

PACSystems™ IC695CPL410 RX3i 64 MB Rackless CPU with Field Agent Quick Start Guide

GFK-3053B

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Front Panel Description

Figure 1: Display, Lights, and Connectors on the CPL410

OLED Display

- LAN Settings
- Control Status
- I/O Status
- Device Info
- Linux Settings
- Redundancy (RDN) Info
- Redundancy (RDN) Commands

TPM Physical Presence

Indication>Select (Phy Pres)
(Green = Present)

Solid State Disk Activity (SSD)

(Green = Activity)

Overtemperature (TEMP)

(Amber = Overtemperature)

Active Redundant Unit (RACT)

(Green = Active)

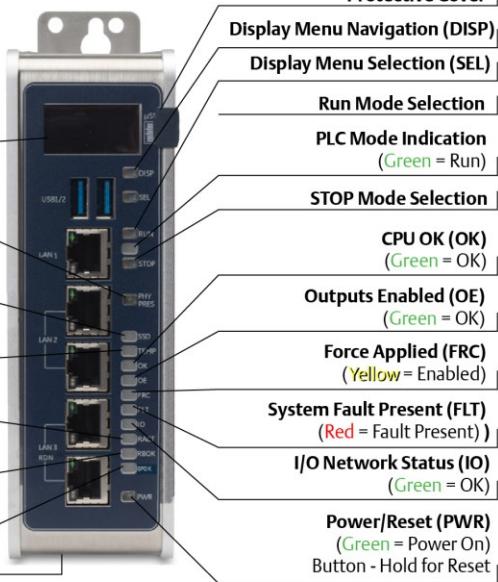
Redundant Backup Unit OK (RBOK)

(Green = OK)

General Purpose OK (GPOK)

(Blinking Green = Linux Running)

Underside Ports and Connectors



User Features

The PACSystems™ RX3i CPL410 deploys with an integrated Linux server. The CPL410 augments real-time deterministic control with an Ubuntu 16.04 Server Linux, open to modifications and enhancements. With this product, customers can implement custom data processing like Edge- or Cloud-based analytics, Cloud storage, WEB visualization and many more. Full Linux root access is granted, allowing the user to enhance CPL410 in a virtually limitless manner, thereby achieving outcomes that today's businesses require. Use cloud services which best fit your application; install freely-available data visualization tools and analytics programs or use professional software to customize the CPL410 controller. CPL410 can be programmed to dynamically influence business outcomes, generate new forms of revenue, and improve profitability. The stand-alone CPL410 uses a quad-core microprocessor and real-time hypervisor technology to run real time deterministic control applications concurrently with an Ubuntu Server Linux 16.04 LTS. Hypervisor technology ensures the separation of the real-time and Linux world security; performance-wise, each is independent of the other. OPC UA industry standard protocol allows data exchange between the controls and the Linux application.

- A built-in RX3i PLC:
 - User may program in Ladder Diagram, Structured Text, Function Block Diagram, or C.
 - Contains 64 Mbytes of configurable data and program memory.
 - Supports auto-located Symbolic Variables that can use any amount of user memory.
 - Reference table sizes include 32k bits for discrete %I and %Q and up to 32k words each for analog %AI and %AQ. Bulk memory (%W) also supported for data exchanges.

- Supports up to 768 program blocks. Maximum size for a block is 128KB.
- For a more extensive feature list of the RX3i PLC please consult the *PACSystems Reference Manual*, GFK-2222
- A built in Ubuntu 16.04 Server LTS:
 - Ubuntu is a free, open source operating system. It is very well known and in widespread use. For CPL410 the Ubuntu Server variant has been selected as it includes multiple network utilities and protocols and has a smaller footprint than the Desktop version. In contrast to the latter, the Server version offers a purely text-based user interface, unlike the graphical desktop. LTS (Long Term Support) indicates availability of updates till 2021. Running Ubuntu Server concurrently with the real-time control applications allows the CPL410 to rapidly leverage external data. External monitoring may be used to analyze and optimize entire business operations. The analysis can then be used to dynamically adjust real-time industrial controls to align with changing business objectives in today's Industrial Internet age.
- Supports four independent 10/100/1000 Ethernet LANs. The three Ethernet ports located on the front panel, are exclusively assigned to the RX3i PLC: LAN1 attaches via the upper, dedicated RJ-45 connector. LAN2 and LAN3 each attach via a pair of internally-switched RJ-45 connectors.
The fourth LAN, labeled ETH, is located on the underside (Figure 2), and is exclusively used for Linux connectivity.
- The embedded communications interface has dedicated processing capability, which permits the CPU to independently support LAN1 and LAN2 with:
 - up to 48 simultaneous SRTP Server connections;
 - up to 16 simultaneous Modbus/TCP Server connections;

- 32 Clients are permitted; each may be SRTP or Modbus/TCP.
 - OPC UA Server with support for up to 5 concurrent sessions with up to 10 concurrent variable subscriptions and up to 12,500 variables;
 - up to 255 simultaneous Class 1 Ethernet Global Data (EGD) exchanges.
 - DNP3 Outstation support with up to 8 master client connections.
- The embedded PLC may use one or both Ethernet LAN2 ports to support the embedded PROFINET® I/O Controller. PROFINET supports up to 32 I/O devices with update rates of 1 – 512 ms. I/O device update rates of 8 ms and faster are possible with 16 or fewer devices. Update rates of 16 ms and higher result whenever more than 16 devices are configured.
- Media Redundancy Protocol (MRP) allows the CPL410 RX3i PLC to participate in a PROFINET I/O network with MRP ring technology. This eliminates the I/O network as a single point of failure. The RX3i PLC may be used as either a Media Redundancy Manager or Media Redundancy Client.
- The CPL410 RX3i PLC supports Hot Standby Redundancy with PROFINET IO. In this configuration, LAN3 is used as a high-speed data synchronization link between the two redundant CPUs. Only the Primary and Secondary CPUs may be attached to LAN3. Two OLED menu items support Redundancy operation: RDN Info and RDN Command. The RACT and RBOK LEDs reflect the status of the Redundant CPUs.
- The CPL410 RX3i PLC supports two independent Redundant IP addresses, one for LAN1 and one for LAN2. LAN2 Redundant IP is supported when configured for Ethernet mode only. Redundant IP is supported by the SRTP Server, Modbus TCP Server, and EGD protocols. It is not possible to use Redundant IP with the OPC UA Server or with the Ethernet firmware update web page.

- The real-time part of CPL410 is secure by design, incorporating technologies such as Trusted Platform Modules, secure boot, and encrypted firmware updates. It is neither accessible or modifiable by customers nor intruders, thus guaranteeing the integrity of the controller.
As the Linux part of the CPL410 is open to modifications, this security cannot be provided for Linux. Customer must take care about sealing Linux to the degree necessary for the actual use case. Emerson provides a Secure Deployment Guide to support customers in this task.
- Optional Energy Pack, IC695ACC403, allows the RX3i PLC of CPL410 to instantly save user memory to non-volatile storage in the event of loss of power.
- OPC UA Sweep Mode & Sweep Time: The RX3i PLC's sweep mode and sweep time are available through the OPC UA server. The Sweep Mode variable reports the controller's current mode: Stop Disabled, Run Enabled, Stop Enabled, Run Disabled, Stop Faulted, and Stop Halted. The Sweep Time variable reports the sweep time in seconds. These variables are located under Emerson Device Information -> PACSystems RX3i -> Controller.
- An OLED display that provides access to basic CPL410 status and control information including each LAN's configured IP Address.
- Operating temperature range -40 °C to 70 °C (-40 °F to 158 °F).
- Alternate panel-mount adaptor plate included.

