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DEVCOM Army Research Laboratory Visualization and Processing for Embedded Research Systems (ARL-ViPERS) User Manual V.08.2025

by Colby Conish, Stephen Vinci, and Zachary Drummond

NOTICES

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14. ABSTRACT
Over the past 2 years, many changes and improvements have been made to ViPERS (Visualization and Processing on Embedded Research Systems). This instruction manual introduces all the new features, alongside restating the core features already described in previous versions of this manual. This is the most up-to-date usage guide for ViPERS installed on ARL Mobile Power Meters and Mobile Unattended Ground Sensors as of August 2025.

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Acknowledgments

This publication represents a significant revision to prior versions of this user manual. However, for purposes of continuity, some sections describing portions of the ViPERs application that did not significantly change are reprinted verbatim from prior manuals authored by Abigail Snellman, Zachary Drummond, David Hull, Brandon Parks, Kevin Claytor, Hugh Chung, Jeremy Hu, and Alex George.

1. Introduction

Several prototype U.S. Army Combat Capabilities Development Command (DEVCOM) Army Research Laboratory (ARL) sensor systems have been built on common, modular data acquisition, storage, processing, and communications hardware known as ARL's Autonomous Real-Time Electric-power Measurement and Instrumentation System (ARL-ARTEMIS). Two examples of these systems are ARL's Mobile Unattended Ground Sensor (ARL-MUGS) and Mobile Power Meter (ARL-MPM) seen in Figure 1. These systems come equipped with software that can be used for sensor configuration as well as live analysis of data collected on electric-power (EP) systems. This ARL-developed software framework for "Visualization and Processing on Embedded Research Systems" is called ARL-ViPERS. Hereafter, ARL-ARTEMIS and ARL-ViPERS will be referred to as ARTEMIS and ViPERS, respectively.

Figure 1. ARL-MUGS (left) and ARL-MPM (right).

ViPERS includes both an embedded web application that can be accessed through a web browser on a user's device such as a mobile phone, tablet, or personal computer, as well as the Dataserver application that is used to run custom processing code. Both the web application and the Dataserver run on the sensor and work together to provide user interfaces (UIs) for easy configuration of sensors as well as several data visualization tools that users may find useful for "at-the-edge" data analysis. The Dataserver's primary responsibility is to manage ongoing data processing tasks in the background, while the web server is used to provide users with the corresponding UIs. The Dataserver can be thought of as the "brain" of ViPERS whereas the web server is the "face."

All required ViPERS software runs on the ARL sensor hardware; therefore, users do not need to install any software on the user devices. ViPERS was also built with modularity in mind. It includes several base modules built for EP analysis and allows users to easily extend the software to include their own modules. Users can also upload custom processing code and visualizations that will run in real time on the sensor (see Section 3.10.1 for details).

This ViPERS User Guide provides a step-by-step walkthrough of the features made available to users through the web application. Section 2 provides basic information needed to connect to and use ViPERS. Section 3 covers detailed information on each module included with the ViPERS web application; Section 4 provides information on the ViPERS Dataserver. See the companion ViPERS Implementation Guide[1] and the ViPERS Programming Manual[2] for instructions on adding new modules and available application programming interfaces (APIs).

This publication represents a significant revision to prior versions of this user manual. However, for purposes of continuity, some sections describing portions of the ViPERs application that did not significantly change are reprinted verbatim from prior manuals.[2]

2. ViPERS Basics

The ViPERS software framework includes the following:

1) An embedded web server that provides a UI for interaction with the sensor.
2) The Dataserver application used to run processing modules in the background on the sensor.

Users can use this section as a basic "quick-start" guide for ViPERS. This section explains how to access the ViPERS web application in the default networking configuration, navigate the application, and basic troubleshooting. Much of this information will be covered in more detail in later sections.

2.1 Connecting to ViPERS

The ViPERS web application runs an embedded web server on ARTEMIS sensors and provides several capabilities including specialized tools related to EP sensing. In the standard configuration, users can connect an ARTEMIS-based sensor to an end-user device such as a laptop, tablet, or mobile phone over their network. Users will have to connect their device to their local network via Ethernet or wireless connection. Once connected, there are three possible URLs that the device can respond to:

1) http://mpm-<serial-number>
2) http://mpm-<serial-number>.local
3) http://192.168.0.x; local IP on user's network

<serial-number> should be replaced with the device serial number (e.g., mpm-6001).

This configuration requires the user's device to be configured for node operation; however, devices are configured this way by default. If the device is configured for the Dynamic Host Configuration Protocol (DHCP), only then can the user connect via direct ethernet connection to their laptop at http://10.10.0.1. Different networking configuration options are discussed in Section 3.1.2. When connected to the ViPERS web server, users will be brought to the Login page (Figure 2).

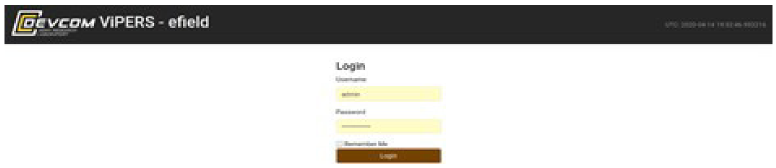

Figure 2. ViPERS Login screen.

On the Login page, users will be prompted for a username and password. After logging in, users are directed to the home page.

2.2 Navigation: Home Page and Navigation Bar

The ViPERS home page contains icons for each available ViPERS module and serves as the main navigation page for the application. Clicking on any icon brings the user to the corresponding page for that module. Some of these pages are designed to display system information and system configuration, while others are focused on data display, interaction, and download.

The specific applications and layout included may be different, but the primary setup pages (Figure 3) are included in all units. Section 3 shows a page-by-page overview of the ViPERS modules.

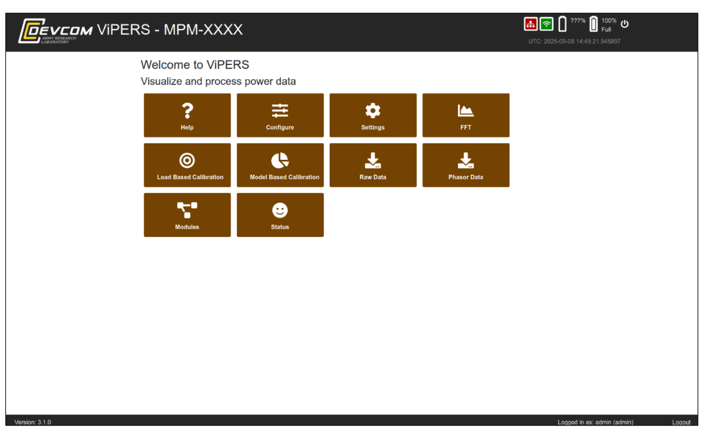

Figure 3. ViPERS home page with links to all primary pages.

The navigation bar is an important tool for users to be familiar with. The navigation bar provides users with vital system information at a quick glance and is visible at the top of every ViPERS page. At the top left of the navigation bar, there is a

DEVCOM ViPERS logo. Immediately to the right of that is the system name or “host name” (Figure 4). By default, this is set based on the serial number (SN) of the device. For example, if the SN of an MPM is 3007, the host name on display at the top left will be MPM-3007.

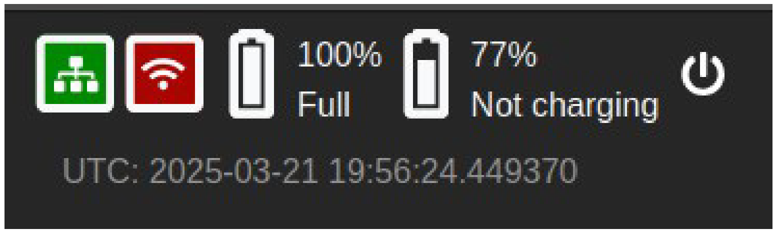

Figure 4. ViPERS navigation bar icons for local-area network (LAN), wide-area network (WAN), and battery.

LAN connection is the device’s connectivity to a router or direct connection with a device, and WAN connection is the device’s connectivity to the outside internet. If the corresponding icon is green, this indicates connection to the corresponding network; if it is red, this indicates that the device is not connected to the corresponding network. The battery icon displays an approximate percentage of battery charge. The exact battery charge percentage as well as its charging status is displayed next to or below the battery icon. The device’s current time (in coordinated universal time) is also located in the top right corner.

For some ARTEMIS versions, the device’s time setting may be unreliable on start-up without connection to a WAN and therefore must be reconfigured manually when setting up the device. If a unit is connected to the Internet, the device’s time will be configured automatically. If the device is in a GPS-accessible area, the time can also be set automatically without a WAN connection. See Section 3.1.1 for details.

2.3 Architecture and Basic Troubleshooting

The ViPERS web application works by interfacing to a “Dataserver”—an application on the ARTEMIS sensor system that runs both processing code (called “Dataserver modules”) and visualizations (“plots”). If anything is not working, it is likely because the module or plot is disabled in the Dataserver. On many plot pages there are hints to ensure the correct modules and plots are enabled. When in doubt, check the ViPERS pages: “/dataserver/modules” (see Section 3.10.1) and “/dataserver/plots” (see Section 3.10.2). ViPERS also interfaces with other Linux utilities for managing required sensor functions (e.g., the network state). Further information about the modules and plots that must be enabled for the default sensor configuration to work properly is available in Section 3.10.

3. Detailed Page-by-Page Guide

Figure 5 provides an overview of each of the icons on the ViPERS home page. Each topic is numbered according to its corresponding section in this report (i.e., the numerals in parenthesis ( ) after section headings).

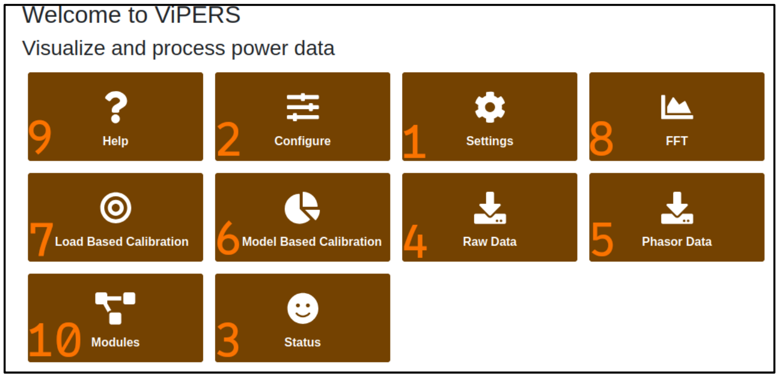

Figure 5. Use the home page to select different UIs during the setup process.

3.1 Settings (1)

The Settings page is the main page used to perform system-level configurations. There are several subpages that allow users to check system information and set important parameters such as the system date and type and network operating mode. This page is separate from the Configure (2) page, which is only concerned with data-level configurations such as setting sampling parameters and creating circuits.

3.1.1 Date and Time

The Date and Time page is used to set the system date and time. This step is crucial to the initial setup of an ARTEMIS device in a GPS- or network-denied area of operation. All versions of the ARTEMIS hardware before the MPMv4 (manufactured in 2023) do not have a real-time clock (RTC); therefore, they are unable to track time when the devices are not powered. In environments with external network access or GPS, the current time will be obtained through the GPS first, if available, and if not available, time can automatically be set with the network time protocol. If all else fails, the time can be updated manually through the form as shown in Figure 6. If the current device time is too far in the past (e.g., Linux defaults to the Unix epoch, 1970), the user may be unable to connect to the web application through the browser because of the required handshake that takes place between the browser and the device's web server. In this case, it is recommended to instead use the secure shell protocol to connect to the sensors and set the time from the Linux command prompt. The command for setting the Date and Time when users cannot do so through the ViPERS web page is: date –s “YYYY-MM-DD HH:MM:SS”; hours are in 24-h format.

Figure 6. System Date and Time can be updated manually if external network access or GPS are unavailable.

The newest versions of ARTEMIS hardware (starting with MPMv4) will have an onboard RTC.

3.1.2 Network

The next subpage of settings is the Network page, which allows the user to enable and disable Wi-Fi and Ethernet connection modes (Figure 7); users must enable Wi-Fi to connect to Wi-Fi networks.

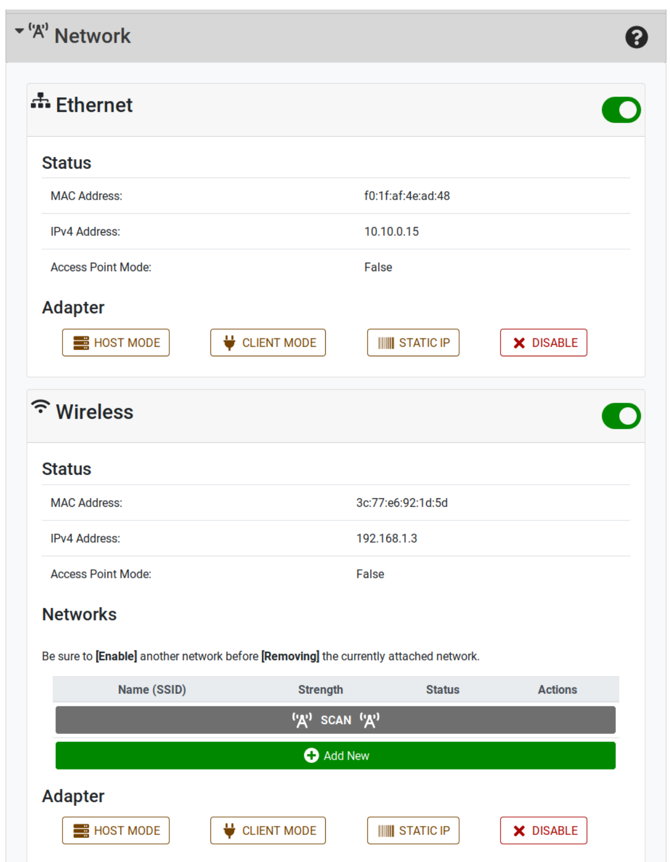

Figure 7. The Network page allows configuration of both the Ethernet and Wi-Fi interfaces, in addition to connection to Wi-Fi networks.

