

groov RIO ENERGY MONITORING UNIT

Features

- > Three-phase power and energy monitoring
- > Category III wye (up to 400 VAC; higher with potential transformer)
- > Category III 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
- > CODESYS runtime engine to run control programs in any IEC 61131-3 compliant language (license required)
- > Send energy data where you need it with web-based applications including *groov*® Manage, Node-RED, and MQTT
- > 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
- > USB port for adding devices like Wi-Fi adapter or USB memory drive (user supplied)
- > Cybersecure with encryption and authentication



GRV-R7-I1VAPM-3

Edge I/O With Power

The *groov* RIO EMU brings you a new kind of I/O product—*edge I/O*. It does not require an external PLC, PAC, or industrial PC, but is designed as an intelligent, distributed energy monitoring unit to meet the needs of IIoT projects, especially those that require energy data acquisition.

If you need control capability, the on-board CODESYS runtime engine fully supports IEC 61131-3 application programs written in the programming language of your choice: structured text, ladder logic diagram, functional block diagram, and continuous or sequential function chart. Licensing for the CODESYS runtime engine is available separately (see [GROOV-LIC-CRE-RIO](#) or below).

With *groov* RIO EMU, you can:

- Capture remote data almost anywhere. The module 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.

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
GROOV-LIC-SHELL	Activation key for secure shell access to Linux operating system
GROOV-LIC-CRE-RIO	Activation key for CODESYS Runtime Engine software on <i>groov</i> RIO modules

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.

Embedded software and protocols help you quickly set up data communication between electrical equipment and on-premises or cloud-based systems and software. Built-in security features help you build a secure system to communicate energy data where it's needed. CODESYS runtime engine for IEC 61131-3 applications and available SSH access for developing your own custom applications that run on the module.

- Supply power to *groov* RIO EMU 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.
- Configure the module 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.
- 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 EMU’s USB port (these optional devices are user supplied).
- Simplify connections to electrical equipment using the removable terminal connector with spring clamp wire retention.
- Easily see the status of power and network activity on the module’s LEDs.
- Run a control program you build using the CODESYS Development System—right there on your remote EMU.

Access or Send Data Anywhere

groov RIO EMU 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:

OPC UA—Use the native OPC UA Server in *groov* RIO EMU to allow clients access to I/O and memory map Scratch Pad data. (The native server is just one of the OPC UA server options in the module.)

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 EMU 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 EMU 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 EMU is a Modbus TCP slave out of the box. Use your favorite Modbus TCP master device or software to poll

the module’s channels. A Modbus TCP calculator is built into the *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 the module 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 EMU by accessing the OptoMMP memory map locations of each channel. An OptoMMP calculator is built into *groov* Manage, making it simple to identify the MMP addresses of channels and their features.

groov RIO EMU in a Custom Program or SCADA

In addition to its use as autonomous edge I/O, *groov* RIO EMU 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 EMU 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. (If you plan to use *groov* RIO EMU as a PLC, see below.) Update your application and you’ll be ready to add a *groov* RIO EMU and configure channels.

In an Ignition SCADA—*groov* RIO EMU 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).

groov RIO EMU as a PLC

Automation control programming and energy monitoring in one box? It's possible with the on-board CODESYS runtime engine (requires purchase of [GROOV-LIC-CRE-RIO](#)). Download and install version 3.1.0.0 or later of the [Opto 22 Library Package for CODESYS Development System](#) to create applications that you can then download to your groov RIO EMU. Running a control program, your groov RIO EMU becomes a compact PLC, great when the local energy monitoring footprint is small but your application require access to remote I/O or additional energy monitoring data.

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_{rms} delta
- 0–520 V_{rms} delta
- 0–260 V_{rms} delta
- 0–400 V_{rms} wye
- 0–300 V_{rms} wye
- 0–150 V_{rms} wye

For wye configurations, higher voltages are supported with the addition of a potential transformer. For more details, see wiring diagram on [page 17](#).

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 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_{rms} 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 $(520 \times 0.05) = 26$ V_{rms}. The default value is 0.0.

When you set the threshold ratio to 1.0, it disables the phase. All input values (except 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, frequency, and energy totals) are set to 0. This value is specified in units of RMS amps (A_{rms}). The default value is 0.

Power Creep Adjustment

The power threshold below which all measured values for the phase are set to zero (except V_{rms} , I_{rms} , frequency, and energy totals.) This threshold is specified as percent of full-scale apparent power (full-scale V_{rms}) * (full-scale I_{rms}). 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_{rms} wye and the full-scale current is set to 50 A_{rms} , all values for this phase are set to zero when apparent power is below $300 V_{rms} * 50 A_{rms} * 0.1 = 1500 VA$.

