DLI DC3 User's Guide

1.11.4.0

Contents

1 Overview

Congratulations on selecting the DLI DC Power Controller, an IP-controlled high-power DC switch.

Check out the main product features. Some more technical specifications are available as well.

Be sure to check the package contents when unpacking the unit, then follow the instructions for basic setup and use if you are a first-time user. The device is controllable using LCD and keypad, which have several modes. This should allow you to access the basic device features. More advanced settings are located on the Setup page.

DLI DC3 can be:

- extended with user scripts;
- customized to add branding;
- accessed via a growing number of external APIs;
- upgraded to newer firmware versions.

It can be configured to:

- ping other devices and take action if they don't respond;
- send notifications when certain events occur;

DLI DC3 utility functions include:

- monitoring and logging data from miscellaneous sensors;
- reading the system log
- setting date/time;
- backing up settings;
- locking down security-sensitive functionality;
- resetting settings to defaults.

The firmware is based on open-source code which is provided to give you the option to build totally custom firmware.

Please contact technical support in case of any problems.

We offer a limited one-year warranty on these units.

2 Product features

Congratulations on selecting the DLI DC Power Controller, an IP-controlled high-power DC switch. Its features include:

- 8 DC Output Connections — 100A Total Load

  Eight individually switched circuits are provided on two branch circuits each with four outputs. Branch circuits are protected by 50A breakers and each switched circuit is protected by a 15A breaker.

- Simple Web Interface

  The internal web server is accessible from any browser. Simply enter an IP. Configuration and control are web-based.

- AutoPing™ Reboot

  AutoPing continuously monitors an IP address. If a server, router, or other peripheral goes down, AutoPing can automatically reboot it without user intervention. Several devices can be monitored simultaneously.

- Programmable LCD Display

  Custom messages can be displayed via user scripts.

- Multi-User Password Security

  Multi-user authentication limits access to the power controller. The administrator selects which relays each user can control.

- Sequenced "On Timer"

  A programmable delay timer allows relays to be switched on in sequence, rather than simultaneously. Most devices draw a surge of power when initially switched on. Using this timer, more equipment can share a single circuit without overloads. Programmable scripts can be used to create customized power-up and shut-down sequences with variable timing.

- MOV Surge Suppression

  Dual 3600W metal oxide varistors clamp power surges and spikes, protecting attached devices.

- Scripting Language, Syslog, and Utilities

  Lua scripting can be used to create custom control and reboot sequences, schedule periodic reboots, etc. Internal and external event logs are provided.

- New Features

  New features include CPU temperature sensor, HTTPS, WiFi support, web power meters/charts and Lua scripting.

- Field Upgradeable Firmware

  Firmware is field upgradeable via Ethernet or WiFi.

3 Package contents

- DLI DC3 .
- RP-SMA WiFi Antenna.

Please contact the freight carrier immediately if your package appears opened or damaged in transit. Call DLI at (408) 330-5599 for tech support, service, and hardware upgrades.

4 Basic setup and use

4.1 Factory defaults

The factory default network configuration is as follows:

- wired network: fixed IP address 192.168.0.100, netmask 255.255.255.0;
- wireless network: fixed IP address 192.168.254.1, netmask 255.255.255.0.

You can log in with username `admin` (lower case) and password `1234`. It is recommended that you change the password. You will be reminded to do so by a big red banner on the top of each page.

To reset to factory defaults, gently press the reset-to-defaults button below the LCD to enter the reset menu, then select a reset option.

4.2 Initial setup

Use these shortcuts if you are an experienced installer. We recommend reading the entire manual for first-time installation.

- Unpack. Save the carton.
- Apply power to the controller.
- Attach an Ethernet cable from the controller to your LAN. Switch power on. If you are attached through a switch, you may need to cycle switch power to establish a connection.
- Ping the default address 192.168.0.100 to confirm that a network connection is established. If you don't receive a response, proceed to the IP setup section below.
- Log in to the power controller using the default user name admin and the password 1234. Note: "admin" must be entered in lower case.
- Click the Settings link to reach the configuration page. Select the safest power-loss configuration for your installation: all OFF, all sequential ON or pre-powerloss state.
- Configure the power switch as described below. After each change, click Submit and wait for the page to refresh before continuing.

4.3 IP setup

If your network settings won't access the default IP, use a direct cable connection (temporarily bypass any switch or router) and follow these steps to add a compatible static IP, such as 192.168.0.50.

4.3.1 Windows IP setup

Before adding an IP, close all programs and browsers. After the link is established, you can enable DHCP.

4.3.1.1 Locating IP settings

In Windows, the first step is locating the network adapter TCP/IP properties. The procedure differs for each Windows version:

Windows XP, 2000, 2003:

- Open Start / Control Panel / Network Connections.
- In "classic view", select Start / Settings / Control Panel /Network Connections.
- Right-click on Local Area Network Connection and select Properties.
- Proceed to step 2.

Windows Vista:

- Open Start, right click on Network, then on Properties.
- Double click Network and Sharing Center.
- Click Manage Network Connections. A Network Connections window appears.
- Right click on the network connection to the switch, i.e. Local Area Network.
- Proceed to step 2. Windows 7:
- Open the Start orb, click on Control Panel.
- Click View Network Status and Tasks, then Change Adapter Settings.
- Proceed to step 2

Windows 8:

- Mouse or swipe to the bottom right corner and select Settings.
- Select Control Panel.
- Select Network and Sharing Center.
- Change Adapter Settings.
- Right click on your connected network and select Properties.
- Proceed to step 2

4.3.1.2 Configuring static IP

The second step is adding an IP such as 192.168.0.50. Temporarily disable DHCP while configuring the switch.

- Select Internet Protocol TCP/IP V4 Properties and click Properties.
- Enter a compatible static IP such as 192.168.0.50.
- Click Apply and close windows.
- Ping the power switch to confirm the connection.
- Point your browser to 192.168.0.100
- Log in.

Detailed instructions are at http://digital-loggers.com/ip_setup.html

4.3.2 Mac OS X IP setup

- Turn AirPort off temporarily.
- Click the Apple logo, then System Preferences, then Network.
- Select Built-In Ethernet and then Configure.
- Under the TCP/IP tab, select Manually.
- Enter an IP address such as 192.168.0.1.
- Make changes shown.
- Point a browser to 192.168.0.100.
- Log in.

Find Mac setup details at http://digital-loggers.com/mac_ip_setup.html

4.4 Windows IP configuration (2000, 2003, XP, Vista)

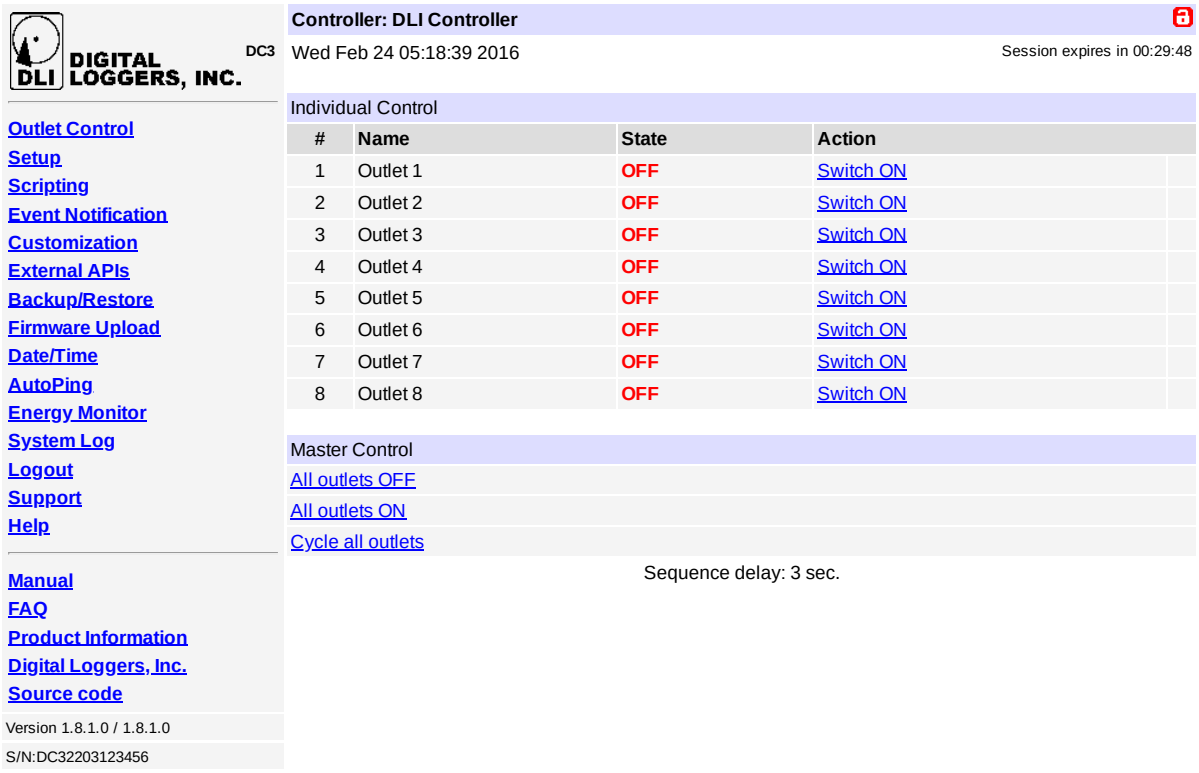
If your default Windows settings won't access the controller, use a crossover cable and follow these steps to reach the controller's IP:

1. Close network programs and browsers
2. Go to Network Settings -> Local Area Network.
3. Use the keyboard shortcut — type "ncpa.cpl" and click OK.
4. Right click on your LAN connection and choose "Properties".
5. Highlight "Internet Protocol" and click the "Properties" button.
6. Click the "Advanced" button.
7. Under the IP Address settings, click the "Add" button.
8. Enter a new IP, such as 192.168.0.10, and a subnet mask of 255.255.255.0.
9. Press the "Add" button; this new IP is added the list.
10. Close all windows for the configuration to take effect.
11. Start your Browser and type 192.168.0.100 in the URL field.

The default user name and password are "admin" (lower case) and "1234".

4.5 Basic switch operation

After power-up, the controller performs a sequence of self-tests to ensure reliability. The controller may then be operated via a web browser. To access the controller, simply enter the IP address in the URL field of your web browser, then log in. You will be presented with a screen similar to this:

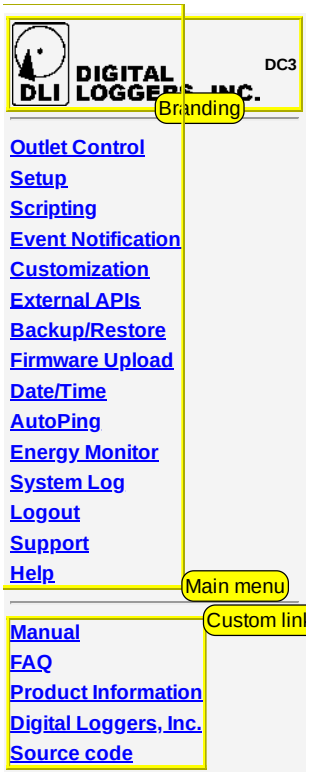


Main power controller page

Note that in this and many other pages, logical blocks can be collapsed by clicking in their right-hand corner, and later expanded by clicking .

4.6 Common page layout

You can navigate the menu links to access the controller's features:



Power controller menu

Custom links can be configured on the Admin page. The branding block can be customized on the Customization page.

4.7 Switching relays on and off

The relay control page lets you control relays. The sequence in which relays will be switched on is determined by settings on the Admin page. To switch an relay on or off, simply click to the right of the relay name or number. Switching an relay off is immediate. Switching an relay on may be delayed if a different (or possibly even the same) relay was recently turned on. The delay acts to protect the device from simultaneous inrush currents and limit cycling rate. You may also "cycle" a device which is connected to the controller. This feature is useful for rebooting Ethernet devices which may interrupt the web link to the controller. Clicking "Cycle" switches power off, waits a few seconds, and then switches power back on. This resets the attached device. You may also "cycle" all relays using the "Cycle all relays" button on the bottom of the page. Depending on your web browser settings, you may need to click the "refresh" button to update the on-screen status display after changing settings. A screen refresh setting is provided on the Setup page.

4.8 Logout

Browser logout is automatic when a session is closed or after a time-out period. You can use a menu link to log-out in advance.

5 LCD and keypad

The LCD has 2 lines, 16 character positions each. The displayed data depends on the mode, and possibly also on user scripting.

The keypad has 5 keys:

- ▲ (UP),
- ▼ (DOWN),
- | (ON),
- ⟲ (CYCLE),
- 0 (OFF).

During normal operation, the DC3 LCD and keypad interface can be in one of the following modes:

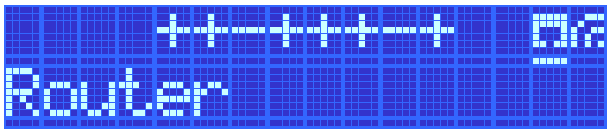
- Relay mode, which displays status of and allows to manipulate the unit's relays;
- Meter mode, which allows to read measurements of the DC3 meters ;
- Network mode, which displays and allows to configure network settings.

You can cycle through the modes by pressing ▲ and ▼ keys simultaneously.

If the keypad is locked via web UI, the keypad doesn't work, and if you press a key, a message about this is displayed and stays in place until the next update of the LCD data; no action is taken.

5.1 Relay mode

At boot, DC3 starts in Relay mode.



Relay mode

In Relay mode, the ▲ and ▼ keys allow to choose the relay to display. The first line shows states of all relays.

The selected relay is marked by a blinking cursor. Its name is displayed on the second line.

If the relay is not locked (see below) and its physical state matches the expected state, it is displayed as:

- a plus sign + for relays that are on, or
- a minus sign − for relays that are off.

If the relay's physical state doesn't match the expected state, (e.g. it will be switched on in sequence), its state is marked by:

- a minus/plus sign for relays that are physically off, but should be on, or
- a plus/minus sign for relays that are physically on, but should be off (this should be rare).

The top-right corner contains icons indicating status of wired (/) and wireless (/ /) networks. The icons are underlined (,) if the respective interface is online, and not underlined (,) otherwise. A minus sign in place of the wireless interface icon indicates that the wireless module is disabled. Empty space in place of the wireless interface icon indicates that no wireless support is installed.

The I button switches the selected relay on, likewise the 0 button switches it off.

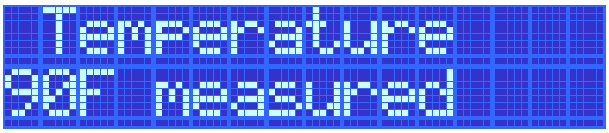
You can press and hold each of the buttons for 3 or more seconds to lock the relay in the corresponding state. Locked relays can't be manipulated from web UI or with scripting, and won't be switched by using the hardware I / 0 keys unless you hold the corresponding key for 3 or more seconds to unlock it. Locked relays are displayed as:

- a zero sign for relays that are locked off, or
- an asterisk for relays that are locked on.

The button cycles the selected relay unless it's locked.

Managing relay lock state can only be done using the LCD and keypad (unless you enable SSH). Locked relays' states cannot be altered, and they are not affected by power loss recovery mode.

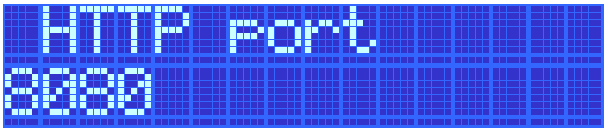
5.2 Meter mode



Meter mode

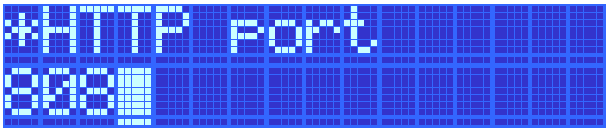
In Meter mode, the and keys allow to choose the selected meter.

5.3 Network mode



Network mode

In Network mode, the ▲ and ▼ keys allow to select the network parameter.



Network configuration submode

The following parameters are present:

Parameter	Type	Default/sample value
HTTP port	TCP port∗	80
HTTPS port	TCP port∗	443
SSH port	TCP port	22
SSH enabled	Yes/No	No
Syslog server	IP address	0.0.0.0 (none)
LAN protocol	Static/DHCP	Static
LAN IP	IP address	192.168.0.1
LAN netmask	Netmask	255.255.255.0
LAN gateway	IP address	0.0.0.0 (none)
LAN metric	integer	0
LAN DNS server	IP address∗	0.0.0.0 (none)
LAN MAC	MAC	7C:E1:FF:..:..:..
WiFi enabled	Yes/No	Yes
WiFi SSID	String	DLI....
WiFi mode	Access Point/Station	Access point
WiFi encryption	None/WPA/WPA2	WPA
WiFi key	Random string	...
WiFi channel	Channel number or auto	11
WiFi protocol	Static/DHCP	Static
WiFi IP	IP address	192.168.254.1
WiFi netmask	Netmask	255.255.255.0
WiFi gateway	IP address	0.0.0.0 (none)
WiFi metric	integer	0
WiFi DNS server	IP address∗	0.0.0.0 (none)
WiFi MAC	MAC	7C:E1:FF:..:..:..

Most values can be changed. Pressing the I button allows to change the parameter. The leading character of the first line, previously a whitespace , becomes an asterisk * to indicate that.

Different kinds of values are changed in different ways:

- for selectable options, like static/DHCP IP address mode, WiFi mode and encryption, the ▲ / ▼ keys cycle through the available options;
- for netmasks, the ▲ / ▼ keys decrease or increase the number of set bits in the mask;
- for IP and MAC addresses, a virtual cursor is used to allow modification of individual address bytes; the cursor is initially placed on the last byte, and can be advanced to the preceding byte by pressing ⟲ ; the ▲ / ▼ keys increase or decrease the current byte's value;
- for the WiFi pre-shared key, any of the ▲ , ▼ or ⟲ buttons generates a new key;
- the WiFi SSID can't be changed from keypad.

Options marked with a star (∗) correspond to configuration items which can have multiple values (including none) which can be set from the web UI. You can only can only set a single value from the keypad for these, and **. . .** is displayed on the LCD if the option doesn't have a single value. For IP addresses, 0.0.0.0 means 'none' (e.g. no default gateway, no syslog server, etc.).

Pressing I saves the current value and starts network reconfiguration if needed. The display isn't updated instantly, and you need to refresh it by pressing ▲ / ▼ . You can cancel editing at any time by pressing 0 .