3.1.2.1 Ethernet

The Ethernet section of the page shows the status of the wired network (Media Access Control [MAC] address, current IPv4 address).

When in DHCP-HOST MODE only (DHCP-HOST is not the default mode), users can reach ViPERS by connecting to the Ethernet port directly and navigating to 10.10.0.1 in the browser's address bar. The four buttons at the bottom allow users to toggle between different adapter states (Table 1).

Table 1. Ethernet interface configuration buttons and their actions.

Button	Effect
DHCP-HOST-MODE	The interface will become a router and perform DHCP and hand out IP addresses
DHCP-CLIENT MODE	The interface will request an IP address from the network router
Static IP	Sets a static IP address and netmask for the network
Disabled	Disables the adapter (fully turns off the adapter)

3.1.2.2 Wireless

The Wireless section of the page shows the status of the wireless network (MAC address, current IPv4 address). DHCP-HOST MODE is no longer supported for this interface.

When in DHCP-CLIENT MODE, wireless networks are scanned and displayed in the table under Networks. Users can add a scanned network by clicking on the "Add" button next to its name. Once a network is added, the following additional options become available:

> [SELECT] will make that network the active network and [DISABLE] all others.
> [ENABLE] will allow the device to connect to that network should the currently [SELECTED] network become unavailable.
> [DISABLE] will prevent the device from connecting to that network.
> [REMOVE] will cause the device to forget about that wireless access point.

Additionally, the "Add New" button allows users to fully specify a network that was not scanned. This is useful for hidden service set identifiers, in which case the "scan_ssid" box must also be checked. The four buttons at the bottom allow users to toggle between different adapter states (see Table 2).

Table 2. **Wi-Fi interface configuration buttons and their actions.**

Button	**Effect**
DHCP-HOST-MODE	No longer supported
DHCP-CLIENT MODE	The interface will request an IP address from the network router
Static IP	Sets a static IP address and netmask for the network
Disabled	Disables the adapter (fully turns off the adapter)

3.1.3 Storage

Users can view disk usage information from the Storage settings page (Figure 8). This page displays disk usage information for all mounted data partitions on the system's secure digital (SD) card. In the default configuration of ARTEMIS, there are three mounted partitions: the root file system ("/"), the boot partition ("/boot"), and the on-card data partition ("/data"). The root file system refers to all files on the Linux operating system (OS). The boot partition contains information necessary for ARTEMIS to read on start-up and should not be edited. Finally, the /data partition contains phasor data files that have been streamed from the Zynq field-programmable gate array (FPGA) onto the main system's SD card. This data is stored in a separate partition to avoid collisions with the OS file system and to ensure safe data storage.

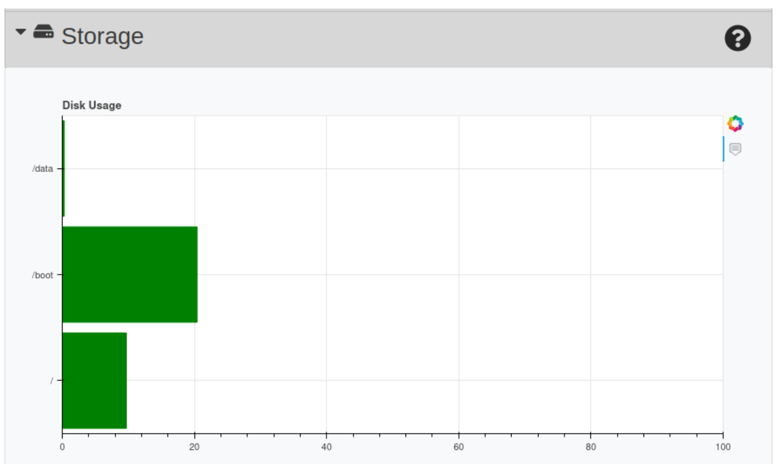

Figure 8. Disk usage data as presented on the Storage settings page.

3.1.4 Battery

The Battery page details several battery statistics so that users can assess the current battery health of their system (Figure 9). This page includes data to approximate the battery percentage, charging status, estimated time until battery depletion in minutes, available charging statistics (e.g., charging voltage and current), and current battery health and status.

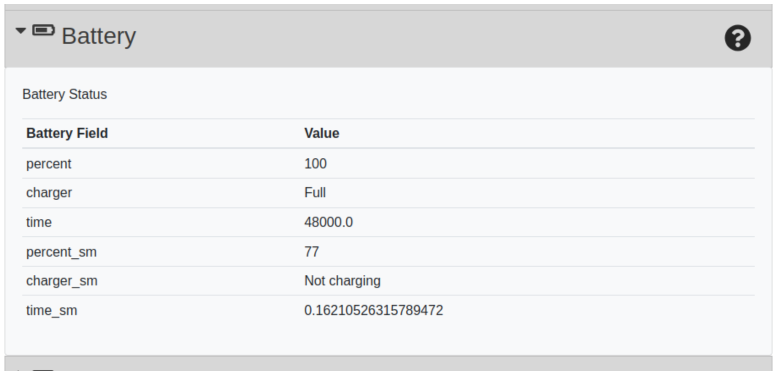

Figure 9. Battery page displays key metrics to help users assess battery health.

3.1.5 Auto-Shutdown

The Auto-Shutdown page lets users configure at what percentage the device will power off to prevent any corruption and/or data loss that could occur if the device were to deplete its battery (Figure 10).

NOTE: It is not recommended that users change this value.

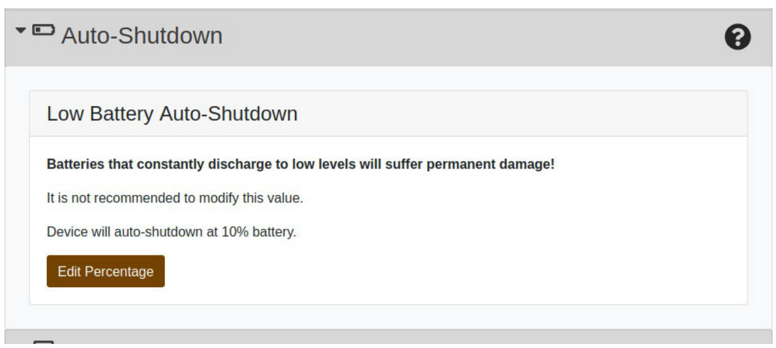

Figure 10. The Auto-Shutdown page displaying current battery cut-off.

3.1.6 System Info

The System Info page is broken down into several sections that detail general system information, system version, CPU usage, memory and disk usage, and details for the top 10 running processes (Figure 11). All resource utilization data presented from this page is instantaneous resource utilization shown from when the request was made. Users should refresh this page for a new capture of resource utilization.

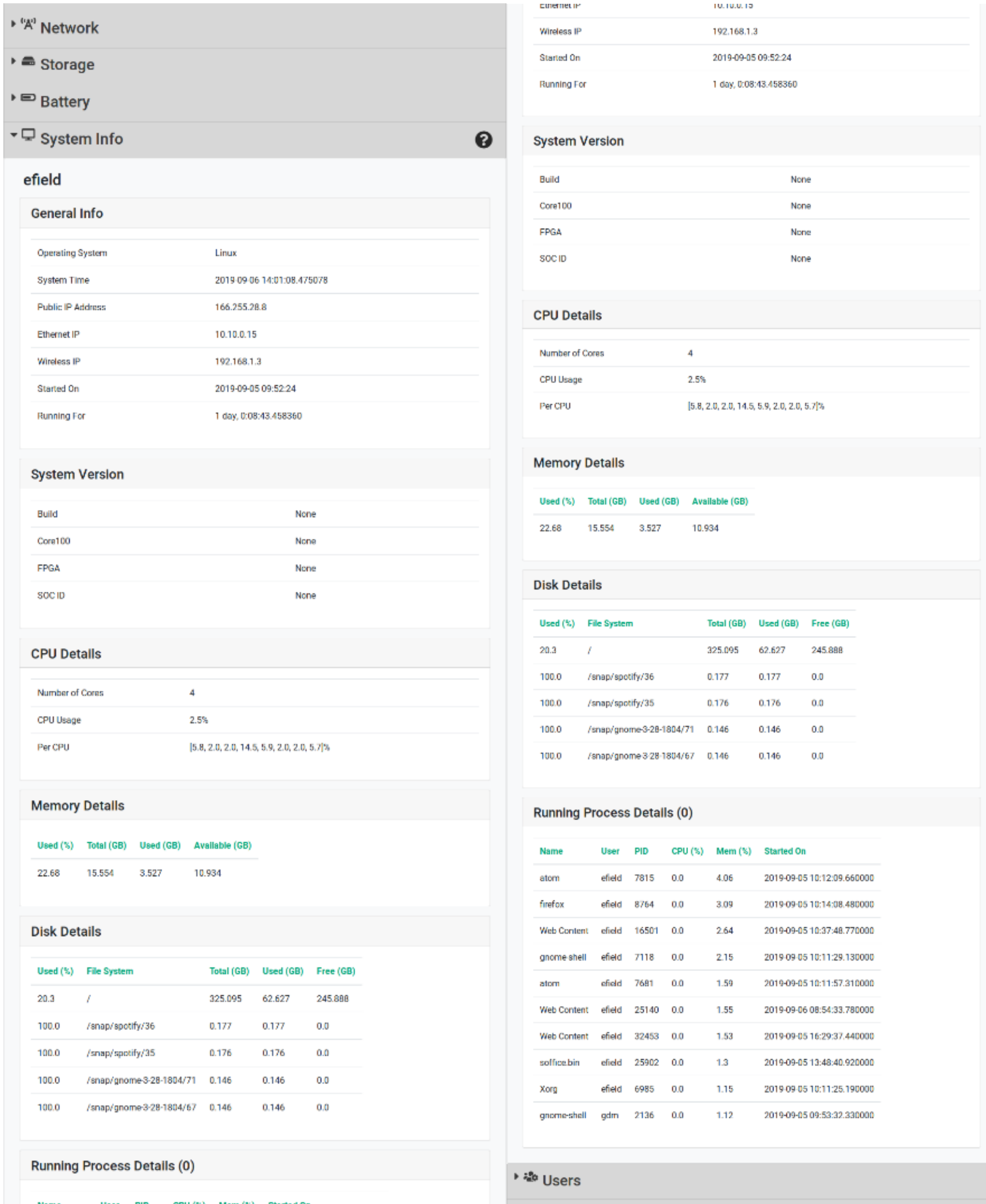

Figure 11. The System Info page is a snapshot of system status.

3.1.7 Users

Administrative users can add/delete users from this page (Figure 12). Users can be created by inputting a new username and password to the device and clicking the "Add" button. Users can be given administrative privileges when they are created by clicking the "Administrator" button.

NOTE: The last administrative user cannot be removed.

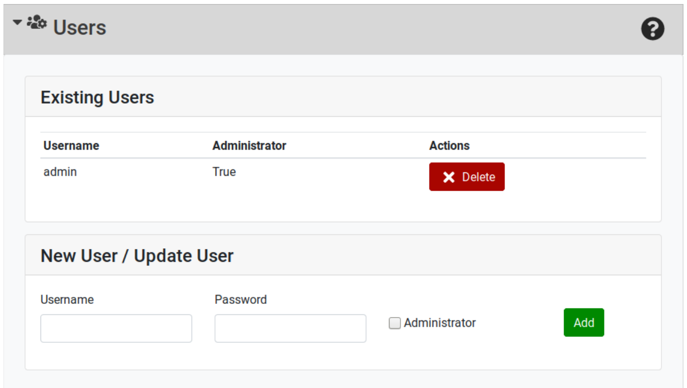

Figure 12. Users page to add/remove additional administrative or regular users.

3.2 Configure (2)

The Configure (2) page allows users to edit the data processing configuration of their system to include configuring the hardware, labeling channels, setting scale factors, and creating circuits. The following subsections provide instructions on using the Configure page to perform these various types of configurations.

3.2.1 Save and Restore

From the Save and Restore page, users can save, load, upload, download, and delete saved configuration files. These saved configuration files pertain to the user configuration for the Dataserver power processing modules. Saved files contain the settings for the following:

- Hardware data (e.g., transport control protocol [TCP], dbus, simulator source)
- Channel data (e.g., channel names and scale factors)
- Circuit data (e.g., which channels are connected and wiring)

This information is stored by writing data to the phasors.conf file. To save the current configuration, simply type a name in the "Save Current Config" box and select "Save." This will create a new ".conf" file under conf/saved/ with the chosen name. When any binary phasor data file is retrieved from the ARTEMIS unit, the phasors.conf file is required to retrieve information about the data such as the sampling rate and channel names.

All currently saved configurations are listed under the "Saved Configs" heading. Users can select one of these to make it the active configuration by clicking on "Activate." Clicking the saved configuration's "Filename" will download the file through the user's browser. Finally, the saved configuration can be deleted by clicking "Delete" next to the file name. Users can also upload a configuration from their computer by clicking on the "Choose File" button, selecting the configuration, and then clicking "Upload" (Figure 13).

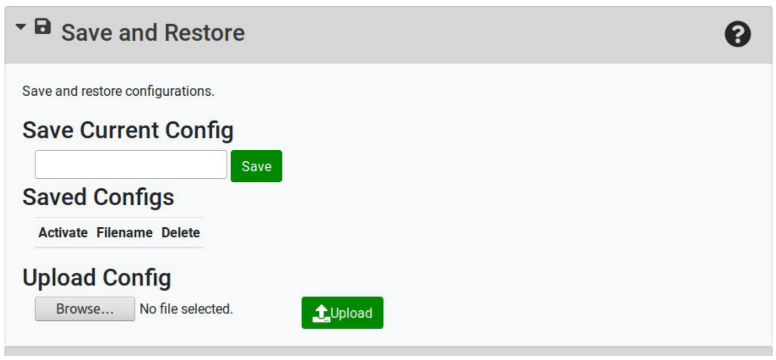

Figure 13. Configurations for hardware, channels, and circuits can be saved and then downloaded/uploaded/restored.

