

## groov RIO ENERGY MONITORING UNIT

### Features

- > Three-phase power and energy monitoring
- > Category III wye (up to 400 VAC) or delta (up to 600 VAC)
- > Compatible with 0.333 V, 1 V, or 5 A current transformers
- > Measures AC RMS voltage and AC RMS current; provides power measurements and accumulated energy
- > 64 channels of voltage, current, power, energy, and frequency data
- > Powered by either 10-32 VDC power supply or Power over Ethernet (PoE) (star topology only)
- > Two switched Gigabit Ethernet network interfaces for wired networks; supports star or daisy-chain topologies
- > Embedded web-based applications including *groov*® Manage, Node-RED, and MQTT
- > USB port for adding devices like Wi-Fi adapter or USB memory drive (user supplied)
- > Cybersecure with encryption and authentication

### DESCRIPTION

The **GRV-R7-I1VAPM-3** is an energy monitoring unit that provides an effective way to monitor AC voltage, current, power, and energy usage on wye or delta circuits up to UL 61010-3 measurement category III. It can monitor three-phase AC current using 0.333 V, 1 V, or 5 A current transformers (CT).

The module measures AC RMS voltage and AC RMS current for up to three phases. From the measured field inputs, the module automatically calculates additional values of significant data, for a total of 64 data values. Calculated data includes true, reactive and apparent power, power factor, frequency, net energy, and other values for each phase as well as combined totals for all phases (summation values). For more details, see "[Map of Channels to Measurements, Accumulation, and Summation Values](#)" on page 5.

The module can be configured to ignore small signals that fall below a specified threshold (see "[Input Signal Filtering](#)" on page 3). The accumulated energy values are preserved in non-volatile memory every 30 seconds to survive across power interruptions to the module.

### Edge I/O With Power

*groov* RIO energy monitoring units (EMU) bring you a new kind of I/O product—*edge I/O*. It does not require a PLC, PAC, or industrial PC, but is designed as an intelligent, distributed energy monitoring unit to



**GRV-R7-I1VAPM-3**

meet the needs of IIoT projects, especially those that require energy data acquisition.

With *groov* RIO, you can:

- Capture remote data almost anywhere. *groov* RIO operates through a wide range of operating temperatures (-20 to 70 °C), is UL/cUL listed, and complies with the ATEX, Low Voltage, and EMC CE directives.
- Supply power to *groov* RIO through **one of the following (but not both)**:
  - The ETH1 network interface connected to a Power over Ethernet Switch and cable (802.3af PoE Class 0).
  - The power supply terminals connected to a 10–32 V DC power supply.
- Connect the two switched Gigabit Ethernet network interfaces in a standard star configuration or in a daisy-chain configuration. Both physical Ethernet interfaces use a single IP address.
- Connect additional devices like a Wi-Fi adapter, a USB memory stick (up to 32 GB), or a USB-to-serial adapter via the *groov* RIO's USB port (these optional devices are user supplied).
- Simplify connections to electrical equipment using the removable terminal connector with spring clamp wire retention.

### Part Number

| Part            | Description   |
|-----------------|---|
| GRV-R7-I1VAPM-3 | Edge EMU; 3-phase power and energy monitoring, 18 data & accumulation values per phase; 10 summation values |

- Easily see the status of power and network activity on the module's LEDs.

Use embedded software to quickly set up data communication between electrical equipment and on-premises or cloud-based systems and software.

### Access or Send Data Anywhere

*groov* RIO supports both OT and IT protocols and tools, making it easier to safely move data among electrical equipment and computer networks, in some cases without requiring a PLC or middleware. Choose the method that works best for you:

**Node-RED**—Create a data flow with the built-in Node-RED editor and runtime to send data to cloud services, databases, and APIs through pre-built nodes. Even develop simple user interfaces (UIs) with Node-RED UI nodes and serve them directly from *groov* RIO to any mobile or web-based device.

**MQTT/Sparkplug-B**—An efficient and robust publish/subscribe protocol, MQTT is an ideal method of exchanging energy data for industrial internet of things (IIoT) applications. *groov* RIO has support for MQTT built in, requiring only a simple configuration to publish energy data and subscribe to commands as Sparkplug-B or string payloads.

**Modbus TCP/IP**—*groov* RIO is a Modbus TCP slave out of the box. Use your favorite Modbus TCP master device or software to poll *groov* RIO's channels. A Modbus TCP calculator is built into *groov* RIO's *groov* Manage application, helping you to quickly find the Modbus Unit ID and register of channels and their features.

**HTTP/S, JSON, and REST APIs**—The developer community has embraced REST APIs as a method of accessing energy data with HTTP/S and JSON. Opto 22 provides REST APIs for *groov* Manage, which you use to access the energy data on a *groov* RIO EMU. A Swagger API document is built into *groov* RIO to quickly access REST API calls and evaluate responses.

**Python using SSH**—Develop your own custom applications by adding Secure Shell access to a *groov* RIO EMU. (Requires purchase of free [GROOV-LIC-SHELL](#).)

**.Net or C++ and free SDKs**—With your favorite development tool and our free SDKs, you can programmatically access energy data on a *groov* RIO by accessing the OptoMMP memory map locations of each channel. An OptoMMP calculator is built into *groov* RIO's *groov* Manage, making it simple to identify the MMP addresses of channels and their features.

### *groov* RIO in a Custom Program or SCADA

In addition to its use as autonomous edge I/O, *groov* RIO can also be used to expand the scope of existing energy monitoring programs or

industrial applications. You can add *groov* RIO EMUs to monitor, and collect data from electrical equipment:

**In a PAC Control™ strategy**—With PAC Project™ Basic or Professional Software Suite, add a *groov* RIO as an I/O unit, configure your channels, then download your strategy to a *groov* EPIC® processor running firmware version 3.3.0 or higher.

**In a CODESYS® application**—Download and install the Opto 22 Library Package for CODESYS Development System, version 2.0.4.0 or higher. Update your application and you'll be ready to add a *groov* RIO and configure channels.

**In an Ignition SCADA**—GRV-R7-11VAPM-3 offers efficient IIoT communications using MQTT with Sparkplug B payloads, making it a smooth addition to your Ignition SCADA application. The Modbus/TCP support provides another interface through which you can add the energy monitoring capabilities of a *groov* RIO EMU to your application.

**In a custom program**—You can access *groov* RIO EMU data programmatically using an SSH license ([GROOV-LIC-SHELL](#)) or remotely through REST APIs or with free .Net or C++ SDKs (available for download on our website).

### Cybersecurity

*groov* RIO provides several features to help keep your data secure.

**User account management**—*groov* RIO has no default username or password. You must set up the first Admin user account and remember its username and password, as these user credentials are secure and cannot be recovered. You can also locally create more users, set their passwords and permissions, and set global and individual user session timeouts.

**Centralized user management**—*groov* RIO can help you scale your control system by supporting user management through LDAP. Configure your *groov* RIOs to connect to your LDAP-compatible directory service, then your IT staff can manage users/groups from one spot. LDAP support can also help satisfy data integrity requirements in regulated industries.

**VPN client**—You can securely connect to *groov* RIO using a VPN. Support is provided for OpenVPN servers.

**Configurable firewall**—Configure the device (or host) firewall in *groov* RIO for greater security. You can control which ports, protocols, and interfaces are open for incoming connections to the services listening on each port number. For example, you should disable the ports of unused protocols.

**Security Certificate management**—You have control over the Client and Server Security Certificates used with your *groov* RIO, from a self-signed certificate you can create on the module to a signed

certificate from an internet-based Certificate Authority (CA). See the *groov* RIO EMU User's Guide for details.