Switches

All user-accessible switches are provided as pushbuttons on the front panel as described below.

Pushbutton	Function
DISP	Permits user to navigate menus in the OLED display.
SEL	Permits user to select the menu item on the OLED display.
RUN	Activates OLED Menu to select RUN/Enabled or RUN/Disabled Mode for the embedded PLC.
STOP	Activates OLED Menu to select STOP/Enabled or STOP/Disabled Mode for the embedded PLC.
PHY PRES	Not functional.
PWR	Hold down for brief period to induce CPU Reset. Note that this does not turn unit power off, but only holds unit in Reset

Displays and Indicators (LEDs)

OLED Display

The monochrome organic light-emitting diode (OLED) display is used to display CPL410 system menus. It interacts with the DISP pushbutton, which jogs the cursor from one menu item to the next, and with the SEL pushbutton, which activates the currently indicated menu item for further action.

The OLED display permits the user to:

- Display Ethernet LAN Settings: IPv4 address.
- Display the PLC firmware revision.
- Set/view PLC mode and view sweep time.
- Set the PLC mode to RUN/STOP with I/O Enabled/Disabled via the display.
Note: the RUN and STOP pushbuttons activate the PLC Mode menu items per section switches
- View whether all, some, or none of the PROFINET I/O devices are connected.
- Display EFA Settings: IPv4 address, subnet mask, gateway, MAC address, IPv6 address.
- Issue Field Agent Commands: Enter/Exit Configuration mode, Clear Configuration, Perform factory reset.
- View Field Agent Status: Off, Starting, Connecting, Connected, Connected-ACT.
- View HSB Redundancy Mode and State (Release 9.30 and later)
- Command an HSB Redundancy Role Switch (Release 9.30 and later)

Status Indicators (LEDs)

LED	LED State	Operating State
PLC MODE ¹	On Green <input type="radio"/> Off	PLC is in RUN mode. PLC is in STOP mode.
RUN OE	Blinking in unison	CPU is updating an internal programmable hardware device.
PHY PRES	On Green <input type="radio"/> Off	TPM Physical Presence (not functional).
SSD	On Green <input type="radio"/> Off	Activity detected on Solid State Disk. No activity detected on Solid State Disk.
TEMP	On Red <input type="radio"/> Off	CPU Overtemperature condition detected. Overtemperature condition not detected.
OK	On Green <input type="radio"/> Off Blinking; All other LEDs off	CPU has passed its power-up diagnostics and is functioning properly. (<i>Following initialization sequence.</i>) Power is not applied, or CPU has a problem. PLC in STOP/Halt state; possible watchdog timer fault. If the programmer cannot connect, cycle power with charged Energy Pack attached and refer to fault tables.
OK OE	Blinking alternatel	CPU encountered a Secure Boot Error.

¹ This LED is located between the RUN and STOP pushbuttons. It indicates the PLC Mode.

LED	LED State	Operating State
OE	On Green	Output scan is enabled.
	Off	Output scan is disabled.
FRC	On Yellow	One or more Overrides active in I/O Reference Table(s).
	Off	No Overrides active in any I/O Reference Table.
FLT	On Red	PLC is in STOP/Faulted mode: a fatal fault has occurred.
	Off	No fatal faults detected.
IO	On Green	PROFINET Connection Status = OK.
	Off	PROFINET Connection Status not OK.
RACT	On Green	Local Redundant CPU is Ready & Active.
	Off	Local Redundant CPU is not Ready.
RBOK	On Green	Remote Redundant CPU is Ready.
	Off	Remote Redundant CPU is not Ready.
GPOK	Blinking Green	Blink at 1 Hz: Linux Running.
	Off	Linux not running.
PWR	On Green	CPU running.
	Blinking Green	Booting up – diagnostics in progress.
	On Red	Off
	Off	Reset / Power not detected.

Front Ethernet Indicators (LAN1, LAN2, LAN3 RJ45 Built-in LEDs)

LED	LED State	Operating State
Link Status (upper)	On Green	The corresponding link has been established.
	Blinking Green	Traffic is detected at the corresponding port.
	Off	No connection established at corresponding port.
Link Speed (lower)	On Green	Corresponding data speed is 1 Gbps or 100 Mbps.
	Off	Corresponding network data speed is 10 Mbps

Bottom Ethernet Indicators (EFA RJ45 Built-in LED)

LED	LED State	Operating State
Link Status (upper)	On Green	The corresponding link has been established.
	Blinking Green	Traffic is detected at the corresponding port.
	Off	No connection established at corresponding port.
Link Speed (lower)	On Green	Corresponding network data speed is 1 Gbps.
	On Yellow	EFA port only: network data speed is 100 Mbps
	Off	Corresponding network data speed is 10 Mbps

USB Ports

On the front panel CPL410 features 2 USB 3.0 ports, labeled USB1 and USB2.

- USB1 is assigned to Linux and can be used for keyboards, memory sticks or other memory devices. For other USB devices an appropriate Linux driver will need to be installed.
- USB2 is assigned to the Controller run time PACS.

Front-Panel Ethernet Ports

LAN1 connects to the uppermost RJ45 connector. It is not switched.

LAN2 connects to the middle two RJ45 connectors. These two ports are switched internally.

LAN3 connects to the two lower RJ45 connectors. These two ports are switched internally. LAN3 may only be used to supply a high-speed synchronization link between the Primary and Secondary CPUs in Hot Standby Redundancy. Both ports are typically used, as described in the *PACSystems Hot Standby CPU Redundancy User Manual*, GFK-2308 (revision L or later).

Each of the embedded Ethernet interfaces automatically senses the data rate (10 Mbps or 100 Mbps or 1 Gbps), communications mode (half-duplex or full-duplex), and cabling arrangement (straight-through or crossover) of the attached link. LEDs embedded in each RJ45 connector provide indications per the table above.

LAN1 or LAN2 may be used to communicate with the PME programming software using the Service Request Transport Protocol (SRTP).

To establish Ethernet communications between the PME programming and configuration software and the CPU, you *first* need to know the target IP address. Use the OLED menu function to check the IP Address. The factory-shipped default settings are:

	CPL410 LAN1	CPL410 LAN2	CPL410 LAN3
IP Address:	192.168.0.100	10.10.0.100	N/A
Subnet	255.255.255.0	255.255.255.0	N/A
Mask:			
Gateway:	0.0.0.0	0.0.0.0	N/A

Linux Port

The RJ45 port, marked ETH, is located on the underside of the CPL410, as shown in Figure 2. This Ethernet port is exclusively assigned to Linux. By default, this port is configured to use the DHCP protocol to receive a valid IP Address. Therefore, a DHCP server is needed to make first use of this port and to access Linux.

The GPOK LED, located on the front panel, indicates the status of the Linux interface. Green blinking indicates Linux running and ready for login.

