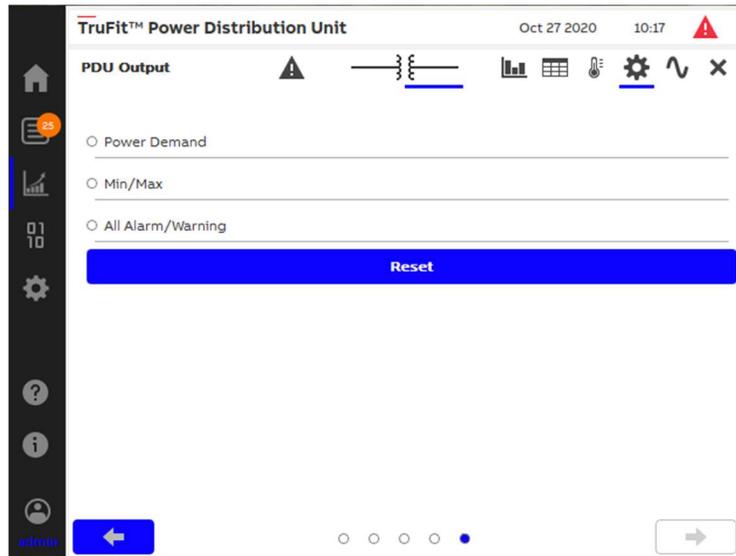


#### 5.6.1.4 PDU Parameter Reset screen

Some metering parameters for the PDU have maximum and minimum values logged over time. The logging of these values can be reset to start over, as shown below.

To reset a value, click on that value, then click the blue RESET button.

**Figure 5-37: PDU Reset screen**



#### 5.6.2 Panel configuration settings

The ratings and limits for a selected panel can be viewed or changed on the Panel's Settings screens, which are opened by selecting the setting icon (  ) under the Panel's submenu after selecting a panel on the Metering Overview screen. The user needs to be logged in as ADMIN to change values in these screens. The values can be viewed with USER access.

**Figure 5-38: Panel submenu options with 'Settings' icon**



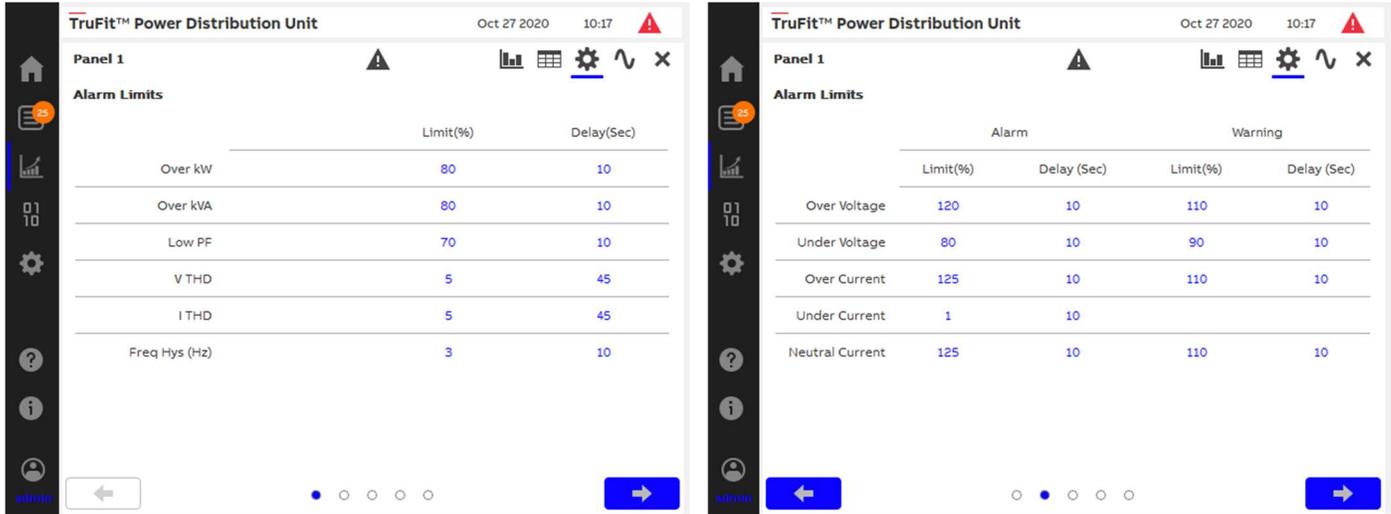
Click the blue arrows   to move through the screens.

### 5.6.2.1 Panel Alarm Limits Settings screens

The alarm /warning limit settings for power, voltage and current for the selected panel can be set in the Panel Configuration Limits screen (shown below). The selected panel is noted in the screen's upper left corner.