### Leverage Existing *groov* Knowledge

If you already have a *groov* EPIC system, you can expand your energy monitoring footprint with the addition of *groov* RIO EMUs. *groov* RIO EMUs works as remote energy monitoring units with *groov* EPICs, and they use many of the same principles and technologies found in your existing *groov* control system:

- *groov* Manage for channel configuration and other tools to help manage your *groov* RIO
- MQTT to transmit Sparkplug or string payloads
- Node-RED for simple data flows
- OpenVPN client to connect to an OpenVPN server running a virtual private network
- PAC Control for programming and channel configuration

## SUPPORTED CONFIGURATIONS

The GRV-R7-I1VAPM-3 module supports the following configurations:

- 0–600 V<sub>rms</sub> delta
- 0–520 V<sub>rms</sub> delta
- 0–260 V<sub>rms</sub> delta
- 0–400 V<sub>rms</sub> wye
- 0–300 V<sub>rms</sub> wye
- 0–150 V<sub>rms</sub> wye

## INPUT SIGNAL FILTERING

Each phase can be configured to ignore small signals like leakage current and low voltage noise in power measurement and energy accumulation through the adjustment of three options: Minimum Voltage Threshold Ratio, Minimum Current Threshold Ratio, and Power Creep Adjustment.

### Minimum Voltage Threshold Ratio

When the voltage falls below the Minimum Voltage threshold, the module sets all input values for the phase (except current and energy totals) to 0. Specify the value of the threshold ratio as a fraction (in decimal format) of the full-scale voltage. For example, if the full-scale voltage is set to 0–520 V<sub>rms</sub> delta and the Minimum Voltage Threshold Ratio is set to 0.05, input values for the phase are set to 0 when the voltage measured on the phase drops below  $(520 \times 0.05) = 26 \text{ V}_{\text{rms}}$ .

When you set the threshold ratio to 1.0, it disables the phase. All input values (except current and energy totals) for this phase are set to zero regardless of the measured voltage.

To specify the Minimum Voltage Threshold Ratio:

- In PAC Control, search for "Voltage Type for All Phases" in the PAC Control User's Guide (form 1700).
- In *groov* Manage, search for "input signal filtering" in the *groov* RIO EMU User's Guide (form 2372).

### Minimum Current Threshold

The minimum current below which all input values for a phase (except voltage and energy totals) are set to 0. This value is specified in units of RMS amps (A<sub>rms</sub>).

### Power Creep Adjustment

The power threshold below which all measured values for the phase are set to zero (except V<sub>rms</sub>, I<sub>rms</sub>, and energy totals.) This threshold is specified as percent of full-scale apparent power (full-scale V<sub>rms</sub>) \* (full-scale I<sub>rms</sub>). The default value is 0.0%.

For example, to set all power values for this phase to zero when the power drops below 10%, specify a value of 10.0. If the full-scale voltage is set to 0–300 V<sub>rms</sub> wye and the full-scale current is set to 50 A<sub>rms</sub>, all values for this phase are set to zero when apparent power is below  $300 \text{ V}_{\text{rms}} * 50 \text{ A}_{\text{rms}} * 0.1 = 1500 \text{ VA}$ .

## POWER MEASUREMENTS, ENERGY ACCUMULATIONS, AND SUMMATIONS

The *groov* RIO EMU measures & calculates data (power) values and accumulates energy values for each phase that it monitors. It also sums all of those values into totals called summation values. All these values are provided through 64 channels:

- **Data (power) values** are provided through channels 0-12 for phase A, 18-30 for phase B, and 36-48 for phase C. For each phase, the module provides:
  - True Power
  - Reactive Power
  - Apparent Power
  - Frequency
  - Harmonic True Power
  - Power Factor
  - Peak Voltage
  - Peak Current

- True Power at Fundamental Frequency
- Average Reactive Power
- Reactive Power at Fundamental Frequency
- **Accumulated energy values** for Net, Positive, Negative, Net Reactive, and Apparent energy are provided through channels 13-17 for phase A, 31-35 for phase B, and 49-53 for phase C.
- **Summation values** for Net, Positive, Negative, Net Reactive, and Apparent energy are provided through channels 57-62.

The "[Map of Channels to Measurements, Accumulation, and Summation Values](#)" on page 5 outlines which channel provides each of these values and describes the formulas it uses for calculations.

These data values, accumulations, and summations are stored to non-volatile memory every 30 seconds.

### Data Types Required to Read or Write Accumulation and Summation Values

The following channels provide accumulation and summation values:

| Channels | Phase                 |
|----------|-----------------------|
| 13–17    | A                     |
| 31–35    | B                     |
| 49–53    | C                     |
| 57–62    | Totals for All Phases |

The module provides read, write, and read & clear operations to these channels; each operation supports specific data type(s).

#### Reading Accumulation and Summation Values

The read operation reads the units as either kWh or mWh, depending on the data type:

- **32-bit IEEE floating-point:** kWh (kvarh or kVAh).  
In a PAC Control strategy, you can read these 32-bit IEEE floating point values with the Get Counter command.  
*Note: With this data type, you lose precision as the magnitude of the value increases. This is due to the properties of the 32-bit IEEE floating-point data type. (For an explanation of working with 32-bit IEEE floating-point, see [Using IEEE Floats in OPTO 22 Products, form 2386](#).) If your application requires greater precision, use the 64-bit signed integer.*
- **64-bit signed integer:** mWh (mvarh or mVAh).  
In a PAC Control strategy, you can read these 64-bit signed integer values with the Get Counter 64 command.

#### Writing Accumulation and Summation Values

The write operation stores the value to non-volatile memory immediately. The operation requires that the value be specified as a **64-bit signed integer**.

In a PAC Control strategy, you can write these 64-bit signed integer values with the Set Counter 64 command.

#### Reading and Clearing Accumulation and Summation Values With One Operation

The read-and-clear operation reads the value as units of mWh (mvarh or mVAh) and sets it to zero in a manner that prevents the loss of summation values during the operation. The operation stores the cleared value into non-volatile memory immediately. The operation requires that the value be specified as a **64-bit signed integer**.

In a PAC Control strategy, you can read and clear the values as 64-bit signed integers with the Get & Clear Counter 64 command.