3.2.2 Hardware (Connect Sensors and Source Data)

The Hardware page allows users to edit the hardware configuration for the fields, which are described in Table 3, and in further detail in their respective subsections.

Table 3. **Form fields and their descriptions.**

Field	Used by	Definition
Source	synchro.py	Selects the source of phasors for subsequent processing
Broadcast	synchro.py	Enables broadcast of phasors on the LAN (via 0.0.0.0) from synchro.py. If disabled, phasors are only broadcast to local host.
Log raw data	hardware.py	If checked, hardware.py will log raw data to the corresponding SD card
Bank no.	hardware.py synchro.py	Specify hardware Bayonet Neill–Concelman (BNC) attenuation for a given bank of four signals. NOTE: This field is for older ARTEMIS versions.
Sample rate binimation decimation	FPGA	Sets the appropriate sampling and decimation rates to achieve desired raw data and phasor data rates
Frequencies	FPGA	Nominal frequencies for phasors produced by the FPGA phasor processing algorithms; default is 60, 180, and 300 Hz (first, third, and fifth harmonics, respectively)
ARLTX on start-up	hardware.py	This ARLTX command is issued by hardware.py on start-up. (This deprecated feature is still included to support legacy ARTEMIS configurations.)

3.2.2.1 Source

The Source field allows users to select where to pull data from for subsequent processing. ViPERS provides the following source options to users:

None: No data source
dbus: Use the Core100 application dbus subscription
tcp: TCP stream of phasors
Simulator: Simulated phasors from a three-phase voltage source (VA, IA, IB, IC) and a cable sensor (H1, H2, H3, E1)
Simulator-3phase: Simulated phasors from a three-phase voltage (+ neutral) and three-phase current (+ neutral) source

3.2.2.2 Logging Raw Data and Broadcasting

Users have the option to log raw data to two internal SD cards on the ARTEMIS baseboard. By default, ARTEMIS logs raw data to these SD cards in a circular buffer where the oldest files are overwritten first; however, this behavior can be further configured from the Raw Data page covered in Section 3.4. The options provided on this page allow users to turn on and off raw data storage to each of the SD cards.

This configuration persists when ARTEMIS reboots. Broadcasting allows users to broadcast the binary streams for raw and phasor data on ports 2346 and 4444, respectively, so that they can be accessed from external devices and not just internally by the ARTEMIS unit.

3.2.2.3 Bank and Channel Attenuation

The BNC inputs (MUGS) accept signals in the ±1-V range when the BNC1:1 attenuator is selected, or in the ±10-V range when the BNC10:1 attenuator is selected. In ViPERS, BNC attenuation is configured by a bank, with a bank being a group of four channels. MUGS-8 units and MPMs have two banks (e.g., Bank 1 is made up of Channels 1–4 and Bank 2 is made up of Channels 5–8), whereas MUGS-16 units have four banks. Additionally, LEMO[*] inputs can be selected in each bank of channels for smart sensor use.

NOTE: When LEMO connection is selected for a particular bank on a MUGS unit, the corresponding four BNC ports will not be used by the ARTEMIS, and instead inputs for that bank will be taken from the LEMO connectors on the back of the MUGS unit. The MPM connections should **always** be set to LEMO. It is left up to the ARTEMIS MUGS user to determine whether BNC1:1 versus BNC10:1 attenuation or LEMO connection is required for their sensors.

3.2.2.4 Sampling Rates, Binimation, and Decimation

ARTEMIS units can be configured to produce both raw and phasor data at different rates. Higher data rates will yield larger bandwidth and/or potentially more detail on short time-scale phenomena. However, increased data rates have an impact on system resources such as CPU, RAM, and disk storage. Most of the long-term stability testing performed by ARL has been conducted with the sampling frequency set to 8000 Hz and the binimation factor set to eight, which produces a 15.625-Hz phasor rate. We recommend not using data rates higher than 8000 Hz, especially with 16-channel hardware variants. This is an active issue that ARL is addressing in newer hardware and firmware releases.

These page options will set the frequencies, binimation, and decimation rates for the signal processing taking place on the ARTEMIS' FPGA. The frequency parameter controls the raw sampling rate and may be set to anything at the user's discretion. The binimation factor may only take a power of two (2, 4, 8, 16, 32 . . .), and the decimation is a combination of two values. Decimation

[*] LEMO is a registered trademark of the LEMO Group.

“a” may only be 8 or 10, whereas decimation “b” may be 0, 8, or 10. All three factors govern the output sample rate according to Equation 1:

$$f_8 = \left\{ \begin{array}{l} \frac{\text{sample\_rate}}{b* \text{ da} * \text{db}}, \text{db} \neq 0 \\ \frac{\text{sample\_rate}}{b* \text{ da}}, \text{db} = 0 \end{array} \right\} \tag{1}$$

where b is the binimation and da, db are the decimation a and b factors, respectively. This is for an 8-channel device. Further, the binimation sample determines the frequency cutoff,

$$f_{\text{nyquist}} = \frac{\text{sample\_rate}}{2 * b} \tag{2}$$

Some example raw sampling rates combined with different binimation and decimation factors and their resultant output frequencies and Nyquist rates are shown in Table 4. The first row of Table 4 is the default ARTEMIS configuration.

Table 4. Phasor rates for specific filter settings and analog-to-digital converter (ADC).

Raw sampling frequency (Hz)	Binimation	Decimation (a:b)	Output frequency (Hz)	Nyquist (Hz)
8000	8	8:8	15.625	500
8000	2	8:8	62.5	2000
8000	4	10:10	20.00	1000
8000	8	10:8	12.50	500
16000	8	8:8	31.25	1000
16000	8	10:10	20.00	1000
16000	16	8:8	15.625	500

Additionally, because the decimation factors determine the bandpass filter roll-off, they affect how sharply the frequency band attenuates. In situations where excess noise or clutter signals are anticipated, larger decimation factors may be desired to reduce interference. Users can change the sample, binimation, and decimation rates from the ViPERS UI (Figure 14).

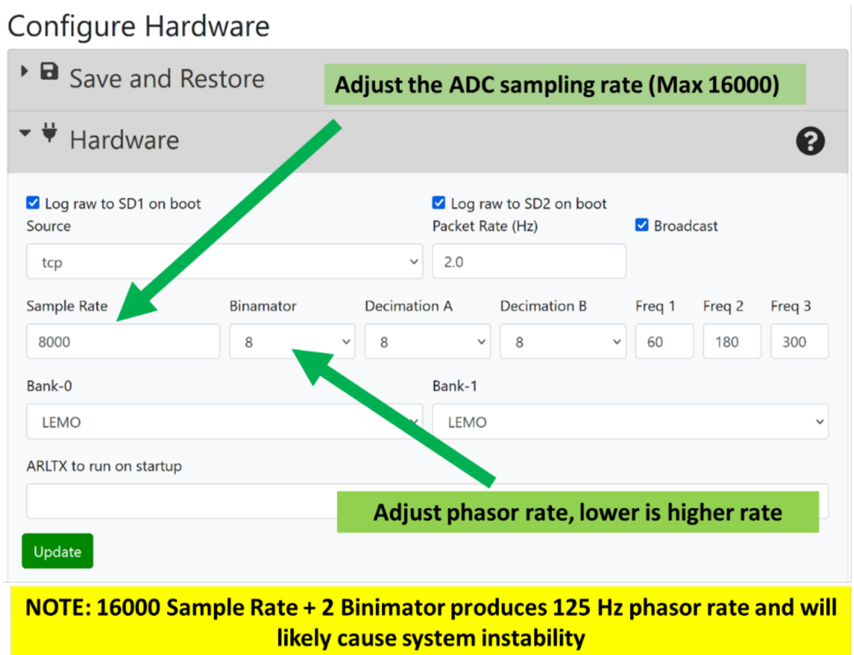

Figure 14. Phasor rate can be adjusted on the Hardware page. Ensure that the TCP source is selected when increasing the phasor rate beyond the default setting of 15.625 Hz.

If the phasor rate is increased from 15.625 Hz, the TCP source **must be selected**. The dbus source transfers data too slowly for use at higher speeds and will cause system instability. In addition, **do not select** a phasor rate of 16000 when using a binimation rate of 2. This will produce a phasor rate that will compromise software that delivers data to key components of the system.

Increased phasor rates require more storage to achieve the same duration of data storage as slower data rates. For example, in Table 5, a 15.625-Hz phasor data rate for 8-channel systems will produce approximately 335 MB of binary data per day leading to approximately 690 days of storage on a 256-GB SD card. However, at a higher phasor rate of 62.5 Hz, this storage capacity is much less as 1340 MB of data will be produced daily, leading to only approximately 170 days of data storage on a 256-GB SD card. It is therefore encouraged that users desiring a higher data rate either a) more frequently download data files from their ARTEMIS units or b) upgrade their system with a larger SD card.

Table 5. Estimated storage capacity for given data rates for 8 channels.

Phasor rate (Hz)	Primary OS storage (GB)	Data rate (MB/day)	Duration (230 GB)	Sample rate	Binimation
15.625	256	335	~690 days	8000	8
62.5	256	1340	~170 days	8000 (16000)	2 (4)

3.2.2.5 Frequencies

The frequency parameters are used by the ARTEMIS FPGA to calculate phasors for each of the provided frequencies. The defaults are 60, 180, and 300 Hz, the first, third, and fifth harmonics for a 60-Hz power system, respectively, but these values can be set to whatever is desired for the user's application.

3.2.2.6 Channels (Names, Scaling, and Sensitivities)

Once sensors are connected and the ARTEMIS is receiving data, the input signals need to be transformed into physically useful units. The Channels page allows users to configure each input channel by providing a channel name, specifying its input type, and providing sensor-specific impedance, sensitivity, and scale factors (Figure 15). These fields update phasors.conf, which is used by several ViPERS modules for configuration on start-up. Table 6 lists channel configuration options and their descriptions. Further descriptions of each form field and its options are described in their corresponding subsections.

Figure 15. Individual channel names, characteristics, and scaling can be set through the channels page.

Table 6. Channel configuration form fields and their descriptions.

Field	Definition
name	A user-specified name[a]
type	One of "voltage," "current," "efield," "hfield," "undefined." Only voltage, efield, and undefined can be used as phase references for Circuits (Circuits [Configuration for Power Monitoring])
impedence	Specifies whether the attached sensors are low-impedance (50-Ω) or high-impedance (1M-Ω) sensors
sensitivity	The sensitivity of the physical sensor (usually in mV/V or mA/V)[b]
units	The units for the sensitivity value
multiplier	An arbitrary additional multiplicative factor[c]

[a] Duplicate names may cause data to be overwritten and negatively impact performance.
[b] The raw values are divided by sensitivity.
[c] This is useful when using current transformers/potential transformers to step up/down the currents/voltages. It is also useful if a sensor is installed backward (use a negative factor).

3.2.2.7 Channel Names and Types

The leftmost form field for each channel allows users to enter a name for each specified channel. The characters [.] and [:] are NOT allowed in channel names. Users are free to name channels however they see fit, but it is recommended to use names such as I_A or V_A so that voltages, currents, and their respective phases can be easily identified by later observers of the data. It is also recommended to use unique names for channels that will be matched within the same circuit. Channels with the same name, reference, and circuit may lead to overwritten and, therefore, lost data. However, channel names can be repeated for different circuits (e.g., users may have both an I_A and V_A in circuit main breaker and circuit garage breaker). Creation of circuits is further discussed in Section 3.2.2.11, Circuits (Configuration for Power Monitoring).

After selecting a channel name, users should select a channel type that most appropriately matches the type of signal that the sensor at that channel is measuring. For example, current probes should be labeled with type "current" and D-dot sensors should be labeled with type "EField."

On MPM units, channel names and types should already be configured given that they are static with respect to the cable sensor inputs. Channels 1–3 and 5–7 are typically labeled H1 through H6 and with type "HField," and Channels 4 and 8 are labeled E1 and E2 with type "EField."

3.2.2.8 Phase

The phase of the channel refers to how the measurement is performed. For instance, users can measure voltage either between the phase and neutral (AN) or between two phases (AB). If users are measuring between phase BA, they should use phase AB with a –1 multiplier. By selecting the phase correctly here, the correct phase factors are applied at the circuit level to turn current and voltage into real and reactive power.

3.2.2.9 Channel Impedance and Sensitivity

Setting the channel impedance and sensitivity is an important step in the configuration process so that correct physical units can be reported by ARTEMIS. Channel impedance and sensitivity are two scale factors that are determined by the sensors residing on those channels. These values should be found in the sensor data sheet and the user provides these values for accurate measurement transformation. The channel impedance field allows users to compensate for high-impedance (1M-Ω) sensors, although most sensors are of 50-Ω impedance. Sensitivities and their respective units are usually listed in the sensor data sheet and are usually in the form mV/A or mV/V. Examples of different sensitivities and their effects are shown in the following.

Example 1: A voltage probe is showing 1.2 V on the synchro phasor page and has a sensitivity of 10 mV/V. After this stage, the phasor will have a value of

$$\frac{1.2\ \mathrm{V}}{10\ \mathrm{mV/v}} = \frac{1200\ \mathrm{mV}}{10\ \mathrm{mV/V}} = 120\ \mathrm{V} \tag{3}$$

Example 2: A current clamp is showing 200 mV on the synchro phasor page and has a sensitivity of 100 mV/A. After this stage, the phasor will have a value of

$$\frac{200\ \mathrm{mV}}{100\ \mathrm{mV/A}} = 2\ \mathrm{A} \tag{4}$$

When using an MPM or other smart sensors connected via LEMO cables to the MUGS, these scaling factors are likely integrated into the sensor electrically erasable programmable read-only memory and read by ARTEMIS on start-up. However, when using traditional commercial off-the-shelf current and voltage sensors with the BNC inputs, the scale factors must be input manually.

3.2.2.10 Multipliers

The final configuration field is the Multiplier field. This is an arbitrary multiplier that allows users to incorporate additional factors that cannot be accurately captured as an impedance or sensitivity factor. The Multiplier field is meant to be a general scale factor that may encompass either the physical installation condition or some other factor from the sensor data sheet. For instance, for a sensor installed backward, a multiplier of –1 can be used. For a 5:1 step-down coil, a multiplier of 5 is desired to bring the values back to what is being measured. This multiplier can also be used for channel calibration in cases where the ARTEMIS is not reporting the correct expected values for particular signals.