6 Setup page

The setup page allows the administrator to configure the power controller. These settings are supported:

6.1 Controller and relay names

Unit Names		Confirm
Controller name	DLI Controller	
Outlet 1 name	Outlet 1	☐
Outlet 2 name	Outlet 2	☐
Outlet 3 name	Outlet 3	☐
Outlet 4 name	Outlet 4	☐
Outlet 5 name	Outlet 5	☐
Outlet 6 name	Outlet 6	☐
Outlet 7 name	Outlet 7	☐
Outlet 8 name	Outlet 8	☐

Submit

Controller and relay names

Use the controller name fields to assign a Controller Name to the power controller itself. Examples are "Server Rack Power Strip" or "Plutonium Refinery Control". The Controller Name field appears on the top of the home page. Assign a separate name to each relay, such as "Missile Launcher" or "Email Server" to make identification of each circuit simple.

You can use characters from the full Unicode character set; they'll be transliterated for display on the LCD if necessary.

6.2 Delays

Delay	
Wrong password lockout	60 minutes. (0-60)
ON sequence delay	3 seconds. (1-255)
Cycle delay	0 seconds. (1-255)
Brown-out re-latch delay	10 seconds. (1-255)
Refresh screen every	1 minutes. (1-255)
Enable screen refresh	☑

Submit

Delays

When a time value is entered in the "All ON sequence delay" field, the power controller will pause for a period of time before switching each relay on in sequence. This delay helps prevent the power surges and blown circuit breakers which can occur when multiple devices are switched on simultaneously. A delay of 60 seconds is suggested for server applications. You may also enter a screen refresh delay in this section. If "Enable screen refresh" is checked, and a delay value is entered, your browser should periodically update the status screen.

6.3 Power loss recovery modes

Power Loss Recovery Mode	
When recovering after power loss	◉Turn all Outlets off ○Turn all Outlets on ○Return to pre-powerloss state

Submit

Power loss recovery modes

The power loss recovery mode setting has three settings which take effect after a power failure:

1. You can turn all relays off (all systems will be switched off until manually turned on later) by checking the first box.
2. You can automatically turn all relays on using the "All ON sequence delay" described above. Check the second option to do this.
3. You can return to the same relay settings that were used prior to the power loss. The "All ON sequence delay" will also be used in this instance. Click the third option to return to pre-powerless state.

6.4 User-defined links

User Defined Links

#	URL	Description
1	http://www.digital-loggers.com/	Digital Loggers, Inc.
2	/src.tar.gz	Source code

Submit

User-defined links

You may link to other power controllers, your own web pages, or remote web sites by entering up to four URLs and descriptions in the Setup page. For example, enter "Site Two Power Controller" in the description field with a URL of "http://192.168.0.250/". These links appear on every page of the main web UI.

6.5 Network settings

General Network Settings

Hostname	power
Location	Rack #3
Contact	Joe Random <joe@random.example>
HTTP Port	80
HTTPS Port	443
Enable SSH Server	☑
SSH Port	22
Syslog Server	192.168.0.2
Syslog severity threshold	Debug
Same subnet access only	☑ **FROM 192.168.0.0-192.168.0.255 (wired), 192.168.254.0-192.168.254.255 (wireless) ONLY**
Allowed SSH public keys	

Submit

General network settings

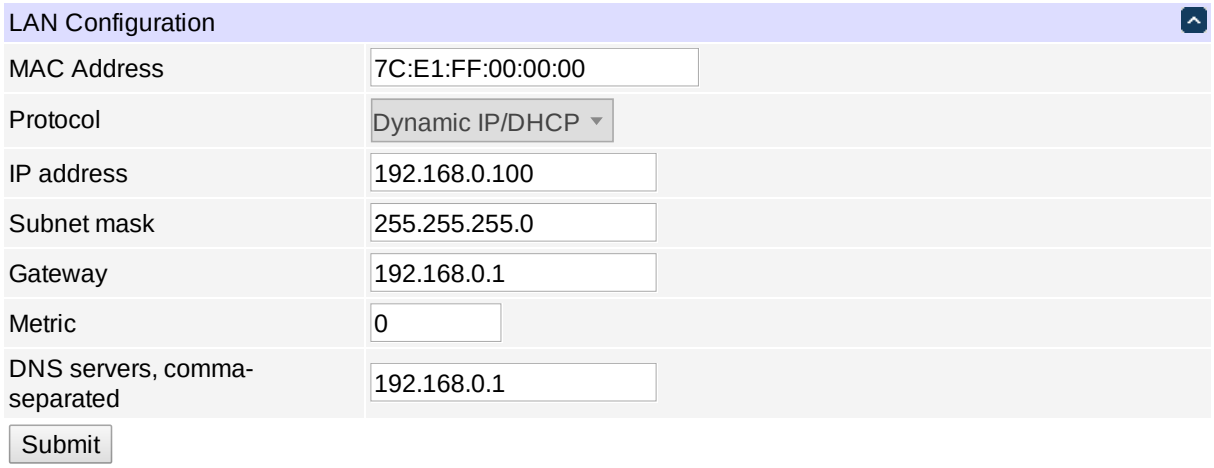
You can adjust the HTTP and HTTPS port bindings. If left empty, the corresponding service is not accessible. It may be a good idea to disable HTTP if HTTPS satisfies your needs. Disabling both for security is possible; you can use the LCD and keypad, or SSH to re-enable them if needed.

Enabling SSH will allow full control over the device, possibly bypassing most of the restrictions, e.g. setting protection. The SSH port is customizable as well. The SSH server also accepts public key authentication for a configurable set of keys (the format is the same as in the `authorized_keys` file).

You can limit the severity of the locally recorded log messages by setting a minimal severity. Note that the local log is circular, with old messages being replaced by newer ones; messages aren't persisted across reboots. For persistent storage, you can configure the unit to send the system log to a syslog server. All messages, regardless of severity, are sent; the receiver is expected to do the filtering.

Same subnet restriction can used to prevent remote access from outside. ONLY MACHINES IN THE SAME SUB↩NET WILL CONNECT AFTER ENABLING THIS. If connectivity is lost, use a local connection such as a laptop with a crossover cable to restore your original network settings; you can also use the LCD and keypad for that.

6.5.1 Wired network settings



Wired network settings

The device MAC address is provided for reference only and cannot be changed in this form. If you need to change the MAC address, you may do so via LCD+keypad, SSH or using the REST-like API. Be sure you know what you're doing, as e.g. assigning a conflicting MAC address, or a broadcast MAC address will make an interface unusable.

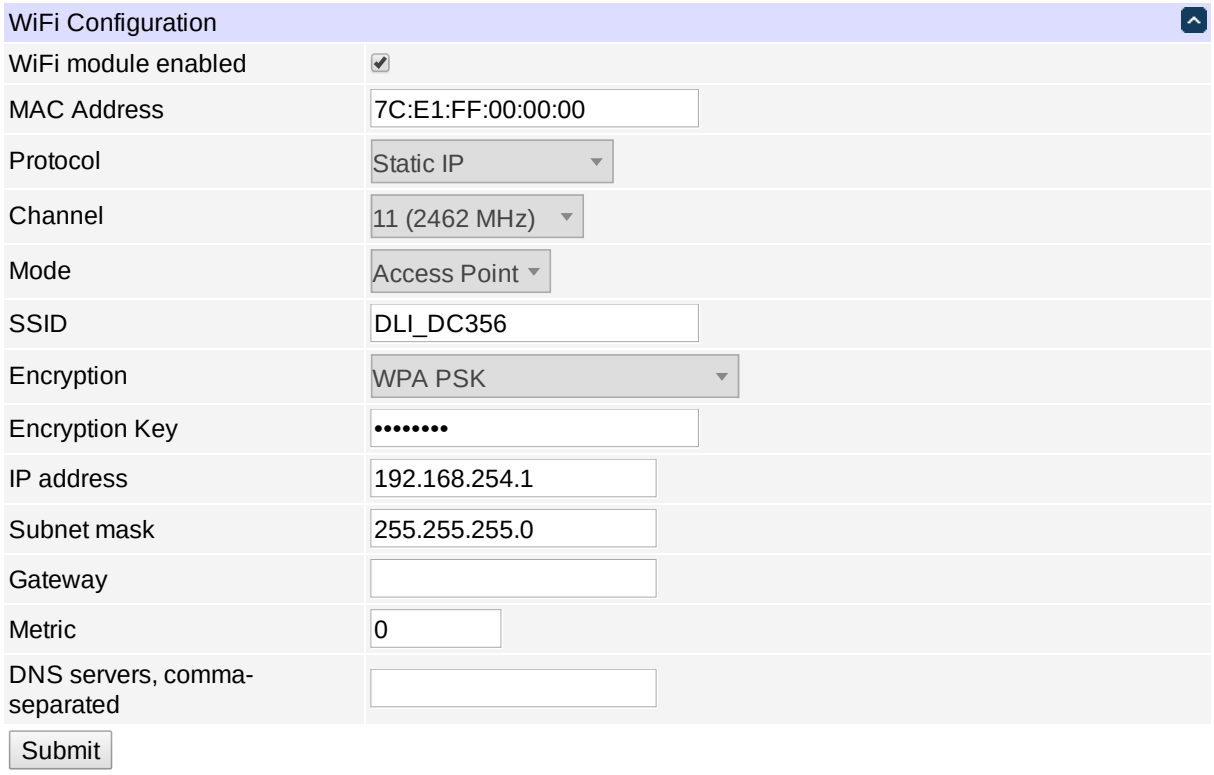
To configure the unit to use static IP assignment, a fixed IP address and network mask must be entered. If a default gateway is specified it must be on the same subnet as the IP address specified. A number of DNS server IP addresses can be supplied separated by commas, e.g. `192.168.0.1,8.8.8.8`. If DNS servers are available, some other configuration variables can accept hostnames instead of IP addresses.

If you wish to configure the unit to use DHCP IP assignment, you needn't change the IP, network mask, default gateway and DNS servers; rather, after the unit obtains a DHCP lease, the parameters will be displayed for reference.

It is recommended to configure the DHCP server to provide a static lease for the DC3 using its MAC address (also displayed).

When changing IP addresses, you may need to restart the unit and your network switch to validate the new IP on an "auto-configuring" switch port.

6.5.2 Wireless network settings



Wireless network settings

The wireless network adapter has settings similar to those of the wired network adapter (see above), and adds WiFi-specific ones. This configuration section will not be shown if wireless support is absent.

It's possible to disable the wireless module entirely by unchecking the "WiFi module enabled" checkbox. The wireless MAC address is configured to match the wired MAC address as the adapters will never be on the same subnet in a regular setup. Use LCD+keypad, SSH access or the REST-like API if you need to change that.

The WiFi module can operate either in Access Point ("server") or Station ("client") mode. Either way, the name of the wireless network to create/connect to must be specified as the SSID.

If the unit is configured to be an Access Point and have a static IP assignment, it starts a DHCP server on the wireless interface.

It is possible to use no encryption on the WiFi channel, or one of the WPA, WPA2 or WPA/WPA2 mixed mode with pre-shared key (the key has to be entered then). WEP encryption is considered insecure and is not supported. Other encryption modes are not supported.

6.5.3 Network settings protection

You may press the "protect" button to lock the network settings (this will also affect the external API settings). Once locked, the network settings cannot be changed except by pressing the physical reset button on the front of the unit.

6.6 Access control

The administrator's username and password can (and should) be changed from the default values. Note that you need to provide the current password for confirmation.

Administrator credentials

Administrator login	admin
Old administrator password	
New administrator password	
Confirm new administrator password	

Submit Protect

Administrator credentials

In addition to the administrator, any number of users with individual passwords and relay permissions may be configured on the setup page. Only the administrator can edit user names and passwords (users can only inspect and switch relays).

Access control:

User Name	Password	Controlled Outlets								Apply
		1	2	3	4	5	6	7	8	
tom	•••••••	☐	☑	☐	☑	☐	☐	☐	☐	Change
dick		☑	☐	☐	☐	☐	☐	☑	☐	Change
harry	•••••••••	☐	☐	☐	☑	☐	☐	☑	☑	Change
		☐	☐	☐	☐	☐	☐	☐	☐	Change

User access control

Checkboxes to the right of each user name relay control access privileges. Users can only see and interact with the chosen relays. For example, user 'harry' would see the following on login:

#	Name	State	OFF / ON	CYCLE
1	Outlet 4	OFF	Switch ON	
2	Outlet 7	OFF	Switch ON	
3	Outlet 8	OFF	Switch ON	
Logout			Help	3 sec.

User relay control screen

Individual relays can be manipulated as usual. The top links allow switching all accessible relays on, off or cycling them.

Notice the relay numbering difference for non-administrative users vs the previous generations of EPCR/LPC controllers. In DC3, non-administrative users see all outlets accessible to them numbered consecutively starting from 1; previously the indices used to match those seen by the administrator. Naive relay state manipulation links like `http://192.168.0.100/outlet?3=ON` will work differently depending on the user you're logged in as; however, certain use cases may benefit from this change. Consider using the REST-like API if you need consistent relay manipulation.

The next group is comprised of miscellaneous settings for access control.

Access settings

If you need to access the controller with clients supporting Basic authentication, or by browsers without JavaScript, you may need to enable the "Allow legacy plaintext login methods" setting. Those methods transmit passwords over the network and are thus considered insecure. This includes Basic authentication over HTTPS, which is secure relative to Basic authentication over HTTP, but relies solely on TLS for security, which is considered risky by some experts. DLI Ethernet Sender should not require this setting.

If you need to configure relays or run scripts on the controller via links or use browsers without JavaScript, you may need to enable the "Allow legacy state-changing GET requests" setting. This allows configuring the controller by following links, but is insecure as you or your browser can be tricked into following such a link. This setting is on by default for compatibility, but is deprecated, and its use is discouraged; it will become disabled by default in future firmware versions, and you're encouraged to disable it manually. Links defined in the Links section will be rewritten on the fly to not require this setting if JavaScript is enabled.

The "Hide user passwords" and "Hide WiFi password" settings configure whether clients should be able to read back the relevant values; this may be a security issue if there are untrusted administrator users.

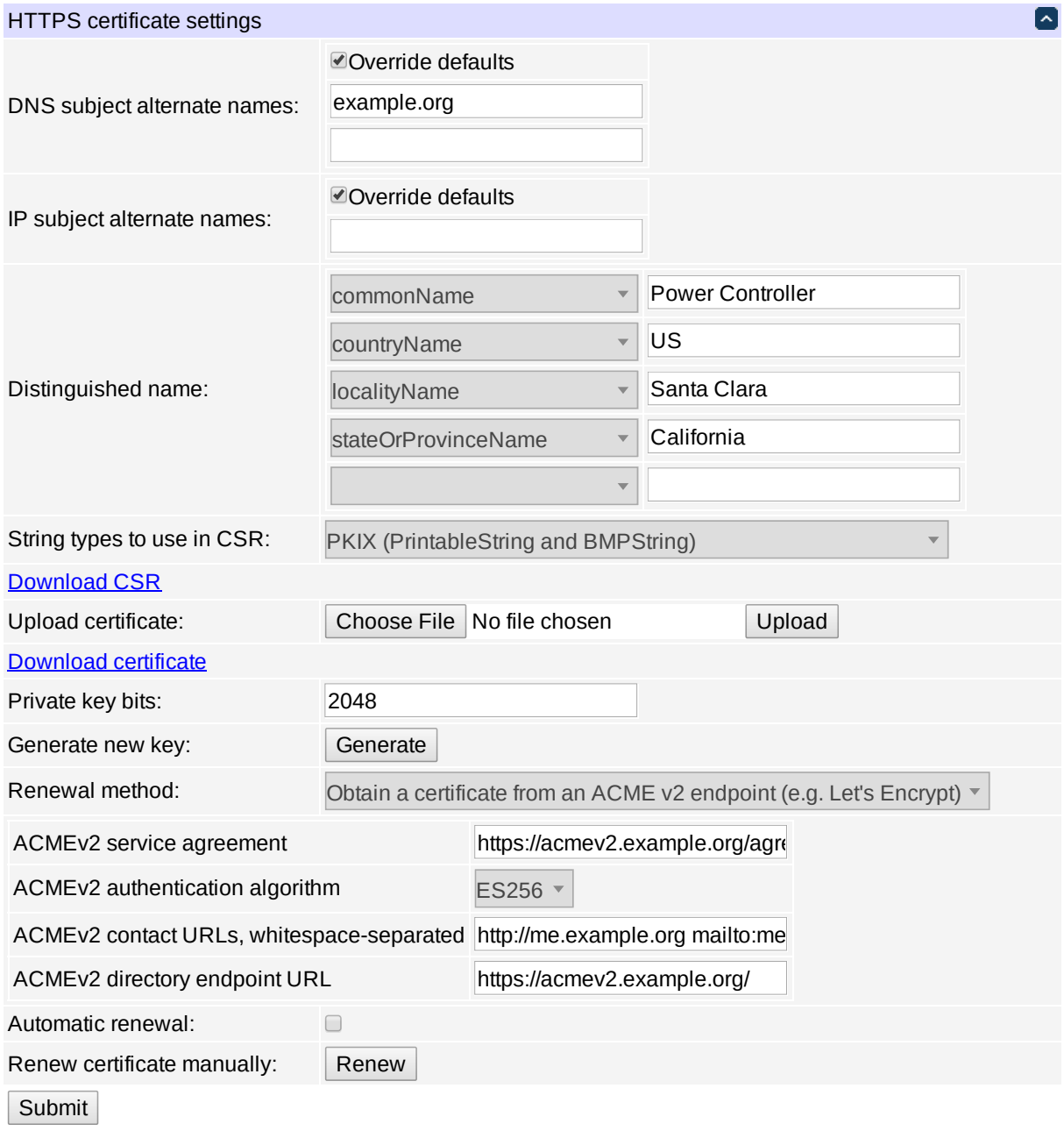
The "Disable local keypad" setting is designed for untrusted physical environments. When enabled, the LCD will briefly indicate that the keypad is disabled on each keypress and otherwise ignore it.

Note that this still leaves the reset button available to an attacker.

The "Show device name on login page" setting can be used to control if unauthenticated users can see the device name (it used to be controllable by a space character preceding the device name in previous controller models, but is now an individual setting). This may be a convenience, but also a possible security issue.

6.7 HTTPS certificate generation and renewal

HTTPS clients rely on certificates to ensure the server's identity. Operating as an HTTPS server, the DC3 is capable of generating self-signed certificates or obtaining certificates from third parties, such as certificate authorities (CAs).