## MAP OF CHANNELS TO MEASUREMENTS, ACCUMULATION, AND SUMMATION VALUES

| Ch | Phase | Description                             | Details   |
|----|-------|---|---|
| 0  | A     | $V_{rms}$                               | <p>Root-mean-square voltage for the phase in units of <math>V_{rms}</math>, measured relative to the neutral terminal, calculated once per second from 4000 samples. (See equation to the right.) This value is always positive. This channel can be configured with one of the following channel types:</p> <ul style="list-style-type: none"> <li>• 0–600 <math>V_{rms}</math> delta</li> <li>• 0–520 <math>V_{rms}</math> delta</li> <li>• 0–260 <math>V_{rms}</math> delta</li> <li>• 0–400 <math>V_{rms}</math> wye</li> <li>• 0–300 <math>V_{rms}</math> wye</li> <li>• 0–150 <math>V_{rms}</math> wye</li> </ul> $V_{rms} = \sqrt{\frac{\sum_{n=1}^{4000} (V^2)_n}{4000}}$ |
| 1  | A     | $I_{rms}$                               | <p>Root-mean-square current for the phase in units of <math>A_{rms}</math>, calculated once per second from 4000 samples. (See equation to the right.) This value is always positive. This channel can be configured with one of the following channel types:</p> <ul style="list-style-type: none"> <li>• 0–5 <math>A_{rms}</math> CT</li> <li>• 0–1 <math>V_{rms}</math> CT</li> <li>• 0–0.333 <math>V_{rms}</math> CT.</li> </ul> $I_{rms} = \sqrt{\frac{\sum_{n=1}^{4000} (I^2)_n}{4000}}$  |
| 2  | A     | True Power                              | <p>True (or real or active) power for the phase in units of W, calculated once per second from 4000 samples of instant power. (See equation to the right.) This value can be positive or negative.</p> $P = \frac{\sum_{n=1}^{4000} V_i \times I_i}{4000}$  |
| 3  | A     | Reactive Power                          | <p>Reactive power for the phase in units of var. This value is calculated once per second from the square root of the apparent power squared minus the true power squared. (See equation to the right.) This value is always positive.</p> $Q = \sqrt{(S^2 - P^2)}$   |
| 4  | A     | Apparent Power                          | <p>Apparent power for the phase in units of VA, calculated once per second from <math>V_{rms}</math> times <math>I_{rms}</math>. (See equation to the right.) This value is always positive.</p> $S = V_{rms} \times I_{rms}$   |
| 5  | A     | Power Factor                            | <p>Ratio of true power to apparent power for the phase, calculated once per second. (See equation to the right.) This ratio is always between -1.0 and 1.0.</p> $Power\ Factor = \frac{P}{S}$   |
| 6  | A     | Peak Voltage                            | <p>Instantaneous peak voltage over the last second for the phase in units of V. This value can be positive or negative.</p>   |
| 7  | A     | Peak Current                            | <p>Instantaneous peak current over the last second for the phase in units of A. This value can be positive or negative.</p>   |
| 8  | A     | Frequency                               | <p>AC line frequency for the phase in units of Hz. This value is updated once per second and is always positive.</p>  |
| 9  | A     | True Power at Fundamental Frequency     | <p>True (or real or active) power at the fundamental frequency for the phase in units of W, calculated once per second from a discrete Fourier transform at the fundamental frequency on the voltage and current and multiplying the result. This value can be positive or negative.</p>  |
| 10 | A     | Harmonic True Power                     | <p>True (or real or active) power in the harmonics for the phase in units of W, calculated once per second by subtracting true power at the fundamental frequency from true power. This value can be positive or negative.</p>  |
| 11 | A     | Reactive Power at Fundamental Frequency | <p>Reactive power at the fundamental frequency for the phase in units of var, calculated once per second from a discrete Fourier transform at the fundamental frequency on the voltage and current and multiplying the result. This value can be positive or negative.</p>  |

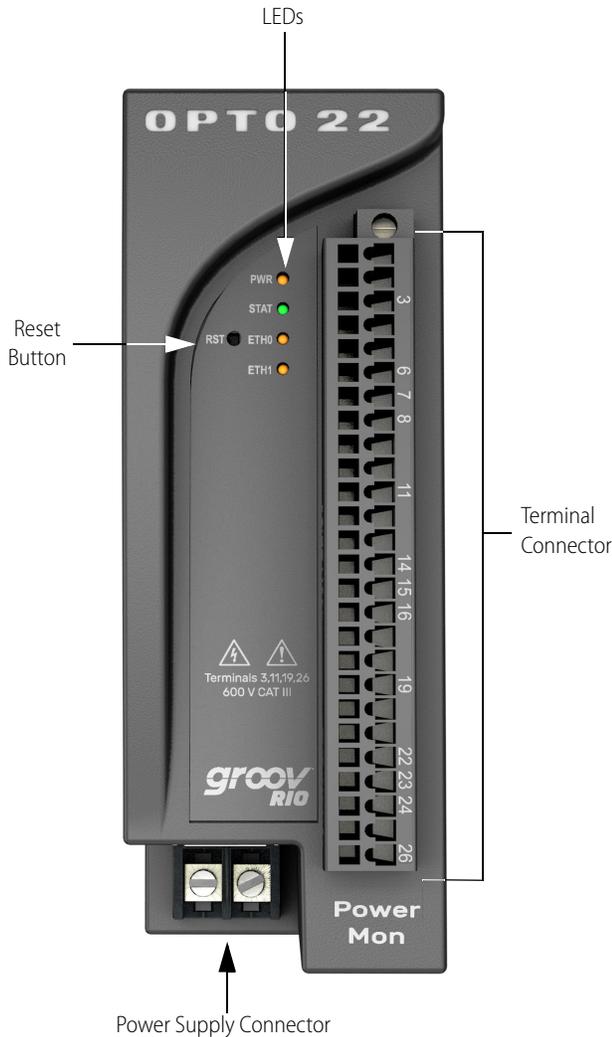
| Ch | Phase | Description                             | Details   |
|----|-------|---|---|
| 12 | A     | Average Reactive Power                  | <p>Reactive power for the phase in units of var. This value is updated once per second from the average of 4000 samples of the product of the voltage, shifted 90 degrees, and the current. (See equation to the right.) This value can be positive (due to a capacitive load) or negative (due to an inductive load).</p> $Q_{avg} = \frac{\sum_{n=1}^{4000} V_{Q_n} \times I_n}{4000}$  |
| 13 | A     | Net Energy                              | <p>Net energy for the phase, accumulated by adding true power once per second to a signed 64-bit integer in units of mWh. This value can be positive or negative and is stored to non-volatile memory every 30 seconds. This value can be read in three different formats: 32-bit IEEE float in units of kWh, 64-bit signed integer in units of mWh, and 32-bit signed integer in units of mWh. For more details, see <a href="#">"Energy Values" on page 8</a>.</p>                          |
| 14 | A     | Positive Energy                         | <p>Positive energy for the phase, accumulated by adding true power, if it is positive, once per second to a signed 64-bit integer in units of mWh. This value can be positive or negative and is stored to non-volatile memory every 30 seconds. This value can be read in three different formats: 32-bit IEEE float in units of kWh, 64-bit signed integer in units of mWh, and 32-bit signed integer in units of mWh. For more details, see <a href="#">"Energy Values" on page 8</a>.</p> |
| 15 | A     | Negative Energy                         | <p>Negative energy for the phase, accumulated by adding true power, if it is negative, once per second to a signed 64-bit integer in units of mWh. This value can be positive or negative and is stored to non-volatile memory every 30 seconds. This value can be read in three different formats: 32-bit IEEE float in units of kWh, 64-bit signed integer in units of mWh, and 32-bit signed integer in units of mWh. For more details, see <a href="#">"Energy Values" on page 8</a>.</p> |
| 16 | A     | Net Reactive Energy                     | <p>Net reactive energy for the phase, accumulated by adding reactive power once per second to a signed 64-bit integer in units of mvarh. This value can be positive or negative and is stored to non-volatile memory every 30 seconds. This value can be read in three different formats: 32-bit IEEE float in units of kvarh, 64-bit signed integer in units of mvarh, and 32-bit signed integer in units of mvarh. For more details, see <a href="#">"Energy Values" on page 8</a>.</p>     |
| 17 | A     | Apparent Energy                         | <p>Apparent energy for the phase, accumulated by adding reactive power once per second to a signed 64-bit integer in units of mVAh. This value can be positive or negative and is stored to non-volatile memory every 30 seconds. This value can be read in three different formats: 32-bit IEEE float in units of kVAh, 64-bit signed integer in units of mVAh, and 32-bit signed integer in units of mVAh. For more details, see <a href="#">"Energy Values" on page 8</a>.</p>             |
| 18 | B     | V <sub>rms</sub>                        | For details, see channel 0  |
| 19 | B     | I <sub>rms</sub>                        | For details, see channel 1  |
| 20 | B     | True Power                              | For details, see channel 2  |
| 21 | B     | Reactive Power                          | For details, see channel 3  |
| 22 | B     | Apparent Power                          | For details, see channel 4  |
| 23 | B     | Power Factor                            | For details, see channel 5  |
| 24 | B     | Peak Voltage                            | For details, see channel 6  |
| 25 | B     | Peak Current                            | For details, see channel 7  |
| 26 | B     | Frequency                               | For details, see channel 8  |
| 27 | B     | True Power at Fundamental Frequency     | For details, see channel 9  |
| 28 | B     | Harmonic True Power                     | For details, see channel 10   |
| 29 | B     | Reactive Power at Fundamental Frequency | For details, see channel 11   |
| 30 | B     | Average Reactive Power                  | For details, see channel 12   |
| 31 | B     | Net Energy                              | For details, see channel 13   |
| 32 | B     | Positive Energy                         | For details, see channel 14   |