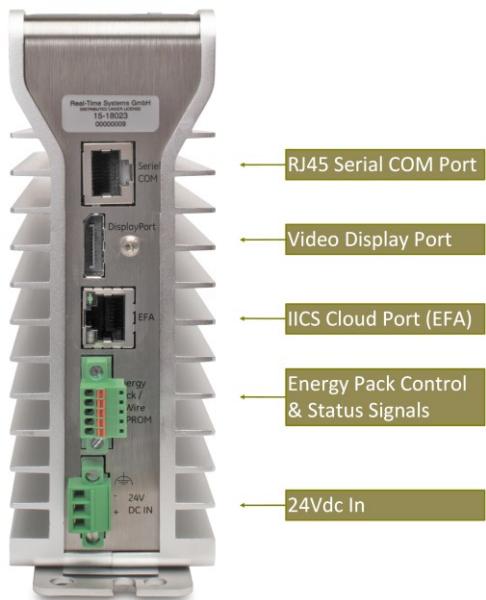
Serial COM Port

The RJ45 port marked Serial COM is located on the underside of the CPL410, as shown in Figure 2. Effective with firmware release 9.40, the CPL410 supports the serial port. This port supports Serial IO protocol.

Video Display Port

The Display Port is located on the underside of the CPL410, as shown in Figure 2. It provides signals for connecting either a suitable monitor or video adapter to the unit. **This port is not currently supported.**

Figure 2: Underside Ports & Connections



Energy Pack Connector

The CPL410 compatible Energy Pack, IC695ACC403, is supplied with a purpose-built cable, IC695CBL003, which installs in the 24 VDC In and Energy Pack Control & Status connectors shown in Figure 2. Use of the

Energy Pack is optional. When used, it allows the CPL410 to save its current state upon loss of power. Refer to the *PACSystems RX3i Rackless Energy Pack IC695ACC403 Quick Start Guide*, GFK-3000, for complete wiring and grounding instructions.

Input Power Connector

If no Energy Pack is to be connected, refer to the *Connect to Power Supply* section. Otherwise, refer to the *PACSystems RX3i Rackless Energy Pack IC695ACC403 Quick Start Guide*, GFK-3000.

Removable Data Storage Device (RDSD)

The CPL410 is equipped with a micro-SD card slot and two USB ports. **These are not currently supported.**

Hardware Installation

Initial Checks

Upon receiving your equipment, carefully inspect all shipping containers for damage. If any part of the system is damaged, notify the carrier immediately. The damaged shipping container should be saved as evidence for inspection by the carrier.

As the consignee, it is your responsibility to register a claim with the carrier for damage incurred during shipment. Emerson will fully cooperate with you, however, should such action be necessary.

After unpacking the equipment, record all serial numbers. Serial numbers are required if you should need to contact Customer Care during the warranty period. All shipping containers and all packing material should be saved should it be necessary to transport or ship any part of the system.

Verify that all components of the system have been received and that they agree with your order. If the system received does not agree with your order, contact Customer Care.

Installation

As shipped, the CPL410 is intended for mounting on a DIN rail. A panel-mount adaptor is also available. If panel-mounting is required, replace the DIN-rail adaptor with the panel-mount adaptor using the screws supplied with that adaptor. Both adaptors attach to the rear of the CPL410 chassis using four Torx M3 screws. Torque newly-installed screws to 5.3 in-lbs (0.6 Nm) if installing a new adaptor plate. For installation to standards, refer to the *Installation and Maintenance Requirements* document, GFK-3004.

Note the thermal requirements for mounting the equipment (Figure 3).

Mount on the DIN rail per Figure 4.

1. Incline the unit so that the upper hooks of the DIN rail adaptor engage with the upper edge of the DIN rail.
2. Press on the lower part of the unit until you hear a click. The click indicates that the lower hooks of the DIN rail adaptor have engaged with the lower edge of the DIN rail.

Dismount from the DIN rail per (Figure 4).

1. Grasp the unit securely.
2. Press down on the release bar as indicated.
3. Swivel the unit away from the DIN rail, then remove.

Figure 3: Thermal Spacing Requirements

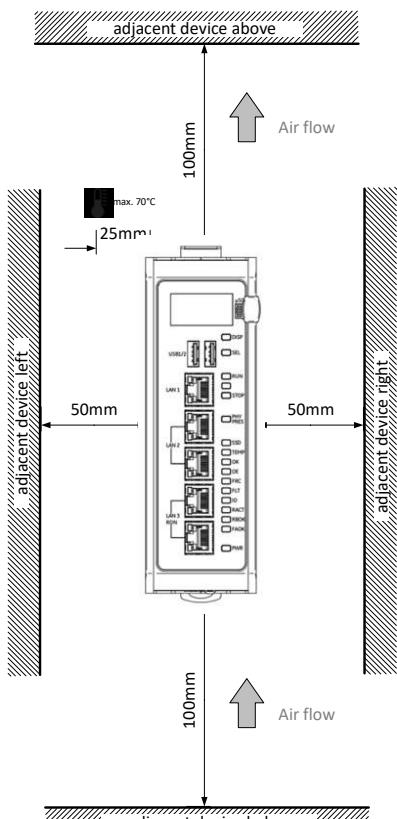


Figure 4: Mounting on DIN Rail

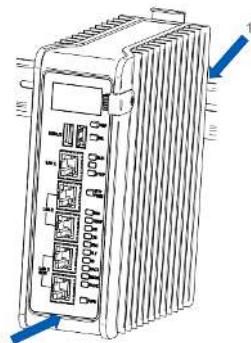
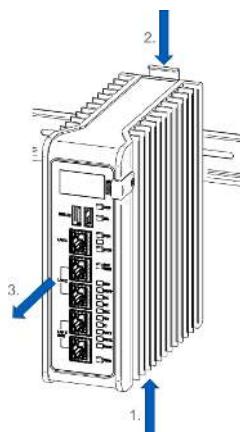


Figure 5: Dismounting from DIN Rail



If using the panel-mount adaptor, two options are available: mount using two screws (Figure 6) or, for more secure mounting, mount using four screws (Figure 7).

Figure 6: Two-Screw Panel Mount

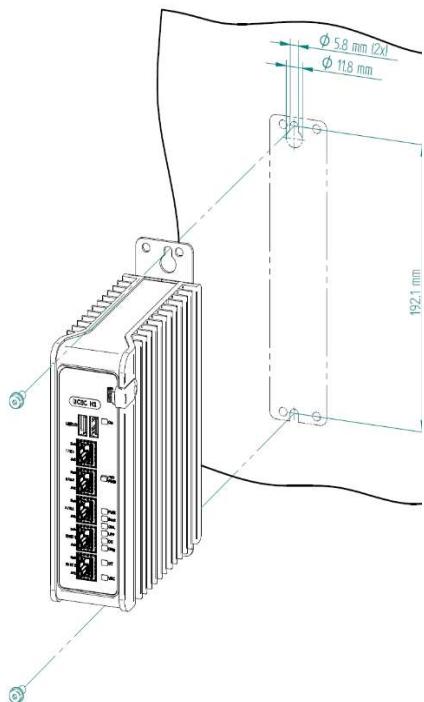
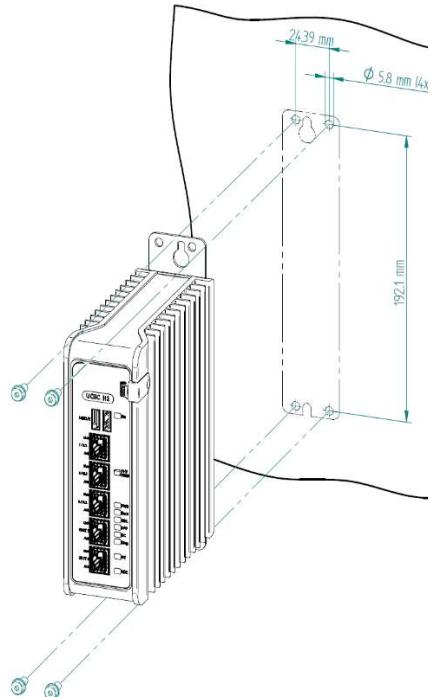


Figure 7: Four-Screw Panel Mount



Installation in Hazardous Areas

Refer to *Installation and Maintenance Requirements*, GFK-3004.