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:

- **Measurement values** are provided through channels 0 & 1 for phase A, 18 & 19 for phase B, and 36 & 37 for phase C:
 - Channels 0, 18, & 36 measure V_{rms} .
 - Channels 1, 19, & 37 measure I_{rms} .
- **Data (power) values** are provided through channels 2-12 for phase A, 20-30 for phase B, and 38-48 for phase C. For each phase, the module provides:
 - True Power
 - Power Factor
 - Reactive Power
 - Peak Voltage
 - Apparent Power
 - Peak Current
 - Harmonic True Power
 - Frequency
 - 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 True, Reactive, Apparent, Net, Unsigned, Positive, Negative, Net Reactive, and Apparent energy are provided through channels 54-62.
- **Average power factor** is provided through channel 63.

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.

The accumulated and summation values 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 (or kvarh or kVAh).
This value rolls over at 9,223,372,013,568.0 to -9,223,372,013,568.0 due to the characteristics of the signed 64-bit integer from which it is calculated.
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.
- In a PAC Control strategy, you can read these 32-bit IEEE floating point values with the Move command.
- **32-bit signed integer:** mWh (or mvarh or mVAh).
This value rolls over at 2,147,483,647 to -2,147,483,648.
In a PAC Control strategy, you can read these 32-bit signed integer point values with the Get Counter command.
Note: Support for 32-bit signed integer with the Get Counter command requires PAC Control R10.5a and the following firmware: *groov EPIC firmware version 3.5.0 or SNAP PAC firmware version 10.5a¹*, as appropriate for your application.
- **64-bit signed integer:** mWh (or mvarh or mVAh).
This value rolls over at 9,223,372,036,854,775,807 to -9,223,372,036,854,775,808.
In a PAC Control strategy, you can read these 64-bit signed integer values with the Get Counter 64 command.

1. Available Q2 2024.

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 (or 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 V_{rms}, measured relative to the neutral terminal, calculated once per second from 4000 samples. (Review 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"> • 0–600 V_{rms} delta • 0–520 V_{rms} delta • 0–260 V_{rms} delta • 0–400 V_{rms} wye • 0–300 V_{rms} wye • 0–150 V_{rms} wye <p>For wye configurations, higher voltages are supported with the addition of a potential transformer. Review wiring diagram on page 20 page 101.</p> $V_{rms} = \sqrt{\frac{\sum_{n=1}^{4000} (V^2)_n}{4000}}$
1	A	I_{rms}	<p>Root-mean-square current for the phase in units of A_{rms}, calculated once per second from 4000 samples. (Review 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"> • 0–5 A_{rms} CT • 0–1 V_{rms} CT • 0–0.333 V_{rms} CT. $I_{rms} = \sqrt{\frac{\sum_{n=1}^{4000} (I^2)_n}{4000}}$
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. (Review 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. (Review 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 V_{rms} times I_{rms}. (Review 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. (Review equation to the right.) This ratio is always between -1.0 and 1.0.</p> $Power\ Factor = \frac{P}{S}$

Ch	Phase	Description	Details
6	A	Peak Voltage	Instantaneous peak voltage over the last second for the phase in units of V. This value can be positive or negative.
7	A	Peak Current	Instantaneous peak current over the last second for the phase in units of A. This value can be positive or negative.
8	A	Frequency	AC line frequency for the phase in units of Hz. This value is updated once per second and is always positive.
9	A	True Power at Fundamental Frequency	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.
10	A	Harmonic True Power	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.
11	A	Reactive Power at Fundamental Frequency	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.
12	A	Average Reactive Power	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. (Review equation to the right.) This value can be positive (due to a capacitive load) or negative (due to an inductive load). $Q_{avg} = \frac{\sum_{n=1}^{4000} V_{Q_n} \times I_n}{4000}$
13	A	Net Energy	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, review "Data Types Required to Read or Write Accumulation and Summation Values" on page 4.
14	A	Positive Energy	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, review "Data Types Required to Read or Write Accumulation and Summation Values" on page 4.
15	A	Negative Energy	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, review "Data Types Required to Read or Write Accumulation and Summation Values" on page 4.
16	A	Net Reactive Energy	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, review "Data Types Required to Read or Write Accumulation and Summation Values" on page 4.
17	A	Apparent Energy	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, review "Data Types Required to Read or Write Accumulation and Summation Values" on page 4.

Ch	Phase	Description	Details
18	B	V_{rms}	For details, see channel 0
19	B	I_{rms}	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
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

Ch	Phase	Description	Details
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, review "Data Types Required to Read or Write Accumulation and Summation Values" on page 4.
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, review "Data Types Required to Read or Write Accumulation and Summation Values" on page 4.
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, review "Data Types Required to Read or Write Accumulation and Summation Values" on page 4.
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, review "Data Types Required to Read or Write Accumulation and Summation Values" on page 4.
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, review "Data Types Required to Read or Write Accumulation and Summation Values" on page 4.
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, review "Data Types Required to Read or Write Accumulation and Summation Values" on page 4.
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 15.