3.2.2.11 Circuits (Configuration for Power Monitoring)

ViPERS may come preconfigured for three-phase DELTA or three-phase WYE power monitoring without any additional configuration. Simply connect 10-mV/V voltage probes to Channels 1–4 (for phases A, B, C, and N, respectively), and 100-mA/V current clamps to Channels 5–8 (for phases A, B, C, and N, respectively). When using sensors with different sensitivity or another phasing scheme (e.g., monitoring two DELTA circuits), settings will have to be updated.

In general, a configuration follows these steps:

1) Connect sensors and select signal source, data rate, and frequencies from the /configure/hardware page.
2) Check signal integrity on the /synchro page.
3) Input sensor names, sensitivities, and phase angles on the /configure/channels page.
4) Configure circuit (phase reference) on the /configure/circuits page.
5) Log data.

ViPERS uses the circuit method to compare current and voltage phasors. By referencing a current to a voltage phasor and using a "phasing," real apparent power can be extracted. This page shown in Figure 16 allows users to combine channels into a meaningful circuit. These fields update the phasors.conf file.

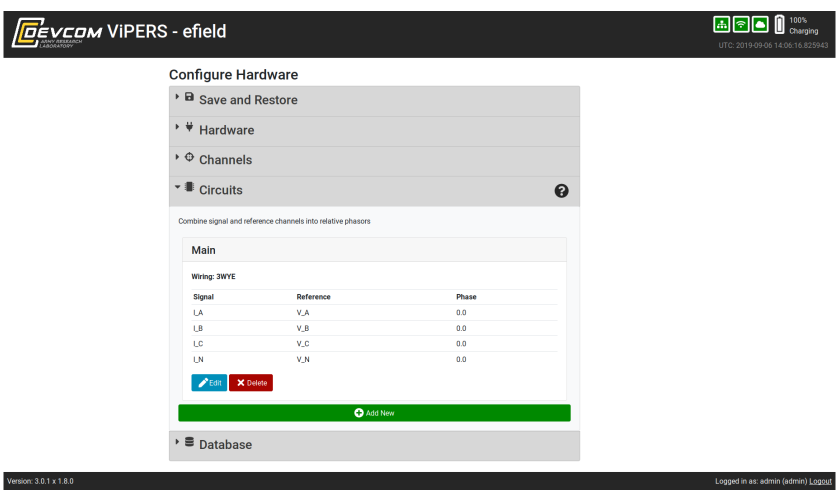

Figure 16. Channels are referenced and combined into circuits.

To create a new circuit, click the "Add New" button at the bottom of the page. An existing circuit can be edited by clicking on the "Edit" button. Clicking the "Delete" button will cause the circuit to be removed. When creating or editing a circuit, a dialog box will appear where the user can specify form fields and their descriptions (Table 7).

Table 7. Creating/editing a circuit: form fields and their descriptions.

Field	Definition
name	The name of the circuit[a]
signal	Specify up to eight signal channels as part of a circuit
reference	Each signal channel will have the phase of the corresponding reference subtracted off. Leaving this blank will use the default reference for that channel. The default is the first reference displayed in the dropdown box.
wiring	Can be "NONE," "SINGLE," "SPLIT," "3DELTA," or "3WYE"

[a] Duplicate circuit names will overwrite existing circuits and negatively impact performance

Each current should have a voltage reference. The easiest configuration is to reference each current to the corresponding voltage as shown in the following examples.

Example 1: I_A:V_A, I_B:V_B, I_C:V_C (phasing = "NONE," "3DELTA," "3WYE")

However, the user may want to only monitor one voltage (e.g., when monitoring two three-phase circuits with one MUGS-8). In this case, currents can be referenced to a single voltage and a "phasing" scheme can be applied.

Example 2: I_A:V_A, I_B:V_A, I_C:V_A (phasing = "3DELTA," "3WYE")

3.3 Status (3)

The ViPERS Status (3) page is used for viewing the status of important system processes as well as current alert statuses. These statuses are replicated in the System Report and Alert Report sections of the daily summary message; however, this page provides useful real-time information. Users can also use this page to diagnose and troubleshoot system problems. Status icons are displayed in three colors to represent their statuses. Processes with a green checkmark are known to be okay, while processes that may require user attention are shown with either a yellow exclamation point "!" or a red "X" depending on the severity of the issue. Example status pages are shown in Figure 17.

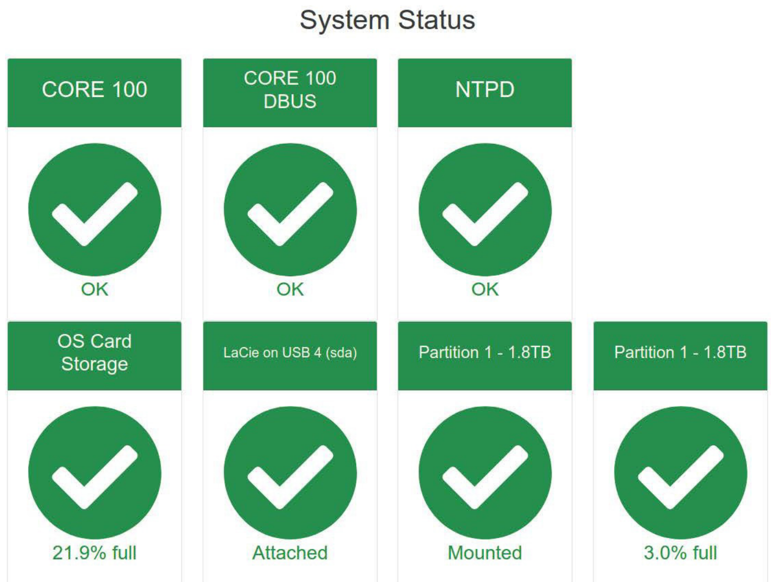

Figure 17. Status page displays the status of the primary components of the ARTEMIS.

The following are important statuses on this page:

1) Core100: System firmware for hardware interaction and lowest-level data streams.
2) Core100 DBUS: System firmware for hardware communication layer.
3) NTPD: Linux service that will acquire time from the network if necessary.
4) Hard-Disk Drive (HDD) Attached: Physical connection of external drive to ARTEMIS.
5) HDD Mounted: Software connection of external drive to ARTEMIS.
6) HDD Storage: Displays percent space left on external drive.

Some status icons also provide troubleshooting steps and automated fixes. Users can access the appropriate troubleshooting guides simply by clicking the icon underneath each status name. For example, if the Core100 System status has a red "X," the process has failed. Users can restart the process by simply clicking on the icon. This will bring up a troubleshooting menu that will allow the user to restart the process from the page.

3.4 Raw Data Management (4)

The Raw Data Management (4) page (Figure 18) allows users to view live data and download raw data files stored on their sensor systems.

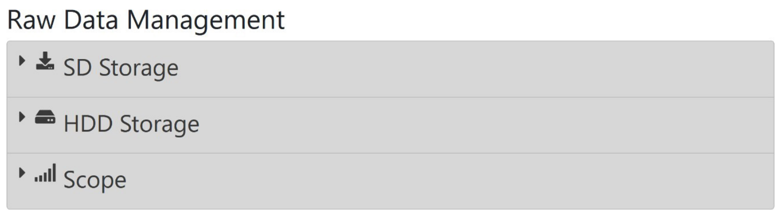

Figure 18. The Raw Data Management page contains multiple methods to view, download, and visualize time–domain (waveform) data.

3.4.1 SD Storage

Users are now able to download their raw data and phasor data via the ViPERS web server using a convenient UI. These downloads are provided for the phasor data stored via the Linux file system as well as raw data from the SD cards or an attached hard disk. Phasor data can be accessed from the Home > Phasor Data > Phasor Data Storage page, whereas raw data can be accessed from the Home > Raw Data page. Files from the SD card are displayed on the Raw Data > SD Storage page in a plot like the one shown in Figure 19. This page allows the user to scan the internal ARTEMIS SD cards for raw data files and download them to the local (OS) SD card for copy to another system. Users can select single or multiple files and then copy them individually or concatenate them together into a single file when copied to the OS SD card.

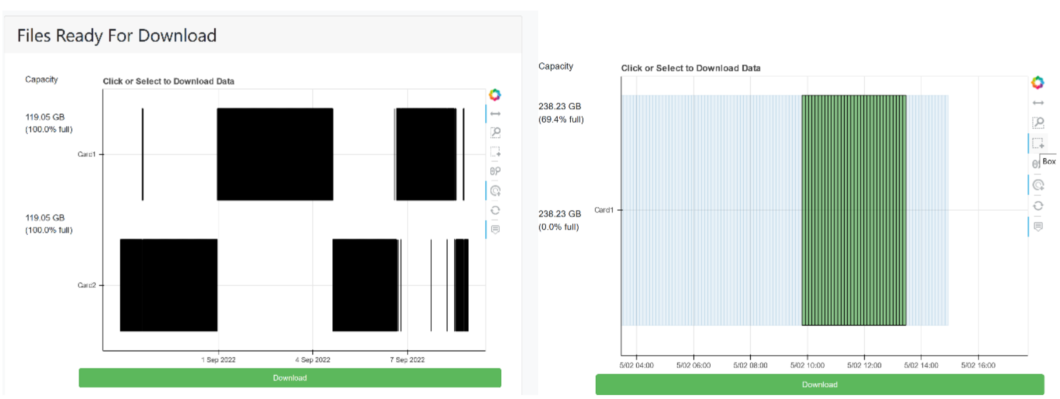

Figure 19. Raw data page file display of the two raw SD cards (left); the "box select" feature can be used to select data for download (right).

Files are displayed as a box according to their start and stop times and the SD card they are located on. Users can download multiple files at a time directly from the SD card. These files will be streamed into one continuous file as part of the download. To initiate a download, simply select the desired file(s)—using the box select tool for multiple files—and click the download button (see Figure 19). File downloads from the SD cards are typically slow (especially if the SD card is currently being written to). To assist users in requesting speedier downloads, a pop-up will appear for larger downloads or ones requesting data from an SD card currently being written to. If the requested SD card is being written to, users are given the option to switch the SD card. Switching the currently writing SD card will have no effect on data storage; therefore, it is recommended to switch if given the option. Also, on the SD Storage page is a form that allows users to configure how their MUGS or MPM writes data to the SD cards (Figure 20).

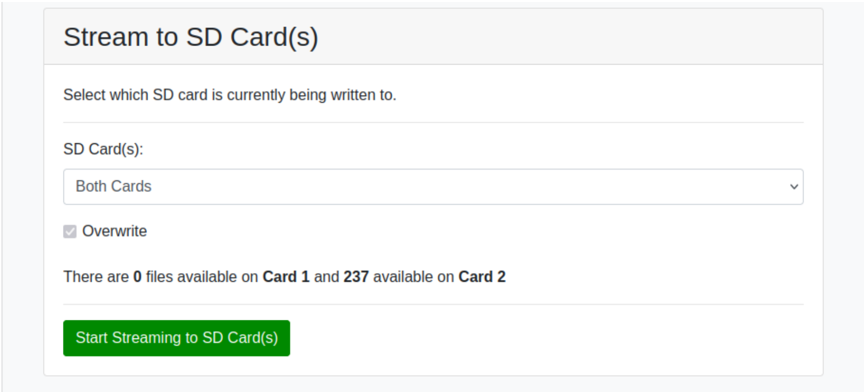

Figure 20. Form for updating raw SD streaming settings.

This form (Figure 20) provides two options and a final submit button. The first option allows you to choose which SD cards will be written to (Card 1, 2, or both). The second option is currently locked but in the future it may allow the user to disable data overwriting when the selected SD cards are full. Once selections have been made, you can start the streaming with the "Start Streaming to SD Card(s)" button. If streaming is already enabled, the form will look like that shown in Figure 21.

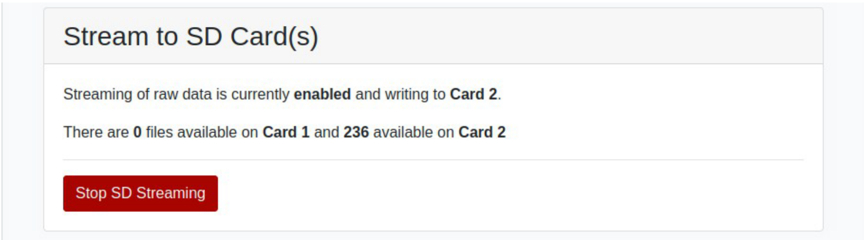

Figure 21. Raw SD streaming form when streaming is active.