Connect to Power Supply

The 24 VDC power input connector is located on the underside of the CPL410, as shown in Figure 8. The signal pinouts are also indicated.

The mating connector for the CPL410 24Vdc power input is the 3-pin Phoenix 1827716 shown in Figure 9. The power supply cable prepared by the user must use the specified mating connector.

The positive “+” and negative “-” signals are required. FGND is optional but recommended.

For the mating connector, the compatible conductor size is from 24AWG to 16AWG. Strip the wires back 7mm before inserting into the connector. Tightening torque for the three signal screws is 2.2 in-lbs (0.248Nm). Secure the mating connector to the power input connector via the two captive screws provided.

Figure 8: 24 VDC Power Input Connector

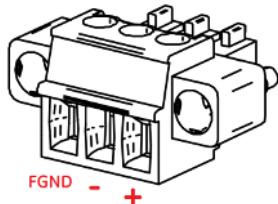


The user-supplied SELV² power supply must supply voltage in the range of 18Vdc to 30Vdc.

Once the power supply cable (or compatible Energy Pack ACC403) has been attached to the CPL410 and the power supply has been turned on, the unit will start booting. There is no need to push any button.

The unit is equipped with built-in reverse polarity protection. If + and - are swapped the unit will not power-up. If + is connected to FGND, this will cause a short. The power supply needs to protect itself against this condition.

Figure 9: 24 VDC Power Input Module Connector



Inrush Current

The CPL410 may experience an inrush current of up to 49 A for 15 μ s.

Overvoltage Protection

In the CPL410, the voltage to the inner loads is clamped to 33 VDC. At 33 VDC, the internal clamping diode starts conducting at 1 mA. Any further increase in the voltage will cause the internal current fuse to blow and/or the clamping diode to break.

² SELV = Safety Extra Low Voltage

CAUTION

EQUIPMENT REPAIR REQUIRED – Internal components must be repaired at the factory; they are not field replaceable. Contact the support team at the link provided at the end of this document.

Overcurrent protection

The function protects the internal circuitry from overcurrent conditions before serious damage can occur, such as overheating of the equipment. The fuse is rated for 4A continuous current. Once the sensed current reaches 40A, the fuse will blow after a period of 10ms to 100ms.

CAUTION

EQUIPMENT REPAIR REQUIRED – Internal components must be repaired at the factory; they are not field replaceable. Contact the support team at the link provided at the end of this document.

Grounding

Grounding via the FGND connection on the 3-pin 24 VDC In power header is recommended (see the *Connect to Power Supply*), but is not required if the CPL410 is mounted to a grounded metal panel. Furthermore, if an Energy Pack is connected, be sure to comply with grounding procedures as described in *PACSystems RX3i Rackless Energy Pack IC695ACC403 Quick Start Guide*, GFK-3000.

Module Start-up

You Will Need:

- This PACSystems Rackless RX3i CPU.
- A compatible SELV 24Vdc, 48W power supply (72W if Energy Pack attached).
- (Optionally) A compatible Energy Pack, IC695ACC403, and corresponding cable.
- If no Energy Pack is to be attached, use the power supply cable described in section *Connect to Power Supply*. Otherwise, refer to *PACSystems RX3i Rackless Energy Pack IC695ACC403 Quick Start Guide, GFK-3000*.
- A DIN rail, typically mounted in an enclosure, as discussed above. Alternately, mount the unit using the compatible panel-mount adaptor.
- A computer running PAC Machine Edition™ (PME) configuration and programming software. PME Version 9.70 SIM 16 or later supports the CPL410. Version 9.50 SIM 5 is required for Hot Standby Redundancy.
- Ethernet cable for connecting the PME programmer computer to the CPL410.
- Additional cables, as needed, to connect each port employed in the application.
- A very small slotted screwdriver to secure the 24 Vdc mating connector.
- A T8 Torx screwdriver, if the micro-SD slot cover is to be removed. Note that the cover must be replaced to achieve immunity from electrical noise.
- A T10 Torx screwdriver, if exchanging the mounting adaptors.

Basic Start-up Steps

For startup and configuration of the CPL410, complete the following steps. For full details on CPL410 operation, refer to the *PACSystems RX3i and CPU Reference Manual*, GFK-2222Y or later.

1. Mount the CPL410, as described in the *Installation* section and per the *Installation and Maintenance Requirements* document, GFK-3004.
2. Attach the user-supplied power supply cable as described in *Connect to Power Supply* if no Energy Pack is being used.
3. (optionally) Mount and attach the compatible Energy Pack, IC695ACC403, as described in the *PACSystems RX3i Rackless Energy Pack IC695ACC403 Quick Start Guide*, GFK-3000.
4. Turn on the power supply unit: the unit should then run without the need to press any buttons.
5. If not previously configured, configure the RX3i PLC using PME 9.00 SIM 8 or later, as described in the *CPL410 PLC Configuration* section below.

Note: When the ACC403 Energy Pack is powered up, a finite period is required to charge it up to its operating level. During this time, the Energy Pack will indicate this condition via its LEDs (refer to the *PACSystems RX3i Rackless Energy Pack IC695ACC403 Quick Start Guide*, GFK-3000).

The CPL410 will begin its boot cycle immediately upon power application. However, the embedded controller will not start its control until the ACC403 is charged. This typically takes 45 seconds or less. In the event the ACC403 is faulty or is not communicating, CPL410 commences operation without the Energy Pack.

Note: In the event of loss of power, with the ACC403 Energy Pack connected and charged up, the CPL410 remains on for 4 seconds to backup user memory into its non-volatile memory.

CPL410 PLC Configuration

To configure, the CPL410, connect the computer running the PME programming software to any of the front-panel Ethernet ports. PME 9.00 SIM 8 or later is required

The CPL410 is the first controller available in the *PACSystems RX3i Rackless* family. Configuration will either start out using the RX3i Rackless CPL410 template when creating a new project or will convert an existing project to the CPL410 using the *Family Conversion* feature in PME.

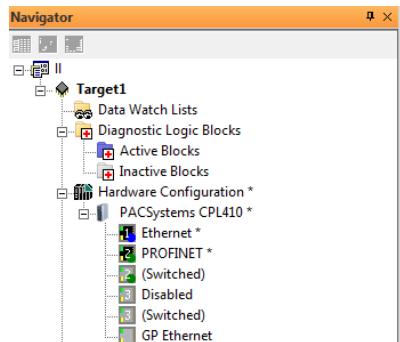
Backwards Compatibility

To convert an existing project which uses any other PLC, use the *Family Conversion* feature in PME. Be aware of the constraints involved, as will be notified in PME. For instance, the first PROFINET Controller in an RX3i CPU320 application will be assigned to the embedded PROFINET Controller feature of the CPL410.

PROFINET Controller Configuration

An Embedded PROFINET Controller may be configured on LAN2. To enable the PROFINET Controller in a CPL410 project, select the CPL410 target in the *PME Navigator* (Figure 10) and open the Hardware Configuration. On the *Settings* tab, change the designated *LAN Mode* of the selected port to *PROFINET*. The *PROFINET Controller* node description then displays that a PROFINET node exists on the selected LAN (under the CPL410). For further details, refer to the *PACSystems RX3i PROFINET IO Controller User Manual*, GFK-2571.