HTTPS certificate settings

Identity of the server is protected by a private key, which must be kept secret. DC3 currently supports RSA private keys only; the number of bits can be configured. A key is generated by default; you can create a new one by pressing the "Generate" button. Note that this may take some time.

Whenever you generate a new key, a matching certificate needs to be issued in order for clients to trust the unit. If automatic enrollment is configured (see below), key regeneration triggers it as well.

Unlike the key, a certificate is public, not secret, and assures that its holder indeed is the entity it claims to be as long as the client trusts the certificate's issuer. To configure what your DC3 claims to be, the following certificate signing request (CSR) fields need to be filled:

- DNS and IP subject alternate names are used by browsers to check HTTPS server identity; if left at defaults ("Override defaults" not checked), the system domain name and the currently configured IP addresses are used, respectively; in many cases, e.g when using port forwarding, this isn't what you want; public CAs will not issue, and most browsers will not trust, certificates issued for private (e.g. RFC1918) IP addresses;
- Additional distinguished name elements can be configured; these can be seen by a browser's user.

Due to historical reasons, strings in certificates can be encoded in various ways; this can also be configured here.

If you rely on a CA to issue your certificates, refer to that CA's documentation on what distinguished name elements are permitted (or even mandatory) and what string type set to use.

To manually generate a certificate, use the "Download CSR" link and transfer the downloaded file to your CA; once the CA issues you a certificate, you should select and upload it using the "Upload certificate" form. The file to upload must be a PEM-formatted file containing the full certificate chain; in case your CA provides you a single-certificate file, you need to convert it to the PEM format and prepend the CA's certificate chain to it.

Note that the CSR you transfer contains only public, not secret, information; the private key need never leave the unit.

For convenience, a link to download a previously uploaded or automatically generated certificate is present as well.

If "Automated renewal" is selected, certificate renewal will be triggered when the certificate is close to expiry.

If you perform CSR signing manually, be sure to switch automated renewal off as it will cause (e.g. generation of a self-signed certificate) once the certificate you have uploaded is close to expiry, which is likely not what you want.

The following automated certificate generation or renewal methods are supported:

6.7.1 Generating a self-signed certificate

Generating a self-signed certificate is always possible and is a viable option if you can persuade clients (e.g. browsers) to trust the certificate generated this way. This method does not rely on any Internet connectivity and is totally self-sufficient; however, such certificates will not be trusted by browsers by default.

The only configurable parameter is the number of days to issue the certificate for.

6.7.2 ACME certificate enrollment

ACMEv2 (Automatic Certificate Management Environment, RFC 8555) is a way of obtaining a certificate from a CA that includes proving that you indeed own the domain names or IP addresses you claim to own; those names and addresses must be public to allow the CA to perform the validation. This method is supported by a number of CAs including Let's Encrypt, Buypass, ZeroSSL and others.

The current implementation only supports the http-01 challenge, so the DC3 (or the network it is on) needs to be configured so that HTTP requests to the names and addresses specified and port 80 are routed to the unit's HTTP port. Additionally, external account binding, which is required by some CAs, is not yet supported.

To use this method, you need to configure the ACMEv2 directory endpoint and the service agreement URLs, which should be provided by the CA. Providing the service agreement URL is considered to be accepting it; that URL is also available via the directory, so if the CA changes its service agreement and the URL no longer matches, DC3 will not perform enrollment of new certificates. You should supply your own contact URLs as a whitespace-separated list for the CA admin to contact you in case of problems. The default ACMEv2 authentication algorithm, as well as the one mandated to be supported by all CAs, is ES256; the digits indicate the SHA$*$ digest function choice; ES$*$ algorithms use NIST prime elliptic curve keys of appropriate sizes, and RS$*$ algorithms use RSA keys of appropriate sizes. Note that initial generation of the authentication key, distinct from the certificate key, may take some time, especially for the RSA variants.

The system log is useful in diagnosing automated certificate generation issues; in particular, it may include messages from ACME CA indicating that the subject alternate names or distinguished name elements you have configured are unsuitable, or the private key you're using is too weak (you'll need to increase the number of bits and regenerate the key then).

ACMEv1 certificate enrollment method is an older, deprecated variant of ACME which is no longer supported for new domains by any known provider.

6.7.3 EST certificate enrollment

EST (Enrollment over Secure Transport, RFC 7030), successor of SCEP, is a simpler method of obtaining a certificate than ACME that only requires proving your identity, from which the EST server can supposedly deduce what domains or IP addresses you can claim. It is useful in environments where a pre-established trust relationship is present, such as a company's local network.

To configure this method, you need to supply the EST server base URL, which must be a HTTPS one, set the credentials and the authentication method to use.

6.8 Miscellaneous settings

The following setting group controls aspects of data presentation of the unit.

Miscellaneous settings

You can force all the text displayed on the LCD to be in CAPS, which may be more legible. However, this won't affect the network settings, as they include the WiFi password which would be useless if capitalized.

You can specify the preferred image format for plots and meters. PNG is the default, as it's supported by most browsers, but SVG can provide a much cleaner result on recent ones.

7 Scripting

On its own, a power switch isn't very smart. Programmers can easily add custom functionality by using the built-in Lua-based scripting language in power controllers.

7.1 Hardware requirements

Lua-based scripting is available in all DC3 controllers. Beeper, backlight, LCD, voltage and current monitoring functions are limited to products with appropriate hardware installed.

7.2 Configuration

The scripting server has the following configurable parameters:

Scripting settings	
Script step delay	1 seconds.
User message force display timeout	0 seconds.
User message timeout	seconds.
Start on reboot at	[Disabled]
Call reboot handler on warm boot and service restart	☑
Trace script	☐

Submit

User script configuration

- Script step delay — the time in seconds to wait after execution of a legacy API function (e.g. ON, OFF, see below). Modern API functions (see below) don't have internal delays unless documented; the `delay()` function should be used there.
- User message timeout — the time in seconds after which user messages (displayed e.g. with the DISPLAY command) disappear even if no keys are pressed on the LCD and no changes have been made to the relay state (leave empty to have the messages displayed indefinitely).
- User message force display timeout — the time in seconds during which user messages are displayed even despite keys being pressed on the LCD or changes to the relay state (leave empty to have the messages forcefully displayed indefinitely).
- Start on reboot at — the scripting function to start at startup.
- Handle warm boots and service restarts — call the reboot handler scripting function not only on cold boot, but additionally on warm boot and service restart, and pass it an argument specifying the event it is handling (one of "cold_boot", "warm_boot" or "restart").
- Trace script — enable diagnostic output about script progress to system log.

7.3 Entering scripts

First, for a quick overview of the script language visit the sample scripts page on the Digital Loggers web site. Log in as admin and use the Scripting link to access the programming page.

Scripting is based on the Lua programming language. A brief introduction is done below, but you may want to consult the general description, especially if you intend to write more complex scripts.

Script code is organized in functions. Configuration items which allow some scripting reaction to an event (reboot, AutoPing failure, etc.) will ask you for the name of the function to call (you will be offered a list of the functions defined in the script).

Script listing

```
--[[ Power controller user script code.

The scripting implementation has changed, and is no longer compatible
with the older BASIC implementation. The most important changes are:

- Now Lua-based.
- No more line numbers, blocks of code identified by functions.
- Most of ON, OFF, etc. are kept as legacy functions, which can be called like
e.g  ON(2345), ON("2345") or ON "2345", your choice.

Execution is still based on threads. Now threads are more visible and
manageable. Try starting some and you'll see them appearing in the
list.

Scripting samples are now available as snippets (below), separate from
the main script code. You can copy/paste them from/to the main script.

Stock snippets have names starting with 'default.'; changing or
creating snippets with such names is not recommended as your changes
may be erased on an upgrade.

]]--

```

Save

User script source editor

You will need to define your functions to be able to use scripting. Simply putting calls to existing functions in the script will not work. Functions are defined like this:

```
function my_function()
    ... statements go here ...
end
```

All functions defined this way will be usable from the web UI and callable externally. If you want to define a function for internal use, not to be called from outside, prefix it with `local`:

```
local function my_internal_function()
    ... statements go here ...
end
```

Local functions declared this way must be placed before any function that uses it. If you want to move the definition elsewhere and don't need to call the function before the definition, you can use the following structure:

```
local my_internal_function

... functions that use my_internal_function in bodies ...

function my_internal_function()
    ... statements go here ...
end
```

This works as long as all calls to `my_internal_function` occur in other functions not immediately executed. `my_internal_function` is still local (not visible externally). This works because a function is just another type of value, and `function fn()...end` is just like `fn=function()... end`, so it works the same way as

```
local x
...
x=5
```

Here, `x` has the value `nil` until it's assigned the value `5`. Similarly, `local function x()... end` is just like `local x; x=function()... end`.

Functions in Lua are called with their arguments parenthesized, e.g. `func(arg1,arg2)`. Functions with no arguments are called with empty parentheses, like `func()`. However, according to Lua syntax, a single string function argument doesn't need parentheses, thus allowing the BASIC-like commands to avoid them if there's only one argument.

You can also create functions with arbitrary names (including Unicode) like this:

```
_G["Turn on lamp"]=function()
    ... statements go here ...
end
```

All the above declarations are essentially assignments to (global and local) variables. Therefore, if multiple scripts functions have the same name, the one closest to the bottom will effectively mask preceding ones.

When you're prompted for a script function to choose, choices will appear in the order they're specified in the script source. If you wish to change that, you can define a global `ui_order` table with a list of quoted function names to appear at the top of the list, in the desired order (others will be at the bottom of the list in alphabetical order). E.g.

```
ui_order={"important_function","frequently_useful_function"}
```

Most APIs listed below are only available when used inside functions, not in the global context. That is, attempts to write e.g.

```
ON(1)
```

without an enclosing function will fail (such actions cannot be taken at script load time).

7.4 Snippets

Snippets are script fragments not part of the main script, stored for later use or shipped with the device.

User script snippet editor

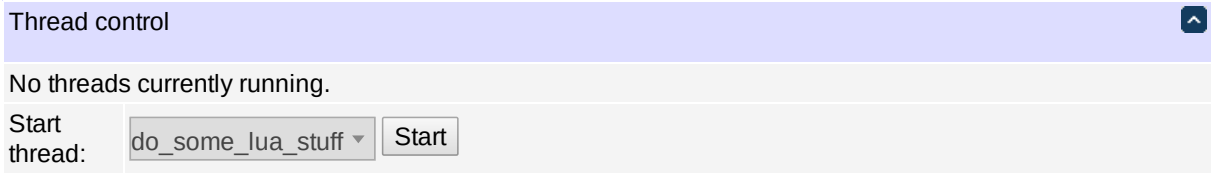
The snippet name selector can be used to choose an existing snippet, or to enter a new name, e.g. to create a new snippet or save the current snippet under a different name. Use the "Load" button to load the snippet with the selected name in the snippet editor. Use the "Save" button to save the currently edited snippet under the selected name. The "Remove" button can be used to erase the selected snippet.

Snippet code can be copied/pasted from/to the main script code. It is not subject to syntax or other checks so it's OK to place incomplete code fragments there.

Snippet names starting with 'default.' are reserved for snippets shipped with the device. It is not recommended to change or create snippets with such names because your changes may be erased on an upgrade.

7.5 Threading

Multiple threads of execution can be running at the same time. Any number of threads may run concurrently.



User script thread list

Threads can be started from the web UI, via an HTTP request, by an AutoPing trigger, or from other threads using `thread.run`. They can be explicitly stopped using the web UI or by calling `thread.kill` or `thread.killall` from the script, or implicitly by calling `thread.limit`.

Every thread has an 'origin', which is usually a string identifying the function that started the thread. For instance, when you create a function like this:

```
function my_function()
    ... statements go here ...
end
```

and then start it with the web UI, its origin is the `"my_function"` string. Threads created by other threads inherit their parent's origin, which can be useful when stopping a group of threads.

7.6 API levels

The scripting engine presents two sets of functions that you can use to write scripts:

- Legacy functions — functions which are designed to resemble the BASIC commands of the previous generations of EPCR/LPC controllers;
- Modern API — functions and objects which are designed to be easier to use.

You can use and even freely mix them as you wish, but only the modern API will receive further development attention. Some features are exposed only via the modern API because they had no corresponding legacy commands.

7.6.1 Legacy functions

Legacy functions (written in CAPS) are executed in sequence with a "step delay" after them. The legacy functions are designed so as to resemble the BASIC commands of the previous generations of EPCR/LPC controllers while remaining compatible with the Lua language.

Arguments to the legacy functions can be written as e.g. `ON(12345678)`, `ON "12345678"` or `ON("12345678")`.

The supported legacy functions are:

- `ON`, `OFF`, `CYCLE`, `RESTORE` — perform the action on a list of relays by numbers (as a number or a string);
- `BEEP(ON)` or `BEEP(on)` or `BEEP(true)` — turn beeper on;
- `BEEP(OFF)` or `BEEP(off)` or `BEEP(false)` or `BEEP(0)` — turn beeper off;
- `BEEP(number>0)` — turn beeper on for the specified number of seconds, then off;
- `SLEEP(number[,"unit"])` — suspend execution for the given amount of time (units default to "seconds", but can be "seconds", "minutes", "hours" or "days"; abbreviations like "sec", "h", "d" are also accepted);
- `WAIT "cron time mask"` or `WAIT(minute_mask,hour_mask,day_mask,month_mask,weekday_mask)` — wait for the local time to match the condition (each separate mask element must be a number or `"*"`, and a `"cron time mask"` must be a string of 5 such elements separated by whitespace);
- `LOG "String"` — write a message to the system log
- `DISPLAY "String"` — display a string on the LCD when it's in relay mode. The following strings are expanded:
  - `%%` — literal "%";
  - `%o` — state of relays, in the form "12456" (ON relays are listed);
  - `%O` — state of relays, in the form "++-+++--";
  - `%n` — serial number;
  - `%f` — firmware version;
  - `%d` — system time/date;
  - `%M` — MAC address of the power controller;
  - `%i` — IP address of the power controller;
  - `%m` — IP network mask;
  - `%g` — IP gateway;
  - `\1` — move cursor to the beginning of line 1;
  - `\2` — move cursor to the beginning of line 2;
  - `\f` — clear screen;
  - `\v` — clear end of current line;
- `WOL "MAC address"` — attempt to wake device with specified MAC address up using Wake-on-LAN protocol (the device has to be in the same LAN segment);
- `TIME "server"` — synchronize time with server specified by IP address or hostname in quotes; you can use `TIME()` without arguments to synchronize with "pool.ntp.org" if the DNS is configured correctly.

You still need to enclose the function contents in a `function name() ... end` as explained above.

7.6.2 Modern API

Modern API allows more object-oriented approach to scripting. You need to explicitly use the `delay()` function if you use the modern API and need a delay. Note that the relay power-on sequence delay applies anyway.

Lua objects can have fields (data contained in the object) and methods (functions which affect the object's state). Object fields are accessed with a dot `.`, like `meter.reading`. However, different object implementations in Lua may use the colon `:` or the dot `.` to access the object's methods (`outlet:cycle()` or `outlet.cycle()`). In the modern API, all objects use the dot `.` to access their methods, to prevent confusion.

Modern API objects and functions are grouped into several categories for convenience.

7.6.2.1 Core Lua functions

To make scripting safer, only a limited subset of Lua features is supported by sandboxing. The following Lua standard library features are supported:

Globals: `_VERSION`, `assert`, `error`, `next`, `ipairs`, `pairs`, `pcall`, `xpcall`, `select`, `tonumber`, `tostring`, `type`, `unpack`.

`string` library: `string.byte`, `string.char`, `string.find`, `string.format`, `string.gmatch`, `string.gsub`, `string.len`, `string.lower`, `string.match`, `string.rep`, `string.reverse`, `string.sub`, `string.upper`.

`table` library: `table.insert`, `table.concat`, `table.maxn`, `table.remove`, `table.sort`.

`math` library: `math.abs`, `math.acos`, `math.asin`, `math.atan`, `math.atan2`, `math.ceil`, `math.cos`, `math.cosh`, `math.deg`, `math.exp`, `math.floor`, `math.fmod`, `math.frexp`, `math.huge`, `math.ldexp`, `math.log`, `math.log10`, `math.max`, `math.min`, `math.modf`, `math.pi`, `math.pow`, `math.rad`, `math.random`, `math.sin`, `math.sinh`, `math.sqrt`, `math.tan`, `math.tanh`.

`os` library: `os.clock`, `os.difftime`, `os.date`, `os.time`.

Additionally, `_G` points to the sandbox environment.

Unlike most APIs, core Lua functions are available in the global context.

7.6.2.2 Delay functions

The `delay` function accepts the number of seconds to wait as an argument (it is assumed to be the script step delay if not specified). Only a single script thread is active at any given time; switching to a different thread is not performed until you call delay() (or other function possibly introducing a delay). If a scripting thread doesn't call `delay()` or one of the legacy API functions every now and then, it can't be terminated by `thread.kill` and will eventually be shut down by the runtime.

The `wait_until` function can be used to wait for an arbitrary number of conditions on local time. It may have any number of arguments, each named a condition. It waits for one of the conditions to be satisfied, and returns its 1-based index. If several conditions would be satisfied simultaneously, the first match wins.

A condition is a table which may (but does not have to) contain any set of the following keys:

- `year`, which stands for the year;
- `month`, which stands for month (1 is January);
- `day`, which stands for day of month;

- `wday`, which stands for day of the week (1 is Sunday, 2 is Monday, 7 is Saturday);
- `yday`, which stands for day of the year (1 is January, 1st);
- `hour`, which stands for hours;
- `min`, which stands for minutes;
- `sec`, which stands for seconds;
- `isdst`, which stands for the daylight savings time flag (true or false).

The values corresponding to the keys are the actual restrictions, all of which must be met in order for the condition to be satisfied. A simple value (i.e. a number for anything but the DST flag, and true/false for the DST flag) matches only itself. A function (receiving the field's value as argument) matches anything for which it returns true.

Here are some examples of conditions that can be used:

```
{hour=0,min=0,sec=0} -- matches at midnight;
{hour=7} -- matches anywhere between 7:00:00 and 7:59:59;
{wday=function(d) return d==1 or d==7 end} -- matches weekends.
```

It is not advised to perform exact matches on seconds since delays of internal operations may be greater than 1 second. It is advised to introduce additional delays to avoid triggering the same match again. The following sample switches relay 1 on at 8:00 and off at 17:00.

```
while true do
    local event=wait_until({hour=8,min=0},{hour=17,min=0})
    if event==1 then
        ON(1)
    else -- event==2
        OFF(1)
    end
    delay (120)
end
```

We match with minute precision here and wait for 2 minutes to avoid double matching.