3.4.2 HDD Storage

Raw data can also be streamed to an external hard drive in raw streaming binary data format. The HDD Storage page allows the user to view and download those files via the graph under "View and Download Raw Data on HDD." Downloading data from the external hard disk is similar to downloading data from the SD cards and can be done on the Raw Data > HDD Storage page. Typically, downloading data from the external hard disk is faster. All external hard disks will store header files in addition to their data files (Figure 22). These header files should be downloaded alongside any data files on the HDD, as they contain important metadata for processing the data via the dLAMP MATLAB or PMEPS applications. Usage of the dLAMP MATLAB and PMEPS applications are covered in greater detail in associated documentation.[3]

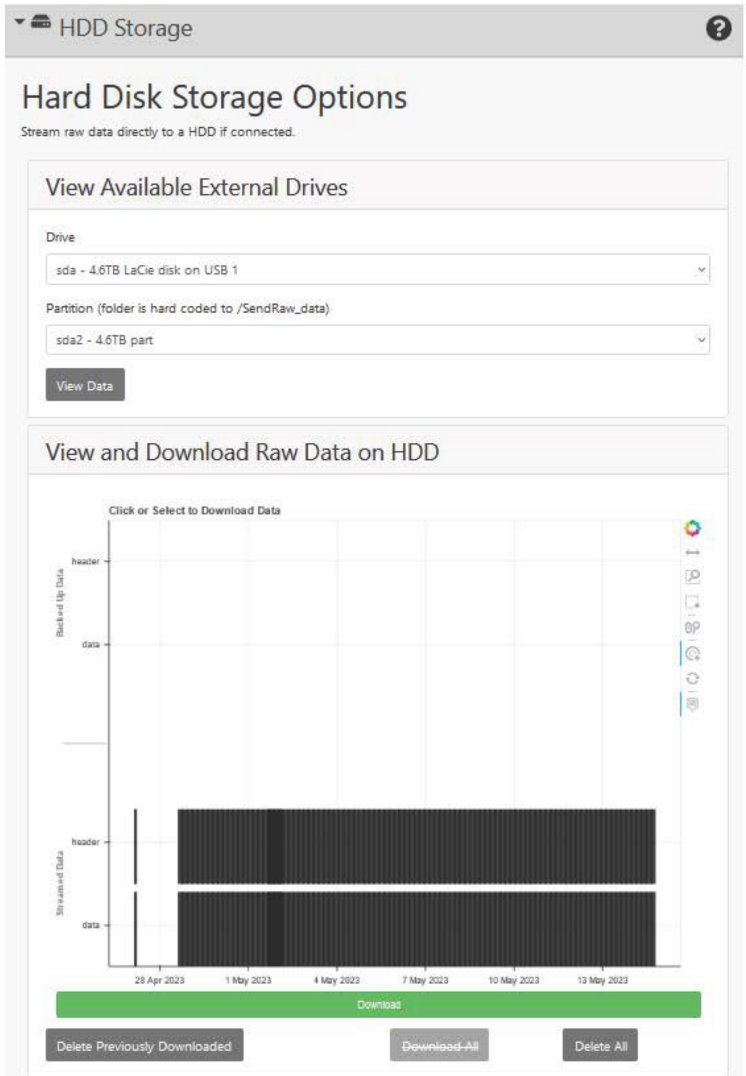

Figure 22. The HDD Storage page contains raw data files as well as headers with sensor scale factors.

The HDD Storage page also provides options for streaming raw data directly to the external hard disk and formatting the disk (Figure 23). Before streaming or backing up data to the hard disk, users should click the “Format Disk” button to properly reformat the disk. This button will take care of wiping the data on the hard disk, creating a single exFAT partition, and creating the “raw data” and “raw SD data” folders on the HDD where streamed raw data and data copied from the SD cards will be kept, respectively.

NOTE: Before removing any HDDs, users should click the "Unmount Drive" button to prevent data corruption.

Users should also specify the duration in hours for each raw streamed file and select whether they want the raw data streaming service to restart after changes are made.

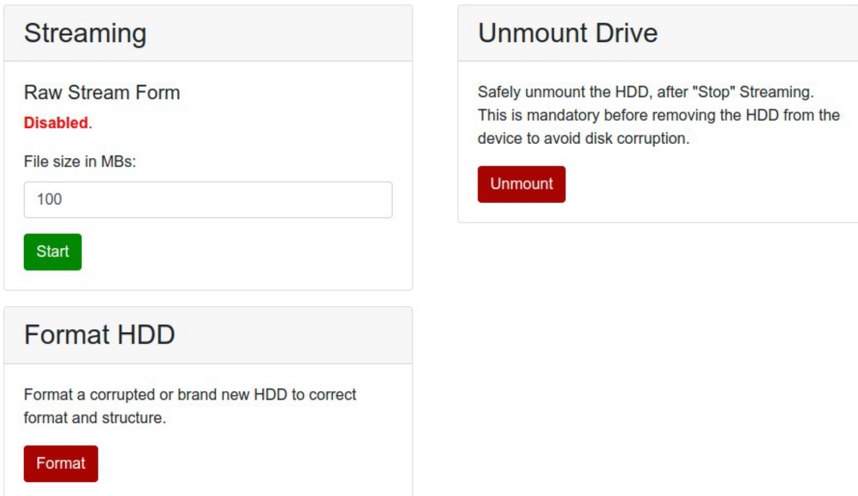

Figure 23. Starting and stopping raw data streaming and file size (in megabytes) can be set on this page.

Users can also enable or disable the raw TCP stream under "Streaming Options." Finally, the attached hard drive must be formatted as ExFAT, which can be done by the "Format Disk" section. Users are urged to use the "Unmount Device" button when removing the HDD to ensure a safe removal.

NOTE: Formatting the HDD will destroy all existing data on the device.

3.4.3 Scope Plot

ViPERS includes an in-browser, onboard oscilloscope for viewing live raw data. The oscilloscope can be accessed from the Home > Raw Data > Scope page (shown in Figure 24) and provides a useful tool for users checking sensor inputs and waveforms. All the important basic features of a traditional oscilloscope are included, which makes it intuitive for new users. The features provided by the oscilloscope tool are four-channel selection, per channel DC offsets and scaling, rising and falling edge triggering, downsampling at rates of 2, 4, and 8 times, and root-mean-square (RMS) amplitude display.

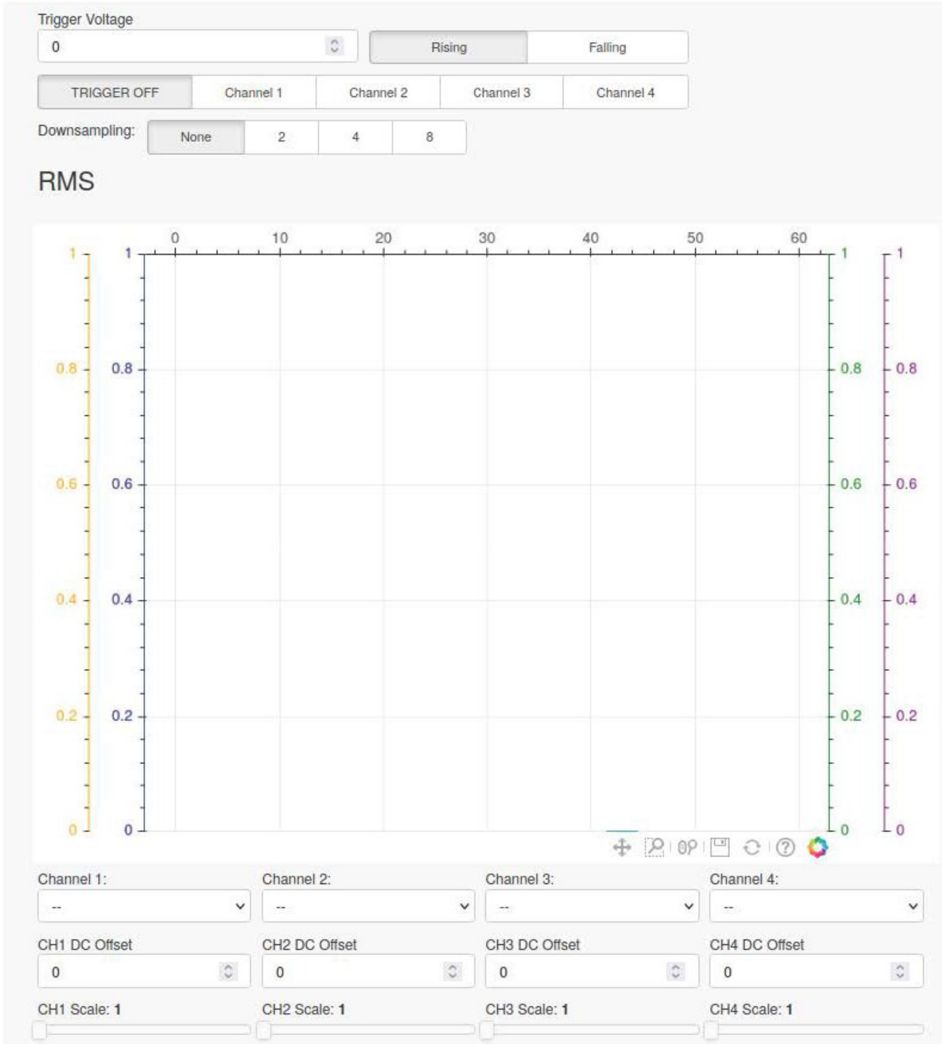

Figure 24. The initial Scope page prior to setting channels and triggers.

Using the Channel Selection drop-down options found underneath the main plot, users can select from any number of inputs to MUGS or MPM. These input channels are defined using the Configuration > Hardware page where each channel can be configured and named appropriately. The oscilloscope plot has four Y-axes that are tied to the channels on display, showing users the appropriate amplitude values for each waveform. These axes are color coded and correspond to the four selectable channels at the bottom of the plot. Blue corresponds to Channel 1, yellow to Channel 2, green to Channel 3, and purple to Channel 4. When a waveform has been selected from the channel drop-down options, a live plot of that waveform is displayed in the plot, and its RMS amplitude is displayed above the plot (Figure 25).

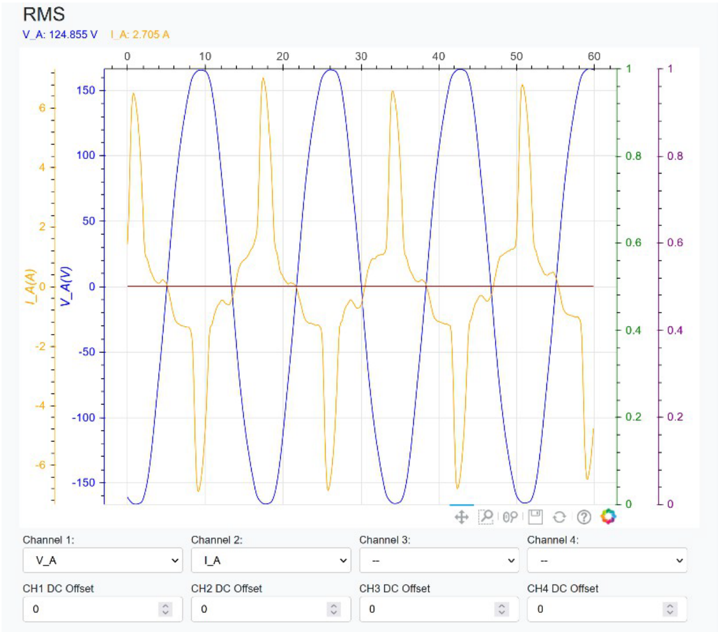

Figure 25. Raw waveform data produced by the scope function.

Users are also able to set DC offsets and scale factors for each channel individually, and those changes will be reflected in the corresponding axis. All trigger options for the plot are found above the center plot. The "Trigger Voltage" spinner accepts decimal input and increments by steps of 0.05. Moving to the right, the "Rising" and "Falling" radial buttons allow users to select either rising or falling edge triggering. With the current software version there is no option to trigger on both the rising and falling edges. Directly below the trigger voltage and edge controls are the trigger channel controls. The "TRIGGER OFF" button allows users to turn triggering functionality off, while the Channel selections 1– 4 allow users to trigger on the waveforms shown on Channels 1–4, respectively. Triggering on a specific channel will cause that channel—and all other channels—to stabilize in the center of the plot if the corresponding rising or falling edge passes through the trigger voltage. In this way, triggering with the ViPERS oscilloscope works in the same way as triggering with a traditional oscilloscope. Options for downsampling are below the trigger options. Users can plot their data without downsampling or with rates of 2, 4, or 8 times. This option is provided solely to improve the performance of the real-time plotting capabilities and may be useful for a variety of applications. For example, in cases of intermittent network or degraded network quality it may be difficult for a large number of points to be broadcast to the user's browser for plotting. Reduced data may help users achieve real-time operation in this case. Additionally, when all four oscilloscope channels are in use, users may experience a drop in performance for higher data rates that can be mitigated by using the downsampling options.

3.5 Phasor Data (5)

Users can download phasor from the Phasor Data (5) storage page. This page functions in the same way as the HDD and SD storage pages. Users can use the box select tool to download multiple files at once. These files will be downloaded as a zipped file, additionally containing the phasors.conf configuration file generated by the ViPERS configuration page. This page also gives options to delete previously downloaded files, delete all phasor data files, and download all files. Previously downloaded files should be deleted every time the user downloads to conserve space in the Linux file system on the MUGS/MPM. Downloading many phasor files at a time may be time-consuming, especially if the file is large (i.e., over 2 GB). For each phasor data download, a pop-up window will warn the user of the data size and the estimated download time (Figure 26).

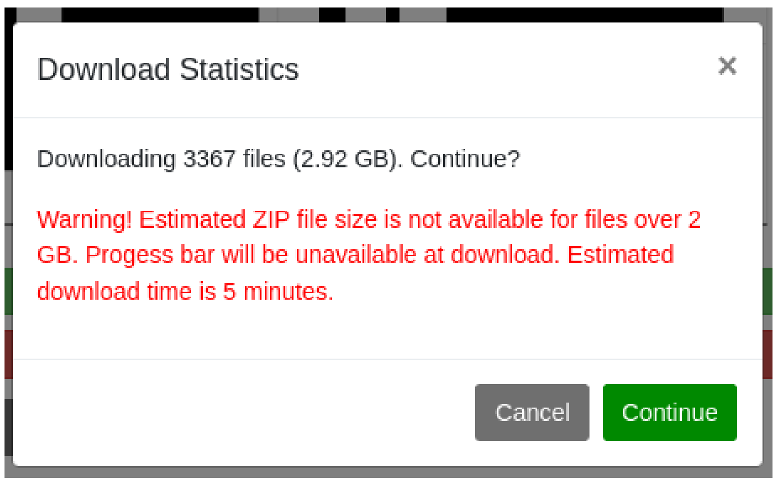

Figure 26. Download pop-up warning.