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.

Power Supply Connector

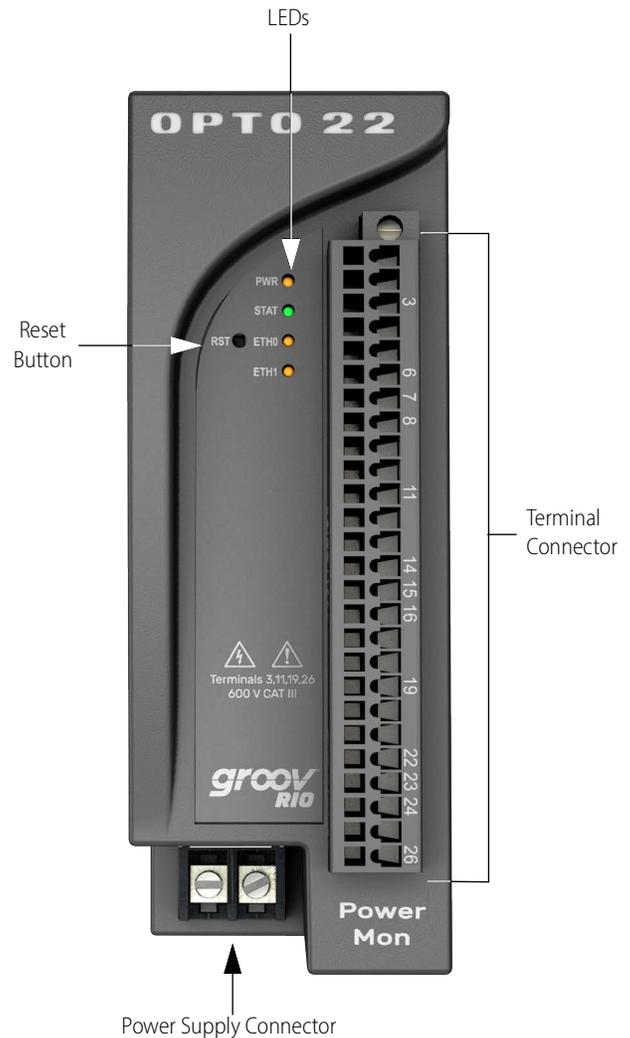
To supply power with an external power supply, Opto 22 recommends you follow these wiring guidelines:

- 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

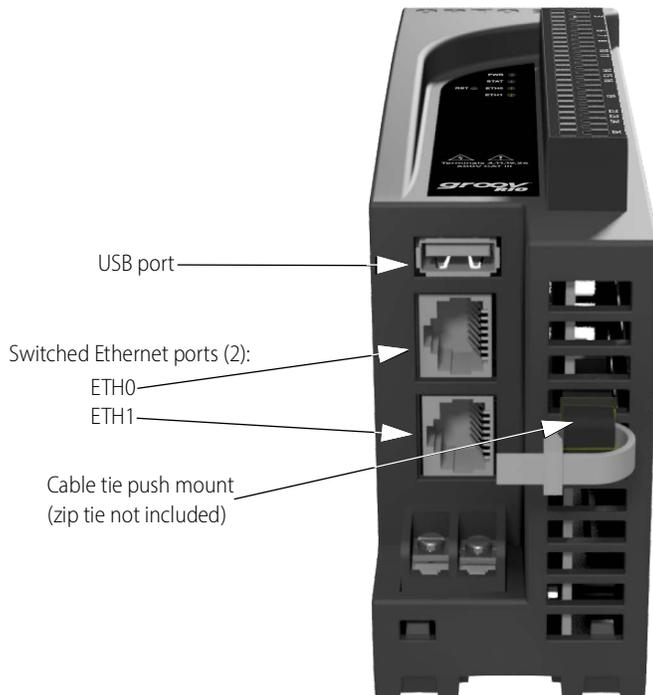
Before wiring the *groov* RIO EMU to an external power supply, verify that your wiring cables conform to the requirements described above.