| Ch | Phase | Description                        | Details   |
|----|-------|------------------------------------|---|
| 33 | B     | Negative Energy                    | For details, see channel 15   |
| 34 | B     | Net Reactive Energy                | For details, see channel 16   |
| 35 | B     | Apparent Energy                    | For details, see channel 17   |
| 36 | C     | $V_{rms}$                          | For details, see channel 0  |
| 37 | C     | $I_{rms}$                          | For details, see channel 1  |
| 38 | C     | True Power                         | For details, see channel 2  |
| 39 | C     | Reactive Power                     | For details, see channel 3  |
| 40 | C     | Apparent Power                     | For details, see channel 4  |
| 41 | C     | Power Factor                       | For details, see channel 5  |
| 42 | C     | Peak Voltage                       | For details, see channel 6  |
| 43 | C     | Peak Current                       | For details, see channel 7  |
| 44 | C     | Frequency                          | For details, see channel 8  |
| 45 | C     | True Power At Fundamental Freq     | For details, see channel 9  |
| 46 | C     | Harmonic True Power                | For details, see channel 10   |
| 47 | C     | Reactive Power At Fundamental Freq | For details, see channel 11   |
| 48 | C     | Average Reactive Power             | For details, see channel 12   |
| 49 | C     | Net Energy                         | For details, see channel 13   |
| 50 | C     | Positive Energy                    | For details, see channel 14   |
| 51 | C     | Negative Energy                    | For details, see channel 15   |
| 52 | C     | Net Reactive Energy                | For details, see channel 16   |
| 53 | C     | Apparent Energy                    | For details, see channel 17   |
| 54 | All   | Total True Power                   | True power for all 3 phases in units of W, calculated once per second from the sum of true power for each phase. This value can be positive or negative.  |
| 55 | All   | Total Reactive Power               | Reactive power for all 3 phases in units of var, calculated once per second from the sum of reactive power for each phase. This value is always positive.   |
| 56 | All   | Total Apparent Power               | Apparent power for all 3 phases in units of VA, calculated once per second from the sum of apparent power for each phase. This value can be positive or negative.   |
| 57 | All   | Total Net Energy                   | Net energy for all 3 phases, accumulated by adding the sum of true power for all phases once per second to a signed 64-bit integer in units of mWh. This value can be positive or negative and is stored to non-volatile memory every 30 seconds. This value can be read in three different formats: 32-bit IEEE float in units of kWh, 64-bit signed integer in units of mWh, and 32-bit signed integer in units of mWh. For more details, see <a href="#">"Energy Values" on page 8</a> .   |
| 58 | All   | Total Unsigned Energy              | Net energy for all 3 phases, accumulated by adding the sum of the absolute value of true power for each phase once per second to a signed 64-bit integer in units of mWh. This value can be positive or negative (due to rollover) and is stored to non-volatile memory every 30 seconds. This value can be read in three different formats: 32-bit IEEE float in units of kWh, 64-bit signed integer in units of mWh, and 32-bit signed integer in units of mWh. For more details, see <a href="#">"Energy Values" on page 8</a> .                 |
| 59 | All   | Total Positive Energy              | Positive energy for all 3 phases, accumulated by adding the sum of true power for all phases if this sum is greater than zero once per second to a signed 64-bit integer in units of mWh. This value can be positive or negative (due to rollover) and is stored to non-volatile memory every 30 seconds. This value can be read in three different formats: 32-bit IEEE float in units of kWh, 64-bit signed integer in units of mWh, and 32-bit signed integer in units of mWh. For more details, see <a href="#">"Energy Values" on page 8</a> . |

| Ch | Phase | Description               | Details  |
|----|-------|---------------------------|--|
| 60 | All   | Total Negative Energy     | Negative energy for all 3 phases, accumulated by adding the sum of true power for all phases if the sum is less than zero once per second to a signed 64-bit integer in units of mWh. This value can be positive or negative (due to roll-over) and is stored to non-volatile memory every 30 seconds. This value can be read in three different formats: 32-bit IEEE float in units of kWh, 64-bit signed integer in units of mWh, and 32-bit signed integer in units of mWh. For more details, see <a href="#">"Energy Values" on page 8</a> . |
| 61 | All   | Total Net Reactive Energy | Net reactive energy for all 3 phases, accumulated by adding the sum of reactive power for all phases once per second to a signed 64-bit integer in units of mvarh. This value can be positive or negative and is stored to non-volatile memory every 30 seconds. This value can be read in three different formats: 32-bit IEEE float in units of kvarh, 64-bit signed integer in units of mvarh, and 32-bit signed integer in units of mvarh. For more details, see <a href="#">"Energy Values" on page 8</a> .                                 |
| 62 | All   | Total Net Apparent Energy | Positive energy for all 3 phases, accumulated by adding the sum of true power for all phases if this sum is greater than zero once per second to a signed 64-bit integer in units of mVAh. This value can be positive or negative and is stored to non-volatile memory every 30 seconds. This value can be read in three different formats: 32-bit IEEE float in units of kVAh, 64-bit signed integer in units of mVAh, and 32-bit signed integer in units of mVAh. For more details, see <a href="#">"Energy Values" on page 8</a> .            |
| 63 | All   | Average Power Factor      | Average power factor for all 3 phases, calculated once per second from the ratio of Total True Power to Total Apparent Power. This value can be positive or negative.  |

## LEDs, ETHERNET NETWORK INTERFACES, USB PORTS, AND CONNECTORS

The LEDs, Ethernet network interfaces, USB port, and connectors (terminal and power supply) on the *groov* RIO offer features to help you review the status and health of your *groov* RIO, as well as connect it to a power supply, an Ethernet network, and electrical loads (for example, main electrical panels, subpanels, or electrical equipment). For more information about these features and how to utilize them, see *groov* RIO EMU User's Guide (form 2372).



### Reset Button

This button can reboot your *groov* RIO or can reset it to factory defaults, erasing all the changes you made to your module and restoring the firmware to the version installed when it was shipped, depending on how long the button is pressed.

### Terminal Connector

The terminal connector provides a spring-clamp wiring system to securely connect the wires from your electrical systems to *groov* RIO. To learn how to use the spring-clamp wiring system, see “Pinout and Wiring” on page 14.

The terminal connector for power and energy monitoring modules like GRV-R7-I1VAPM-3 and GRV-IVAPM-3 is black and keyed so that it can't be inserted into other modules which prevents you from accidentally connecting a high-voltage load to a module that doesn't support high voltages. It has POWER MON imprinted on one side and only some of the pin numbers are labeled to help you identify the live pins.

### LEDs

| LED        | Indicates  |
|------------|--|
| PWR        | <p>The status of power.</p> <ul style="list-style-type: none"> <li>Solid green—RIO is powered on.</li> <li>Solid red—RIO is restarting.</li> </ul>   |
| STAT       | <p>Indicates whether RIO is running or resetting.</p> <ul style="list-style-type: none"> <li>Solid green—RIO is running normally.</li> <li>Blinking green—RIO is starting (power on) or restarting (initiated by Reset Switch).</li> <li>Blinking between green and red—RIO is resetting to factory defaults.</li> </ul>   |
| ETH0, ETH1 | <p>Network connection speed and whether there is any transmission activity:</p> <ul style="list-style-type: none"> <li>Solid green: 1 Gbps; transmission activity = No</li> <li>Blinking green: 1 Gbps; transmission activity = Yes</li> <li>Solid orange: 10 or 100 Mbps; transmission activity = No</li> <li>Blinking orange: 10 or 100 Mbps; transmission activity = Yes</li> </ul> |

### Power Supply Connector

To supply power with an external power supply, Opto 22 recommends you follow these wiring guidelines:

- Use a 10 to 32 V DC power source or supply.
- Use wire size 22 to 14 AWG. Keep the wires as short as possible.