Alarms and warnings will trigger after the delay time. After parameter remains outside its threshold for the specified delay time, the alarm/warning will trigger.

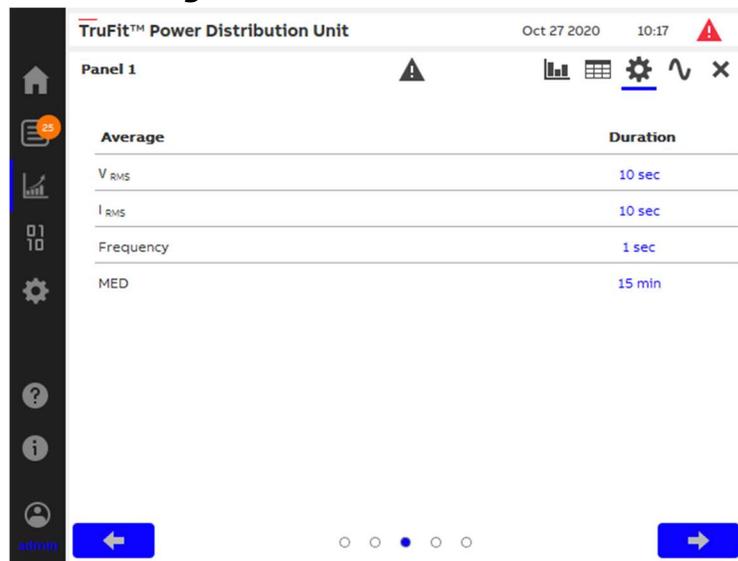
**Figure 5-39: Panel Alarm Limits screens**



### 5.6.2.2 Panel Duration Settings screen

Some metering parameters for the selected panel are averaged over time. The duration for averaging these parameters is set on the duration screen, shown below. The selected panel is noted in the screen's upper left corner.

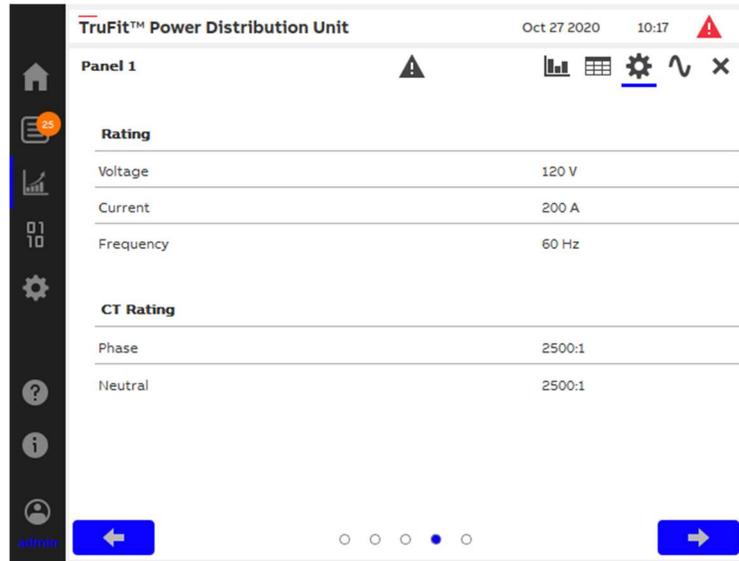
**Figure 5-40: Panel Duration Settings screen**



### 5.6.2.3 Panel Ratings screen

The selected panel's voltage, current, and frequency ratings and CT information are shown in this screen. These settings cannot be configured; they are set by the factory or ABB Service and are read only. The selected panel is noted in the screen's upper left corner.

**Figure 5-41: Panel Ratings screen**

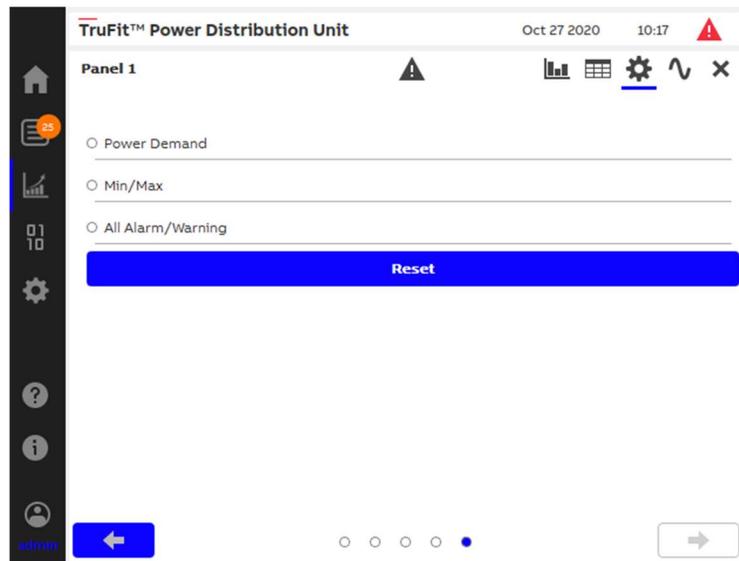


### 5.6.2.4 Panel Parameter Reset screen

Some metering parameters for the selected panel have maximum and minimum values logged over time. The logging of these values can be reset to start over, as shown below. The selected panel is noted in the screen's upper left corner.