7.6.2.3 Relay management

The global variable `outlet` represents a Lua array of relay objects.

- `outlet[N].on()`: switches the relay on (affects transient state);
- `outlet[N].off()`: switches the relay off (affects transient state);
- `outlet[N].cycle()`: cycles the relay (affects transient state);
- `outlet[N].name`: string representing the name of the relay;
- `outlet[N].persistent_state`: boolean representing the persistent requested state of the relay (writes will affect transient state as well);
- `outlet[N].transient_state`: boolean representing the transient requested state of the relay;
- `outlet[N].physical_state`: read-only boolean representing the physical state of the relay;
- `outlet[N].state`: boolean reflecting outlet physical state when read, modifying transient state when written;
- `outlet[N].locked`: read-only boolean indicating if the relay is locked.

The variable name is chosen to match AC products.

Global constants `on` and `off` are `true` and `false`, respectively, useful to make scripts more readable, like `outlet[1].state=on`;

7.6.2.4 Thread management

Several threads can be executed simultaneously in a pseudo-parallel fashion. The global `thread` table contains these methods:

- `thread.run` can be used to start new threads; it accepts the thread function as argument, and returns the identifier of the resulting thread; it can accept a second string parameter to act as a description of the thread running and a third string parameter to redefine the thread origin, which may be useful for `thread.killall` and `thread.limit`;
- `thread.kill` can be used to stop a thread; it accepts the identifier of the thread as an argument;
- `thread.killall` can be used to stop many threads; it accepts the origin of the threads to kill as an argument (without an argument, all threads are killed, including the calling one);
- `thread.limit` allows to ensure that no more than the specified number of threads with the same origin are present; its first argument is the maximum number of threads, and the second one is one of the strings `"this"`, `"earliest"` or `"latest"`, indicating which thread(s) should be killed if their count is above the limit (it's possible to specify an array of values, like `{"this","latest"}`, instead).

7.6.2.5 User interface

The global `ui` table provides means of configuring the LCD display, backlight and beeper.

Functions `ui.beep` and `ui.blink` configure the beeper and LCD backlight, respectively. Their first argument should be a string of `"1"`s and `"0"`s, which specifies the pattern, and their second argument should be the number of seconds after which the preceding behaviour is restored.

The `ui.line` table has two elements `ui.line[1]` and `ui.line[2]`, specifying the custom displayed strings for the LCD rows (or nil for regular operation of said row). This offers more fine-grained control than the `DISPLAY` command above.

As follows from the above, the number of LCD rows is `# ui.line`. Use `ui.column_count` to retrieve the number of LCD columns (usually 16).

7.6.2.6 Configuration access

The global variable `config` represents a partial read-only view on the unit configuration (most of them strings):

- `config.serial`: unit serial number;
- `config.hostname`: unit hostname;
- `config.contact`: primary unit contact;
- `config.contacts`: a table storing contacts related to the unit in different ways;
- `config.location`: physical location of the unit;
- `config.timezone`: system time zone;
- `config.hardware_id`: unit hardware model;
- `config.oid`: object identifier of unit model;
- `config.version`: firmware version;
- `config.outlet_label`: kind of endpoint manipulated by the unit (Outlet/Relay).

7.6.2.7 Transient state management

Local and global variables of scripts are shared between threads created in a single script environment but are in general separate between separately loaded script environments. In the example below, if you create several threads using `thread_creator`, they will all reference the same instances of `local_var` and `global_var`:

```
local local_var=0
global_var=0

function thread_fn()
  while true do
    ...
    local_var=local_var+1
    global_var=global_var+1
    ...
  end
end

function thread_creator()
  for i=1,10 do
    thread.run(thread_fn)
  end
end
```

Even if you run `thread_creator` several times (e.g. from the web UI) without changing source code, all of the threads will share both `local_var` and `global_var`.

However, if you change the code and launch `thread_creator` again, new instances of `local_var` and `global_var` will be created; the 10 new threads will be completely separate from the old threads.

This makes handling global functions and variables consistent (e.g. if you don't have a global variable in the script, you won't accidentally trip over it if it was there in a script you loaded several edit iterations earlier), but this default behaviour may or may not be what you want.

To store arbitrary data between script edits, you can create entries in the global `sticky` table, like this:

```
sticky["variable"]="some value to save between script edits"
```

As usual in Lua, for identifier-like keys you can alternatively use the dot syntax:

```
sticky.variable="some value to save between script edits"
```

The above example then becomes:

```
function init_sticky()
  sticky.local_var=0
  sticky.global_var=0
end

function thread_fn()
  while true do
    ...
    sticky.local_var=sticky.local_var+1
    sticky.global_var=sticky.global_var+1
    ...
  end
end

function thread_creator()
  for i=1,10 do
    thread.run(thread_fn)
  end
end
```

If you overwrite the whole `sticky` table like this:

```
function init_sticky()
  sticky={local_var=0,global_var=0}
end
```

the changes will only apply from that environment on (threads started in previous environments will be unaffected).

In both cases you'll need to call `init_sticky` once explicitly before calling `thread_creator`, which might be inconvenient. Alternatives include setting default values, if they are not nil, on entry to functions that use the values:

```
function thread_fn()
  sticky.local_var=sticky.local_var or 0
  sticky.global_var=sticky.global_var or 0
  while true do
    ...
    sticky.local_var=sticky.local_var+1
    sticky.global_var=sticky.global_var+1
    ...
  end
end
```

or writing code that it handles default nil values transparently:

```
function thread_fn()
  while true do
    ...
    sticky.local_var=(sticky.local_var or 0)+1
    sticky.global_var=(sticky.global_var or 0)+1
    ...
  end
end
```

Variables created this way are not persisted across reboots; see below for those that are.

7.6.2.8 Externally accessible state management

Local and global variables of scripts are in general not accessible from outside the scripting engine, e.g. they cannot be manipulated from the REST-like API.

You can create entries in the global `external` table, like this:

```
external["variable"]="some value"
external["variable2"]=12345
```

and have them accessible under `/restapi/script/variables/`variablename`/`.

You can only store strings, numbers, booleans or nil into this table at nonempty string indices. Attempts to use nonstring keys, or table or function values, or overwrite the `external` table, will result in an error:

```
external={}          -- error
external["x"]=outlet -- error
external[5]=external -- error
```

The `external` table otherwise behaves like `sticky`; in particular, variables created this way are not persisted across reboots; see below for those that are.

7.6.2.9 Persistent state management

User scripts can read and write state variables which persist across power cycles. This is done by modifying the global `persistent` table. For example, the following `log_boot_count` function, if configured to be started at cold boot, can report the current cold boot number (and the `ordinal` function is a convenience for printing strings like "1st", "2nd", "3rd", etc.).

```
local special_suffixes,ordinal

function log_boot_count()
  local boot_count=persistent.boot_count or 0
  boot_count=boot_count+1
  persistent.boot_count=boot_count
  LOG("This is my "..ordinal(boot_count).." power cycle")
end

special_suffixes={"st","nd","rd"}

function ordinal(number)
  local d=number%100
  return tostring(number)..((d<11 or d>19) and special_suffixes[d%10] or "th")
end
```

Here, the "boot_count" key is used to store the number of boots. Like with ordinary Lua tables, nonexistent keys have nil values; to remove a key from `persistent`, write nil to it.

Only strings can be used as keys of `persistent`. Only numbers, strings and booleans can be stored (or nil can be written to erase a value). Some of these limitations may be raised in future.

All keys of `persistent` can be enumerated if necessary using `pairs()`.

7.6.2.10 Meter access

The global `meter` table allows to read the following measured values :

- `meter.values`: a table storing properties of different values measured by meters.

Keys of `meter.values` are unique human-readable but possibly platform-specific identifiers (e.g. `power_voltage`), and values are tables with the following form:

- `meter.values[key].name`: human-readable name of the measured value;
- `meter.values[key].quantity`: kind of the physical quantity of the value (e.g. "current", "voltage", etc.);
- `meter.values[key].value`: number representing the current value measured by the meter in standard units;
- `meter.values[key].custom`: boolean indicating if the value is custom (user-defined);
- `meter.values[key].bus`: always nil for DC3;
- `meter.values[key].internal`: boolean indicating if the value is internal (and should not appear in the web UI);
- `meter.values[key].get_history`: function which can be called to obtain historical data points.

The `get_history()` function must be called like this: `get_history(desired_start_time, desired_end_time, desired_step)`. The `desired_start_time` is the timestamp of the start of the desired interval (in seconds since the epoch, 1970-01-01T00:00:00Z). Similarly, `desired_end_time` is the desired end time. `desired_step` is the desired step between adjacent time points. Resulting data may not match the requirements exactly, but will be generated so that it overlaps the desired time range and has the closest time step. The function returns a table with 3 elements `{actual_start, actual_step, data}` (note that it doesn't return 3 values, which is possible for Lua functions, but a single table containing them). `actual_start` is the timestamp of the start of the output interval, `actual_step` is the step between adjacent time points, and `data` is a table whose `i`th element is the (averaged) value of the meter around time `actual_start+(i-1)*actual_step` (mind that indices in Lua are 1-based) or `false` if no reading was obtained within that time interval (e.g. if the device was offline).

Its use is best illustrated by an example. Suppose `temperature` is a value of the form:

```
local temperature=meter.values[...]
```

Then the following script could be used for obtaining bounds for the 5-minute-average temperature for the last 24 hours:

```
local now=os.time()
local history_data=temperature.get_history(now-86400,now,300)
local start,step,data=unpack(history_data)
-- or local start,step,data=history_data[1],history_data[2],history_data[3]
local mintime,mintemp,maxtime,maxtemp
for pos,temp in ipairs(data) do
  if temp then
    local time=start+(pos-1)*step
    if mintemp==nil or mintemp>temp then
      mintemp=temp
      mintime=time
    end
    if maxtemp==nil or maxtemp<temp then
      maxtemp=temp
      maxtime=time
    end
  end
end
if mintime then
  LOG(string.format("Min temperature was %gK at %s",mintemp,os.date("%H:%M:%S",mintime)))
  LOG(string.format("Max temperature was %gK at %s",maxtemp,os.date("%H:%M:%S",maxtime)))
else
  LOG("No temperature readings for the last 24 hours!")
end
```

Note that values of `meter.values[key].value` and `meter.values[key].get_history()` are in standard SI units, e.g. degrees Kelvin for temperature.

7.6.2.11 AutoPing integration

The global `autoping` table allows to query and configure AutoPing.

- `autoping.enabled`: boolean variable which allows enabling (`true`) or disabling (`false`) AutoPing;
- `autoping.items[N].enabled`: read-only boolean value indicating if the Nth AutoPing item is enabled;
- `autoping.items[N].enable`: function to call to attempt to enable (with the argument `true`) or disable (with the argument `false`) the Nth AutoPing;
- `autoping.items[N].addresses`: array of hostnames or IP addresses of the Nth AutoPing item's elements;

- `autoping.items[N].outlets`: array of relays controlled by the Nth AutoPing item; the field name is chosen to match AC products;
- `autoping.items[N].script`: the name of the scripting function run by the Nth AutoPing item when it's triggered (`""` to cycle the controlled relays);
- `autoping.items[N].status`: the run-time status of the Nth AutoPing item;
- `autoping.ping_interval`: ping interval;
- `autoping.ping_timeout`: ping timeout;
- `autoping.post_reboot_delay`: post-reboot delay;
- `autoping.max_reboot_count`: maximum total reboot count;
- `autoping.max_consecutive_reboot_count`: maximum consecutive reboot count;
- `autoping.pings_before_enabling`: pings before enabling;
- `autoping.resume_without_retrial`: activate enabled entries immediately when service is restored;
- `autoping.handle_failures_immediately`: handle explicit failures immediately instead of waiting for timeout.

7.6.2.12 Network state access

The global `network` table has two similarly-structured members, `network.wired` and `network.wireless`, which represent partial read-only views on state and configuration of the respective networks (all fields are strings unless indicated otherwise):

- `network.(wired|wireless).online`: boolean value indicating if the interface is online;
- `network.(wired|wireless).protocol`: method for obtaining the IP address (static/dhcp);
- `network.(wired|wireless).ip_address`: IP address;
- `network.(wired|wireless).netmask`: network mask;
- `network.(wired|wireless).gateway`: default gateway;
- `network.(wired|wireless).metric`: metric (cost associated with sending data over the interface);
- `network.(wired|wireless).mac_address`: MAC address;
- `network.wireless.enabled`: boolean value indicating if the wireless interface is enabled;
- `network.wireless.mode`: wireless module mode;
- `network.wireless.ssid`: wireless network name;
- `network.wireless.channel`: wireless channel (channel number as string, e.g. "11", or "auto");
- `network.wireless.encryption`: wireless encryption (none/psk/psk-mixed/psk2).

`network.wireless` may be `nil` if wireless support is absent.

7.6.2.13 Event APIs

The global `event` table allows limited integration of user scripts with the notification subsystem.

The `event.send` function can be used to send a `dli.script.script_event` event with custom message and data. It takes the event properties `script_message` and `script_data` as arguments. `script_message` must be a string that will be included in the event message. `script_data`, if supplied, must be a table with string keys and scalar (boolean, number or string) values, and can be analyzed by the rule conditions and/or used by rule actions. Non-string keys or non-scalar values are ignored; if the `script_data` argument is not a table, an empty table is sent. All script-generated events have a (possibly empty) table as `script_data`, and only they have it, so its existence is a distinctive feature of script-generated events.

For example, the following code

```
event.send("coil 1 energized",{coil_index=1,coil_state=true})
```

will send an event that can be matched by, among others, the following notification rules:

```
id=="dli.script.script_event" and script_data.coil_index==1
```

```
script_data and script_data.coil_state
```

All script-generated events have INFO severity level.

Events can also be waited for and received, and that is not limited to system-level events discussed above. An event can have several components with integer indices (the components themselves can be any types, e.g. tables). Events generated by the API generally have two components, a numeric timestamp (in seconds since the epoch, 1970-01-01T00:00:00Z) and a property table, but totally custom events are possible.

It is usually essential not to miss an event when processing them, so events are placed into queues waiting to be processed. The `event.stream` function is a Lua generator to be used in a `for` loop like this:

```
for queue_idx,value1,value2,value3... in event.stream(queue1,queue2,queue3...) do
    ...
end
```

`event.stream` accepts any number of queue arguments and waits for events to be received (causing a delay and allowing other threads to run), then extracts and returns their components. Queues are processed in priority order (e.g. `queue1` messages get processed before `queue2` messages).

The `event.queue` function creates a totally custom event queue not bound to any event source. Additional custom events can be placed into any queue using `q[# q+1]={value1,value2,value3...}` regardless of the method used to create the queue; for queues created by `event.queue`, this is also the only way for events to appear there.

The `event.listener` function creates an event queue listening to the global system events (i.e. the ones received by the notification system and generated by other systems and `event.send` function). Events have a timestamp and a property table as components. The property table contains event-type-dependent properties (e.g. the `id` is the event type identifier).

The following example function can be used to display all system events in internal form in the event log:

```
function dump_system_events()
  for i,t,data in event.stream(event.listener()) do
    dump({i,t,data})
  end
end
```

The `event.change_listener` function takes any number of API objects `object1,object2,object3...` as arguments and creates an event queue listening to changes in the API objects' states. Events have a timestamp and a property table as components; the property table contains the following fields:

- `object`: the changed object;
- `index`: the object's number in the argument list;
- `key`: the property of the object that has changed;
- `value`: the new value of the property.

Only a subset of the API's objects support change notifications; they include relay objects `outlet[i]` , meter values `meter.values[k]` and AutoPing items `autoping.items[i]`. Additionally, objects may not receive change notifications for properties you haven't previously read or written.

The following example function can be used to attempt to mirror physical state of relay 1 to relay 2:

```
function mirror_outlet_1_to_2()
  outlet[2].state=outlet[1].physical_state
  for i,t,data in event.stream(event.change_listener(outlet[1])) do
    if data.key=="physical_state" then
      outlet[2].state=data.value
    end
  end
end
```

The `event.timeout` function accepts a single `timeout` value and returns an event queue that receives a single event `timeout` seconds after the function is called. The event has a timestamp and an empty property table.

The `event.local_time` and `event.utc_time` functions take any number of time-matching condition tables as arguments and creates an event queue where events appear in time moments matching the conditions. This can be seen as an improved `wait_until` function which doesn't miss triggers if handling the event takes too long. The most important difference is that new checks are "edge-triggered", not "level-triggered": an event is placed into the queue only when the condition becomes true; no events are created when the condition stays true until it becomes false and then true again. For example, if you start a loop waiting for `{hour=7,min=10}` at 7:10, the event will not be created right away and the loop will not be executed until the next day, whereas `wait_until` would return immediately. This is because a "level-triggered" approach might have to add an infinite number of events to the queue. This also means that you usually won't have to add e.g. min=0,sec=0' or similar to the condition to make it start only at the beginning of an hour. Additionally, `wait_until` only handles local time, which corresponds to `event.local_time` behaviour, but you can match UTC time with `event.utc_time`, which has no corresponding `wait_until` option. Events have a timestamp and a property table as components; the property table contains the following fields:

- `index`: the condition's number in the argument list;
- `time`: the time matching the condition (not necessarily exactly one of the timestamp).

The following example function can be used to check relay 1 state and report if it remains physically off for more than an hour. Note that we do not simply poll the relay e.g. every minute, but subscribe to state change events instead so that we don't miss any changes. We also create the change event queue before the initial state check so that we don't miss any state changes during initialization.

```
function monitor_1()
  local reported
  local off_since
  local changes=event.change_listener(outlet[1])
  if not outlet[1].physical_state then
    off_since=os.time() -- We don't know that for sure but that's when we start monitoring
  end
  for i,t,data in event.stream(changes,event.utc_time({sec=0})) do
    if i==2 then
      if off_since and t-off_since>3600 then
        if not reported then
          log.warning("Off for too long, since %s",os.date("%c",off_since))
          reported=true
        end
      end
    elseif data.key=="physical_state" then
      if data.value==true then
        off_since=nil
        if reported then
          log.notice("On again, phew")
          reported=true
        end
      elseif off_since==nil then
        off_since=t
      end
    end
  end
end
```

Of course we could have used e.g. `event.send` instead of `log`, or flipped another relay, etc.