Also on the Phasor Data storage page, users have the option to enable or disable the phasor data stream and set the length of each phasor file (Figure 27). Submitting this form immediately stops the phasor data stream and restarts it with the desired parameters, which means that the most recent phasor data file may be truncated in the process. As files are written, they are displayed in a UI to show where data is available. Individual blocks can be selected, which enable file downloads through the web browser. The display has a few options that need to be understood to navigate the data, especially when there are many files. The zoom feature can be used with a middle mouse wheel. This will likely be necessary to identify the desired download files from specific time periods as the number of files grows. An individual file can be selected, but multiple files will require the click-and-drag feature to be enabled. The plot "options" in the upper right contain a "Box Select" option. Once selected, the user can select multiple files. Hit the download button to initiate the zipping up and downloading of files through the web browser. All downloads will include the phasor.conf file. This file contains channel names, sensor scaling, and circuit setups. These can be used for postprocessing. Analysis of downloaded phasor data can be performed with the dLAMP application,[3] which is mentioned throughout this manual.

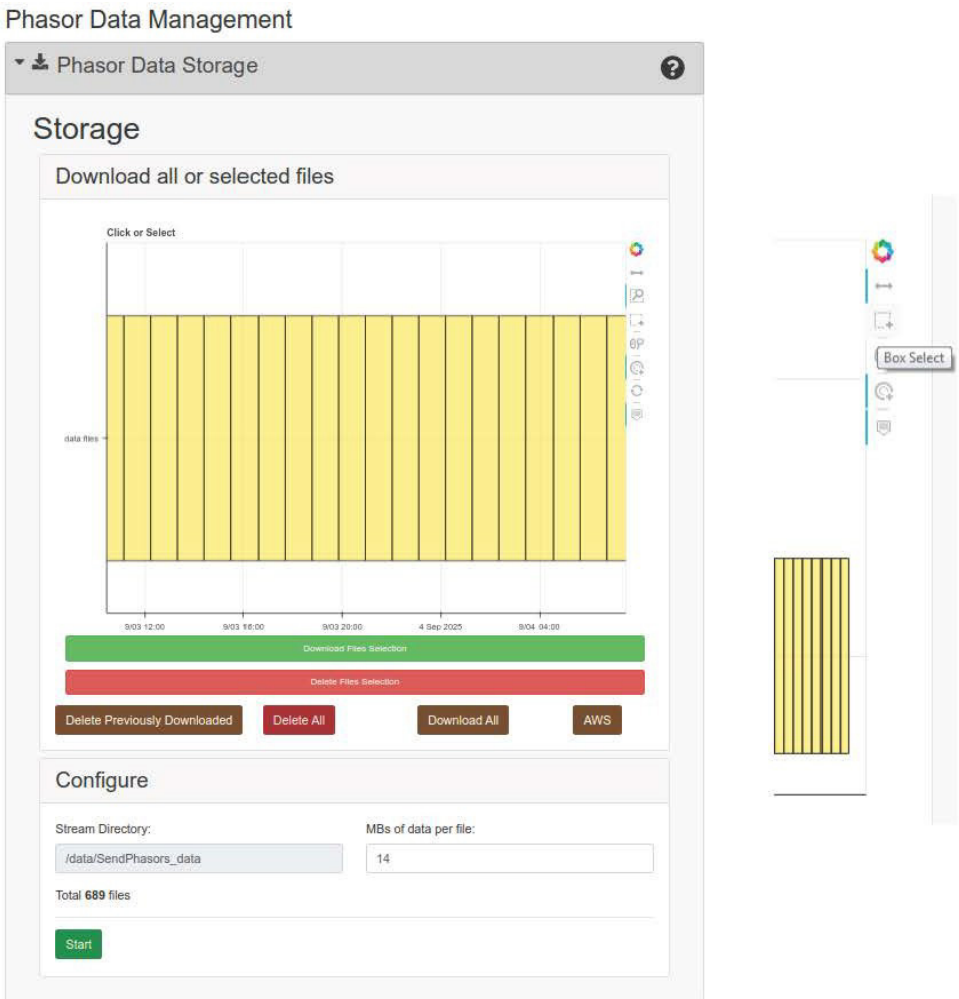

Figure 27. **Single data files are accessed with a left click; the "Box Select" option is used for multifile selection.**

The dLAMP architecture is built on phasor processing, and phasor data files are available to access on the MPM/MUGS units through the "Phasor Data" page. The phasor data files contain GPS, accelerometer, and 8/16 channels of three phasor harmonics (typically 60, 180, and 300 Hz) data. Individual data files contain 14 MBs of phasors by default, but this can be changed through the "Configure Data Stream" option on the ViPERS page.

3.6 Model-Based Phasor Calibration (MPM-Exclusive) (6)

The MPM, unlike MUGS, only uses electric- and magnetic-field sensors that are already integrated into the sensor package. Therefore, the setup and configuration process is different, but still uses the ViPERS and dLAMP software.[4] MPMs can have their configuration changes (e.g., channel names and scalings in the configuration page); however, changing from the default state is not recommended outside of advanced users with specific use cases. The default configuration uses a 1:1 voltage output from the sensors, which is then calibrated for all sensors for each MPM at ARL using a custom UI. This process will typically be conducted at ARL prior to deploying/delivering an MPM.

3.6.1 Settings

The Settings tab contains several options for configuring the MPM for an automated "Model-based Phasor Calibration." The settings will arrive preconfigured to the correct MPM model, but the interface allows a user to change this. Changing the existing configuration is not recommended unless changes are recommended by ARL. For model-based phasor calibration, only certain cables (namely, North Atlantic Treaty Organization [NATO] 8-conductor 200-amp and the Navy LSTGU-400) have been embedded in the MPM because these cable sensors were available for this version of the installation manual. In the Settings tab, there are several options for setting up the model-based phasor calibration (Figure 28). In most cases, the MPM will be "Production" (6000 series), and the cable twist will be –2.25 for the 200 A NATO cable and 1.00 for the Navy LSTGU-400. The nominal voltage should be set to the voltage of the cable being measured. Finally, there are several options for the "Estimator." These are algorithms used to estimate the voltages and currents on the conductors. If the user is unsure of what algorithm to apply, use the "VoltageEstimator." Once these settings are applied, the user can view the Streaming tab to see live estimates out of the phasor calibration.

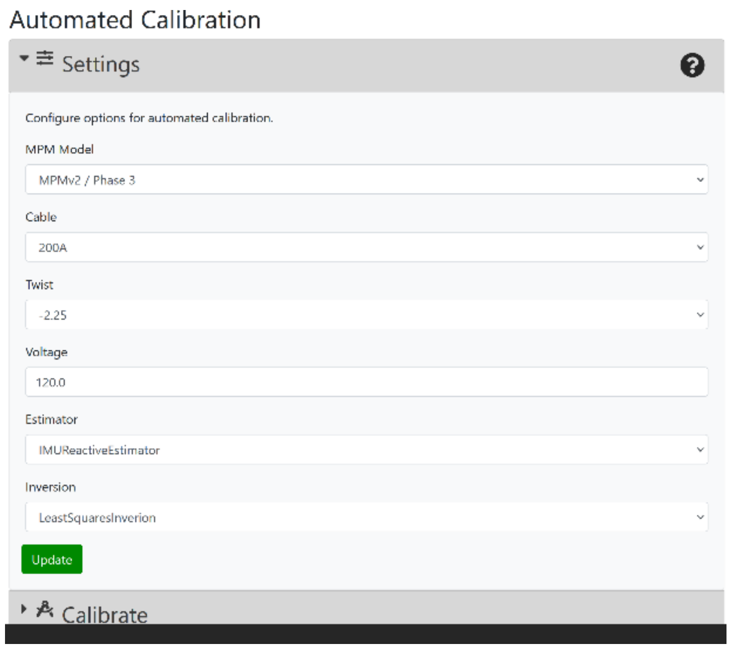

Figure 28. The model-based calibration settings page can be used to set MPM model, cable type, and calibration algorithm.

3.6.2 Calibrate

While a partial calibration of the magnetic field sensors can be performed in a magnetic field coil, there is interplay between the ground planes of the cable sensors and the MPM requiring calibration after installation in the MPM that would not be accounted for. Therefore, we developed an app integrated into the MPM device where calibration is performed in situ by sweeping the MPM completely around the cable. In practice, it is unlikely that the user will need to perform this task (usually completed at ARL before shipping); however, for cases where it may be necessary to calibrate in situ, the calibration method has been included with the MPM as a live application to provide initial calibration and recalibration capability. This is accessible through the ViPERS Model-Based Calibration page. This application running on an MPM is shown in Figure 29. The user can select the MPM version, the load being applied, and cable features during the calibration procedure. Once set up, the user rotates the MPM around the circumference of the cable. Real-time feedback is provided in the plots and circular image, which updates red sections to green as the MPM is rotated. This UI provides an excellent method for calibration that can be understood by standard users when sensor calibration is performed. Once the calibration is complete, the sensor scale factors are saved and applied to all measurements. The procedure only needs to be performed once per unit unless hardware components are replaced.

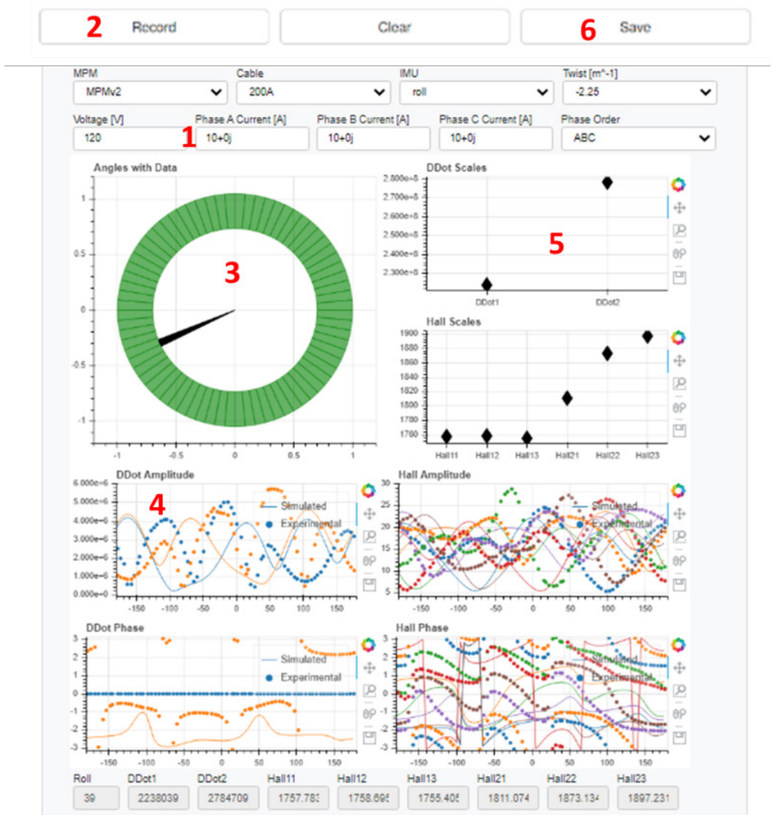

Figure 29. Calibration web interface in the MPM.

3.6.3 One Time (per MPM) Calibration Procedure

1) An 8-conductor 200-amp NATO cable and known loads are used during the calibration process. The known loads (complex if not fully resistive) are entered in the text boxes (1) along with the nominal voltage.
2) The MPM being calibrated is placed on the cable and secured so that it can be rotated around the cable without slipping. Putting thick zip ties in front and behind the sensor wings helps to avoid moving the MPM forward or backward on the cable while rotating. Once ready, the loads are turned on and the "Record" (2) button is pressed.
3) The angular plot (3) will start as all red, but the 5° sections will turn green as they accumulate data. The inertial measurement unit is used to measure the angular position on the cable and measurements from the sensors are binned accordingly. A full rotation of the MPM around the cable should be performed. Ideally, all sections will be green at the end of the run, but this is not required to perform the calibration.
4) There are D-Dot and Hall Amplitude and Phase plots (4) that display the expected sensor responses as the MPM is rotated around the cable. As

measurements are accumulated, they will show in these plots. The final fit is used to produce calibration values for each sensor (5).

5) Once all measurements have been made, press the "Save" button to write the measurements and calibration values to file. This calibration information is used in the MPM until a new calibration is performed.

3.6.4 Live MPM Data

Once an MPM has been configured, the information is accessed by the automated.py module, which broadcasts calibrated EP data. The live MPM page receives this information for display. There are plots for Voltage, Phase Current, and Phasors, in addition to a plot of the MPM position and Quality estimation as determined by the MPM algorithm (Figure 30). See MPM Installation Guide[5] for more information regarding MPM installation and use.

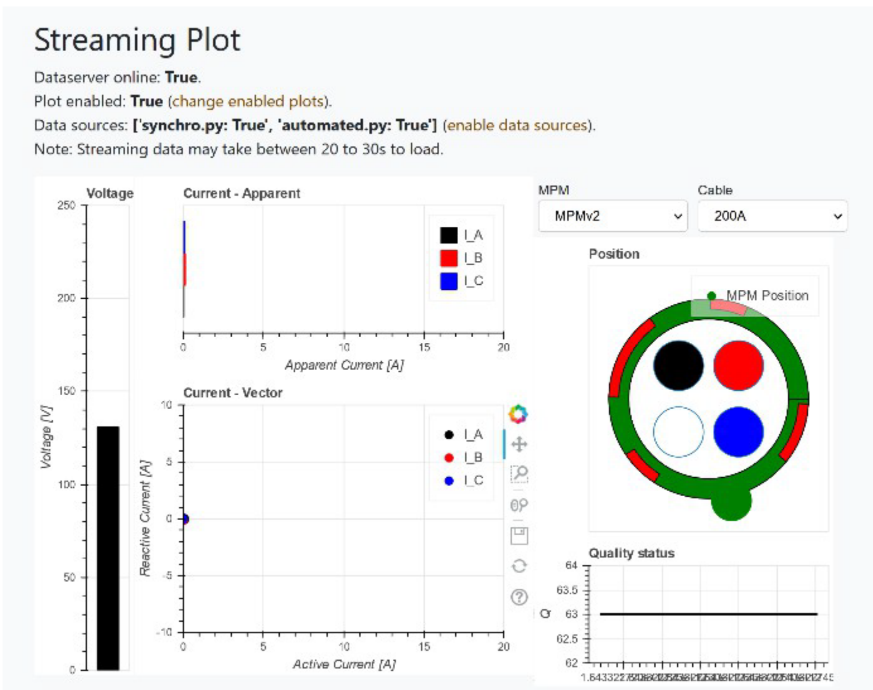

Figure 30. **Live MPM data is streamed showing MPM position and EP data.**

3.7 Load-Based Calibration (MPM Exclusive) (7)

The Load-Based Calibration (MPM Exclusive) (7) page is exclusive to the MPM as it is used to generate the calibration matrix to be used by the MPM to transform the Electric and Magnetic field measurements into the voltages and currents running through each conductor in the cable. This transformation is typically unnecessary on a MUGS because voltage and current can be measured directly using conventional voltage and current probes. This page makes it easy for users to record a calibration sequence using symmetric loads on each phase of the cable and handles the automatic generation of the calibration matrix using the standard load-based calibration method. This application can be accessed from the Home > Load-Based Calibration page, and it requires that the quick_calibrate.py Bokeh plot is enabled in order to run. Users can ensure that this is running using the ViPERS Home > Modules > Plots page. See Modules (Dataserver) (10) for more information about enabling/disabling plots. After its running requirements have been met, the Load-Based Calibration page will provide live instructions and a live plot to assist users in recording the calibration sequence. The UI for this page can be viewed in Figure 31.