To reset a value, click on that value, then click the blue RESET button.

**Figure 5-42: Panel Parameter Reset screen**



### 5.6.3 Branch configuration settings

The ratings and limits for a selected panel can be viewed or changed on the Panel's Settings screens, which are opened by selecting the setting icon (⚙️) under the Panel's submenu after selecting a panel on the Metering Overview screen. The user needs to be logged in as ADMIN to change values in these screens. The values can be viewed with USER access.

**Figure 5-43: PDU's submenu options with 'Settings' icon**

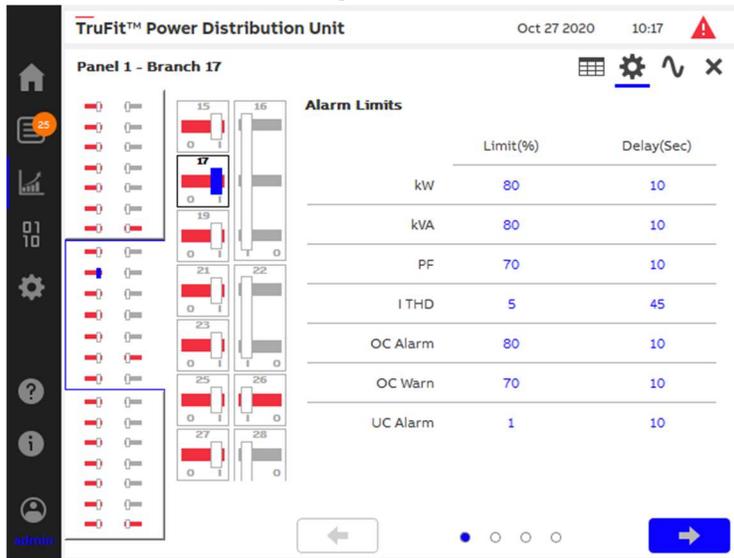


Click the blue arrows to move through the screens. The specific information displayed will depend on whether the branch is single-phase or three-phase.

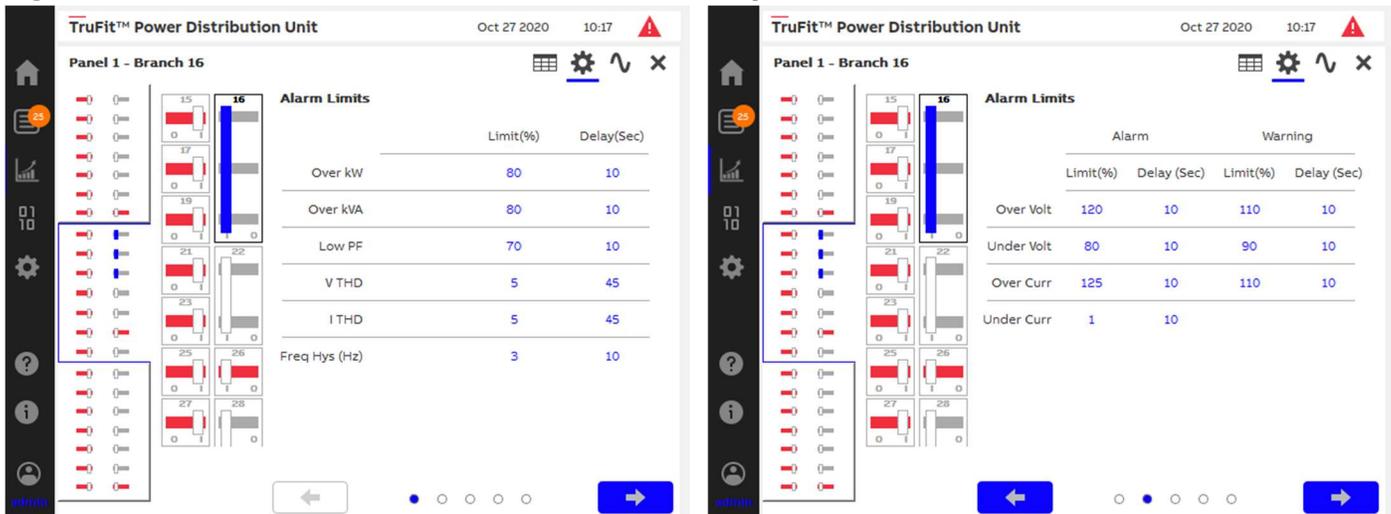
#### 5.6.3.1 Branch Alarm Limits Settings screen

The alarm /warning limit settings for power, voltage and current for the selected branch can be set in the Panel Configuration Limits screen (shown below). The selected branch and panel are noted in the screen's upper left corner.