You should not usually poll the same queue from different threads. Every event from a queue will be processed by a single thread only. A single event can be placed into multiple queues though.

Like any other loop, a loop over `event.stream(...)` can be terminated via a `break` statement in the body. The catch is that the loop body isn't executed until a matching event occurs. If you need to terminate a thread's event loop from another thread, you may e.g. create and share an event queue between them, and place an event into it when you want to terminate the loop, like this:

```
local function event_thread(cancel_queue)
  ...
  for i,t,data in event.stream(cancel_queue,...) do
    if i==1 then
      break
    else
    ...
    end
  end
  ...
end

function caller_thread()
  local cancel_queue=event.queue()
  thread.run(function() return event_thread(cancel_queue) end)
  ...
  cancel_queue[#cancel_queue+1]={}
  ...
end
```

There are obviously other ways to share a queue like this. The location of `cancel_queue` in the `event.stream` argument list above affects whether the loop is terminated immediately after receiving the cancellation message or after processing outstanding events in other queues.

You can also just use `thread.kill` if you don't need the looping thread at all any longer.

7.6.2.14 Modbus interface customization

The global `modbus` table exposes the Modbus integration of user scripts with the Modbus/TCP slave.

The exposed Modbus configuration tables are:

- `modbus.discrete_inputs`: the discrete input table;
- `modbus.input_registers`: the input register table;
- `modbus.holding_registers`: the holding register table.

Each of the tables contains data for a custom Modbus data model element. They have the following common structure:

- `modbus.*[N].name`: a string holding the element name for convenience;
- `modbus.*[N].index`: the zero-based index of the item (without *0...01 added);
- `modbus.*[N].value`: the value of the item (an integer 0..65536 for registers, a boolean for discrete inputs);
- `modbus.*[N].allow_read`: a boolean indicating if the item can be read from Modbus;
- `modbus.*[N].allow_write`: a boolean indicating if the item can be written by Modbus (for holding registers only);

You can create, modify or delete items in these tables and edit their properties via the scripting engine or the APIs. Several items of a table may share a single `index` value, and this is not considered an error; in this case, the first entry matching with the appropriate permission (`allow_read` or `allow_write`) wins (gets read from or written to, respectively). In particular, this means you can have different items for reading and writing of a holding register, which may be convenient.

See the `default.modbus_demo`, `default.modbus_advanced_demo` script snippets for examples.

7.6.2.15 OS-level functions

For security reasons, the scripting engine does not provide access to OS-level functions, such as the while of the unit's filesystem, or process management, by default. Much of the useful functionality described in this section is filtered by the `/etc/relay_script_spawn_wrapper` script which is run as a wrapper for any command spawned with `process.spawn`, and it defaults to ignore the command and generate a diagnostic log message. Editing that script (for which you would need to enable SSH from keypad or from web UI) is required to be able to start new processes. In the most permissive configuration, it may grant anyone with administrative rights to execute of arbitrary commands using the user script engine, which may not be desirable.

The global `process` table provides facilities for managing OS-level processes on the unit.

The `process.spawn([attributes,]command,arguments...)` method allows start a new process via `/etc/relay_script_spawn_wrapper`. The command and any arguments must be strings. No shell escaping is necessary. The optional `attributes` table (considered empty if not supplied) may contain `stdin`, `stdout` and/or `stderr` keys which control the corresponding file descriptors for the child process: each of them may either be:

- `nil`, in which case the child process receives `/dev/null` for that descriptor; or

- a readable (for `stdin`) or writable (for `stdout` and `stderr`) end of a pipe (unidirectional stream communication channel), in which case that descriptor is received by the child process; or
- the string `"pipe"`, in which case `process.spawn` creates a new pipe, supplies the "matching" (as above) end of the pipe to the child process, and returns the "other" (writable for `stdin` or readable for `stdout` and `stderr`) end in the corresponding field of the returned table.

Additionally, the `attributes` table may contain an `env` field whose value must be a table with the OS environment variables to be supplied to the spawned process (keys must be strings corresponding to the names of environment variables, and values must be strings, numbers or booleans and will be converted to strings using `tostring` to be used as values for those environment variables).

If process creation succeeds, a table with the following fields is returned:

- `pid` contains the numeric OS-level process identifier (PID), a positive integer;
- `stdin`, `stdout` and/or `stderr` contain the ends of pipes that can be used to interact with the process, if the corresponding `attributes` field was set to `"pipe"`.

Additionally, the returned table acts as an event queue'; when the created processis terminated, an event containing the timestamp and the exit reason table is placed into the queue. The exit reason table contains the following fields:

- `code`: integer, the exit code of the process computed with shell practice (its exit status if it exited in a regular way, or 128 + signal number if terminated by a signal);
- `status`: optional integer, exit status (`nil` if terminated by a signal);
- `signal`: optional integer, received signal (`nil` if exited in a regular way).

The `process.pipe()` function can be used to create a pipe and returns two file descriptors, the first one being the read end and the second being the write end. The pipe ends may be supplied to `process.spawn()` or used for string input/output (see below).

The `process.kill(pid[,signalname])` function can be used to send a signal to a process created by `process.spawn()`, referenced by its `pid`, which often results in termination of that process. `signalname`, if supplied, must be one of the following string values indicating the signal to be sent:

- "term": the `SIGTERM` signal, requesting graceful shutdown and usually resulting in process termination;
- "kill": the `SIGKILL` signal, unconditionally terminating the process without any cleanups;
- "hup": the `SIGHUP` signal, indicating "controlling terminal detached" condition and sometimes used as a setting reload request by convention;
- "int": the `SIGINT` signal, indicating interrupt from keyboard (as if `Ctrl+C` were pressed) and usually resulting in process termination;
- "quit": the `SIGQUIT` signal, indicating quit from keyboard (as if `Ctrl+\\` were pressed) and usually resulting in process termination;
- "alrm": the `SIGALRM` signal, indicating timeout and usually resulting in process termination;
- "stop": the `SIGSTOP` signal, unconditionally pausing process execution;
- "cont": the `SIGCONT` signal, unconditionally resuming execution of a process paused by `SIGSTOP`;
- "usr1" or "usr2": the `SIGUSR1` or `SIGUSR2` signals, which can be handled by the process in an application-specific way but but result in process termination by default.

`process.kill()` cannot send a signal to a process that hasn't been created by `process.spawn()`. You may set up `/etc/relay_script_spawn_wrapper` in a way to execute the native `kill` command for that.

The `process.kill_group(pid[,signalname])` acts like `process.kill(pid,signalname)`, but sends the signal not only to `pid` but to the whole process group of which `pid` is the leader (mostly useful to terminate a script that starts other processes if you use `chpst -P` to create a new process group). Note that no `process.*` function accepts a negative `pid`.

Note that a process created by `process.spawn()` can outlive the creating thread.

The global `file` table provides facilities for interacting with file descriptors:

- `file.read(f,count)`: reads and returns a binary string of at most `count` bytes from `f`, which must be readable; fewer bytes may be returned; it returns an empty string if an end-of-file condition is met, and `nil` if some other error occurs.
- `file.write(f,data)`: writes a binary string `data` to `f`, which must be writable and returns the number of bytes written; fewer bytes than `#data` may be written, so the caller may need to call `file.write()` again with the remaining data; it returns `nil` if some error occurs.
- `file.close(f)`: closes `f` so that no other operations can be performed on it; `f` is no longer considered readable or writable by `file.read()` or `file.write()`; subsequent `file.close()` calls do not fail but have no effect.

Note that currently all created file descriptors are, in one way or another, pipes (created by `process.pipe()` or `process.spawn()`). You use `/etc/relay_script_spawn_wrapper` to allow certain commands (e.g. `cat` or `dd`) to interact with the underlying filesystem, possibly in a restricted way.

The `/storage` directory is reserved for the unit administrator and is persisted across upgrades. It may be useful to store scripts to be launched via `process.spawn()` or other means or data manipulated by such scripts.

The `chpst` utility may be useful in `/etc/relay_script_spawn_wrapper` to restrict the spawned process permissions and/or resource use.

You may need to set up the environment to have some commands (e.g. `ssh`) behave as though you launched them from the command line. You can set them inside `/etc/relay_script_spawn_wrapper` (e.g. `export HOME=/root`) and/or in the `env` field of `attributes` (e.g. `process.spawn({env={HOME="/root"},...},...)`. The `set` shell builtin can be used to figure out current environment values.

7.6.2.16 Utility functions

The global `util` table provides helpful utility constants and functions which usually have no state or side effects.

`util.hex`, `util.base64`, `util.url` are tables with `encode` and `decode` members which perform hex, Base64 and URL component encoding and decoding, respectively; they both accept and return strings.

The `util.json` table also contains `encode` and `decode` members, which perform JSON encoding and decoding, respectively. `util.json.encode` accepts any regular value (without cycles) and returns a string; `util.json.decode` accepts a string and returns a value corresponding to it.

Due to how Lua handles tables, an empty JSON array `[]` cannot be distinguished from an empty JSON object `{}` once decoded. To help that, `util.json.encode` accepts an optional second argument, which is an "empty array table", that is, a table with keys corresponding to empty Lua tables in the input which represent empty JSON arrays. For example,

```
local data={a={},b={}}
log.notice("%s",util.json.encode(data,{[data.b]=true}))
```

produces:

```
{"a":{},"b":[]}
```

Conversely, `util.json.decode` returns an empty array table as a second value if it is nonempty (that is, if there were empty arrays in the input).

```
local value,is_empty_array=util.json.decode('{"a":{},"b":[]}',is_empty_array)
log.notice("a: %s%s",type(value.a),is_empty_array[value.a] and ":array" or "")
log.notice("b: %s%s",type(value.b),is_empty_array[value.b] and ":array" or "")
```

Thus JSON round-trips, i.e. `util.json.encode(util.json.decode(JSON))` produces a JSON string equivalent to the input `JSON` even in the presence of empty arrays/objects.

All transcoding functions may throw errors on invalid input; using `pcall` / `xpcall` is advised.

`util.null` is the JSON `null` constant, distinct from, but sometimes interchangeable with, `nil`. It may be useful when dealing with some APIs.

The `util.weak_key_table()`, `util.weak_value_table()` and `util.weak_key_value_table()` functions construct tables with weak keys and/or values as if by using `setmetatable({},{__mode="k"})`, `setmetatable({},{__mode="v"})` and `setmetatable({},{__mode="kv"})`, respectively.

The `util.copy(val[,deep_keys])` function returns a deep plain copy of its argument (which can be or contain an API structure). This may be helpful when working with `util.json.encode` as it doesn't by itself support encoding API structures. An optional argument, `deep_keys`, can make `util.copy` perform deep copying of table keys (in case they're tables themselves), otherwise table keys are left intact.

The `util.equal(val1,val2)` function performs a deep equality comparison of its two arguments (each of which can be or contain an API structure) and returns true if they are equal and false otherwise. Tables are compared structurally, i.e. they are considered equal if they have equal keys with equal values. Unlike `util.copy`, `util.equal` doesn't support comparisons with copied table keys as those are in general undecidable without additional information (consider `{[{}]=1,[{}]=2}` and `{[{}]=2,[{}]=1}`).

The `util.argpack` function compresses its arguments into a table with an extra `n` member indicating the number of arguments. It could be implemented as:

```
util.argpack = function(...)
    return {n=select("#",...),...}
end
```

The `util.argunpack` function expands a table into a value list with the number of elements taken from the table's `n` member. It could be implemented as:

```
util.argunpack=function(tbl)
    return unpack(tbl,1,tbl.n)
end
```

In combination, `util.argpack` and `util.argunpack` allow perfect function argument forwarding in presence of `nil` arguments.

Unlike most APIs, utility functions are available in the global context.

7.6.2.17 Debugging

- `dump` — useful debugging function which outputs the argument to the system log, can be used to inspect state and even study the modern API itself (try `dump(_G)`!). Note that this function may delay execution while dumping sufficiently large objects. Other threads may run while execution of the dumping thread is suspended. If they modify the object being dumped, the resulting dump output may be inconsistent.
- `log` — contains methods `debug`, `info`, `notice`, etc. which accept a format string argument and any extra arguments it requires, format the string using `string.format` internally and log it at the corresponding severity level, e.g.

  local i=5 local name="Fridge" log.notice("Switching on %d (%s)",i,name)

7.7 Starting scripts

There are a few ways to start scripts:

- On power up. This feature automatically starts a specified script function when power is first applied. The default is not to start any function, so pressing the "reset to defaults" button will disable this feature.
- By another thread. One thread can create another by using the `thread.run` function. For example, `thread.run(func1)` creates a new thread that starts executing the `func1` function. The execution of the parent thread continues.
- By issuing an HTTP request. Follow a link `http://Your_IP/script.cgi?run=func` to start execution from function `func`. This can be conveniently used by the end users by assigning the programmable web links on the left side of the page a target of the form `script.cgi?run=func`.
- Via AutoPing. The AutoPing system can be configured to automatically start execution when IP connectivity is lost. Select the script to run from the selection box to the right of the corresponding IP on the AutoPing page.
- By manually clicking the Start button. Execution will start with the selected function.

7.8 Editing scripts

You don't need to disable scripting before editing scripts. If you make a syntactic error, the script won't be modified. Instead, you'll receive an explanatory message pointing to the error.

If you modify a running script, existing threads will continue to run with the code and environment that existed when the script was started. New threads won't interact with old ones directly. Use transient and persistent state APIs for that.

7.9 Stopping a thread

A thread terminates automatically when the end of its outermost function is reached. Click "Stop all running threads" to stop everything. You can also stop all scripts via HTTP using `http://Your_IP/script.cgi?stop`.

7.10 Relay debounce warning

Even with the scripting step delays, it is possible to create a script which will rapidly cycle a relay. This rapid cycling could result in a over current condition, tripped breaker, or stress to the power controller or attached equipment. Please be reasonable!

8 Event notification

Certain power controller events can trigger configurable notifications over a variety of media:

- email;
- XMPP (Jabber, Google Talk, etc.);
- SNMPv1, SNMPv2c and SNMPv3 TRAPs;
- SNMPv2c and SNMPv3 INFORMs;
- webhook.

Regardless of the medium type, notifications are inherently asynchronous; you should not rely on a particular ordering of messages sent.

Notification is based on the `Lua` programming language.

8.1 Notification context

When an event happens, a notification thread is started, with event's properties being copied to global variables (and thus constituting the context of further notification code snippets).

The most important of the rule action context (see below) is the `notify` function, which sends the current notification context to matching targets.

All kinds of events share the following properties:

- `id` — the event type identifier,
- `message` — a human-readable message,
- `severity` — the event severity level.

By manipulating the context, rules can check for and adjust the event's properties and prepare it for sending.

For example, you can have a rule with an empty condition and an action altering the 'message' variable like this:

```
message="Server room power: "..message
```

All the following rules will include the "Server room power:" prefix in the generated notifications.

Some properties, e.g. `message_short` or `message_long`, are supported by notification targets but aren't generated by any events; it's up to the action code to set them if necessary.

It's important to note that rules are processed linearly: adjustment of properties doesn't cause preceding rules to be re-examined.

Additionally, different event types have more specific properties. All event properties can be checked for or adjusted.

The following convenience severity level constants are defined:

- `EMERG`, `EMERGENCY` — "emergency" severity level,

- `ALERT` — "alert" severity level,
- `CRIT`, `CRITICAL` — "critical" severity level,
- `ERR`, `ERROR` — "error" severity level,
- `WARNING`, `WARN` — "warning" severity level,
- `NOTICE` — "notice" severity level,
- `INFO`, `INFORMATION`, `INFORMATIONAL` — "informational" severity level,
- `DEBUG` — "debug" severity level.

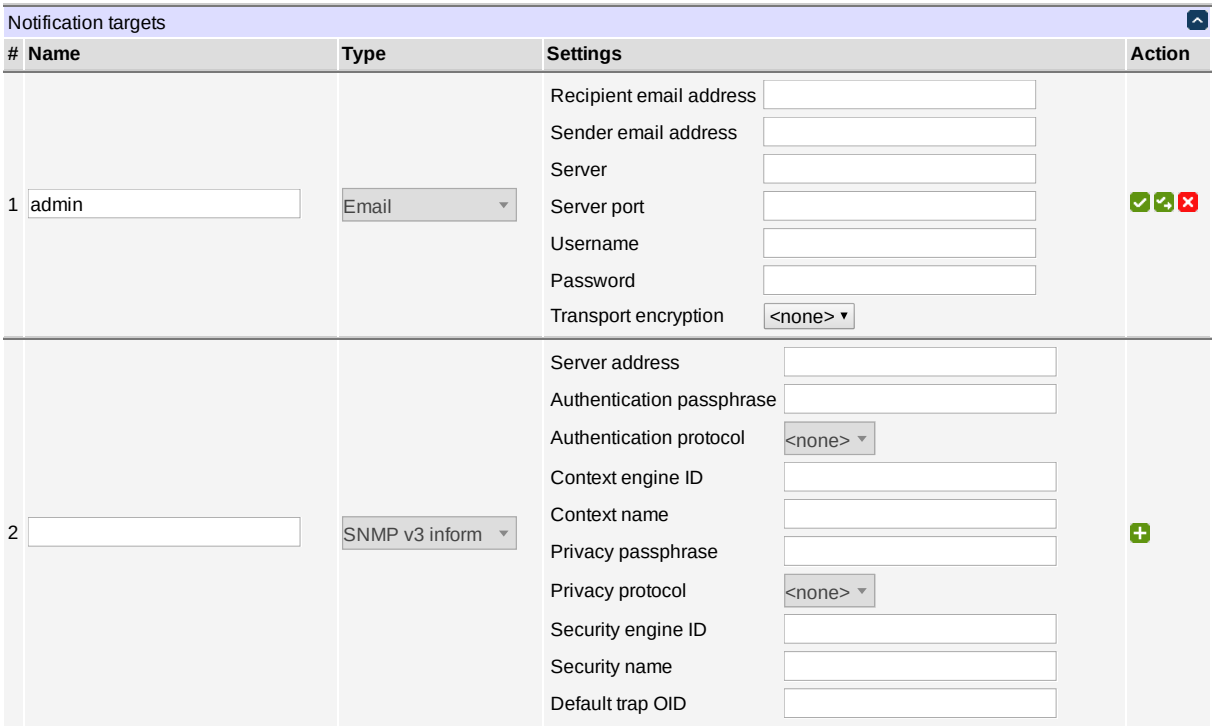
Their numeric values are defined so that a higher severity is larger, so condition like `severity>=CRITICAL` behaves like what you'd expect.