LEDs

LED	Indicates															
PWR	The status of power. <ul style="list-style-type: none"> • Solid green—<i>groov</i> RIO is powered on. • Solid red—<i>groov</i> RIO is restarting. 															
STAT	Indicates whether <i>groov</i> RIO is running or resetting. <ul style="list-style-type: none"> • Solid green—<i>groov</i> RIO is running normally. • Blinking green—<i>groov</i> RIO is starting (power on) or restarting (initiated by Reset button). • Blinking between green and red—<i>groov</i> RIO is resetting to factory defaults. 															
ETH0, ETH1	Network connection speed and whether there is any transmission activity: <table border="1"> <thead> <tr> <th>Color</th> <th>Connection Speed</th> <th>Transmission Activity</th> </tr> </thead> <tbody> <tr> <td>Solid green</td> <td>1 Gbps</td> <td>No</td> </tr> <tr> <td>Blinking green</td> <td>1 Gbps</td> <td>Yes</td> </tr> <tr> <td>Solid orange</td> <td>10 or 100 Mbps</td> <td>No</td> </tr> <tr> <td>Blinking orange</td> <td>10 or 100 Mbps</td> <td>Yes</td> </tr> </tbody> </table>	Color	Connection Speed	Transmission Activity	Solid green	1 Gbps	No	Blinking green	1 Gbps	Yes	Solid orange	10 or 100 Mbps	No	Blinking orange	10 or 100 Mbps	Yes
Color	Connection Speed	Transmission Activity														
Solid green	1 Gbps	No														
Blinking green	1 Gbps	Yes														
Solid orange	10 or 100 Mbps	No														
Blinking orange	10 or 100 Mbps	Yes														

Ports on Bottom Side of Module



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 includes two user-installable cable tie push mounts that 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 (Line-to-Line)
Wye Voltage Input Ranges, V_{rms}	400, 300, 150 (Line-to-Neutral; higher voltages require use of a potential transformer)
Voltage Accuracy (% of range @ 50-60 Hz, 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 (% of CT range @ 50-60 Hz, excluding current transformer)	$\pm 0.5\%$
Power Accuracy (% of (V_{rms} range) * (CT current rating), @ 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 or 10–32 V DC (but not both)
Power Consumption	4.5 W

Specification	GRV-R7-I1VAPM-3
Isolation (field to Ethernet / power input)	3600 VAC working, 5400 VAC transient
Isolation (channel-to-channel)	N/A
Minimum <i>groov</i> RIO 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

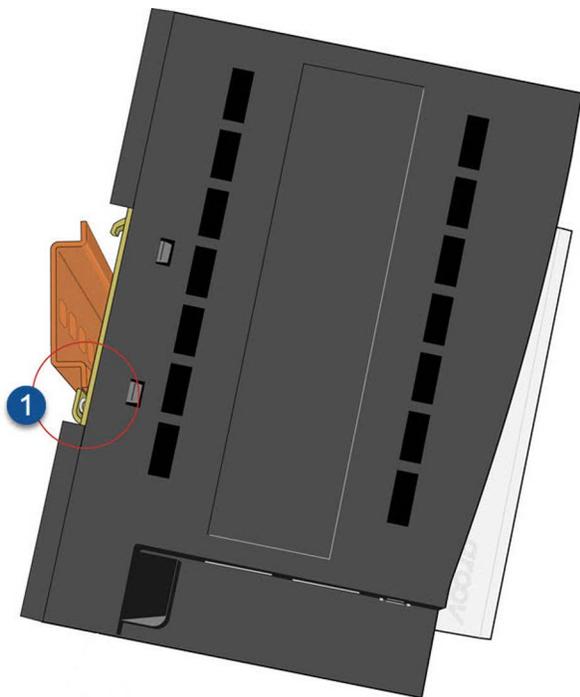
Before mounting your *groov* RIO:

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

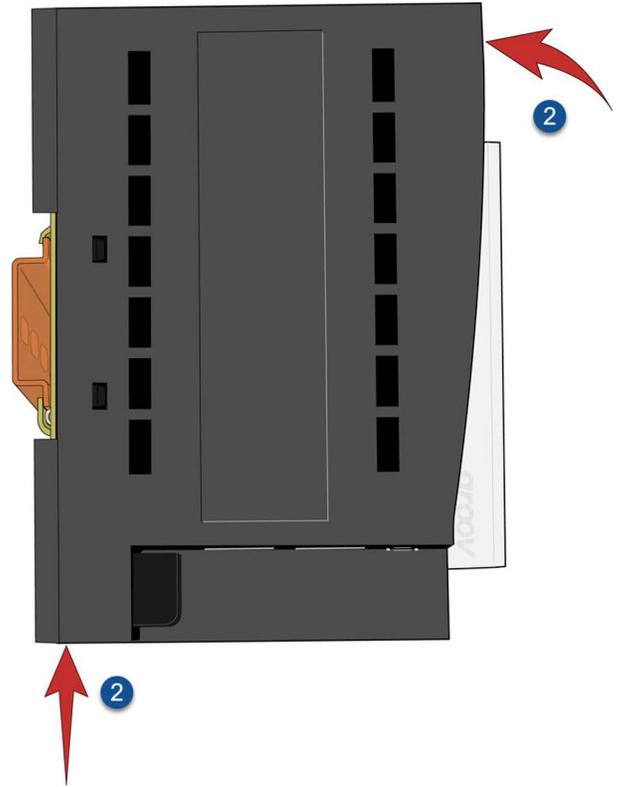
The *groov* RIO is built with DIN rail adapters for use on 35 mm DIN rail. No additional assembly is required.