**Figure 5-44: Branch Alarm Limits screen – 1-pole**



**Figure 5-45: Branch Alarm Limits screen – 2 or 3-pole**

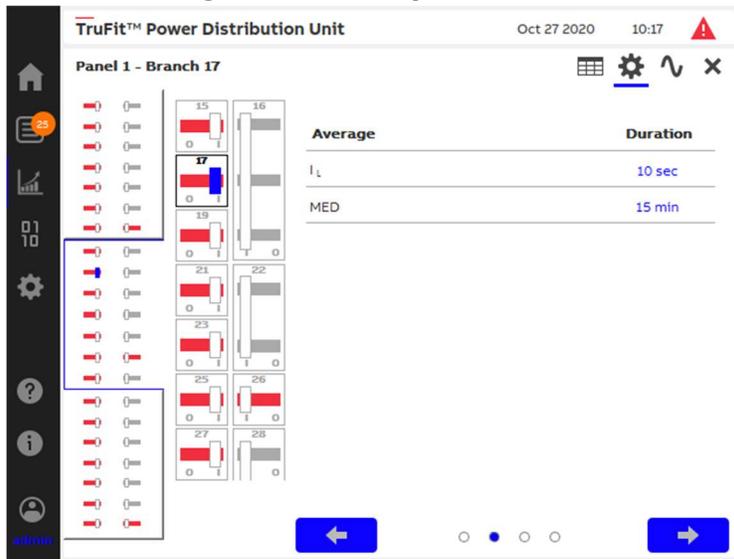


### 5.6.3.2 Branch Duration Settings screen

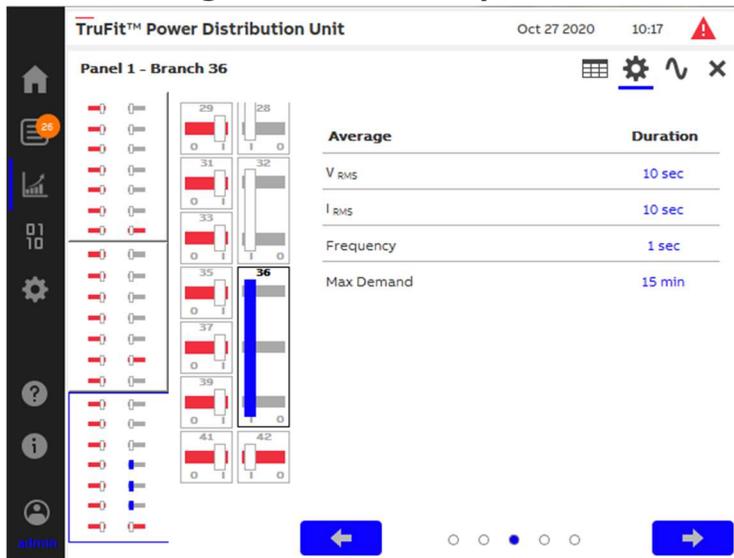
Some metering parameters for the selected panel are averaged over time. The duration for averaging these parameters is set on the duration screen, shown below. The selected panel is noted in the screen's upper left corner.

The selected branch and panel are noted in the screen's upper left corner.

**Figure 5-46: Branch Duration Settings screen – 1-pole**



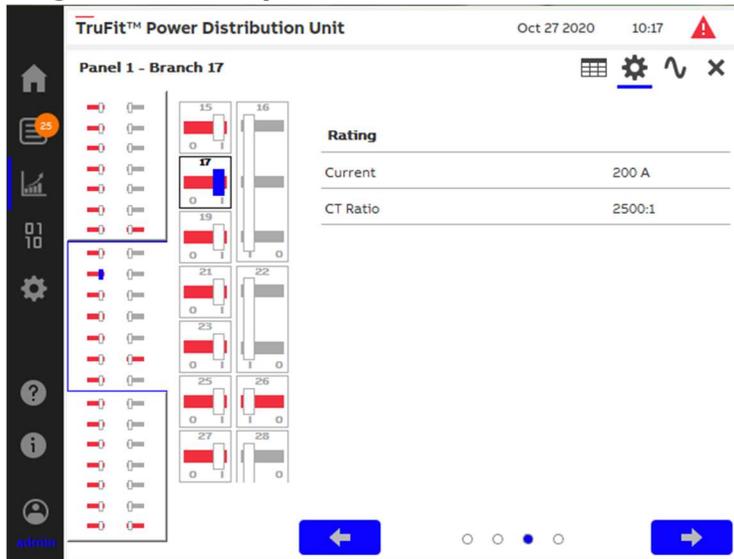
**Figure 5-47: Branch Duration Settings screen – 2 or 3-pole**