The convenience function `severity_string(val)` maps a numeric severity value `val` to the corresponding (lowercase) string describing it, e.g. `severity_string(CRIT) == "critical"`; it is intended for use in generating notification message texts.

The core Lua functions are accessible from the context as well, should you need them.

8.2 Notification targets

The targets are a list of configurations which can deliver preprocessed messages to concrete recipients. Each target has a name, which needn't be unique. When a rule action calls `notify("target_name")`, all targets which have "target_name" specified as name are triggered.



Notification target configuration

Other target properties depend on the kind of the target.

8.2.1 Email notifications

Email notification targets have the following parameters:

- recipient email address (RFC 822);
- sender email address (RFC 822);
- server (hostname or IP address);
- server port (usually 465, 587 or 25 for unencrypted operations);
- username (for authenticating to the server);
- password (for authenticating to the server);
- transport encryption:
  - "smtps" for SMTP wrapped completely in TLS;
  - "starttls" for SMTP+STARTTLS command;
  - "" (the empty string) for no encryption.

Some fields are autofilled for popular email services once you enter the sender's address.

If present, the `message_short` event property is used for the email subject; otherwise, `message` is used.

If present, the `message_long` event property is used for the email body; otherwise, `message` is used.

If present, the `timeout` property can be used to specify the time limit, in seconds, for the notification operation to complete. Consider increasing it, by specifying a higher value in the rule action, if you experience frequent timeouts.

Event properties `client_cert` and `client_key` can be used to specify a pair of client certificate/key files if TLS is used. The `ca_root` event property, if present, can be used to specify the set of trusted CA root certificates (it may point to a single file listing all of them, or to a directory containing the certificate files in OpenSSL format, and defaults to `/etc/ssl/certs`).

8.2.2 XMPP notifications

XMPP notification targets have the following parameters:

- recipient XMPP ID (RFC822-like);
- sender XMPP ID (RFC822-like);
- password (for authenticating to the server).

If present, the `message_short` event property is used for the message; otherwise, `message` is used.

If present, the `timeout` property can be used to specify the time limit, in seconds, for the notification operation to complete. Consider increasing it, by specifying a higher value in the rule action, if you experience frequent timeouts.

Event properties `client_cert` and `client_key` can be used to specify a pair of client certificate/key files if TLS is used. The `ca_root` event property, if present, can be used to specify the set of trusted CA root certificates (it may point to a single file listing all of them, or to a directory containing the certificate files in OpenSSL format, and defaults to `/etc/ssl/certs`).

8.2.3 SNMP notifications

The notification system supports sending:

- SNMPv1 TRAPs;
- SNMPv2c TRAPs and INFORMs;
- SNMPv3 TRAPs and INFORMs.

The difference between a TRAP and an INFORM is that an INFORM requires confirmation of receipt. Thus, the target test function can tell if the message has been delivered.

8.2.3.1 Trap OIDs

The type of a TRAP or INFORM is indicated by its OID. SNMPv2c and SNMPv3 include the full OID in the message; SNMPv1 is different.

SNMPv1 traps are identified by the generic trap type (and correspond to the following trap OIDs):

- 0 — cold start (1.3.6.1.6.3.1.1.5.1),
- 1 — warm start (1.3.6.1.6.3.1.1.5.2),
- 2 — link down (1.3.6.1.6.3.1.1.5.3),
- 3 — link up (1.3.6.1.6.3.1.1.5.4),
- 4 — authentication failure (1.3.6.1.6.3.1.1.5.5),
- 5 — EGP neighbor loss (1.3.6.1.6.3.1.1.5.6).

If the generic trap type is 6, the trap is enterprise-specific (and is usually taken to correspond to OIDs using the template "1.3.6.1.4.1.ENTERPRISE-OID.0.SPECIFIC-TRAP-TYPE").

Unless you send only generic traps or have a OID tree registered to you, you may want to send 'user-configured' traps which carry no additional semantics other than the variable bindings. The `dlinGeneric` user-configured trap type is designed for that. Its OID is 1.3.6.1.4.1.45770.0.1; this can be specified directly for SNMPv2c or SNM↩Pv3, or as an enterprise-specific (generic trap type=6) DLI ("enterprise OID"=45770) trap #1 (specific trap type=1).

8.2.3.2 Security settings

SNMPv1 and SNMPv2c use the 'community' security model which essentially identifies users by a shared secret which is sent over the network in plain text ('public' and 'private' being the most popular 'secrets'). That means that they are very insecure and shouldn't be deployed over an untrusted network. SNMPv3 has a more reasonable security model.

8.2.3.3 Variable bindings

All SNMP TRAPs and INFORMs accept the `snmp_values` event property to send extra values in the message. The property, if not nil, must be an array of the following shape:

```
{{oid1,value1,type1},{oid2,value2,type2},...}
```

The order may be important; you may want to consult the MIB. The following types are supported:

- "integer",
- "unsigned",
- "counter32",
- "string",
- "hex string",
- "decimal string",
- "nullobj",
- "objid" or "oid",
- "timeticks",
- "ipaddress" or "ip",
- "bits".

Type names are case-insensitive. A type may be omitted, in that case it will be inferred (nil values will be encoded as null objects, strings as octet strings, numbers as integers, "true" values as integer 1, and "false" values as integer 2 as per SMIv2).

8.2.3.4 SNMPv1 settings

SNMPv1 trap targets have the following parameters:

- server address (hostname or IP address of management station),
- community string (the shared secret for authentication to server),
- enterprise OID (number),
- default generic trap type (number 0..6),
- default specific trap type (number 0..2147483647).

SNMP v1 accepts `snmp_enterprise_oid`, `snmp_generic_trap_type` and `snmp_specific_↩ trap_type` event properties to override the trap OID; they must be integers or string representations thereof. It also accepts the `snmp_values` event property as described above.

8.2.3.5 SNMPv2c settings

SNMPv2c TRAP and INFORM targets have the following parameters:

- server address (hostname or IP address of management station),
- community string (the shared secret for authentication to server),
- trap OID (string)

SNMP v2c TRAPs and INFORMs accept an `snmp_trap_oid` event property to override the trap OID; it must be a string. They also accept the `snmp_values` event property as described above.

8.2.3.6 SNMPv3 settings

SNMPv3 TRAP and INFORM targets have the following parameters:

- server address (hostname or IP address of management station),
- security name (username to authenticate as),
- security engine ID (hexadecimal string; leave empty to autodetect if possible),
- context name (leave empty for default),
- context engine ID (hexadecimal string; leave empty for default),
- authentication protocol ("MD5" and "SHA" are supported, leave empty "" for no authentication),
- privacy protocol ("DES" and "AES" are supported, leave empty "" for no encryption),
- authentication passphrase (should be at least 8 characters long, or empty if no authentication),
- privacy passphrase (should be at least 8 characters long, or empty if no encryption),
- trap OID (string)

Supplying the security engine ID is required for authenticated SNMPv3 TRAPs, but unnecessary for non-authenticated SNMPv3 TRAPs (which make no use of it) and optional for SNMPv3 INFORMs (which will perform autodetection).

Supplying authentication options is required when privacy options are set (you can either disable authentication and encryption, enable only authentication, or enable both; an encrypted, but not authenticated configuration is invalid).

SNMP v3 TRAPs and INFORMs accept an `snmp_trap_oid` event property to override the trap OID; it must be a string. They also accept the `snmp_values` event property as described above.

8.2.4 Webhook notifications

Webhook notifications send preconfigured POST HTTP requests to URLs.

- recipient URL — the URL to send a request to (must be an HTTP or HTTPS URL);
- recipient addresses — if non-empty, a comma-separated list of IPv4 ranges (addresses possibly followed by masks) that the URL hostname is permitted to resolve to;
- content type — the type of content representation to use (must be "json" for JSON or "urlencoded" for URL-encoded).

In general, recipient URLs must contain regular public IP addresses, or hostnames which resolve to them. In particular, the following IPv4 ranges are prohibited from use due to possible security implications:

```
0.0.0.0/8
10.0.0.0/8
100.64.0.0/10
127.0.0.0/8
169.254.0.0/16
172.16.0.0/12
192.0.0.0/24
192.0.2.0/24
198.51.100.0/24
203.0.113.0/24
192.88.99.0/24
192.168.0.0/16
198.18.0.0/15
224.0.0.0/4
240.0.0.0/4
255.255.255.255/32
```

The list of permitted recipient addresses, if any, overrides this prohibition, replacing it with permission to only access the listed address ranges (individual IPs for netmask /32, or valid IPs of a subnet, e.g. not network IP address .0 nor broadcast address .255).

Additionally, URLs containing non-default privileged (<1024) ports are restricted as well.

The request payload (content) is determined by the `payload` event property if present.

Otherwise, the payload is a key-value map with the following keys:

- `type` — the `id` of the event type;
- `severity` — the severity label for the event (one of the strings "emergency", "alert", "critical", "error", "warning", "notice", "info" or "debug");
- `message` — the human-readable message of the event type;

and, if present, the deprecated `properties` event property is used to populate the payload with additional items; for instance, an action `properties={time=os.time()}` will result in a `time` key being added. Non-string values will be JSON-encoded (regardless of the content type).

`properties` is deprecated and will not be consulted if `payload` is set.

If present and is a table, the `payload_empty_array_table` event property is consulted to resolve the Lua empty table encoding ambiguity (i.e. should a particular `{}` be encoded as a JSON array or an object) in `payload`. For instance, if a sink named "admin" is configured as a JSON webhook, the following action:

```
local array={}
local object={}
payload={array,object}
payload_empty_array_table={[array]=true}
notify("admin")
```

produces a notification with the body:

```
[[],{}]
```

A webhook sink configured for URL-encoded content representation will send content of the form `key1=value1&key2=value2`, with keys and values taken from the above described payload; array keys will be converted to 1-based string indices; values will be JSON-encoded if they are not strings; content will be empty if `payload` is set and is not a table.

If present, the `headers` event property is used to add HTTP headers to the request being sent.

If present, the `message_short` event property is used for the message; otherwise, `message` is used. Note that `payload` overrides both if set.

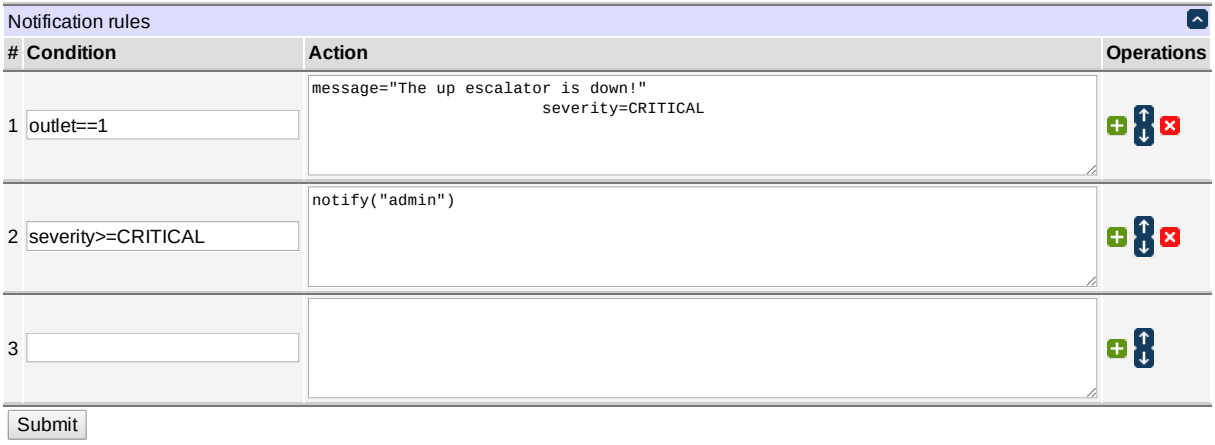
If present, the `timeout` property can be used to specify the time limit, in seconds, for the notification operation to complete. Consider increasing it, by specifying a higher value in the rule action, if you experience frequent timeouts.

Event properties `client_cert` and `client_key` can be used to specify a pair of client certificate/key files if HTTPS is used. The `ca_root` event property, if present, can be used to specify the set of trusted CA root certificates (it may point to a single file listing all of them, or to a directory containing the certificate files in OpenSSL format, and defaults to `/etc/ssl/certs`).

8.3 Notification rules

The rule system is centered around two kinds of entities:

- condition, which determines if a rule is matched, and
- action, which determines what happens if it matches.



Notification rule configuration

A condition is a Lua expression, while rules are Lua blocks (may contain several statements).

Roughly, the condition/action table is equivalent to:

```
if condition1 then action1 end
if condition2 then action2 end
if condition3 then action3 end
...
```

However, an important difference is that if a condition would cause an error, the condition is considered false instead; the corresponding action not taken, but the rule check goes on.

Additionally, an empty condition is equivalent to `true`, and the corresponding action is unconditionally taken. To disable an action without deleting it, you can use an explicitly false condition `false` or a condition that's not a valid Lua expression, e.g. `-`. To keep the condition text, you can wrap it with `false and (...)`.

Rules are applied from the first one to the last one, so order is important. The "Operations" column contains buttons which make manipulating rule order easier.

Though you can filter events by the type identifier, it's not necessary in many cases. For example, the condition `auth_allowed==false` will match only `dli.auth.login_denied` events, as `auth_allowed` is set to `false` for those events only. This is notably distinct from a `not auth_allowed` condition, which will match all sorts of messages which don't have an `auth_allowed` property.

Tricks which allow running code in the condition (as opposed to the action) are possible but discouraged.

8.4 Notification event types

Miscellaneous servers expose the types of events they can produce; they are presented on the notification configuration page in a compact form. Here's an example:

Authentication server events		
Severity	**Message**	**Extra properties**
NOTICE	login allowed for auth_login@auth_ip (auth_method)	id="dli.auth.login_allowed" auth_allowed=true
NOTICE	login denied for auth_login@auth_ip (auth_method): auth_reason	id="dli.auth.login_denied" auth_allowed=false
NOTICE	protection violation attempt: auth_reason	id="dli.auth.protection_violation"
INFO	auth_login@auth_ip session closed	id="dli.auth.session_closed"

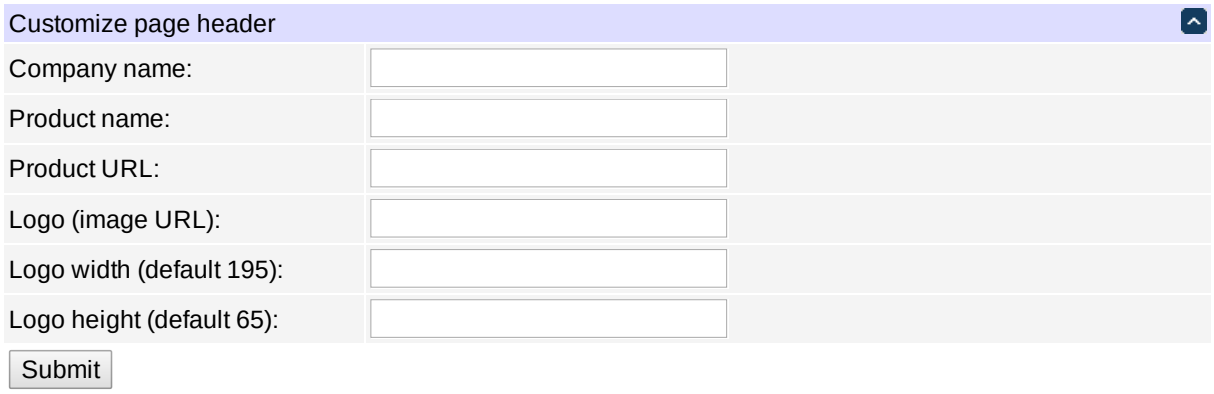
Notification event types

Underlined items (both in the message and in the 'extra properties' column) specify properties which can be checked for. You can hover them for more detailed descriptions.

9 Customization page

The customization page allows the administrator to configure some user interface aspects of controller behavior.

9.1 Web page layout and branding



Layout and branding settings

The branding block that appears on every web page can be customized:

- Product name: the displayed name of the product;
- Logo: the company logo image URL;
- Product URL: the URL that the image points to.

Custom logo dimensions may be supplied if needed. The logo URL may be absolute or relative (e.g. `/my_company.png`), in which case the related file should be placed in the `/www/static/` subdirectory of the unit's filesystem (probably via SSH).

Company name affects the alternative text for the logo image.

9.2 Measurement units

Units

You can choose which units to display temperature, illuminance and energy values in. This affects both textual and graphical web UI display. Note that it's a presentation option only; values are internally stored, and transferred via REST-like API in standard SI units (degrees Kelvin, lux and joules, respectively) regardless of the customization.

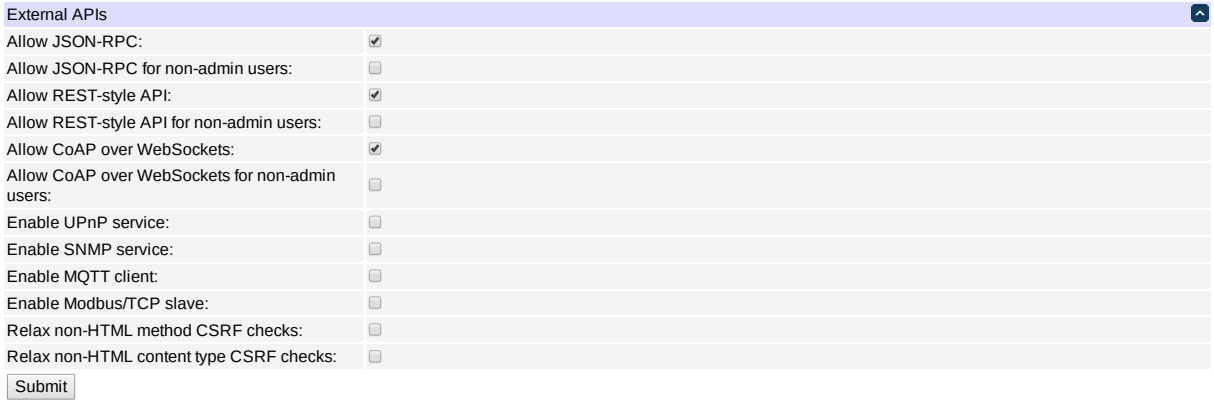
10 External APIs

The controller can be accessed programmatically using a number of protocols and APIS, including:

- the REST-like API, in the following variants:
  - regular HTTP,
  - CoAP over WebSockets over HTTP,
  - command-line via SSH,
- JSON-RPC (over HTTP),
- SNMP,
- MQTT,
- Modbus/TCP,
- UPnP.