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.

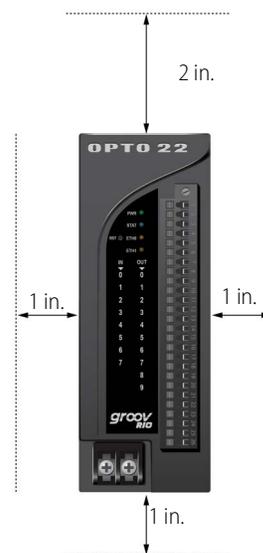


2. Push the bottom part of the module upward, making sure that you feel the clip catch on to the rail, and simultaneously push the top half of the module toward the DIN rail until the top of the DIN rail adapter engages the top lip of the DIN rail.



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 13 to ensure good ventilation and optimal performance.

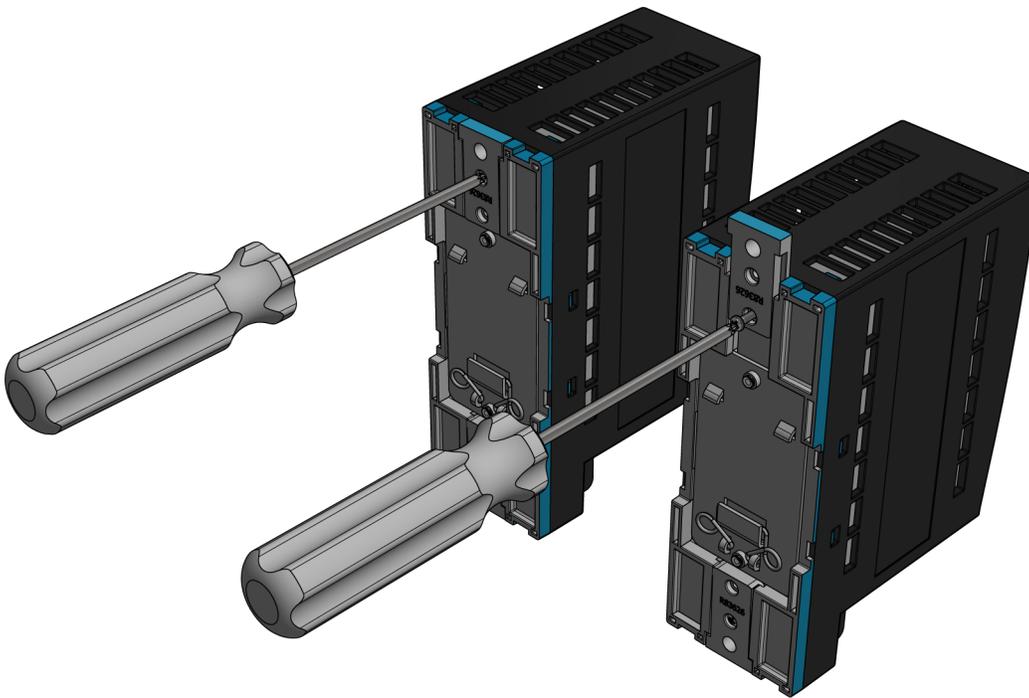
First, extend and secure the tabs to expose the mounting holes on each tab:

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 11).
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.

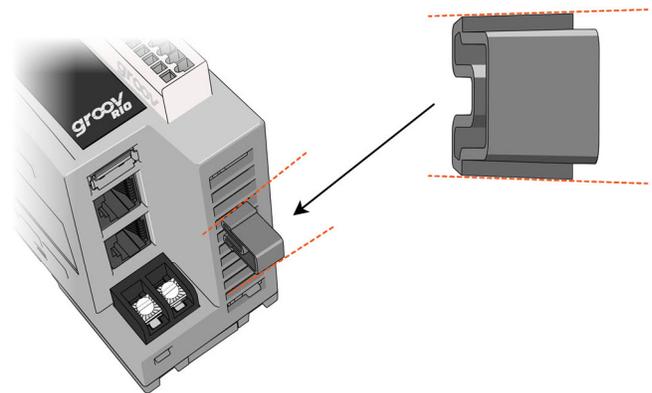


INSERTING A CABLE TIE PUSH MOUNT

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 11](#)).
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.