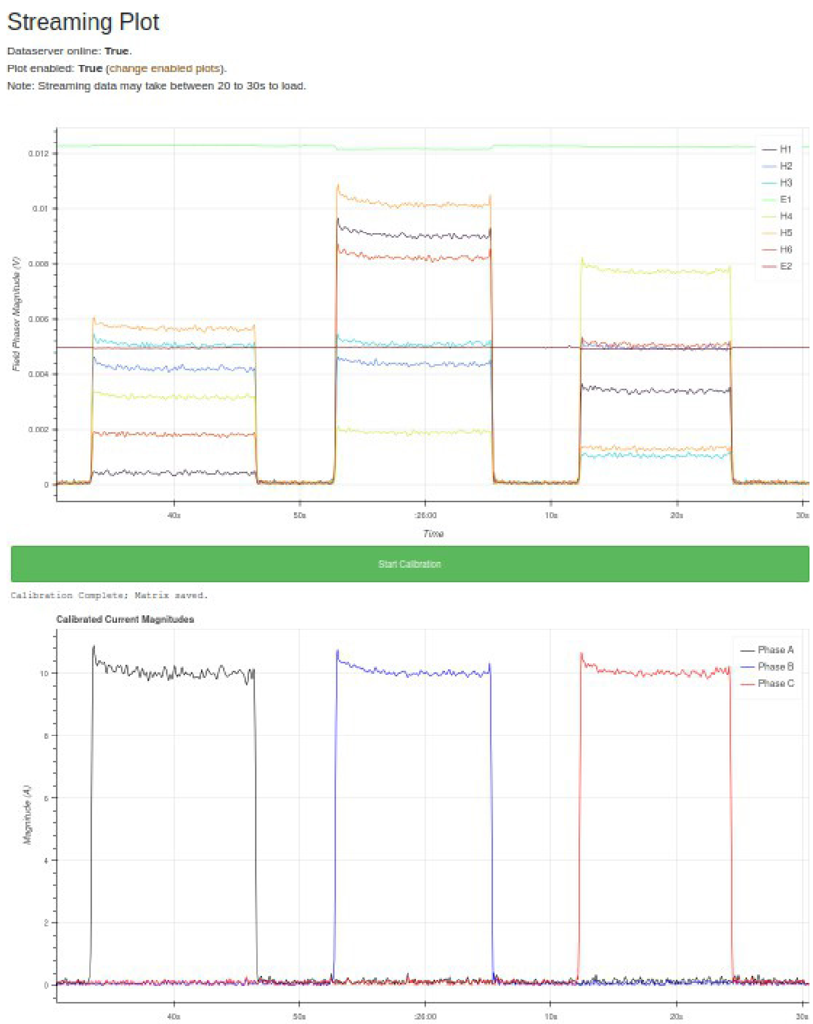

Figure 31. Live data is buffered and displayed during the calibration process.

If the current magnitudes are not identical to the magnitude of the known load and are not properly lined up by phase, ensure that load value is correct in both the real and imaginary domains.

3.8 Fast Fourier Transform (FFT) (MUGS Exclusive) (8)

From the Fast Fourier Transform (FFT) (MUGS Exclusive) (8) page, users can livestream FFT plots for all data channels, either individually or concurrently. The top of the page includes several options for users to select the size of the FFT, potential windowing, and whether to save or load data. When the user selects the "Start Capture Button," the three plots (Figure 32)—showing the raw data signal, the FFT, and an estimate of the total harmonic distortion—will begin updating according to the integration time selected. Options for integration time are provided in seconds and range in powers of two from 1 to 128 s. Figure 32 shows an example of a single-channel, live-FFT plot.

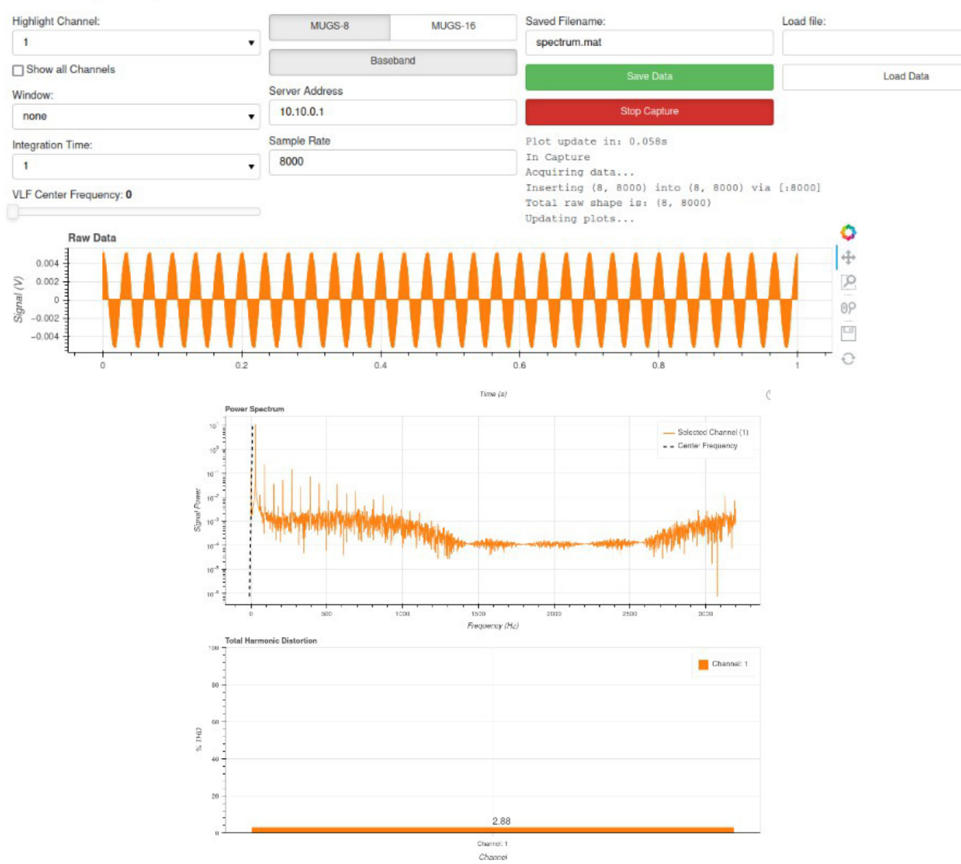

Figure 32. The time–domain raw data can be processed (top) to frequency–domain spectral data (bottom).

3.9 Help (9)

The Help (9) page lists support topics for ViPERS pages. The list of subjects corresponds to major features and can be expanded or collapsed. Within each subject are specific Help subpages, which are ordered alphabetically (Figure 33).

Each Help page can be reached by clicking on the Help icon (located in the gray expansion bar) on the corresponding page.

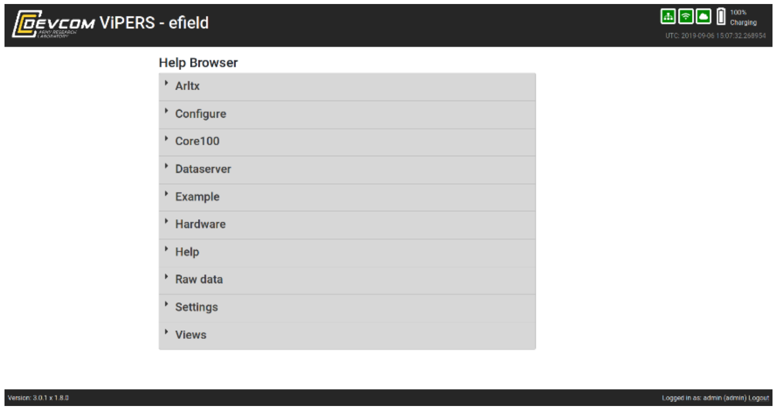

Figure 33. Integrated Help browser.

3.10 Modules (Dataserver) (10)

The Modules (Dataserver) (10) page has several subpages associated with the system configuration of the modules that have been loaded into the system. This page allows users to directly interact with the ViPERS Dataserver, which runs several key processes for the unit. It allows the user to bring specific modules up and down, restart them, and check on individual module statuses. Modules may also be brought up and down by other pages as required for operation or to control their behavior. MPM and MUGS have slightly different modes of operation; therefore, some modules required for the MPM are not relevant to the MUGS (i.e., modules associated with Model-Based Calibration).

3.10.1 Modules

The Modules page allows users to interact directly with the processes running on the ViPERS Dataserver and upload their own custom processing code. The Dataserver can run scripts in Python, Java, and Bash, and users can specify command-line arguments for their custom processing code using the UI on this page. If a user's processing code requires additional data files or configuration files, users should upload those through the "Config Files" interface seen in Section 3.10.3, Config Files (Extra Configuration File). For additional details on implementing custom code on ARTEMIS units, see the ViPERS Implementation Guide[1] and ViPERS Programming Manual.[2] Figure 34 shows an example Modules page with several modules running. As seen, these modules are shown in a table format. The table has columns that map to convenience functions or display the status of the module as described in Table 8.

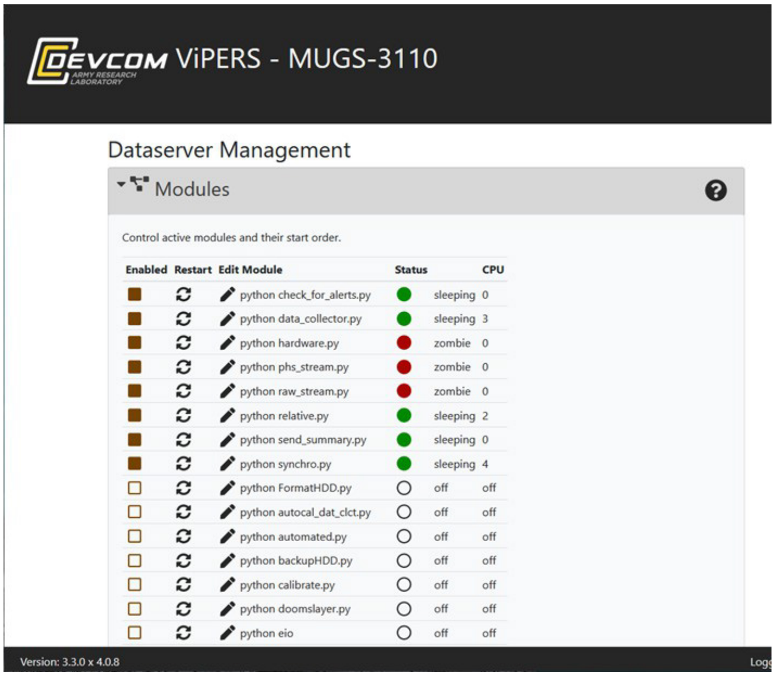

Figure 34. The Modules tab shows the status of active and inactive modules.

Table 8. Modules page: form fields and their descriptions.

Column	Description
Enabled	Indicates whether this module is enabled. Enabled modules start running when they are enabled and will restart on ARTEMIS start-up. Clicking the icon changes the enabled state and starts/stops the module accordingly.
Restart	Will restart (stop then start) the module
Edit module	Brings up a dialog box allowing the user to specify the interpreter and to provide command-line arguments
Status	The OS classification of the module. Frequently, the status is "zombie" (module exited), "running," or "sleeping"
CPU	The current CPU utilization

To add a new module, click "Choose File," select the file, and then click "Upload." The upload time can vary depending on network speed and file size. Individual modules can be enabled and restarted. Additionally, the interpreter or command-line arguments can be changed. This page also gives a glimpse into the CPU consumption of the data processing pipeline.

3.10.2 Plots

The ViPERS Dataserver uses the Bokeh plotting utility to serve live-updating plots. Plots can be enabled and disabled from the Modules/Plots page (Figure 35). To enable a plot, check the box next to the plot's name and click "Update." Due to the tight integration of the Bokeh server with the web application, there is not currently a way for users to upload custom plots that use Bokeh. To create custom streaming plots with Bokeh, see the developer documentation.[6]

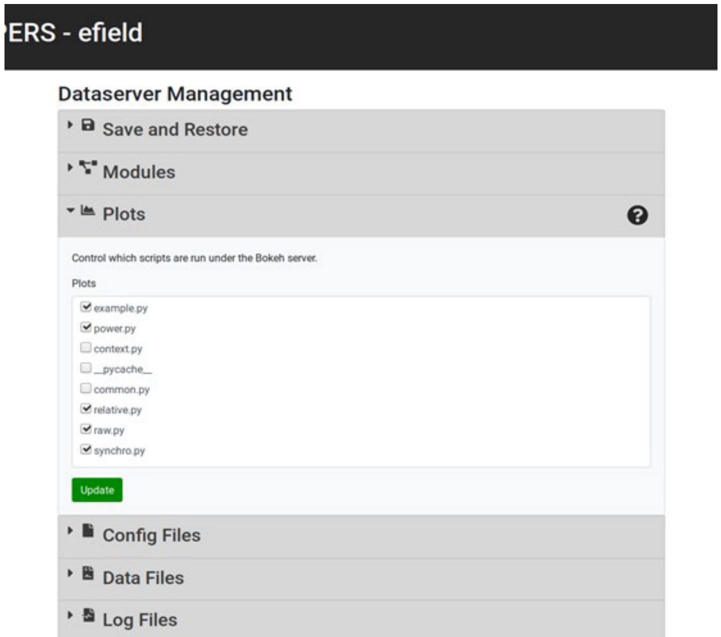

Figure 35. Specific Bokeh applications can be enabled and disabled.