Additionally, a Lua access library is provided for standalone scripts.

10.1 Common external API settings

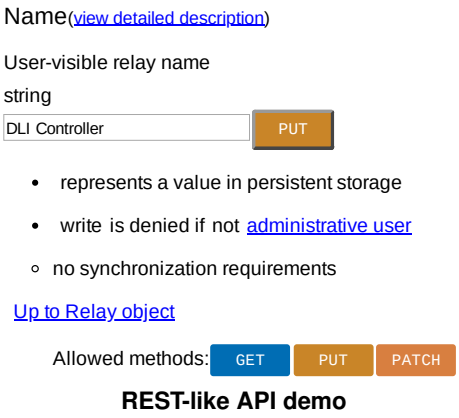


Common external API settings

Each of the external APIs can be enabled separately. Command-line REST-like API, or the standalone Lua access library cannot be disabled, except by e.g. disabling SSH access.

HTTP APIs perform cross-site request forgery checking to make sure they are not called by a misguided browser without JavaScript, bypassing browser security checks (a custom header needs to be present in the requests). Browsers can normally issue GET and POST requests with URL-encoded or multipart content types; you can tick the corresponding "relax ... checks" checkboxes to skip the checks in cases where the method or content type indicates that the request couldn't have been sent by a browser without JavaScript.

10.2 REST-like API over HTTP



REST-like API demo

The REST-style API is based on the REST architectural style. It presents the state and configuration as an hierarchy of resources, and relies on HTTP to perform action signaling and content negotiation. Requests with different HTTP headers yield different representations of resources (e.g. plain text, HTML, JSON, etc.). A type description system is used to outline the object model.

Refer to the REST-style API reference for details.

10.3 REST-like API over CoAP over WebSockets

This REST-style API variant shares the object hierarchy with the plain HTTP variant; however, it relies on a WebSocket connection for transport and CoAP for action signaling and content negotiation. The only supported content type is JSON; the only supported content patch type is JSON patch. To use it, a WebSocket connection with protocol 'coap' must be made to the '/.well-known/coap' URL. From there, CoAP requests can be sent via binary WebSocket packets; the CoAP URL structure matches one of the regular REST-style API (in particular, the first Uri-Path segment is 'restapi', and the trailing segment must be empty for regular data requests).

CoAP Observe option is implemented; change notification stream qualities, e.g. update period, are URI-dependent. In practice, subscribing to individual objects (e.g. relays), not whole trees or individual fields, should yield best results.

REST API matrix URI fragment support requires distinguishing between "percent-encoded" (regular) and "non-percent-encoded" (special) variants of the `sub-delims` characters, which CoAP doesn't have out of the box. As a non-standard extension, Uri-Path segment characters prefixed with the ASCII 16 'DLE' (Data Link Escape) character are interpreted as their "non-percent-encoded" (special) counterparts, and are otherwise interpreted as "percent-encoded" (regular), when mapping a Uri-Path segment to the RFC3986 URI path fragment. This affects the following characters:

- sub-delims: "!" "$" "&" "'" "(" ")" "*" "+" "," ";" "="
- colon: ":"
- at sign: "@"
- percent sign: "%"

Note that the sequence 'DLE "%"' then stands for the non-percent-encoded " sign, and thus must be followed by two hex digits, and result in a single "percent-encoded" (regular) byte.

Depth-limited queries are not implemented; however, you can use the matrix URI mechanism to extract just the keys of a container to browse the hierarchy shallowly.

10.4 REST-like API on the command line

This REST-style API variant shares the object hierarchy with the plain HTTP variant; however, it is usable from the command line, e.g. over SSH. The only supported (and implied) content type is JSON, and the set of CRUD operations is a bit different from the conventional REST-like API. Resources are identified by paths similar to HTTP REST API ones, but with the '/restapi/' part omitted, and needn't be terminated by a '/'; instead, retrieving description of a resource is performed using a designated verb. The API is accessed through the 'uom' command, which has several subcommands. The 'get' and 'set' subcommands correspond roughly to 'GET' and 'PUT' requests, except that 'set' is not to be used to create new resources:

```
uom get <uom/path>
uom set <uom/path> <value>
```

For example:

```
# uom get /relay/name
```

yields:

```
"DLI Controller"
```

Both the 'get' response and the 'set' argument are proper JSON values, so need to be properly quoted independently of shell's own quoting:

```
# uom set /relay/name '"Power Controller"'
```

The 'insert' subcommand is intended for collection element creation; it is different from a 'POST' request as its path argument must point to the element intended to be created, and different from a 'PUT' request as it shifts elements when inserting in the middle of an array:

```
uom insert <uom/path> <value>
```

Use a '-' instead of the last path element for specifying "the element position after the last one" (i.e. appending to an array):

```
uom insert config/links/- '{"href":"http://example.com/","description":"Example link"}'
```

The 'remove' subcommand is intended for collection element deletion; it is similar to a 'DELETE' request; use a '-' instead of the last path element for specifying "the last element's position" (i.e. deleting the last array element):

```
uom remove <uom/path>
```

The 'invoke' subcommand is intended for calling object methods; it is similar to a 'POST' request; however, the argument list is specified as a number of positional arguments (as is common in shell scripts) instead of a JSON array.

```
uom invoke <uom/path> [arg [arg ...]]
```

The 'describe' subcommand retrieves an element's type description; it corresponds to a 'GET' request with a trailing '/description' URI fragment.

```
uom describe <uom/path>
```

The 'keys' subcommand retrieves a JSON array corresponding to the current set of an element's keys.

```
uom keys <uom/path>
```

It can be used on arrays and objects alike:

```
# uom keys relay/outlets/
[0,1,2,3,4,5,6,7]

# uom keys meter/values
["relay_voltage","environment.temperature",...]
```

The 'dump' subcommand prints out a deep text representation of the element, possibly including read or iteration error indicators:

```
uom dump <uom/path>
```

The 'subscribe' subcommand prints the current state of the element, as if obtained via 'get', and waits for changes, printing them as they are received:

```
uom subscribe <uom/path>
```

It does not return unless an error reading the object occurs (e.g. if it's gone).

Depth-limited queries, as well as matrix URI fragments, are not implemented (the 'keys' subcommand can be used to perform depth-limited queries manually).

If you maintain nontrivial command-line scripts, you may want to store them under the `/storage` directory, which is reserved for the unit administrator and is persisted across upgrades.

Refer to the REST-style API reference for details.

10.5 Lua API access library

A library for accessing the object model in standalone Lua scripts (run by e.g. cron or otherwise configured via SSH, i.e. not by the scripting server) is provided. It shares the object hierarchy with the REST-like API; however, note that Lua conventions have array indices start with 1, not 0. The library is accessed from Lua via a `require("uom")` expression, e.g.

```
local uom=require("uom")
```

As usual in Lua, parentheses are optional.

Members of the `uom` table correspond to top-level object model entities (including `uom.cred` representing the credential structure); additionally, the following members are provided:

- `uom.null` represents the JSON null, and is true in a boolean context; for convenience, however, simple object fields instead evaluate to Lua nil instead of null, and are therefore false in a boolean context;
- `uom.weak_key_table()`, `uom.weak_value_table()` and `uom.weak_key_value_table()` functions construct tables with weak keys and/or values as if by using `setmetatable({},{__mode="k"})`, `setmetatable({},{__mode="v"})` and `setmetatable({},{__mode="kv"})`, respectively; unlike the user scripting environment, system-level scripts run with `setmetatable` accessible, so the functions are provided mostly for consistency;

- `uom.pairs(object)`, `uom.ipairs(object)`, `uom.insert(object[,idx],value)` and `uom.remove(object[,idx])` should be used on object model members instead of `pairs`, `ipairs`, `table.insert` and `table.remove`, respectively, and have similar semantics (they work on regular tables fine as well; `uom.remove` doesn't return the removed element as that would make no sense in our case; additionally, `uom.pairs` and `uom.ipairs` may return nil values corresponding to nulls);
- `uom.timer(callback, timeout)` and `uom.periodic_timer(callback, interval)` schedule a callback to be run, respectively, after `timeout` milliseconds elapse and each `interval` milliseconds; both return a callback that can be used to cancel the timer, or otherwise must be held to keep the timer active;
- `uom.publish(object,...)` allows process-wide publishing of, and `uom.subscribe(object,callback)` subscribing to, messages for a topic identified by a particular Lua value, including object model members; `callback` receives all the arguments of the corresponding `uom.publish` in the same order, starting with the object; object model members emit messages on member changes; `uom.subscribe` returns a callback that can be used to cancel subscription, or otherwise must be held to keep the subscription active;
- `uom.dump(object[,sink])` returns a deep text representation of `object`, possibly including read or iteration error indicators if you pass it an object with members you don't have read access to; if a `sink` function is supplied, `uom.dump` calls `sink` with each of the lines it would have returned normally and returns `nil`;
- `uom.json.encode` and `uom.json.decode` utility functions perform JSON encoding and decoding of tables (but not object model entities; use `uom.copy` first);
- `uom.re.match(str,regexp)` returns the result of matching the string `str` against the POSIX-style regular expression `regexp`, and `uom.re.gmatch(str,regexp)` returns a generator which can be iterated over all matches (if the pattern contains capturing groups, the matching result is multivalued, with each value representing the matching group or `false` if the match succeeds but group doesn't occur in it, so consider comparing result with nil for general match success checking);
- `uom.copy(obj)`, `uom.equals(a,b)` and `uom.merge(to,from)` utility functions perform deep copying, equality check and merging of tables (including object model entities);
- `uom.context(partial)` creates a new entity similar to the top-level `uom` object (containing top-level object model entities) but having a separate update queue; if `partial` is `true`, the resulting entities will be optimized for code retrieving only a subset of an entity's properties; additionally, such entities will not receive `uom.subscribe()` notifications for properties you haven't previously read or written;
- `uom.update` fetches any pending changes to the object model into the local proxy representation (the default one, or the `context` created by `uom.context()` and supplied as the argument), and runs handlers for any changes you may have subscribed for using `uom.subscribe`;
- `uom.vacuum` runs a cleanup step for unused object model proxies;
- `uom.run()` starts running an event loop, which is useful if you have previously subscribed to messages or set up timers;
- `uom.stop_running()`, often called from a subscription or timer callback, causes the active `uom.run()` to stop.

The following example scripts are meant to be saved as files to the power controller's filesystem and executed with the standalone `lua` interpreter. If you want to just enter them into the interpreter line by line (possibly interactively as a means of experimentation or convenient configuration tool), you'll need to keep your variables global (e.g. omit `local`) as each interpreter line has its own locals context.

For example, running the following script:

```
local uom=require("uom")
print(uom.relay.name)
```

yields:

```
DLI Controller
```

Setting simple values works the same way:

```
local uom=require("uom")
uom.relay.name="Power Controller"
```

Insertion and removal work as well:

```
local uom=require("uom")
uom.insert(uom.config.links,{href="http://example.com/",description="Example link"})
uom.remove(uom.config.links)
```

You can hold object model members in local variables:

```
local uom=require("uom")
local relay1=uom.relay.outlets[1]
relay1.state=true
relay1.state=false
```

Note that attempts to change a table after it has been assigned to an object model field or inserted into an object model container will not work as expected:

```
local uom=require("uom")
local link={href="http://example.com/",description="Example link"}
uom.insert(uom.config.links,link)
link.href="http://bad.example.com/" -- Don't do this
```

It is possible to partially dump objects you don't have full access to, for instance:

```
local uom=require"uom"
print(uom.dump(uom.auth.users[1]))
```

results in:

```
{
  is_admin = true,
  is_allowed = true,
  name = "admin",
  outlet_access = {
    true,
    true,
    true,
    true,
    true,
    true,
    true,
    true
  },
  password = <read failed>
}
```

and an appropriate access log entry.

Object model members send change notification messages on eligible fields (generally, those not being marked as volatile in their type descriptions). Change notifications contain arguments of the form `key`, `value`, `key_↩adjustment`. For example, the following script outputs the physical state of relay 1:

```
local uom = require("uom")
local count = 10
local subscription = uom.subscribe(
    uom.relay.outlets[1],
    function(o,key,value,key_adjustment)
        if key == "physical_state" then
            print(value and "ON" or "OFF")
            if count == 0 then
                print("Enough!")
                uom.stop_running()
            else
                count = count-1
            end
        end
    end
)
print(uom.relay.outlets[1].physical_state and "ON" or "OFF")
uom.run()
```

`uom.json.decode` produces, and `uom.json.encode` accepts a second argument which is the 'empty array table' consulted to resolve the Lua empty table encoding ambiguity (i.e. should a particular `{}` be encoded as a JSON array or an object). For instance,

```
local array={}
local object={}
print(uom.json.encode({array,object},{[array]=true}))
```

produces the output:

```
[[],{}]
```

and the script:

```
print(uom.dump({uom.json.decode("[[],{}]")}))
```

produces output similar to:

```
{
  {{},{}},
  {[value[1][1]] = true}
}
```

Note that `uom.dump` can produce meaningful output for tables with table keys and even key-recursive tables, but `uom.json.encode`, `uom.copy`, `uom.equals` and `uom.merge` only work with JSON-compatible tables (string or integer keys only).

The result of matching a string against a POSIX-style regular expression is `nil` if there is no match, the whole match string if there are no capture groups (delimited by `(,)`), or multiple strings, one for each capture group, e.g. `uom.re.match("abc","[ab].[cde]")` returns `"abc"`, and `uom.re.match("abcde","[ab].(c|d|e)(d|e|f)")` returns two strings `"c"` and `"d"`; `uom.re.gmatch` enumerates non-overlapping matches only, so the code:

```
for v1,v2,v3 in uom.re.gmatch("abcde","([abc])([bcd])([cde])") do
    print(v1,v2,v3)
end
```

prints only:

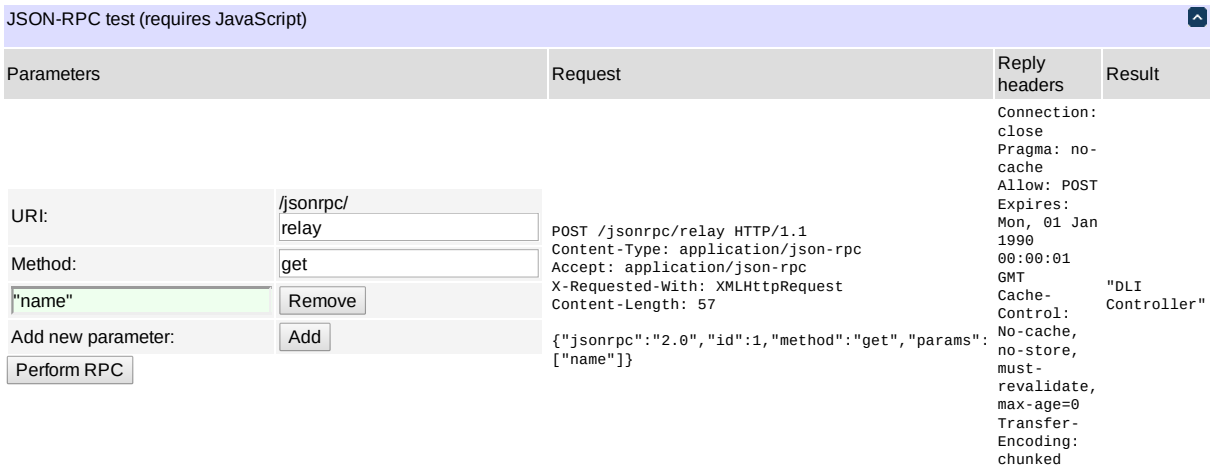
```
a b c
```

`uom.vacuum` and `uom.update` may only be useful for long-running scripts which don't rely on `uom.run` (as the latter performs updates and cleanups automatically).

If you maintain nontrivial OS-level Lua scripts, you may want to store them under the `/storage` directory, which is reserved for the unit administrator and is persisted across upgrades.

Refer to the REST-style API reference for details.

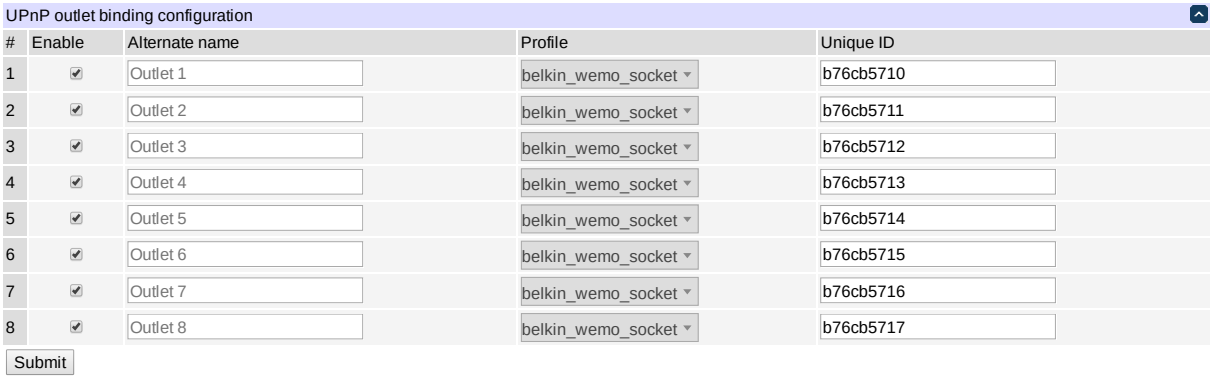
10.6 JSON-RPC



JSON-RPC demo

JSON-RPC allows to access an object model similar to the one of the REST-like API, but in a different manner which may be more suitable for some integration environments. All composite objects are visible using JSON-RPC, with their field values accessible using "get" (with the field name in the argument) and "set" methods (with the field name and value as arguments). Additionally, containers support "add", "remove" and "list" methods. The "describe" method can be used to output a type description for the object (similar to the REST API "description" relative URI).