Figure 10: PME Navigator Showing PROFINET Node on LAN2



Redundancy Configuration

It is possible to configure the RX3i PLC part of CPL410 as a Hot Standby Redundancy CPU with PROFINET IO. The two ports on LAN3 are used exclusively for this purpose: they provide a high-speed data synchronization link between the two CPUs. Connect the upper LAN3 port of the Primary CPU to the upper LAN3 port of the Secondary CPU and connect the lower LAN3 port of the Primary to the lower LAN3 port of the Secondary. Note that no additional hardware, other than the two redundant CPUs, may be connected to LAN3.

To enable redundancy in a CPL410 project, select the CPL410 target in the *PME Navigator* and use the *Property Inspector* to change the *Enable Redundancy* target property to *True*.

Important: Set the *Background Window Timer* to a minimum of 5ms in both the Primary and Backup CPL410 hardware configurations. The *Background Window Timer* setting may be found on the *Scan Tab* in the CPL410's hardware configuration.

Once configured for HSB Redundancy, the RACT and RBOK LEDs (Figure 1) become functional. RACT indicates the Local CPU is Ready & Active; RBOK indicates the Remote CPU is Ready. These two LEDs are also reflected in the Status Data of the CPU and are presented as OPC UA Variables.

The OLED display includes two menu items used in conjunction with Redundancy:

- RDN Info provides status information via the OLED display.
- RDN Command permits the operator to perform a Role Switch.

- For further details, refer to the *PACSystems Hot Standby CPU Redundancy User Manual*, GFK-2308 (rev L or later).

CPL410 Linux

Ubuntu 16.04 Server LTS Linux is preinstalled on CPL410. Please note that the Server variant of Ubuntu does not offer a graphical desktop like GNOME or KDE, but only alphanumerical user interfaces (terminals). Additionally, the usage of graphic drivers is prevented by Kernel parameter to avoid unpredictable side effects (like CPU slow down due to overheating).

This guide assumes the user is already familiar with Linux and therefore only covers topics relevant to CPL410 commissioning.

Start Linux

After providing the CPL410 with power, Linux will begin to boot. The GPOK LED will start blinking to indicate when Linux has booted and is ready for user logins. (This may take about two minutes.)

Remote Login

CPL410 is running an SSH service (daemon) which allows secure login from remote systems via the Ethernet network.

Log in via SSH over Ethernet Network

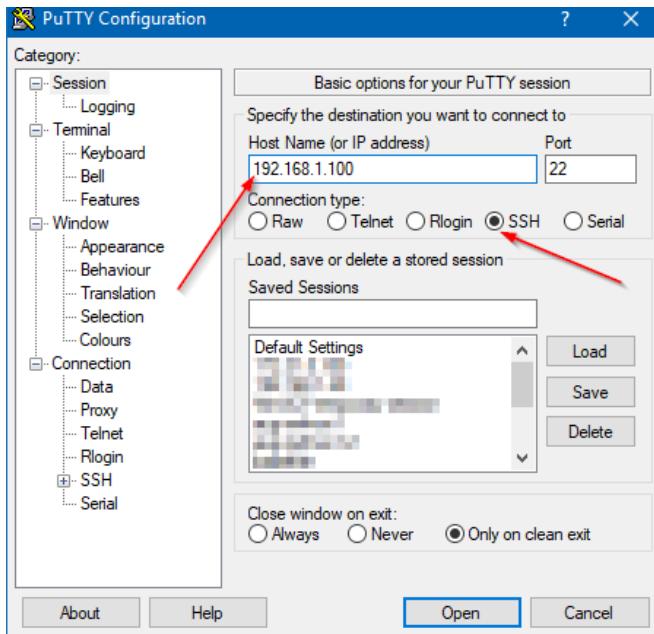
1. Connect the ETH port of the CPL410 (underside Ethernet port) to a DHCP server (see next section).
2. After CPL410 receives its IP Address from the DHCP server, the user can determine the active network parameters (incl. IP Address) via the

display menu:

GP Settings ->Network Config

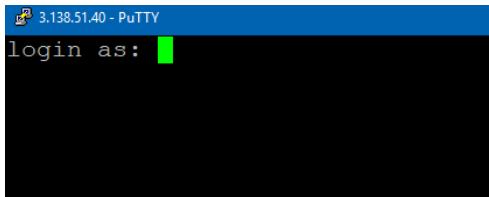
3. On the remote system (e.g. a desktop PC or Laptop) the user will need a SSH client like Putty (<https://putty.org/>) or Kitty (<http://www.9bis.net/kitty/>). Enter the IP Address determined in the prior step, select the SSH protocol and open the connection (Figure 11).

Figure 11: Set up Connection from Remote System



After the connection has been established, the CPL410 login prompt appears:

Figure 12: Login from Remote System



Default user on CPL410 is *admin* with password *admin*. When logging in for the first time, you will be asked to provide a new password. Be sure to remember your new password, as there is no other way to access Linux without it.

- Default User Name: ***admin***
- Default Password: ***admin***

Note: For security reasons, it is common practice not to use the Superuser root account for login. Therefore, user *root* cannot directly login on CPL410, but user *admin* is granted SUDO rights to execute privileged commands. Prepend statement *sudo* to commands requiring privileges.

Network configuration

DHCP

CPL410 Linux is configured by default to receive its IP Address via DHCP over the ETH Ethernet port (Figure 2). After receiving the network parameters, the active IP Address, together with other network information, can be determined via the OLED display menu ***GP Settings -> Network config***, or by issuing the command ***ifconfig*** when logged in.

Note: A DHCP server is essential for the first remote login over SSH. Once logged in, the user can change the configuration to disable use of DHCP (see next section).

As the network 192.168.180.0/24 is used for CPL410 internal communication, the DHCP server must not assign any IP-Address from the address range 192.168.180.0 to 192.168.180.255 to the CPL410.

DHCP Troubleshooting

- If no IP address is assigned, use a laptop connected to the same network appliance to assure that DHCP services are available.
- If no IP address is assigned and DHCP services have been verified, ensure that the ETH ethernet cable is plugged and cycle power or use the Display ***GP Settings->Commands->GP Reboot***

Static IP Addresses

Sometimes it is desirable to avoid use of DHCP. In this case, assign a distinct, static IP Address manually to the target CPL410. Both, DHCP and static IP Addresses are configured in the file */etc/network/interfaces*.

Assign a Static IP Address

- To change from DHCP (default configuration) to static IP Addresses, edit the file */etc/network/interfaces* manually, by using one of the available Editors (see below).

After configuration, reboot Linux either by issuing the **reboot** command or use the display menu **GP settings -> Commands -> GP Reboot**. Both only will reboot Linux and do not affect the PLC (PLC will continue to run).

Note: This is an essential setting. Make sure the entries are correct and that the device will be reachable with the designated IP Address; otherwise Linux will be inaccessible; Linux will need to be reset to factory installation.

As the network 192.168.180.0/24 is used for CPL410 internal communication, the DHCP server must not assign any IP-Address from the address range 192.168.180.0 to 192.168.180.255 to the CPL410.

Configure a Network Proxy

If a network HTTP/HTTPS proxy server is used to route traffic from the intranet to the Internet, the environment variables *http_proxy*, *https_proxy*, *ftp_proxy* need to be set accordingly. To create these variables permanently and for all users edit the */etc/environment* file.

Proxy Settings for APT Package Management

The APT package management (*apt*, *apt-get* commands) uses a different configuration file for proxy settings: */etc/apt/apt.conf*.