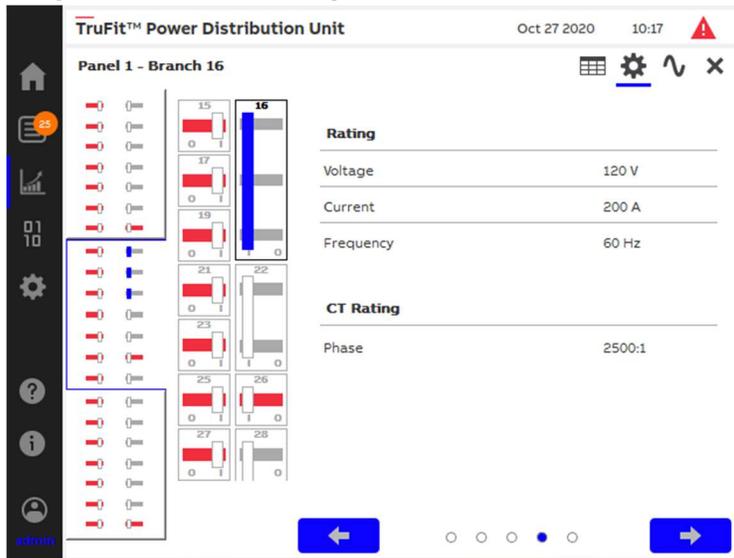
### 5.6.3.3 Branch Ratings screen

The selected branch's current and CT information are shown in this screen. These settings cannot be configured; they are set by the factory or ABB Service and are read only. The selected branch and panel are noted in the screen's upper left corner.

**Figure 5-48: Branch Ratings screen – 1-pole**



**Figure 5-49: Branch Ratings screen – 2 or 3-pole**

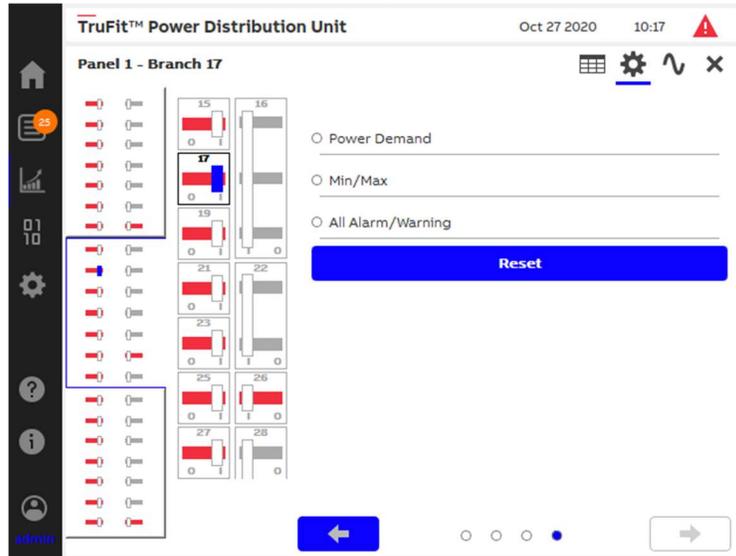


### 5.6.3.4 Branch Parameter Reset screen

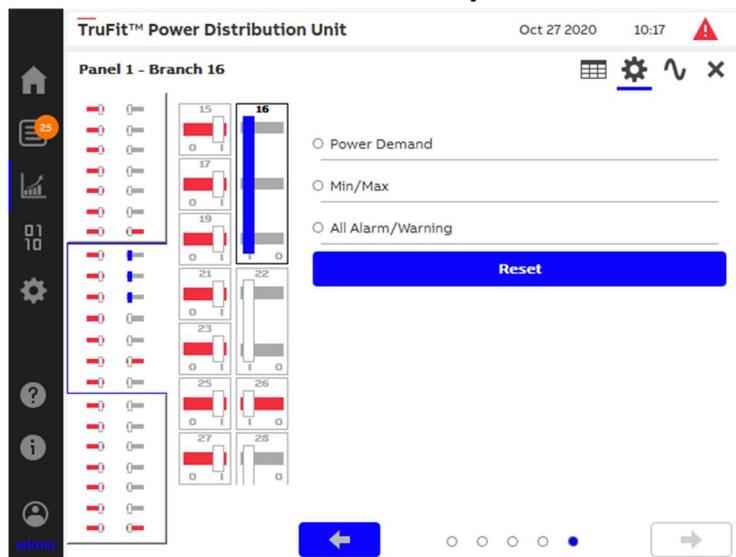
Some metering parameters for the selected branch have maximum and minimum values logged over time. The logging of these values can be reset to start over, as shown below. The selected branch and panel are noted in the screen's upper left corner.