**Note:** If you are using an external power supply, do **NOT** connect PoE; PoE cannot be used as an alternate power source.

### Power Supply Wiring Diagram

Before wiring the *groov* RIO EMU to an external power supply, verify that your wiring cables conform to the requirements described above.



## Ethernet Network Ports

The Ethernet ports are part of an internal Ethernet switch, which means you can network *groov* RIOs in a daisy-chain configuration or in a standard star configuration using either Ethernet port. Both ports share the same IP address.

The network ports support speeds of up to 1 Gbps. Check that your Ethernet cable is rated for the speed of your network.

The **ETH1** port, when connected to Power Sourcing Equipment (PSE)—for example, a PoE switch—through a PoE-rated Ethernet cable, can power the *groov* RIO module. Opto 22 recommends you select a PSE that supports IEEE 802.3af and has sufficient power available for all the powered devices (PDs) connected to it.

**Do not** supply power through PoE as an alternative or backup to powering through a separate external power supply. Supply power through an external power supply or PoE, but not both.

## USB Port

The USB port acts as a USB host device that can help you extend the capabilities of the *groov* RIO. You can connect a:

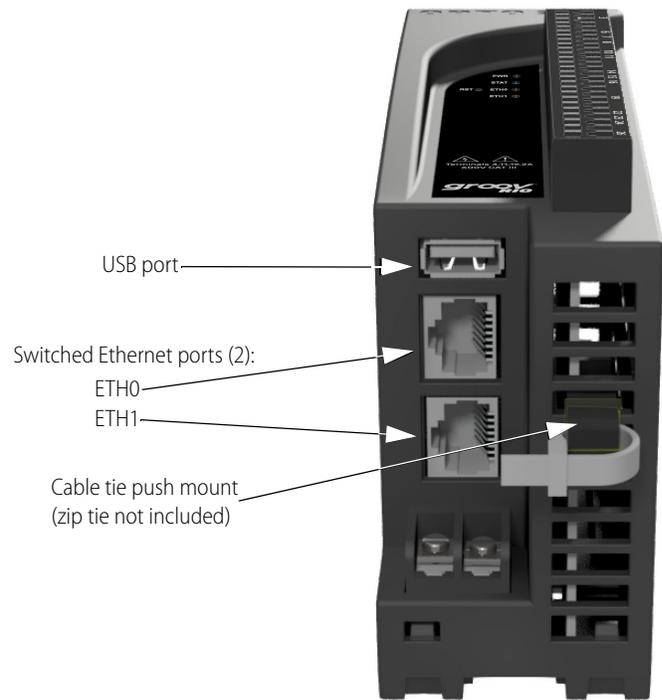
- WiFi adapter to add wireless connectivity.
- USB-to-serial adapter to read and write data to serial devices.
- USB memory stick to expand the storage space; for example, to increase data logging capacity.

The wireless interface WLAN0 (which becomes available when you plug in a WiFi adapter) does not provide access to other *groov* RIOs in a daisy-chain configuration because this interface has a separate IP address on a separate subnet.

## Wireless Connectivity

The following WiFi USB adapters have been tested and proven to be compatible with *groov* RIO:

| Device Manufacturer | Model      |
|---------------------|------------|
| Netis               | WF2190     |
| Linksys             | AE6000     |
| TP-Link             | Archer T1U |
| Sabrent             | AC600      |



## Cable Tie Push Mounts (Optional Usage)

Cable tie push-mounts can help you manage wires. Each *groov* RIO comes with two user-installable cable tie push mounts, which snap into a vent, providing a sturdy loop through which you can thread a zip tie (not included), and then bundle the wires together with the zip tie.



## SPECIFICATIONS

| Specification  | GRV-R7-I1VAPM-3  |
|--|--|
| Maximum UL61010-3 Measurement Category   | Category III 600 VAC   |
| Delta Voltage Input Ranges, $V_{rms}$  | 600, 520, 260  |
| Wye Voltage Input Ranges, $V_{rms}$  | 400, 300, 150  |
| Voltage Accuracy<br>(% of range @ 50-60 Hz,<br>excluding voltage transformer)    | Wye: $\pm 0.35\%$ , Delta: $\pm 0.5\%$   |
| Current Transformer (CT) Outputs Supported                                       | 5.0 A, 1.0 VAC or 0.3333 VAC   |
| Current Accuracy<br>(% of CT range @ 50-60 Hz,<br>excluding current transformer) | $\pm 0.5\%$  |
| Power Accuracy<br>(% of ( $V_{rms}$ range) * (CT current rating),<br>@ 50-60Hz)  | $\pm 0.5\%$  |
| Data Refresh Time  | 1 s  |
| Step Response Time   | 1 s  |
| Problem Indication   | $V_{rms}$ out of range, $I_{rms}$ out of range   |
| Number of Data Channels  | 64   |
| Ethernet   | Two switched Gigabit ports; daisy-chainable; ETH1 with 802.3af PoE powered device (PD) |
| USB  | One Port, USB 2.0 HS   |
| Memory   | 1 GB RAM, 4.0 GB disk space  |
| Power Supply   | 802.3af PoE Class 0 <b>or</b> 10–32 V DC (but not both)                                |
| Power Consumption  | 4.5 W  |
| Isolation (field to Ethernet / power input)                                      | 3600 VAC working, 5400 VAC transient   |
| Isolation (channel-to-channel)   | N/A  |
| Minimum GRV-R7 Firmware Version  | 3.3.0  |
| Minimum <i>groov</i> EPIC Firmware Version                                       | 3.3.0  |
| Minimum PAC Project Version  | 10.4000  |
| Minimum Library Package for CODESYS Version                                      | 2.0.4.0  |
| Field Connector Wire Size  | 28–14 AWG  |
| Torque, field connector screw  | 2.5 in-lb (0.28 N-m)   |
| Power Connector Wire Size  | 22–14 AWG  |
| Torque, DC power connector screws  | 7.0 in-lb (0.79 N-m)   |
| Torque, panel mount tab screw  | 2.0 in-lb (0.23 N-m)   |
| Temperature (operating)  | -20 °C to +70 °C   |
| Temperature (storage)  | -40 °C to +85 °C   |
| Relative Humidity (non-condensing)   | 5–95%  |
| MTBF (minimum, 25 °C)  | 1.2 Mhrs   |
| Agency Approvals   | UL/cUL(Class 1 Div. 2); CE, ATEX(Category 3, Zone 2), RoHS; DFARS; CB Scheme; UKCA     |
| Warranty   | 30 months  |

## MOUNTING ON DIN RAIL

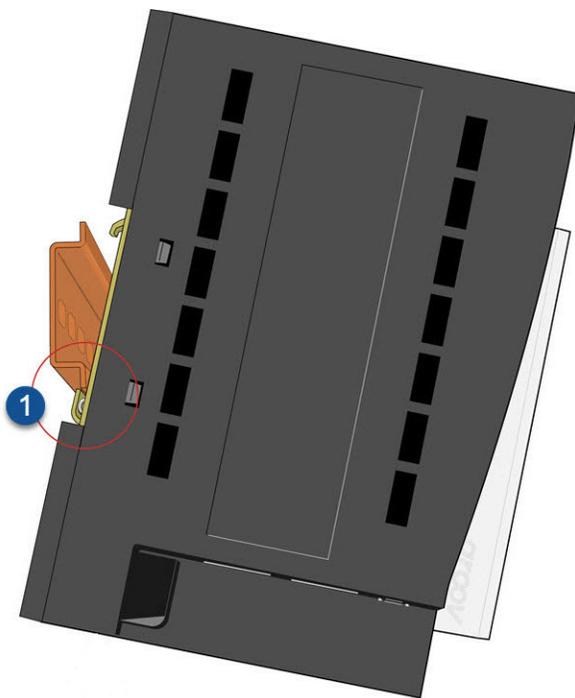
Before mounting your *groov* RIO:

- Ensure that the vents around *groov* RIO will not be obstructed.
- Review “Orientation and Clearances” to ensure good ventilation and optimal performance.