Linux Software

Pre-installed Editors

By default, the following Editors are available:

- VIM
- Nano
- Midnight Commander (mc)

Additional Installed Packages

The CPL410 Linux installation is based on the Ubuntu 16.04 LTS Server distribution. Additional to this software set some more packages have been preinstalled mainly to enable interfacing with the PACS runtime, but also to allow development of Python based OPC-UA communication applications.

The following is the list of additional installed software. Each user can update these and optionally install software of their own choosing.

- | | |
|--|--|
| <ul style="list-style-type: none">• build-essential• linux-generic• swig• cmake• python2.7-dev | <ul style="list-style-type: none">• libssl-dev• libxml2-dev• sqlite3• apache2• libapache2-mod-wsgi-py3 |
|--|--|

- php
- php-sqlite3
- phpLiteAdmin
- zutils
- gdisk
- mc
- FreeOpcUa
- FreeOpcUa Documentation
(/var/www/html/FreeOpcUa)
- python-concurrent.futures
- python-enum34
- python-trollius
- python-dateutil
- python-tz
- python-lxml
- python-sphinx
- python3-dateutil
- python3-tz
- python3-lxml
- python3-crypto
- python3-cryptography

Packages/SW by Emerson

- opc2sqlite.py Python OPCUA Sqlite example in /home/admin
- empty sqlite database sampledb in /home/admin/sqlite
- /usr/bin/predix_scripts/...
- /usr/bin/efaSmiFileManager.py
- /usr/bin/efaSmiApp
- /lib/systemd/system/efasmiaapp.service
- /lib/systemd/system/efasmifilemanager.service
- /lib/systemd/system/fastatemanager.service
- /var/ge/FieldAgentInfo/faState.json
- /sbin/xtables-multi.wrapper
- CPL410 Example Web page, Style sheets,... in /var/www/html
- Example OPCUA-Python Web application in /var/www/cgi-bin/PyOpcUaWeb.py
- Hypervisor Open Source drivers in /boot/rth

Install or Update Packages

CPL410 Linux is open to software individually installed by customers. Standard Debian (Ubuntu is Debian based) package tools may be used to add, delete or update software packages.

Note: Please keep in mind, that preinstalled Ubuntu is a server variant, not offering a graphical desktop like KDE or GNOME. Therefore, installing graphical programs like Web browsers only makes sense if additionally installing a X11 windowing system (or similar) and forwarding the output to a remote device (the CPL410 Display Port cannot be used for graphical output).

On the command line *apt* (Advanced Packaging Tool) or *apt-get* command is used to install, update or delete a software package. Both commands are privileged commands, therefore, *sudo* needs to be prepended if not logged in as root.

For more details see Ubuntu help page about Package Management:
<https://help.ubuntu.com/16.04/serverguide/package-management.html.en>

Note: Depending on the software repositories configured in /etc/apt/sources.list file and in the /etc/apt/sources.list.d directory, new software packages are typically downloaded from external repositories. A working Internet connection is therefore required to install or update packages.

Note: Upgrading a system also can include the Linux Kernel and the initial RAM disk, both located in the /boot directory. If a new Kernel or RAM disk has been installed by upgrade, make sure the symbolic links /boot/vmlinuz and /boot/initrd.img are pointing to the latest Kernel (RAM disk version).

After a new Linux Kernel has been installed, and the links have been set accordingly, a power cycle is necessary to make the Kernel change effective. Whenever a new Kernel version is active, drivers not provided by Ubuntu need to be recompiled. Two drivers are needed for CPL410 communication with the PLC runtime: these are recompiled on the fly, whenever a new Kernel is detected. Driver archives are in the /boot/rth folder and must not be deleted.

Note: There always is a risk of damage to the Linux installation when **upgrading** the system, especially if the Kernel is being updated. Consider performing such an upgrade in a protected environment before attempting such an upgrade on a production system.

CPL410 File Exchange

The ssh service, mentioned earlier regarding remote login, can also be used to copy files from a remote computer to the CPL410 Linux and vice versa. There are several Windows tools freely available to make use of this service from a Windows PC, like WinSCP (<https://winscp.net>) or FileZilla (<https://filezilla-project.org/>). Please configure either the SCP or the SFTP protocol when connecting with this tool to the SSH service of CPL410.

In Linux, the command line program *scp* can be used to copy a file from one CPL410 to another or to another SSH server.

Please pay attention to the CPL410 Secure Deployment Guide (GFK3055) regarding SSH key exchange and key generation.

Sample Web Page

CPL410 instantiates anApache2 Server and provides an example Webpage, offering system information and sample applications. The page can be reached by entering the CPL410 IP-Address into a Web browser: https://<ip-Address>

Current IP-Address can be determined via the display menu: ***GP Settings - >Network Config.***

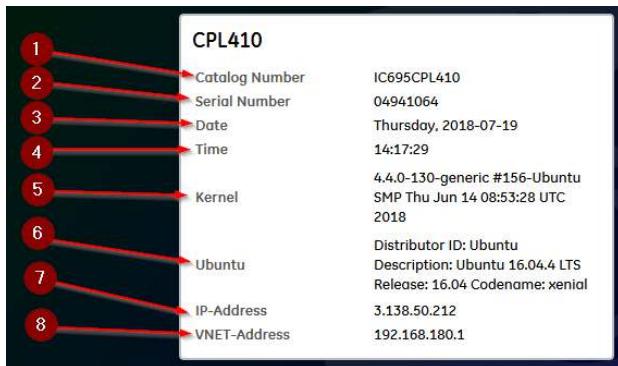
For security reasons all requests using the HTTP protocol are redirected to the encrypted HTTPS protocol. This can be modified by editing the Apache2 configuration file /etc/apache2/sites-available/ 000-default.conf.

As CPL410 uses the Ubuntu default self-signed certificate for encrypted HTTPS communication, a warning is displayed when opening the CPL410 Webpage the first time. Please add a security exception in the browser or provide a SSL certificate for the Apache Server to display the CPL410 Webpage properly.

All pages presented here, are in the /var/www/html directory and may be modified or deleted as needed. They are provided for demonstration purposes only.

CPL410 Information

Figure 13: CPL410 Information Location



-
1. CPL 410 Order Number
 2. CPL410 Serial Number of the Device
 3. Manufacturing Date
 4. Current CPL410 Linux System Time and Date
 5. Linux Kernel Version Currently Running
 6. Current Ubuntu Version
 7. IP Address used by CPL410 Linux on Bottom of ETH port
 8. IP address used for Communication with Runtime

CPL410 Example Webpages and Applications

Figure 14: Example Webpages and Applications



1. Link to the phpLiteAdmin Tool for administering the example SQLite database located in the user “admin” home directory:
`/home/admin/sqlite/sampledb`
2. This link calls the local default Webpage normally provided by Ubuntu as a start page.
3. Link to the Ubuntu Server Guide on the Internet.
4. Local Ubuntu Server Guide in PDF format.
5. Link to the CPL410 PLC Runtime Update page. This link only works if connected to the CPL410 LAN1 front Ethernet port using the IP-Address 192.168.0.100 (Port also used for the PME programming system). If this port is configured for a different IP-Address you

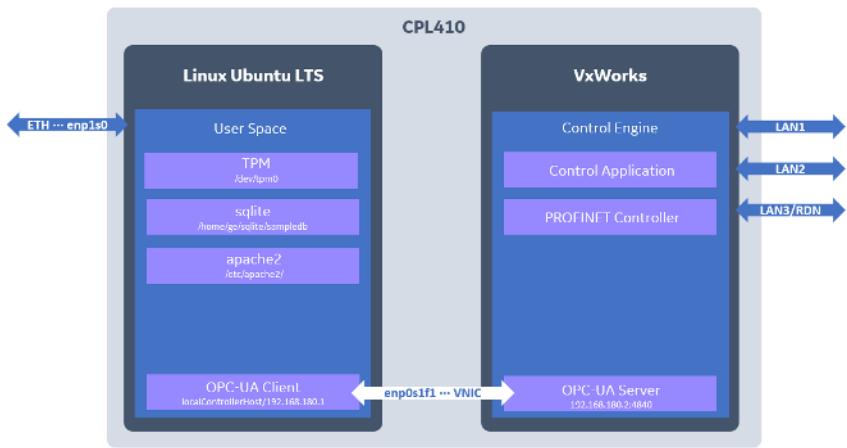
need to adapt the /var/www/html/index.php file accordingly (near line 106).