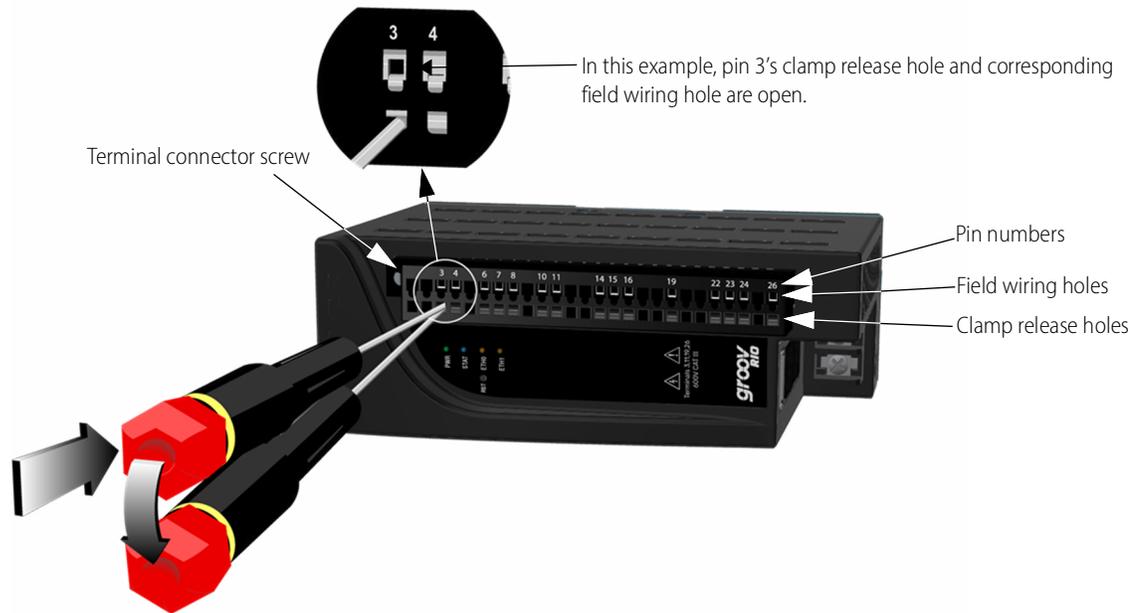
Thread a zip tie (not included) through the mount. Collect the wires into a bundle, wrap the zip tie around the bundle, then clip the excess zip tie.



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.



Connecting Field Wires

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 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 maintain 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](#).

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.

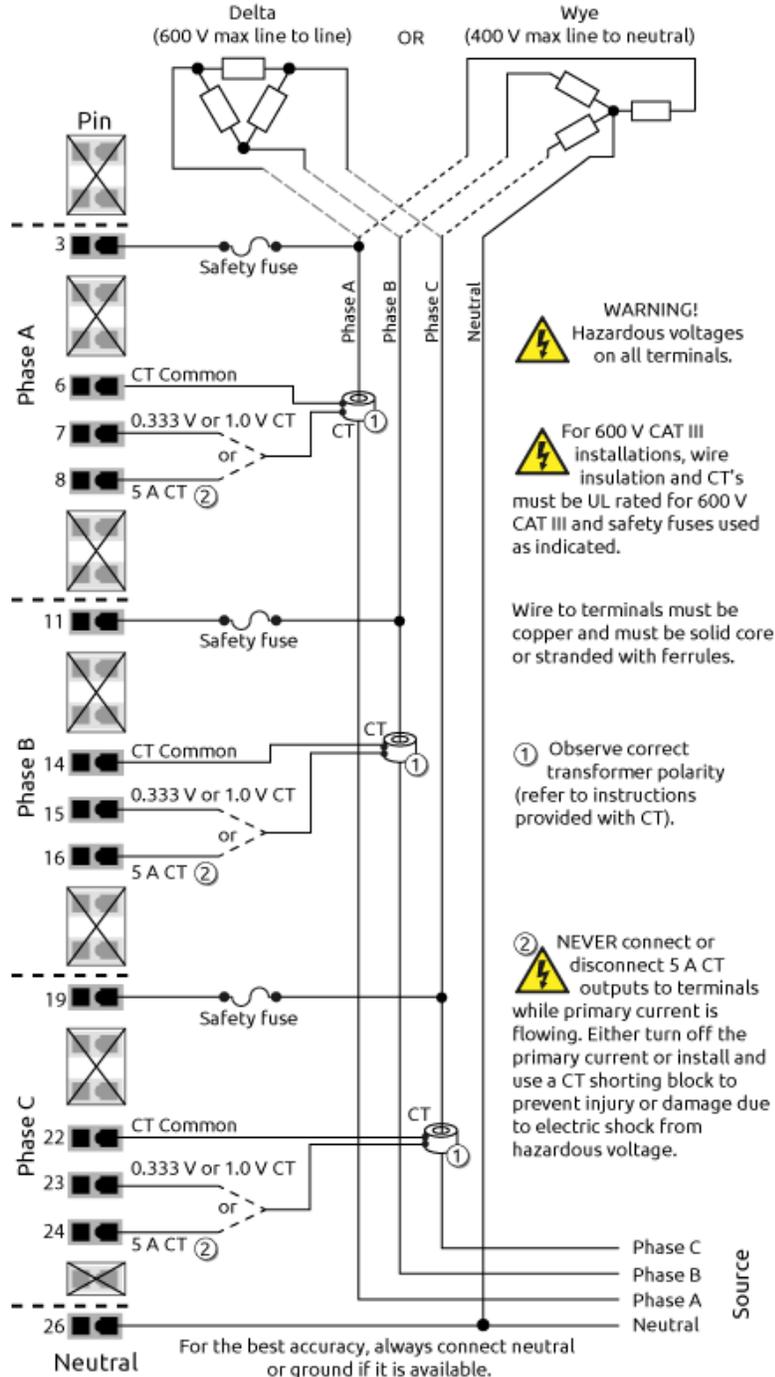
Note: If you push down too hard, the spring-clamp terminal tool might pop out of the clamp release hole.