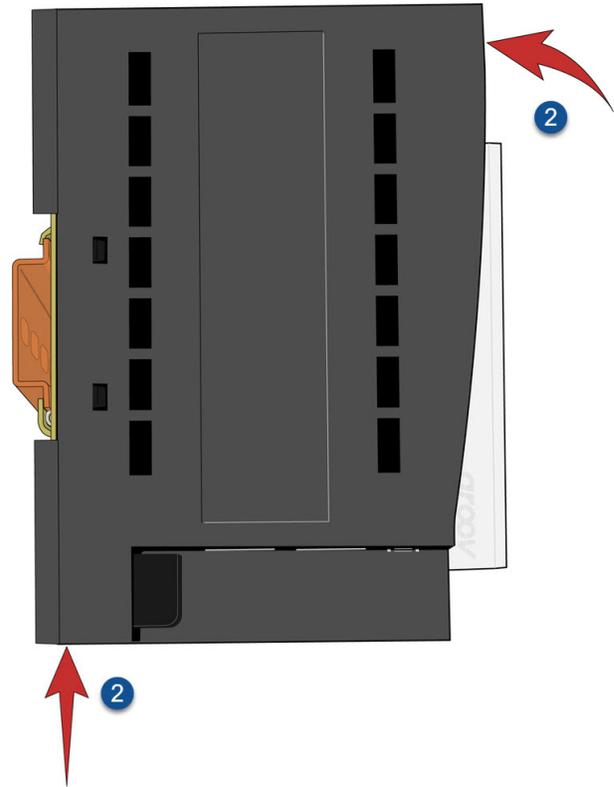
The *groov* RIO is built with DIN rail adapters for use on 35 mm DIN rail. No additional assembly is required.

To mount the *groov* RIO module on a DIN rail, follow these steps:

1. Hold the module so that the Opto 22 logo is at the top and at an angle such that the top of the DIN rail adapter is away from the DIN rail and the bottom of the DIN rail adapter can slide behind the bottom lip of the DIN rail.

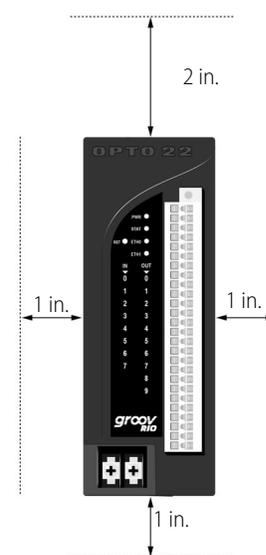


2. Push the bottom part of the module upward, making sure that you feel the clip catch on to the rail, and simultaneously push the top half of the module toward the DIN rail until the top of the DIN rail adapter engages the top lip of the DIN rail.



Before you release the module, verify that the top and bottom of the DIN rail adapters have engaged the DIN rail.

## ORIENTATION AND CLEARANCES



Make sure that there is a minimum of 2 inches clearance on the top, and 1 inch clearance on the bottom, each side, and in front of the *groov* RIO module, after it is mounted. Mount the module as shown in the diagram: with the Opto 22 logo at the top. Compliance with these guidelines helps ensure that the *groov* RIO module performs as described in the specifications.

## MOUNTING ON A PANEL

Before mounting your *groov* RIO module:

- Ensure that the vents around module will not be obstructed.
- Review "[Orientation and Clearances](#)" on page 12 to ensure good ventilation and optimal performance.

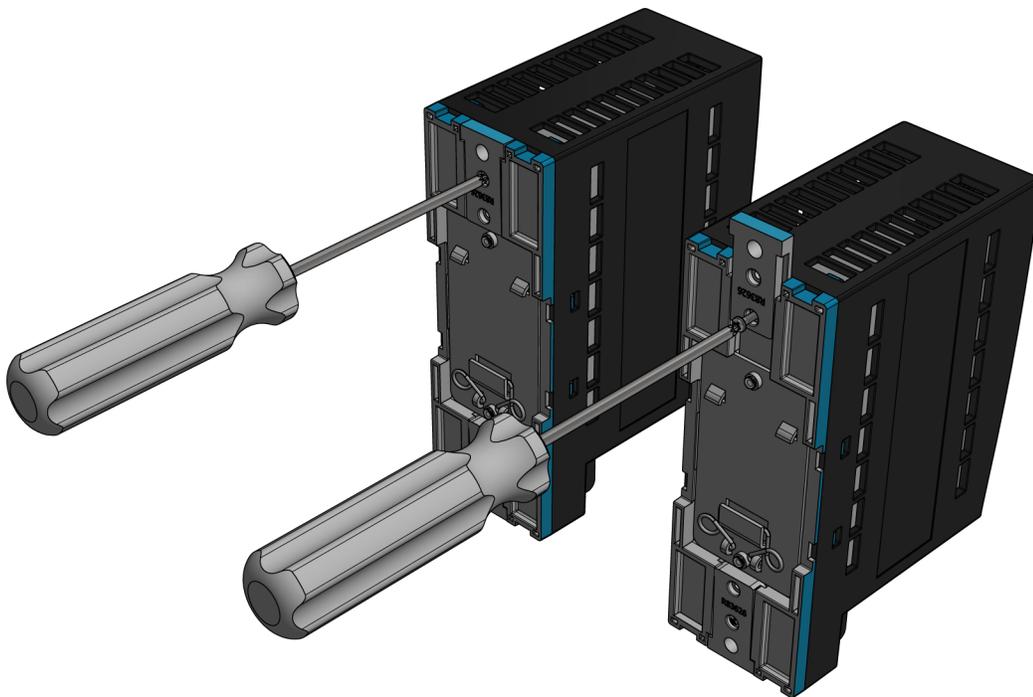
First, extend and secure the tabs to expose the mounting holes on each tab:

1. Flip your *groov* RIO so you can see the backside.
2. With a small Phillips screwdriver, remove the tab-locking screws on the tabs.
3. Slide tabs out so the middle hole on the tab aligns with the screw hole on *groov* RIO.

4. Reinsert the tab-locking screws.

Now you can use the module as a template to mark holes on the panel so that you can drill and tap the holes. Then, mount the *groov* RIO with screws (not provided):

1. Tighten a screw into one tab close to the torque indicated in the "Common Characteristics" section of the specifications (see "[Specifications](#)" on page 8).
2. Tighten another screw into the second tab up to the torque indicated.
3. Return to the first screw and re-tighten the screw up to the torque indicated.

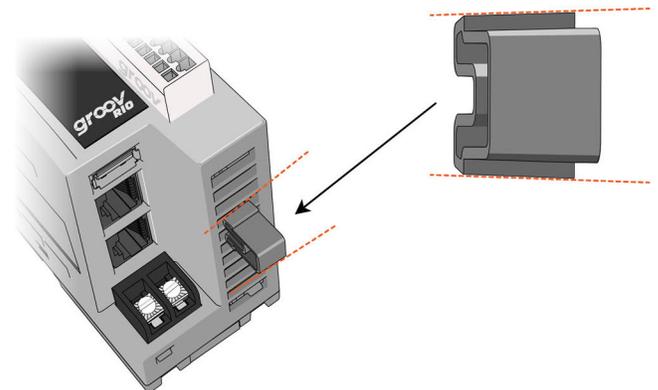


## INSERTING A CABLE TIE PUSH MOUNT

Each *groov* RIO comes with two user-installable cable tie push mounts. You only need to insert one mount.