6. Documentation for the Pure Python OPC UA Library used to exchange data with the PLC runtime via OPC UA.
7. Link to an example Webpage demonstrating the OPC UA data exchange and database storage. This link works properly only, if a PLC program existing exporting OPC UA variables.
8. Information about Open Source Licenses and Open Source used for CPL410.

Data Exchange with PLC - OPC-UA

On CPL410 the Control Engine (PLC) and Linux are running in parallel, strictly separated and encapsulated by a Hypervisor in so called Virtual Machines (VM). The only link between these two worlds is a virtual network (VNIC) simulating an Ethernet connection in a memory, shared between both VMs. The following Figure is illustrating the separation in VMs (Linux Ubuntu and VxWorks) and the connection between both VMs (VNIC: Virtual Network Interface Card):

Figure 15: Data Exchange PLC OPC UA



To exchange data over this virtual network, an OPC-UA server is instantiated in the PLC, implementing the OPC-UA protocol, thus allowing a Linux OPC-UA Client to request and set PLC variables.

OPC-UA protocol makes use of the operating systems TCP/IP stack to send data over the virtual network. The TCP/IP-Parameters for this network are as follows:

PLC:	192.168.180.2
Linux:	192.168.180.1
Network Mask:	255.255.255.0
OPC-UA Server Port:	4840

The network part of the IP-Address as well as the PLC IP-Address cannot be changed by user. The Linux IP-Address of this network can be changed in the /etc/init.d/rthinitVirt script, but it is not recommended to do so.

Note: As the network 192.168.180.0/24 is used for the virtual network between the CPL410 VMs, this network must not be used on any physical Ethernet port.

Note: OPC-UA is the only way to exchange data with the PLC over the VNIC. OPCUA-Server is listening not only on the VNIC, but also on the front-panel Ethernet ports.

To demonstrate the OPC-UA communication, CPL410 has installed the freely available Python Library “Pure Python OPC-UA”. This library is distributed under the LGPL license and can be found here:

<https://github.com/FreeOpcUa/python-opcua> .

“Pure Python OPC-UA” library documentation is available on CPL410 via the CPL410 Web page.

In the home directory of user *admin*, a very basic example, based on the “Pure Python OPC-UA” library, is provided (/home/admin/opc2sqlite.py), demonstrating how to read a variable named *Cosine* from PLC and store the content of this variable in a SQLite database.

Execute this Python script as user *admin* by the following command line sequence:

python /home/admin/opc2sqlite.py

This reads the current value of the variable *Cosine* in the PLC and stores it in the SQLite database /home/admin/sqlite/sampledb.

Note: To successfully read or write PLC variables via OPC-UA, those PLC variables need to be published/exported in the PLC project:

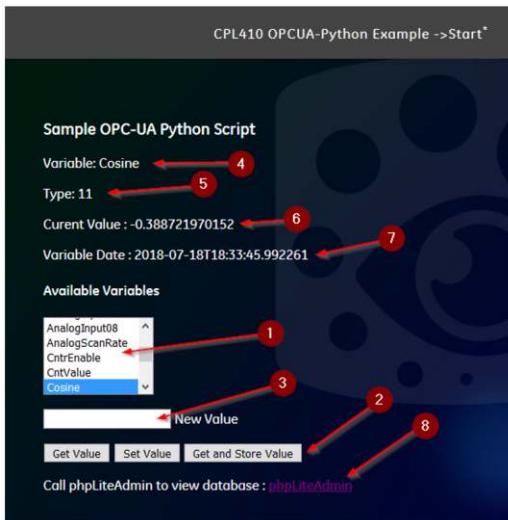
Figure 16: Variable Name Designation

Inspector	
Variable [CPL410_System]	
Name	Cosine
Description	
Publish	External Read/Write
Array Dimension 1	0
Data Source	GE IP Controller
Ref Address	
Data Type	LREAL
Current Value	0.966488182671972
Initial Value	-0.117537397457846
Default Display Format	General format
Precision	15
Retentive	True

The Python example mentioned above especially expects a variable named *Cosine* to be exported. Please modify the script, if a different variable shall be used.

A more sophisticated example can be found via the CPL410 Web page. This example is also implemented in Python and based on “Pure Python OPC UA” library. It is executed by the Apache2 Webserver as a CGI script, generating dynamically HTML code send to a Web browser. To be executable by Apache2, it is stored in the Apache CGI directory /var/www/cgi-bin and named *PyOpcUaWeb.py*. The database used by the *PyOpcUaWeb.py* script to store variables content is the same as used by the example mentioned above: /home/admin/sqlite/sampled.

Figure 17: Python Script Example



-
- 1) When the Web page is opened, the Python script is executed by the Webserver. The script connects to the OPC-UA server in the PLC and ask for

the names available (published) for OPC-UA. Those names are added to this list box. In the list box an entry can be selected for further operations.

- 2) With the Variable selected in (1) 3 actions can be performed:
 - a. Get the value of the selected variable. Result is shown in (4),(5),(6),(7)
 - b. Set the variable to the value entered in (3). After the variable has been set the current value is read and displayed in the output area.
 - c. Get the value of the selected variable and store data in SQLite database
- 3) The value entered here is used for the “Set Value” action
- 4) -7) Output Area showing the name, the value, the OPC-UA variable type and the time PLC time when the variable has been captured.
- 8) Via this link the phpLiteAdmin tool can be started to display and modify the SQLite database, where the “Get and Store” action stores the variables (see also 0).

Factory Reset

It might happen that a user locks him/herself out from Linux, or Linux fails to start following a misconfiguration. In such cases, Linux can be restored to its original manufacturer settings:

- Factory Reset can be triggered via the OLED-Display Menu:
GP Settings->Commands->Factory Reset.
- After the Factory Reset has been triggered, a manual power cycle must be executed by pressing the power button for more than 4 seconds.

Note: Please ensure, the PLC and controlled facilities are in a secure state when cycling power. PLC Stop mode is recommended.

- When CPL410 boots up again, the Linux root (/dev/sda8) and boot (/dev/sda9) partitions are formatted and the original factory software is installed. During the restore process “Resetting GP” is shown on the display when selecting the “GP Settings” menu. Also, the LED GPOK is off during reset. Restoration is finished when the GPOK LED blinks again.

Note: All data, all user modifications, all updates etc. on these partitions are deleted and are unrecoverable following factory reset. Therefore, consider making backups of all changes applied to Linux frequently.

- The original factory software load is extracted from archives located on the /dev/sda12 partition. This partition is not mounted by default and must not be changed by users.
- The home partition (/dev/sda10: folder /home and below), where the customer data is expected to be stored, is not impacted.