WIRING DIAGRAM: GRV-R7-I1VAPM-3

The following diagram shows how to correctly wire delta-configured and wye-configured loads without potential transformers. Wye-configured loads above 400 V *require* the use of potential transformers; see wiring diagram on next page.



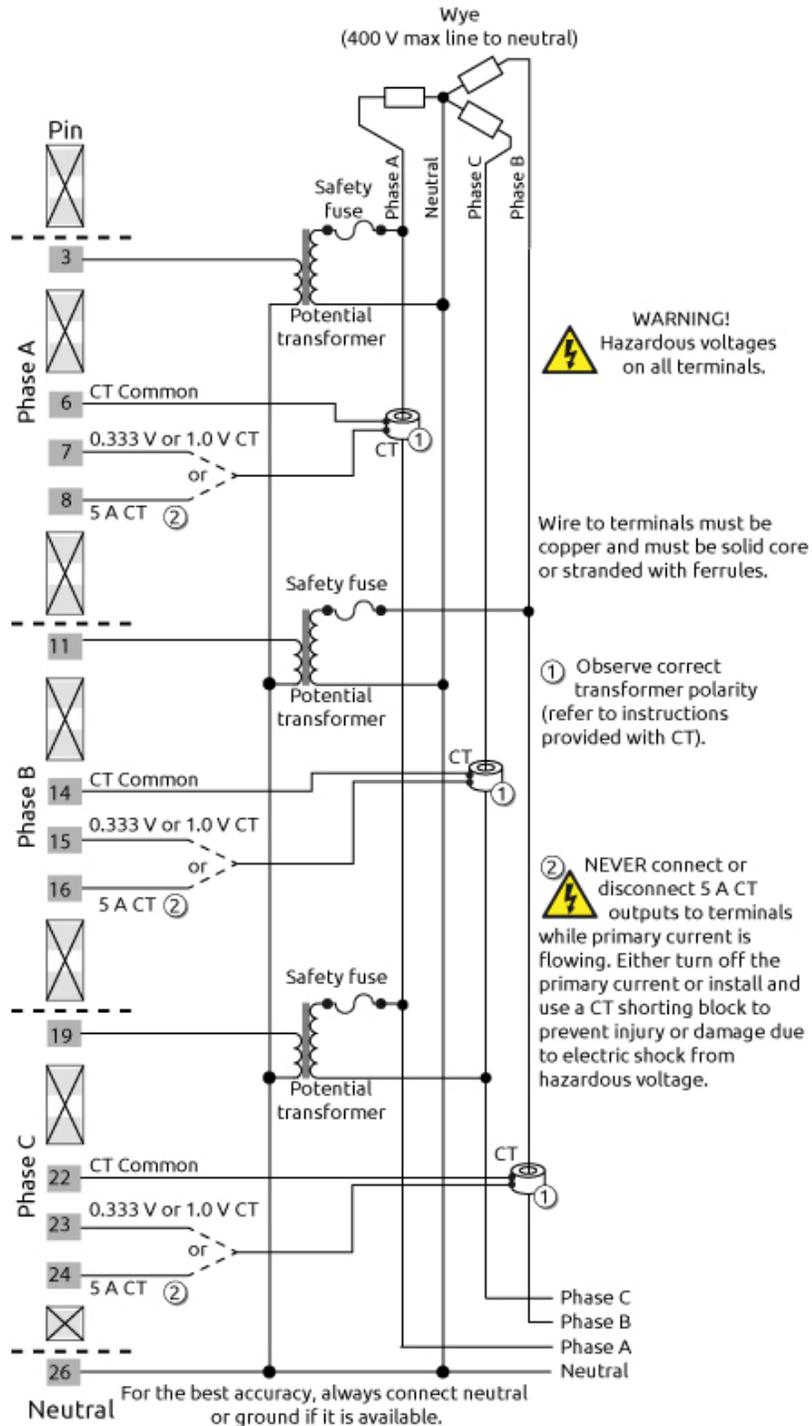
WARNING: DANGER. Hazardous voltage. Direct wiring involves high voltages and must be done by a **qualified technician**.