1. Identify the thin side of the mount, then position it over a vent so that the thin side faces the ports and is away from the PCB, which is visible through the vents (see image on [page 6](#)).
2. With one hand, hold the *groov* RIO down on a sturdy surface. With the other hand, push the mount in, beginning with the thin side. Push until you hear a loud click. Verify that the mount is securely inserted by gently pulling on it; it should not come out.

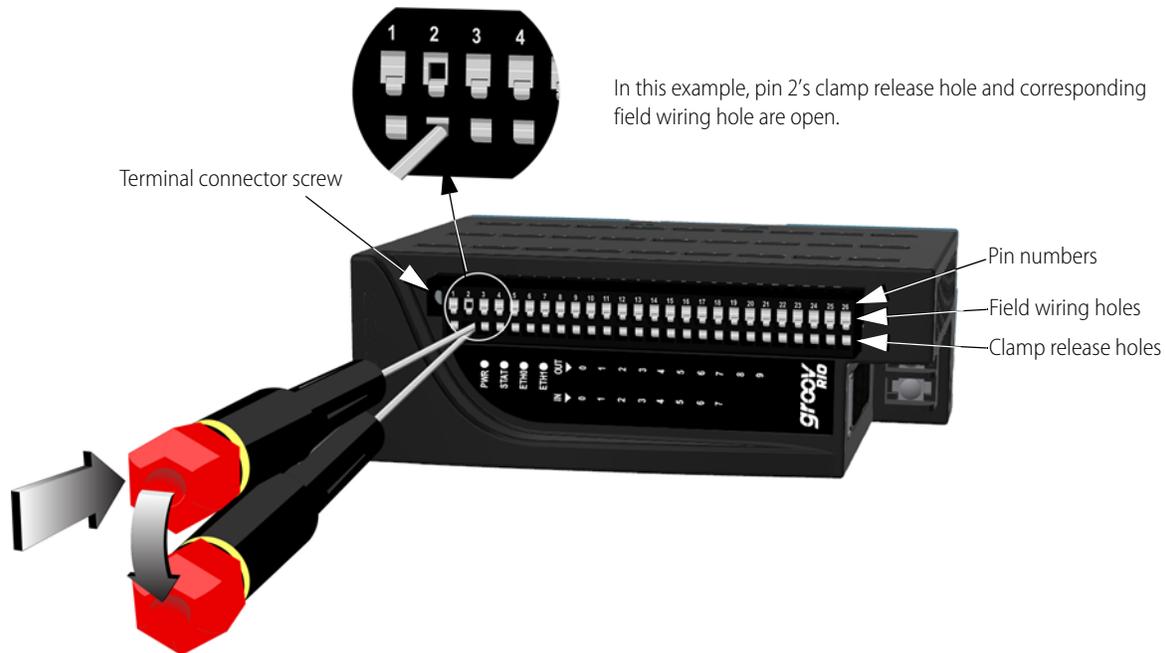
Thread a zip tie (not included) through the mount. Collect the wires into a bundle, wrap the zip tie around the bundle, then clip the excess zip tie.



## PINOUT AND WIRING

Before you begin wiring, do the following tasks:

- It may be easier to insert wires if you remove the terminal connector from the module. To remove the terminal connector, loosen the terminal connector screw at one end of the connector, then pull the connector straight out to remove it from the module.
- If you have never used a spring-clamp wiring system, take a moment to familiarize yourself with the diagram below. Insert the spring-clamp terminal tool in the clamp release hole. Insert field wires in the field wiring holes.
- If you look into the field wiring hole, you will see a highly reflective surface. If you can see that surface, that means that the clamp is closed.



In this example, pin 2's clamp release hole and corresponding field wiring hole are open.

## Connecting Field Wires

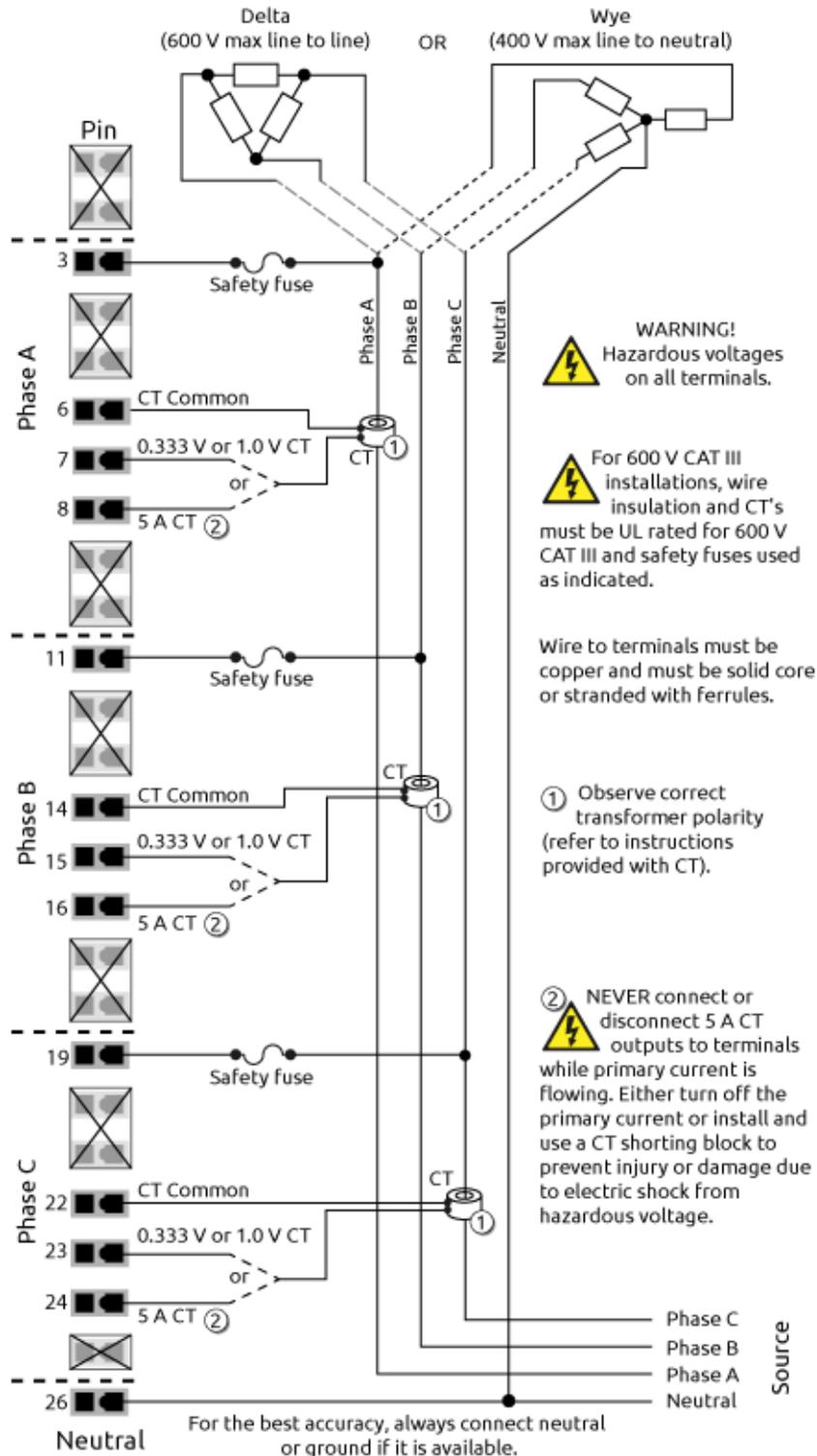
Follow these instructions to connect your field wires to the module:

1. To make it easier to handle the spring-clamp terminal tool and the field wires, secure the module by doing one of the following:
  - If you are working with the terminal connector while it is attached to the module, make sure the module is screwed securely to the chassis.
  - If you are working only with the terminal connector, secure the terminal connector with a clamp.
2. Insert the spring-clamp terminal tool into the clamp release hole, then press and hold down the tool to open the clamp. Look into the field wiring hole. If it is dark, the clamp is open. You can go to [step 3](#). If you can still see the highly reflective surface, gently push down again and keep downward pressure on the spring-clamp terminal tool. Look into the field wiring hole. If it is dark, the clamp is open.
3. Insert the wire into the field wiring hole until it meets complete resistance. Then pull out the spring-clamp terminal tool.
4. Test that the wire is secure by gently pulling on it. If the wire pulls out, repeat steps 2 and 3.