SQLite Demonstration Database

SQLite (<https://sqlite.org/>) is an embedded, file based database engine. SQLite database files are directly modified via library calls and not via a server interface respectively a network service. Therefore, SQLite cannot be accessed remotely and is only suitable for small amounts of data and slow data rates, it is normally not used in a production environment. SQLite and related libraries have been installed on CPL410 for demonstration purposes only.

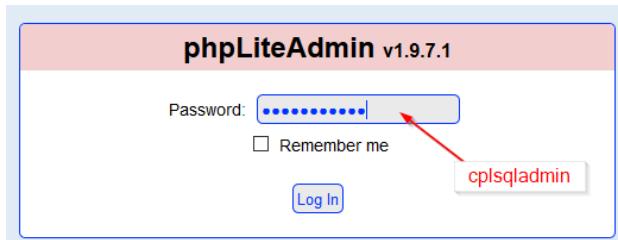
The Python examples mentioned above, all use the same SQLite database to store data: /home/admin/sqlite/sampled.

For administration and visualization of the database content, a small, Web based tool called phpliteAdmin (<https://www.phpliteadmin.org/>) has been installed in the document root of the Apache2 Webserver (/var/www/html). In this directory the tool itself (phpliteadmin.php) and its configuration (phpliteadmin.config.php) reside. In the configuration the admin password and the database directory have been changed as follows:

User:	admin
Password:	cplsqladmin
Database Directory:	/home/admin/sqlite

phpliteAdmin can either be accessed by following the links in the CPL410 example Web pages or by directly entering the URL
<https://<CPL410 Linux IP-Address>/phpliteadmin.php>
in a Web browser.

Figure 18: phpLiteAdmin Login



The table *valutable* in the sample database (sampled) contains the variables stored by the Python examples:

Figure 19: Variables Stored by Python Examples

phpLiteAdmin v1.9.7.1																					
Documentation License Project Site	sampledb → valutable																				
Change Database [rw] sampledb [↓]	Browse Structure SQL Search Insert Export Import Rename Empty Drop																				
sampedb [Table] valutable	Show : <input type="text" value="30"/> row(s) starting from record # <input type="text" value="0"/> as a Table View																				
	Showing rows 0 - 2, Total: 3 (Query took 0.0003 sec) SELECT * FROM "valutable" LIMIT 0, 30																				
	<table><thead><tr><th>— T —</th><th>Nr.</th><th>varname</th><th>value</th><th>time</th></tr></thead><tbody><tr><td></td><td><input type="checkbox"/></td><td>1</td><td>Cosine</td><td>-0.00872653549838865 2018-07-18T20:58:43.263907</td></tr><tr><td></td><td><input type="checkbox"/></td><td>2</td><td>CntrEnable</td><td>1.0 2018-07-18T20:58:49.398407</td></tr><tr><td></td><td><input type="checkbox"/></td><td>3</td><td>TankCmd</td><td>0.0 2018-07-18T20:58:55.928907</td></tr></tbody></table> <p>Check All / Uncheck All With Selected: Edit Go</p>	— T —	Nr.	varname	value	time		<input type="checkbox"/>	1	Cosine	-0.00872653549838865 2018-07-18T20:58:43.263907		<input type="checkbox"/>	2	CntrEnable	1.0 2018-07-18T20:58:49.398407		<input type="checkbox"/>	3	TankCmd	0.0 2018-07-18T20:58:55.928907
— T —	Nr.	varname	value	time																	
	<input type="checkbox"/>	1	Cosine	-0.00872653549838865 2018-07-18T20:58:43.263907																	
	<input type="checkbox"/>	2	CntrEnable	1.0 2018-07-18T20:58:49.398407																	
	<input type="checkbox"/>	3	TankCmd	0.0 2018-07-18T20:58:55.928907																	
Logout	Powered by phpLiteAdmin This is free software. Please donate. Page generated in 0.0035 seconds.																				

Red numbers 1 and 2 are overlaid on the screenshot to point to specific elements: 1 points to the "valutable" table entry in the "Change Database" section; 2 points to the "Edit" and "Go" buttons at the bottom of the results table.

GPOK LED

The General-Purpose operating system OK LED (GPOK LED) signals the status of the Linux operating system. If this LED is blinking Linux is running. As all front LEDs and the OLED display are controlled by the real-time Control Engine, Linux can't set the GPOK LED directly, but needs to signal status indirectly. Two Linux processes -faStateManager and efaSmiApp- are managing the communication to share information, like status or IP-Address, with the Control Engine. Two files, which are written respectively monitored by these processes, may be of interest for users:

1. /var/ge/FieldAgentInfo/faState.json :

This file signals the current Linux state to the Control Engine, thus defining the blink rate of the GPOK LED. This file contains a JSON structure with 3 variables:

- a. osRunning: if true, GPOK blinking slowly. This is the default state, indicating that Linux is up and running.
- b. predixMachineRunning: if true, GPOK is blinking fast; this variable could be used to signal a running user process.
- c. predixMachineCloudConnected: if true, GPOK is solid; this variable could be used to indicate an established internet connection.
- d. Default:
{"osRunning": true, "predixMachineCloudConnected": false, "predixMachineRunning": false }
- e. Only the first line of this file is evaluated.
- f. There are 3 more variables in this JSON file, which are currently not supported by CPL410 (.wifiDisabled, configurationModeOn, recentMachineDataTransferred)

- g. User can manually modify this file to change the GPOK LEDs behavior, or automatically update the file to signal different states of an application.
2. /var/ge/FieldAgentInfo/HwInfo.txt:
This file contains the catalog and the serial number of the CPL410. This data is read by the Control Engine from a Factory EEPROM and transferred to Linux into this file.

Additional Information

<i>PAC Logic Developer-PLC Getting Started</i>	GFK-1918
<i>PACSystems RX3i and RSTi-EP CPU Reference Manual</i>	GFK-2222
<i>PACSystems RX3i and RSTi-EP TCP/IP Ethernet Communications User's Manual</i>	GFK-2224
<i>PACSystems TCP/IP Ethernet Communications Station Manager Manual</i>	GFK-2225
<i>PACSystems Hot Standby CPU Redundancy User Manual</i>	GFK-2308
<i>PACSystems RX3i System Manual</i>	GFK-2314
<i>PACSystems RXi, RX3i and RSTi-EP Controller Secure Deployment Guide</i>	GFK-2830
<i>PACSystems RX3i and RSTi-EP CPU Programmer's Reference Manual</i>	GFK-2950
<i>PACSystems HART® Pass Through User Manual</i>	GFK-2929
<i>PACSystems RX3i PROFINET IO Controller User Manual</i>	GFK-2571
<i>PROFINET I/O Devices Secure Deployment Guide</i>	GFK-2904
<i>PACSystems RX3i Rackless Energy Pack IC695ACC403 Quick Start Guide</i>	GFK-3000
<i>IC695CPL410 RX3i 64MB Rackless CPU w/Field Agent</i>	GFK-3003
<i>Important Product Information</i>	
<i>IC695CPL410 RX3i 64MB Rackless CPU w/Field Agent Installation and Maintenance Requirements</i>	GFK-3004
<i>Field Agent User's Guide</i>	GFK-2993
<i>PACSystems DNP3 Outstation User Manual</i>	GFK-3103

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Attn: General Counsel

2500 Austin Drive

Charlottesville, VA 22911

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General Contact Information

Website

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Technical Support

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