To reset a value, click on that value, then click the blue RESET button.

**Figure 5-50: Branch Parameter Reset screen- 1-pole**



**Figure 5-51: Branch Parameter Reset screen – 2 or 3-pole**



## 5.6.4 Sub-feed configuration settings

The ratings and limits for a selected sub-feed can be viewed or changed on the sub-feed's Settings screens, which are opened by selecting the setting icon (⚙️) under the sub-feed's submenu after selecting a sub-feed on the Metering Overview screen. The user needs to be logged in as ADMIN to change values in these screens. The values can be viewed with USER access.

**Figure 5-52: Sub-feed's submenu options with 'Settings' icon**

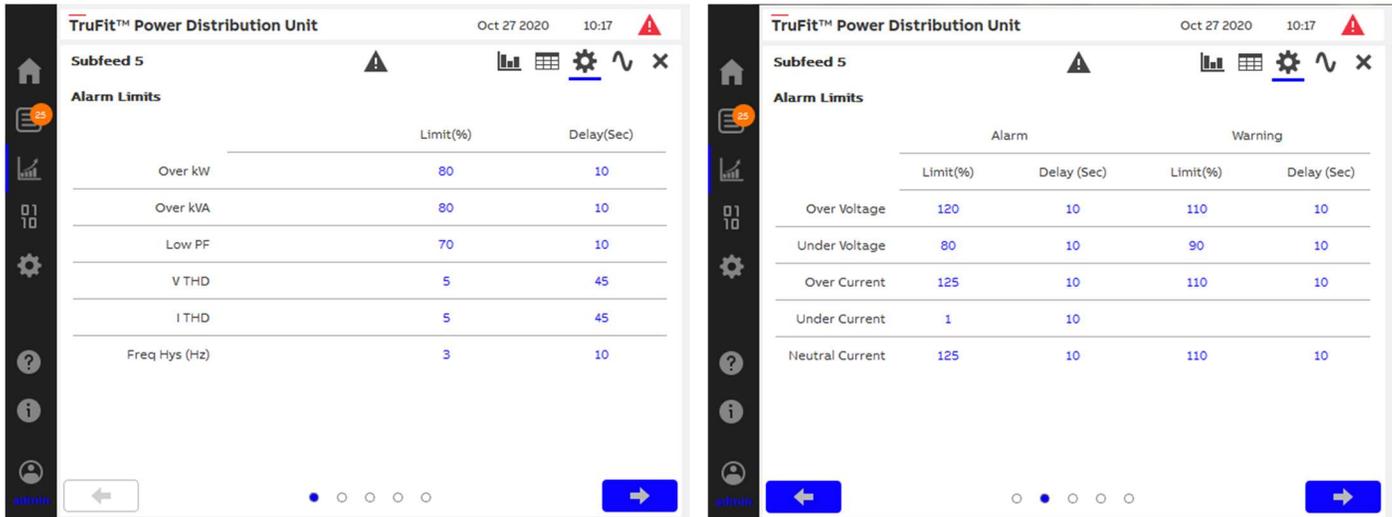


Click the blue arrows   to move through the screens.

### 5.6.4.1 Sub-feed Alarm Limits Settings screen

The alarm /warning limit settings for power, voltage and current for the selected sub-feed can be set in the Panel Configuration Limits screens (shown below). The selected sub-feed is noted in the screen's upper left corner.

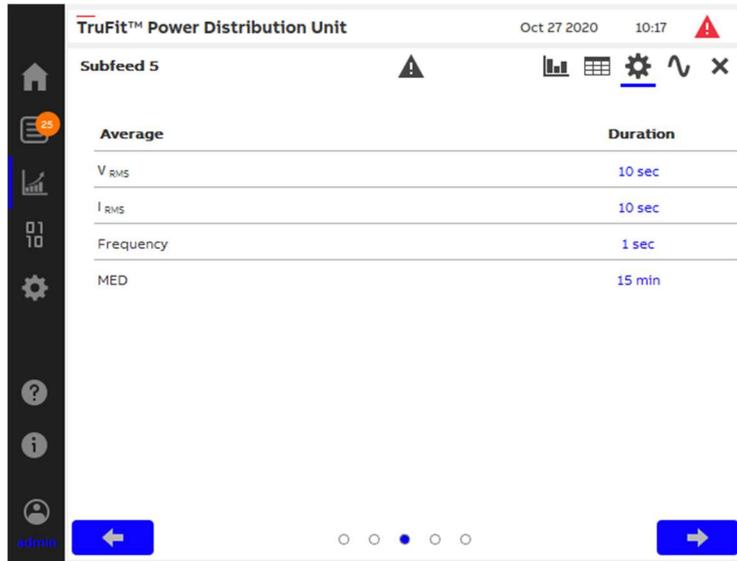
**Figure 5-53: Sub-feed Alarm Limits Settings screens**