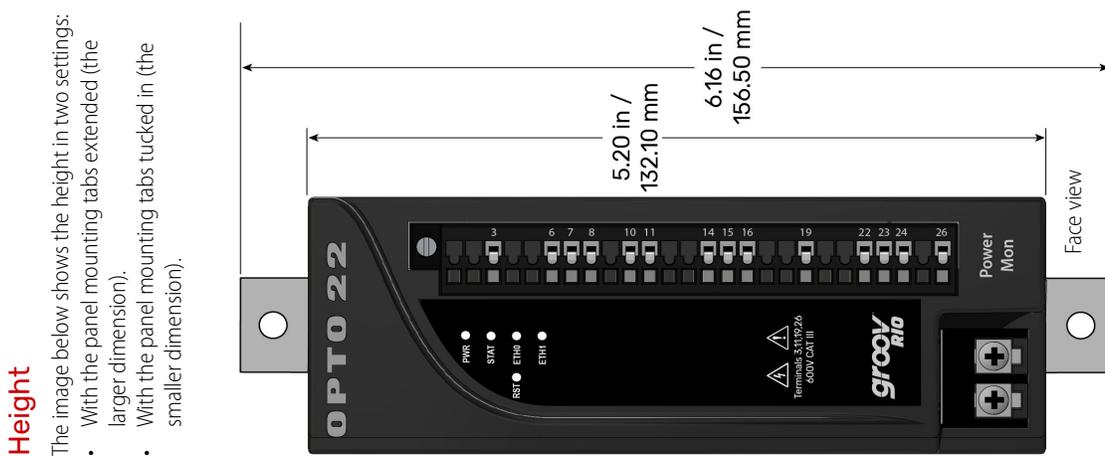
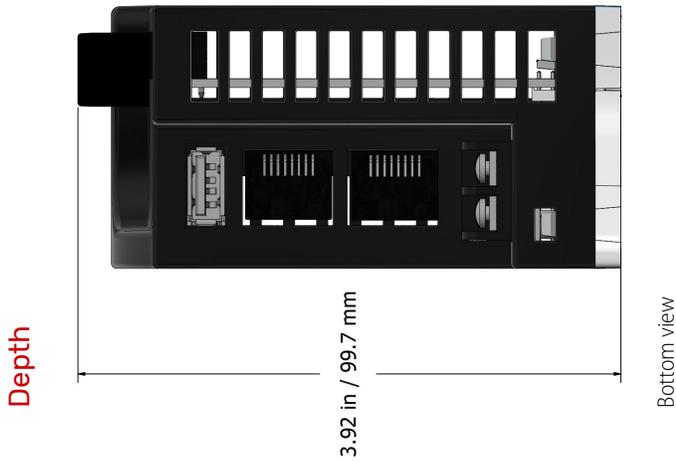
*Note: If you push in too hard, the spring-clamp terminal tool might pop out of the clamp release hole.*

To remove a wire, push the spring-clamp terminal tool into the clamp release hole as described in [step 2](#) above, and then pull the wire out.

## WIRING DIAGRAM: GRV-R7-I1VAPM-3



## DIMENSIONS: GRV-R7-I1VAPM-3



**Note:** If you attach a cable tie mount, the bundle of wires you attach to the mount may exceed the height of the module with the panel mounting tabs extended.

## PRODUCTS

Opto 22 develops and manufactures reliable, easy-to-use, open standards-based hardware and software products. Industrial automation, process control, remote monitoring, data acquisition, and industrial internet of things (IIoT) applications worldwide all rely on Opto 22.

### groov RIO®

groov RIO edge I/O offers a single, compact, PoE-powered industrial package with web-based configuration and IIoT software built in, support for multiple OT and IT protocols, and security features like a device firewall, data encryption, and user account control.

Standing alone, groov RIO connects to sensors, equipment, and legacy systems, collecting and securely publishing data from field to cloud. Choose a universal I/O model with thousands of possible field I/O configurations, with or without Ignition from Inductive Automation®, or a RIO EMU energy monitoring unit that reports 64 energy data values from 3-phase loads up to 600 VAC, Delta or Wye.

You can also use groov RIO with a Modbus/TCP master or as remote I/O for a groov EPIC system.

### groov EPIC® System

Opto 22's groov Edge Programmable Industrial Controller (EPIC) system gives you industrially hardened control with a flexible Linux®-based processor with gateway functions, guaranteed-for-life I/O, and software for your automation and IIoT applications.

### groov EPIC Processor

The heart of the system is the groov EPIC processor. It handles a wide range of digital, analog, and serial functions for data collection, remote monitoring, process control, and discrete and hybrid manufacturing.

In addition, the EPIC provides secure data communications among physical assets, control systems, software applications, and online services, both on premises and in the cloud. No industrial PC needed.

Configuring and troubleshooting I/O and networking is easier with the EPIC's integrated high-resolution color touchscreen. Authorized users can manage the system locally on the touchscreen, on a monitor connected via the HDMI or USB ports, or on a PC or mobile device with a web browser.

### groov EPIC I/O

groov I/O connects locally to sensors and equipment. Modules have a spring-clamp terminal strip, integrated wireway, swing-away cover, and LEDs indicating module health and discrete channel status. groov I/O is hot swappable, UL Hazardous Locations approved, and ATEX compliant.

### groov EPIC Software

The groov EPIC processor comes ready to run the software you need:

- Programming: Choose flowchart-based PAC Control, CODESYS Development System for IEC61131-3 compliant programs, or secure shell access (SSH) to the Linux OS for custom applications
- Node-RED for creating simple IIoT logic flows from pre-built nodes
- Efficient MQTT data communications with string or Sparkplug data formats
- HMI: groov View to build your own HMI viewable on touchscreen, PCs, and mobile devices; PAC Display for a Windows HMI; Node-RED dashboard UI
- Ignition or Ignition Edge® from Inductive Automation (requires license purchase) with OPC-UA drivers to Allen-Bradley®, Siemens®, and other control systems, and MQTT communications



### Older products

From solid state relays, to world-famous G4 and SNAP I/O, to SNAP PAC controllers, older Opto 22 products are still supported and working hard at thousands of installations worldwide. You can count on us for the reliability and service you expect, now and in the future.

## QUALITY

Founded in 1974, Opto 22 has established a worldwide reputation for high-quality products. All are made in the U.S.A. at our manufacturing facility in Temecula, California.

Because we test each product twice before it leaves our factory rather than testing a sample of each batch, we can afford to guarantee most solid-state relays and optically isolated I/O modules for life.

## FREE PRODUCT SUPPORT

Opto 22's California-based Product Support Group offers free technical support for Opto 22 products from engineers with decades of training and experience. Support is available in English and Spanish by phone or email, Monday–Friday, 7 a.m. to 5 p.m. PST.

Support is always available on our website, including [free online training](#) at OptoU, how-to [videos](#), [user's guides](#), the Opto 22 KnowledgeBase, and [OptoForums](#).

## PURCHASING OPTO 22 PRODUCTS

Opto 22 products are sold directly and through a worldwide network of distributors, partners, and system integrators. For more information, contact Opto 22 headquarters at **800-321-6786** (toll-free in the U.S. and Canada) or **+1-951-695-3000**, or visit our website at [www.opto22.com](http://www.opto22.com).