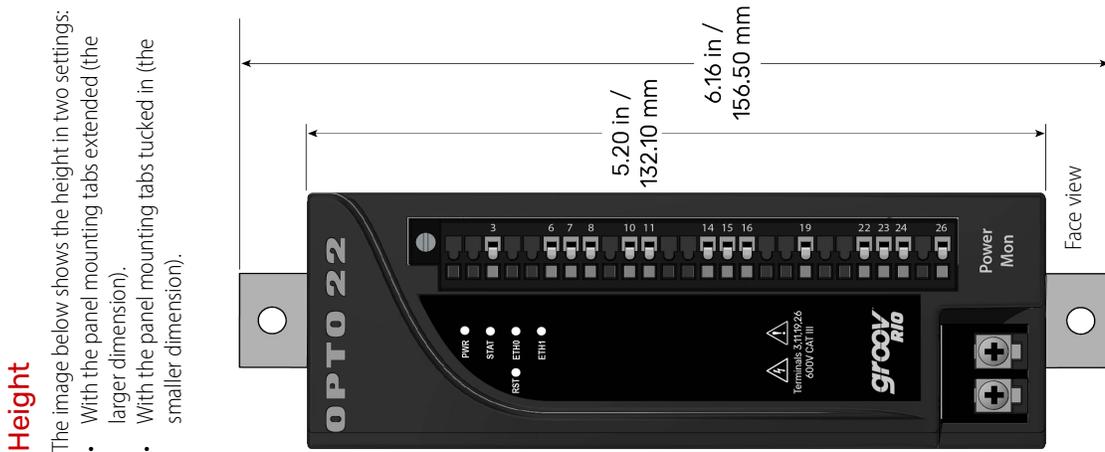
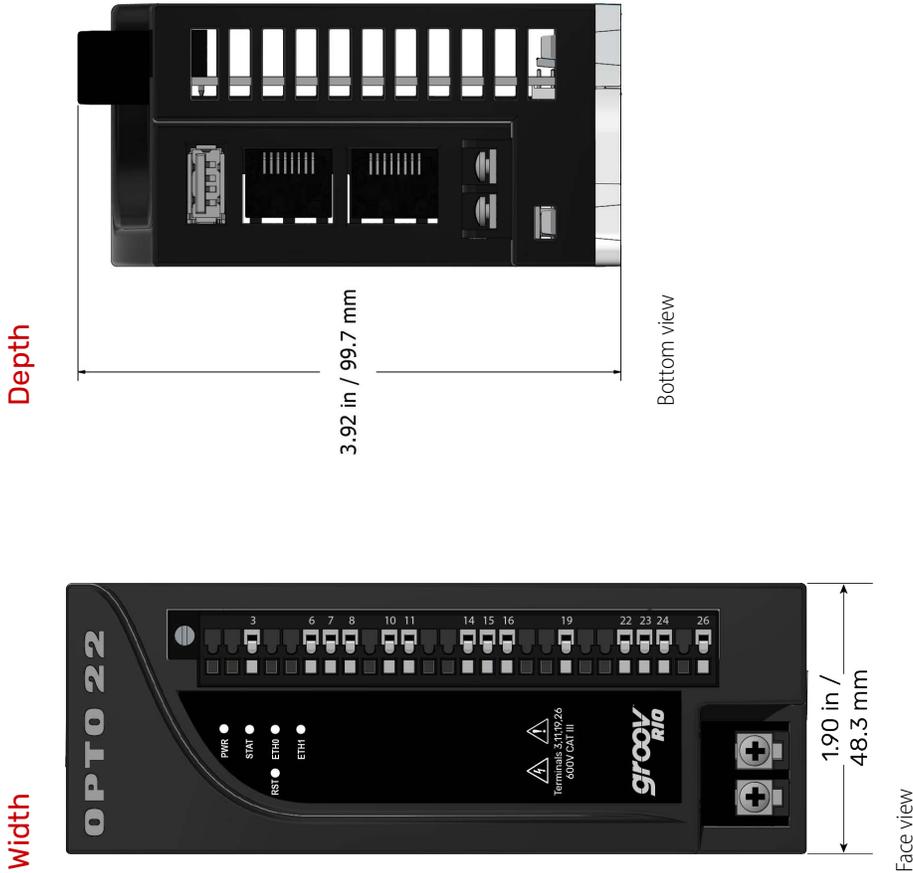
The following diagram illustrates how to correctly wire wye-configured loads when using potential transformers. Wye-configured loads over 400 V require potential transformers.



WARNING: DANGER. Hazardous voltage. Direct wiring involves high voltages and must be done by a **qualified technician**.



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 even write an IEC 61131-3 compliant control program to run on groov RIO, using CODESYS. 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
- Multiple OPC UA server options
- 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.