Plots created through Dataserver are produced by the Bokeh Python package, which produces rich interactive plots. Each plot has a toolbar with icons that allow users to change their interaction with the plot. Table 9 shows options for plot interactions.

Table 9. Bokeh interaction icons and their descriptions.

Name	Icon	Function
Pan	Cross of arrows	Pan around the figure with the mouse or a tap-drag
Box zoom	Magnifying glass	Zoom into the figure with the mouse or a tap-drag
Wheel zoom	Mouse and glass	Use the mouse (or pinch-zoom) to scroll in
Save	Diskette	Save the figure to the local drive
Reset	Circle of arrows	Reset the plot to the default (useful after zooms)
Help	Question in circle	Links to Bokeh documentation[6] on the toolbar

In addition to the toolbar, streaming plots and applications may have additional widgets to allow interaction. All pages that require their respective Bokeh plot to be enabled have a Bokeh notification message at the top of the page. Pages that use this utility include Synchro, FFT, and Raw Data/Scope.

3.10.3 Config Files (Extra Configuration File)

This page allows users to manage ARTEMIS configuration files. These files may be used for both sensor and data configuration (see Configure (2) on configuration for more details) as well as configuration files necessary for any user-provided data-processing module. These files are stored locally in the ARTEMIS unit's OS file system. There are three actions users can take on this page:

1) Upload
2) Download
3) Delete

To upload a file, click on the "Browse" button, select a file on the local file system, and then click "Upload." To download a file, simply click on the corresponding file name. To delete a file, click the red "Delete" text next to the corresponding file name (Figure 36).

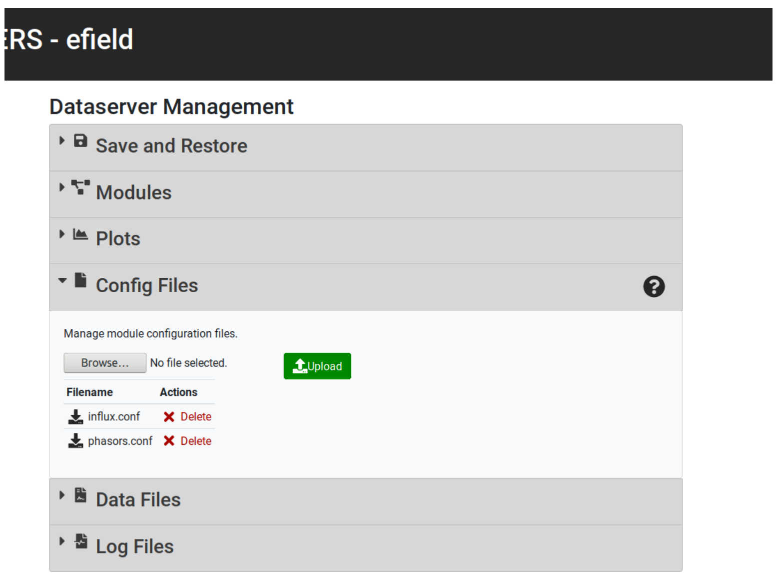

Figure 36. Management page for module configuration files.

User-defined processing modules uploaded through the Modules page that require a corresponding configuration file should reference that file in the directory: /home/snickerdoodle/vipers/dataserver/ modules/conf.

3.10.4 Log Files

This page allows users to view and delete log files generated by the modules managed by Dataserver (Figure 37). To view the contents of a file, click on its name. A box will expand below showing the last few lines of the log file and will update every second. Once a particular log is open, the user can also download the file by clicking the “Download Log” button. Users may also delete the log file by clicking on “Delete Log.”

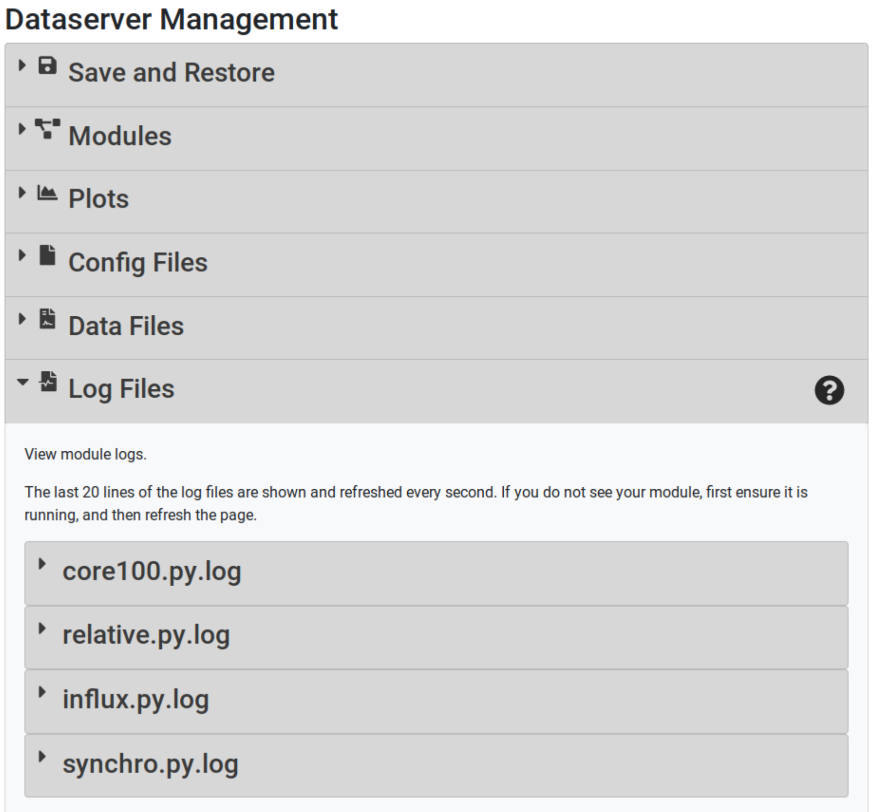

Figure 37. View log files.

4. ViPERS Dataserver Modules

ViPERS includes several stock modules that can be used to process, store, broadcast, and export information related to sensor measurements and system information. Modules are easily added and can interact with one another through socket connections or file reading/writing. Table 10 lists the default modules and their level of importance for each system in a standard configuration.

Table 10. Dataserver modules and their importance level across ARTEMIS.

Module	MPM importance	MUGS importance
synchro.py	High	High
phs_stream.py	High	High
raw_stream.py	High	High
automated.py	High	None

4.1 Data Streaming Modules

The largest class of ViPERS modules are the Data Streaming modules, which primarily insert data from the FPGA into readily usable formats (Table 11).

Table 11. ViPERS Data Streaming modules and their descriptions.

Module	Description
synchro.py	Selects data from a range of sources and format to a standard dLAMP packet
phs_stream.py	Reads binary raw data stream and writes it to file
raw_stream.py	Reads binary phasor data stream and writes it to file

The most important Data Streaming module is synchro.py. This module is present in the main ViPERS phasor data processing chain and is important in providing users' phasor data in the form of dLAMP packets. For more information on the dLAMP packet format, see its associated documentation.[3]

4.1.1 synchro.py

The synchro.py module standardizes the outputs of several different data sources to a single output: the dLAMP packet. As shown in Figure 38, synchro.py can accept inputs from various sources (including dbus, TCP, and simulated). The data source is configurable from the ViPERS Hardware Configuration Page (connecting to ViPERS). The synchro.py module receives data from any source, repackages the data it receives into the standardized dLAMP packet format, and rebroadcasts the data to port 5683. It accepts up to five clients at a time and will perform connection retries if its client or data sources disconnect.

ssn_name -> <ssn_name>.<algorithm>
ssn_name = :string: (=hostname, eg; "snoodle-14")
algorithm = :string: (eg; "ori-m-class")

channel_name -> <type>.<circuit>.<frequency>.<name>:<reference>
type = {"voltage", "current", "efield", "hfield", "undefined", "frequency", "thd", "power"}
circuit = :string: (eg; "Main")
frequency = :number: (eg; 60, encoded as :string:)
name = :string: (eg; "I_a")
reference = :string: (eg; "V_a")

Example channel_names:
voltage.main.60.Va
voltage.main.180.Va
voltage.main.300.Va
frequency.main.60.Va
thd.main.60.Va
…
current.main.60.Ia:Va
current.main.180.Ia:Va
current.main.300.Ia:Va
frequency.main.60.Ia:Va
thd.main.60.Ia:Va
power.main.60.Ia:Va

Figure 38. Example channel names created by synchro.py.

4.1.2 raw_stream.py and phs_stream.py

phs_stream.py is an ARTEMIS-based phasor data module streamed from an internal service that broadcasts the sensor-scaled output of the FPGA phasor algorithm. With phasor-streaming Python services, users are enabled to stream raw and phasor data generated from the internal MPM or external MUGS sensors to external hard drives or internal system SD cards.

Under the ViPERS modules page, activate either raw_stream.py or phs_stream.py to run these processes with default parameters. Both processes accept the following parameter options:

--hours=X

--device=Y

where X is the number of hours per file generated, and Y is the name of the device to stream data to. Inputs can be entered under the respective processes in the Modules page. We assume devices are listed under /dev/abc and only accept the abc portion of the device name. For example, if the device is /dev/sda2, input --device=sda2.

The latest rewrite of phs_stream.py and raw_stream.py are meant to handle two types of common interruptions: disk interrupts and socket interrupts. Upon both types of interruptions, these processes will attempt to remount the disk automatically or reconnect to the streaming service with a new socket. The process will fail and shut down with a logged error message if this cannot be accomplished.

Logs can be viewed under the Modules page's log section, or under /vipers/dataserver/modules/logs.

4.2 MPM-Specific Modules

automated.py interfaces with the MPM configurations and calibrations created through the Autocal page detailed in Model-Based Phasor Calibration (MPM-Exclusive) (6). This module must be active to perform model-based calibration in the MPM. Changes to the MPM configuration through the Autocal page will start-up or restart this module with the configuration changes. Once enabled, the automated.py module will actively determine the proper calibration for the selected cable model using the selected parameters and algorithm. The calibrated voltage and load (current) phasors will appear in the Live MPM Data subpage.

IMPORTANT: If new sensor calibrations are created through the Autocal:Calibrate page Calibrate, the user must manually restart the automated.py module to apply the updated sensor calibrations.

5. Conclusion

ARL-ViPERS software has been developed as a multipurpose utility to provide an easy interface to ARTEMIS-based system information and control, data processing through modules running in the ViPERS Dataserver, and custom web pages allowing interaction with raw and phasor-based data. The interface can be used both with traditional sensors (e.g., current clamps) and smart sensors (e.g., cable sensors) and interfaces with system data logging for binary data files. These capabilities are fully embedded with the hardware, circumventing the need for software installation, and are preloaded on ARTEMIS systems provided by ARL.

6. References

1. Claytor K, George A, Drummond Z, Snellman A. ViPERS web-based interface for internet of things (IoT): implementation guide. DEVCOM Army Research Laboratory (US); 2019 Dec. Report No.: ARL-TR-8863.

2. Snellman A et al. DEVCOM Army Research Laboratory visualization and processing for embedded research systems (ARL-ViPERS) user manual. DEVCOM Army Research Laboratory (US); 2023 Aug. Report No.: ARL-SR-0477.

3. Parks B, Hull D. Army Research Laboratory live animated multi phasor (ARL-LAMP) analysis software. Army Research Laboratory (US); 2015 Sep. Report No.: ARL-TR-743.

4. Snellman A, Parks B, Heintzelman S, Hull D. Continuous, non-intrusive electric field & electric power monitoring using smart low power mode switching for ARTEMIS MPM. MSS BAMS; 2022 Nov.

5. Parks B, Snellman A, Chung H, Hull D. Army Research Laboratory mobile power meter (MPM) installation guide. DEVCOM Army Research Laboratory (US); 2024 Jan. Report No.: ARL-SR-0490.

6. Bird S, Canavan L, Hulsey C, Paprocki M, Rudiger P, Van de Ven B. Welcome to Bokeh. Bokeh 3.2.0 documentation. Bokeh contributors; c2025 [accessed 2023 July 11]. https://bokeh.org/

List of Symbols, Abbreviations, and Acronyms

ADC	Analog-to-Digital Converter
API	Application Programming Interface
ARL	Army Research Laboratory
ARL-ARTEMIS	ARL Autonomous Real-Time Electric-power Measurement and Instrumentation System
ARL-MPM	ARL Mobile Power Meter
ARL-MUGS	ARL Mobile Unattended Ground Sensor
ARL-ViPERS	ARL Visualization and Processing on Embedded Research Systems
BNC	Bayonet Neill–Concelman
CPU	Central Processing Unit
DC	Direct Current
DEVCOM	U.S. Army Combat Capabilities Development Command
DHCP	Dynamic Host Configuration Protocol
EP	Electric Power
FFT	Fast Fourier Transform
FPGA	Field-Programmable Gate Array
GPS	Global Positioning System
HDD	Hard-Disk Drive
IEEE	Institute of Electrical and Electronics Engineers
IP	Internet Protocol
LAN	Local-Area Network
MAC	Media Access Control
MB	Megabyte
MPM	Mobile Power Meter
MUGS	Mobile Unattended Ground Sensor

NATO	North Atlantic Treaty Organization
OS	Operating System
RAM	Random Access Memory
RMS	Root Mean Square
RTC	Real-Time Clock
SD	Secure Digital
SN	Serial Number
TCP	Transport Control Protocol
UI	User Interface
URL	Uniform Resource Locator
WAN	Wide-Area Network

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