### 5.6.4.2 Sub-feed Duration Settings screen

Some metering parameters for the selected sub-feed are averaged over time. The duration for averaging these parameters is set on the duration screen, shown below. The selected sub-feed is noted in the screen's upper left corner.

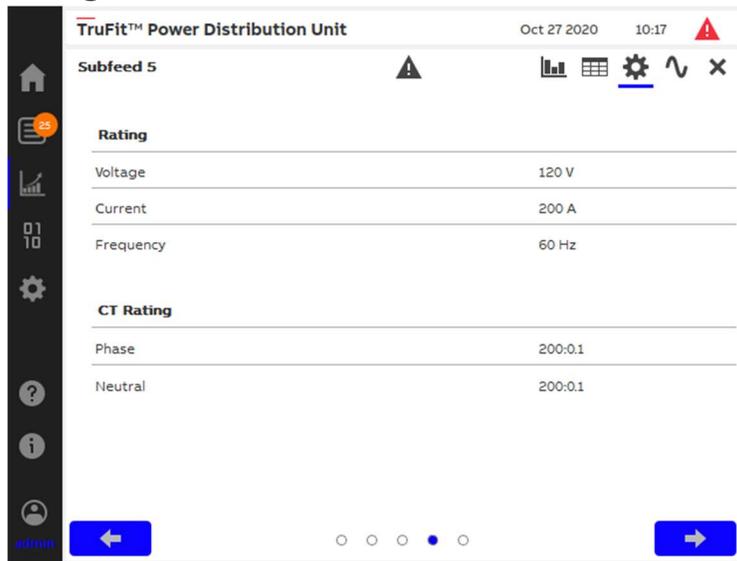
**Figure 5-54: Sub-feed Duration Settings screen**



### 5.6.4.3 Sub-feed Ratings screen

The selected sub-feed's voltage, current, frequency and CT information are shown in this screen. These settings cannot be changed by the customer; they are set by the factory or ABB Service and are read only. The selected sub-feed is noted in the screen's upper left corner.

**Figure 5-55: Sub-feed Ratings screen**

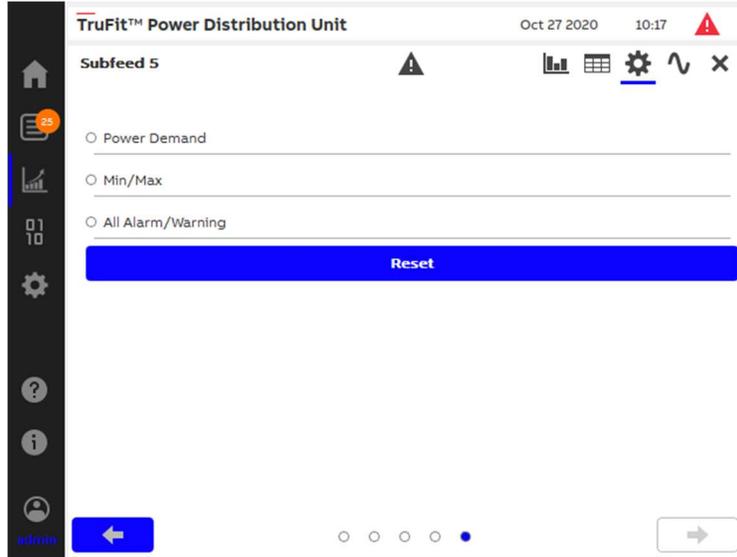


#### 5.6.4.4 Sub-feed Parameter Reset screen

Some metering parameters for the selected sub-feed have maximum and minimum values logged over time. The logging of these values can be reset to start over, as shown below. The selected sub-feed is noted in the screen's upper left corner.

To reset a value, click on that value, then click the blue RESET button.

**Figure 5-56: Sub-feed Parameter Reset screen**

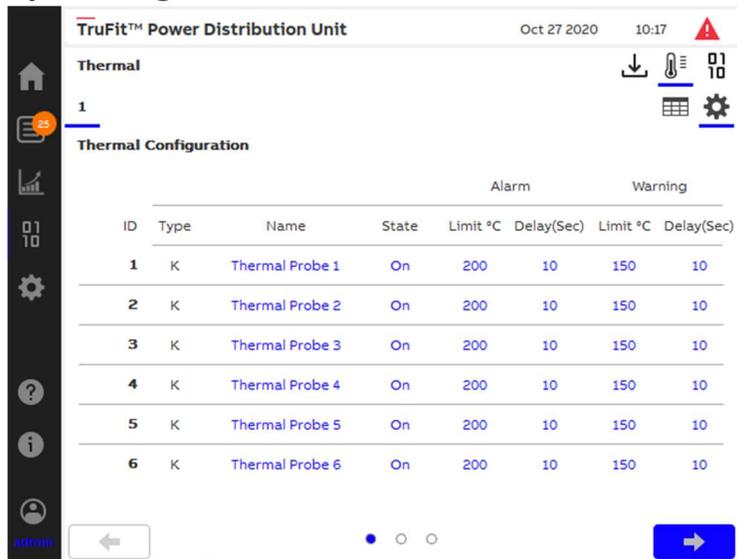


#### 5.6.5 Thermocouple configuration settings

The name, state, limits and delays for a selected thermal sensor can be viewed or changed on the Thermocouple Settings screens, which are opened by selecting the setting icon (⚙️) under the Thermocouple submenu. The user needs to be logged in as ADMIN to change values in these screens. The values can be viewed with USER access.

Click the blue arrows   to move through the screens to access more sensors.

**Figure 5-57: Thermocouple configuration screen**



## 6 Specifications

### 6.1 Standards

The PDU is compliant with the applicable requirements of:

- Listed by ETL to Underwriters Laboratories (UL) 891 Standard for Switchboards

Sub-components are compliant to standards listed:

- Electromagnetic Compatibility (EMC): FCC compliant (part 15)
- Enclosure: NEMA 1
- ANSI/NFPA 70 (2002)
- NEMA ST-20: Dry type transformers
- NEMA AB3-2001: Molded-case Circuit Breakers
- NEMA 250: Enclosures for Electrical Equipment
- Underwriters Laboratories (UL) 50: Cabinets & Boxes
- Underwriters Laboratories (UL) 489: Molded Case Circuit Breakers and Enclosures
- Underwriters Laboratories (UL) 840 for PCB spacing
- IEEE 587 (ANSI C 62.41): Surge/Noise Suppression

## 6.2 Electrical characteristics

**Table 6-1: Electrical characteristics**

kVA	Voltage	Full Load Amps	Main Breaker Rating, Frame
50	480	61	125 AMP
75	480	91	125 AMP
125	480	151	250 AMP
150	480	181	250 AMP
225	480	271	400 AMP
300	480	362	600 AMP

## 6.3 Environmental characteristics

The PDU has the capability of withstanding any combinations of environmental conditions listed below without mechanical or electrical damage or degradation of operation.

- Operating ambient temperature: 0 to 40° C
- Non-operating and storage ambient temperature: -25 to 55° C
- Noise level, Per NEMA ST-20:
  - o <50dbA (up to 150kVA)
  - o <55dbA (up to 300kVA)
- Barometric pressure: At elevations up to 3300 feet above sea level
- Equipment is designated for indoor use in a clean (dust-free), temperature and humidity-controlled environment

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## 7 System maintenance

Minimal periodic maintenance of the unit is required. As with all electrical distribution components, this system should be regularly inspected for electrical connection integrity, signs of excessive temperature, accumulation of dirt, and proper system operation.

As with any electronic devices, critical circuits are subject to normal life cycle effects. ABB offers various service plan levels to keep your equipment in peak operating condition as the unit ages. Contact ABB Service Sales at [ric\\_servicesales@us.abb.com](mailto:ric_servicesales@us.abb.com) or go to <https://new.abb.com/ups/service-ups-and-power-conditioning> to learn more.

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### **⚠ WARNING**

- Only qualified service personnel should perform maintenance on the PDU.
- Exercise extreme care to avoid equipment damage or injury to personnel.
- Lethal voltages exist inside the unit during normal operation.

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#### 7.1 Tightening torques

Recommended tightening torque for all nuts and bolts is listed in the table below. As applicable, torque seal has been utilized to indicate bolt torquing.

**Table 7-1: Recommended tightening torque**

---

Thread Size Inch	SAE Grade 5 120,000 psi Medium Carbon Heat T.	
	Lb-ft	N-M
	1/4	6
5/16	11	15
3/8	20	27
1/2	48	65

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All internal bolts are SAE Grade 5.

Note bolt head markings above to distinguish between grades.

All internal machine screws are Grade 2.

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