10.7 UPnP settings

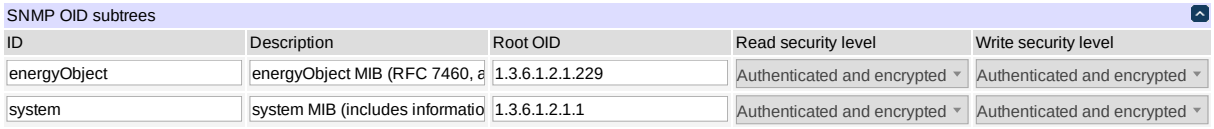


UPnP settings

The unit's relays can be exposed via UPnP as devices with different profiles. The currently supported profile is a Belkin WeMo socket.

10.8 SNMP settings

SNMP (simple network management protocol) exposes the control variables as a set of hierarchical resources identified by object identifiers (OIDs). An object identifier is roughly a sequence of non-negative integers (called arcs), separated by dots ('.'). A leading dot may be used to emphasize that it's an absolute OID; however, all of the OIDs configurable in DC3 are absolute unless otherwise stated explicitly, and the leading dot is not needed, therefore, it's not supported.



SNMP OID subtree properties

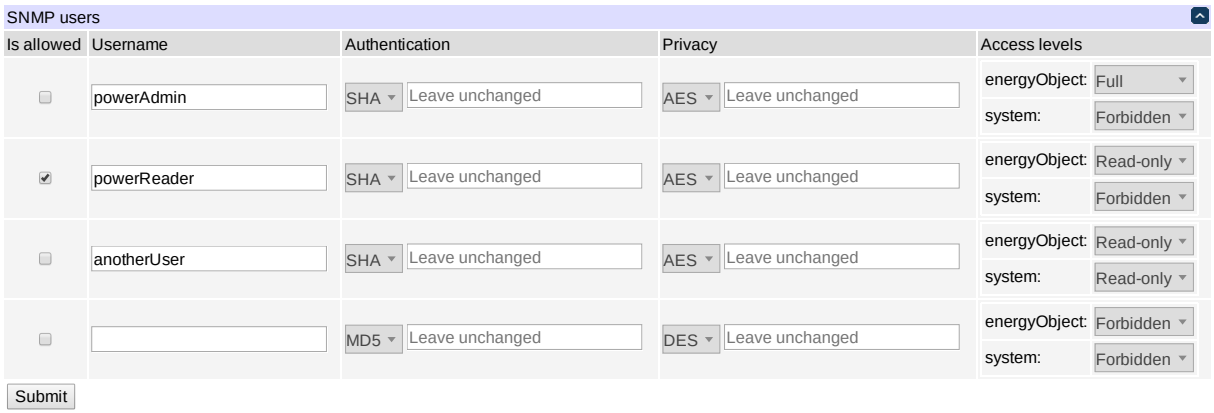
SNMP v3 introduces a user-based security model, where a number of different users can exist whose requests can be signed, and possibly encrypted, and who can have different access rights to the OID tree.

The specified root OIDs and their children will be exposed over SNMP. All OIDs must be absolute but not preceded by a dot.

The root OIDs are actually treated as masks, indicating to set of roots to apply the permission to. In addition to the standard OID syntax, all but the first two arcs of an OID mask may contain:

- an asterisk "∗", which means that any value in this position will match, e.g. "1.2.∗.1" will match both "1.2.1.1" and "1.2.100.1";
- a dash-delimited range, e.g. "1.2.8.1-3" will match both "1.2.8.1" and "1.2.8.2";
- a comma-separated list of arcs, possibly including ranges, e.g. "1.2.8,9" will match both "1.2.8" and "1.2.9", and "1.2.1,6-8" will match both "1.2.1" and "1.2.7".

This can be used to implement fine-grained access to states of individual relays (see below).

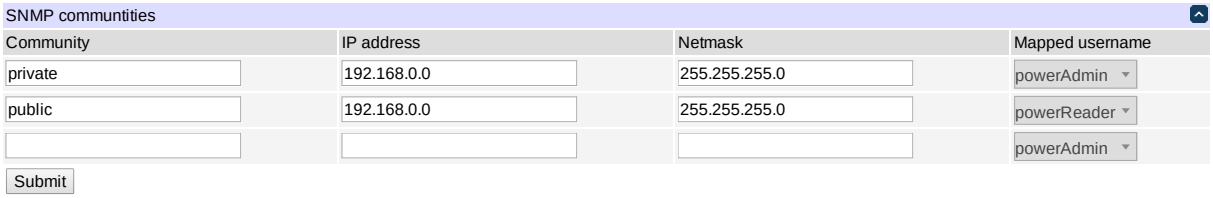


SNMP user table

The engine ID identifies the device, and plays an important role in SNMPv3, in particular in authentication and encryption. It will normally be autodetected by management software (SNMP clients), but you may save it for future

reference (the default value is based on the device factory MAC address). You can even change it; however, if you do, all passwords for SNMPv3 users will be invalidated as they are stored in a localized form to improve security.

SNMP v1 and v2c do not have a notion of 'users'. Instead, a 'community string', acting as a shared secret, is transferred in requests in plain text. The following table allows to configure how community strings are mapped to the above users.



SNMP community-to-user mapping configuration

In this example, requests with the 'private' community string will be serviced as though they were made by the 'powerAdmin' user if they come from the 192.168.0.x subnet, and denied otherwise. Likewise, requests with the 'public' community string coming from the same subnet will be served as the 'powerReader' user.

10.9 SNMP energy object MIB support overview

The Net-SNMP agent included in DC3 has built-in support for several well-known MIBs, e.g. the System group (RFC 3418) with the root at 1.3.6.1.2.1.1, enabling access to which may be required for integrating with management stations. Its elements, e.g. system name, location and contact, are configured in Network settings section.

The power-control-related ENERGY-OBJECT-MIB is described in RFC 7460, and is supported in the following manner:

- the root of the OID tree is at 1.3.6.1.2.1.229 as per RFC;
- the objects are relays, with indices starting at 1 ;
- the current actual power states are indicated in the `eoPowerOperState` (1.3.6.1.2.1.229.1.2.1.9) table;
- the assigned (expected) power states can be manipulated in the `eoPowerAdminState` (1.3.6.1.2.1.229.1.2.1.8) table;
- supported power states are `ieee1621Off` (257) and `ieee1621On` (259) only

Additionally, among others, the following potentially useful parts of the above MIB are implemented:

- eoPowerStateTotalTime;
- eoPowerStateEnterCount.

These accumulate relay state statistics. Note that those don't persist across device reboots.

The following parts of the above MIB are NOT implemented:

- eoEnergyParametersTable;
- eoEnergyTable;

- eoMeterCapabilitiesTable.

The following related MIBs are NOT supported:

- ENTITY-MIB;
- ENERGY-OBJECT-CONTEXT-MIB.

Additionally, modifying the user permissions via SNMP is NOT supported as they are generated from the configuration described above and the process is not easily reversible.

In the default configuration, the security level for accessing the energy object MIB subtree is high. You can set the access level to 'Minimal' to interact with the device using SNMPv2c and SNMPv1, or use SNMPv3 instead, which is the recommended and more secure alternative.

10.10 SNMP sample commands

These examples assume you have your DC3 at 192.168.0.100 with SNMPv3 user `powerAdmin` configured with SHA1 for authentication and AES for encryption, with password `powerAdminPassword` for both authentication and encryption. Requests with the `private` community string are assumed to be serviced as though they were made by the `powerAdmin` user.

You'll need Net-SNMP to run these samples; analogous commands should be available for other management software. The matching of requests vs SNMP protocol version is really arbitrary and is only used to demonstrate different ways of performing requests. Lines are broken using `\\` for readability. We use `-On` to force numeric OID output, and omit the leading '.' in output OIDs for simplicity.

An SNMPv2 SET to turn relay #3 on:

```
$ snmpset -On -v 2c -c private 192.168.0.100 1.3.6.1.2.1.229.1.2.1.8.3 i 259
```

Output:

```
1.3.6.1.2.1.229.1.2.1.8.3 = INTEGER: 259
```

An SNMPv3 GET to get relay #5 status:

```
$ snmpget -On -v 3 -u powerAdmin -l authPriv -a SHA -x AES \
-A powerAdminPassword -X powerAdminPassword 192.168.0.100 \
1.3.6.1.2.1.229.1.2.1.9.5
```

Output:

```
1.3.6.1.2.1.229.1.2.1.9.5 = INTEGER: 257
```

257 is `ieee1621Off`, so now you know the relay is physically off.

An SNMPv3 SET to turn relay #5 on:

```
$ snmpset -On -v 3 -u powerAdmin -l authPriv -a SHA -x AES \
-A powerAdminPassword -X powerAdminPassword 192.168.0.100 \
1.3.6.1.2.1.229.1.2.1.8.5 i 259
```

Output:

```
1.3.6.1.2.1.229.1.2.1.8.5 = INTEGER: 259
```

Using SNMPv1 to enumerate the actual power states table:

```
$ snmpwalk -On -v 1 \
-c private \
192.168.0.100 \
1.3.6.1.2.1.229.1.2.1.9
```

Output:

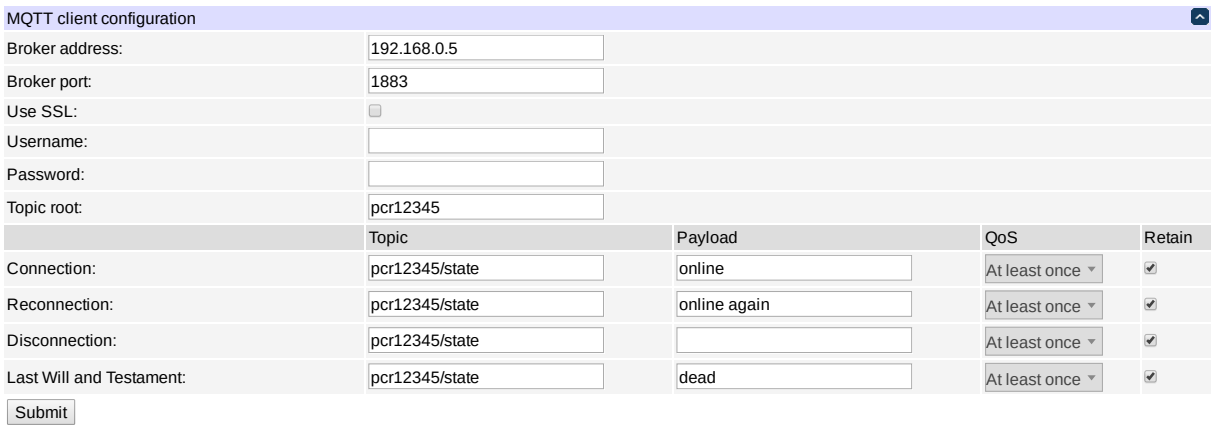
```
1.3.6.1.2.1.229.1.2.1.9.1 = INTEGER: 257
1.3.6.1.2.1.229.1.2.1.9.2 = INTEGER: 257
1.3.6.1.2.1.229.1.2.1.9.3 = INTEGER: 259
1.3.6.1.2.1.229.1.2.1.9.4 = INTEGER: 257
1.3.6.1.2.1.229.1.2.1.9.5 = INTEGER: 259
1.3.6.1.2.1.229.1.2.1.9.6 = INTEGER: 257
1.3.6.1.2.1.229.1.2.1.9.7 = INTEGER: 257
1.3.6.1.2.1.229.1.2.1.9.8 = INTEGER: 257
```

You see that relays 3 and 5 are on, and all others are off ; you can change relay states as described above.

10.11 MQTT API

MQTT is an event-oriented protocol with a centralized publish/subscribe model, which makes it a bit awkward to use for controlling devices; however, an implementation is included due to its popularity.

10.11.1 MQTT client settings



General MQTT settings

DC3 can function as an MQTT client, so you need to have a configured MQTT broker which it could connect to; then, other MQTT clients connected to the same broker could communicate with it (multi-broker configurations are also possible but out of scope of this document). SSL and username/password authentication are supported (leave empty to disable). The default port is 8883 when SSL is enabled, and 1883 otherwise.

Setting and reporting relay state are performed by means of MQTT messages. MQTT messages carry topic markers to identify their type. The topics are arranged in a '/'-separated hierarchy.

The 'Topic root' setting allows to prepend a common string to topics related to all relays, e.g. to group messages related to the same controller. It is advisable that you set a different topic root for every controller that you connect to the same MQTT broker; otherwise, you'll get collisions unless you set different topic subtrees for their relays.

MQTT messages may have different QoS (quality of service) levels, which affect their handling by the broker:

- "At most once" — no delivery guarantee or retransmission attempts;
- "At least once" — acknowledgment is required, but the receiver may receive several copies of the message;
- "Exactly once" — care is taken to make sure receiver receives exactly one copy of each message (highest overhead).

The following connection-related messages can be configured (i.e. have their topic, payload, QoS and retain bit set):

- the connection message is sent after the client has connected to the broker and sent the initial relay state data, if any;
- the reconnection message is sent after the client has reconnected to the broker after an unintentional disconnection (e.g. network outage), and sent the initial relay state data, if any (distinction between this and the above initial connection message may be used to check continuous connectivity over a period of time);
- the disconnection message is sent before the client starts an intentional disconnection (in particular, before relay data clearing is performed), e.g. when MQTT client is disabled or the broker address is changed;
- the Last Will and Testament is a message that will be sent by the broker to notify you if the DC3 unexpectedly goes offline.

Connection-related messages with an empty topic are not sent. Note that the topics of these messages are not prefixed by the topic root.

Changes to the connection, reconnection and disconnection message properties start affecting corresponding events immediately after the change; such changes do not by themselves cause changes to connection status. Unlike them, changes to the Last Will and Testament only take effect on the next (re)connection, i.e. if you have a connection active, change the Last Will and Testament and interrupt that connection, the old message will be sent in that particular occasion, but subsequent unexpected disconnections will result in the new Last Will and Testament sent. It may be useful to disconnect from the broker manually (e.g. by disabling MQTT) before changing connection-related message properties.

10.11.2 MQTT relay bindings

MQTT client outlet binding configuration

#	Topic subtree	Allow read	Allow write	QoS
1	outlets/0	☑	☑	At least once
2	outlets/1	☑	☑	At least once
3	outlets/2	☑	☑	At least once
4	outlets/3	☑	☑	At least once
5	outlets/4	☑	☑	At least once
6	outlets/5	☑	☑	At least once
7	outlets/6	☑	☑	At least once
8	outlets/7	☑	☑	At least once

Submit

MQTT relay bindings

Every relay can be mapped to an MQTT topic subtree, which will be prefixed by the topic root and '/'; the outlet will report its state with a message with that topic if 'Allow read' is checked and honor requests to change its state if it receives a message with that topic suffixed by '/set' and 'Allow write' is checked. The quality of service determines the mode of delivery to request from the broker for messages on reporting relay state; not all brokers may support all delivery modes; the default should be sufficient for most purposes.

Note that there is no explicit way to request the states of relays. MQTT brokers are expected to keep track of the most recent payload of the outlet state topics, since the related messages have the retain bit set. Conversely, outlet state setting messages (ones with the '/set' topic suffix) must be sent by clients with the retain bit cleared: the API treats any such messages with the retain bit set as illegal and ignores them, since they could have been sent long ago and the current outlet state might have been overridden by other means since then.

10.11.3 MQTT payload formats

MQTT payload format is not defined by a standard, so we explicitly define it here. Everything that can be controlled via MQTT in DC3 is an relay state, which can be ON or OFF. We encode ON as '1' (the single ASCII character '1') and OFF as '0'. For compatibility, in addition to decoding '1' as ON and '0' as OFF, we accept '\0' (the ASCII NUL character) and the strings 'off' and 'false' as OFF, and '\1' (the ASCII SOH character) and the strings 'on' and 'true' as ON. Additionally, the empty string '' is used to indicate topic erasure (on topic changes or read access revocation).

10.11.4 MQTT sample commands

These examples assume you have an MQTT broker at 192.168.0.5, it doesn't require authentication and you have the DC3 set up like shown on screenshots above.

You'll need the mosquitto MQTT client to run these samples; analogous commands should be available for other clients. mosquitto also has an MQTT broker implementation.

If you run the command:

```
mosquitto_sub -h 192.168.0.5 -C 1 -t pcr12345/outlets/0
```

it'll print the current state of the first relay as known to the broker (as '0' or '1') and exit. The '-C 1' flags disable waiting for more state changes; if you run the command with them removed:

```
mosquitto_sub -h 192.168.0.5 -t pcr12345/outlets/0
```

you'll see the current state, but the program will wait for more state messages and print the states as they arrive; if you flip the relay, you'll see output like this:

```
0
1
0
1
```

etc.

To change the state of the first relay, use the mosquitto_pub command, e.g. to switch it on use:

```
mosquitto_pub -h 192.168.0.5 -t pcr12345/outlets/0/set -m 1
```

and to switch it off use:

```
mosquitto_pub -h 192.168.0.5 -t pcr12345/outlets/0/set -m 0
```

As mentioned above, alternate value forms, e.g.

```
mosquitto_pub -h 192.168.0.5 -t pcr12345/outlets/0/set -m true
mosquitto_pub -h 192.168.0.5 -t pcr12345/outlets/0/set -m on
```

will also work as expected.

10.12 Modbus/TCP settings

Modbus/TCP slave outlet access configuration

#	Allow read	Allow write
1	☑	☑
2	☑	☑
3	☑	☑
4	☑	☑
5	☑	☑
6	☑	☑
7	☑	☑
8	☑	☑

Submit

Modbus/TCP relay settings

The unit's relays can be exposed via Modbus/TCP as coils. Writes affect the transient state, but the physical state, which may not change immediately, is what's read.

For each relay, read and write permissions can be configured. Reading an inaccessible coil returns OFF, and writing an inaccessible coil has no effect. Only nonexistent elements trigger an "illegal data address" Modbus error.

Additionally, discrete inputs, input and holding registers can be created to serve as a common interaction medium between Modbus/TCP and scripting. The configuration can be done using scripting as well as the UI and REST-like APIs.

Modbus/TCP scriptable discrete input configuration

#	Name	Index (0-based)	Value	Allow read
1	running	1	☐	☑
2			☐	☐

Submit

Modbus/TCP custom discrete input settings

Modbus/TCP scriptable input register configuration

#	Name	Index (0-based)	Value	Allow read
1	temperature	1000	50	☑
2				☐

Submit

Modbus/TCP custom input register settings

Modbus/TCP scriptable holding register configuration

#	Name	Index (0-based)	Value	Allow read	Allow write
1	state	100	5	☐	☐
2				☐	☐

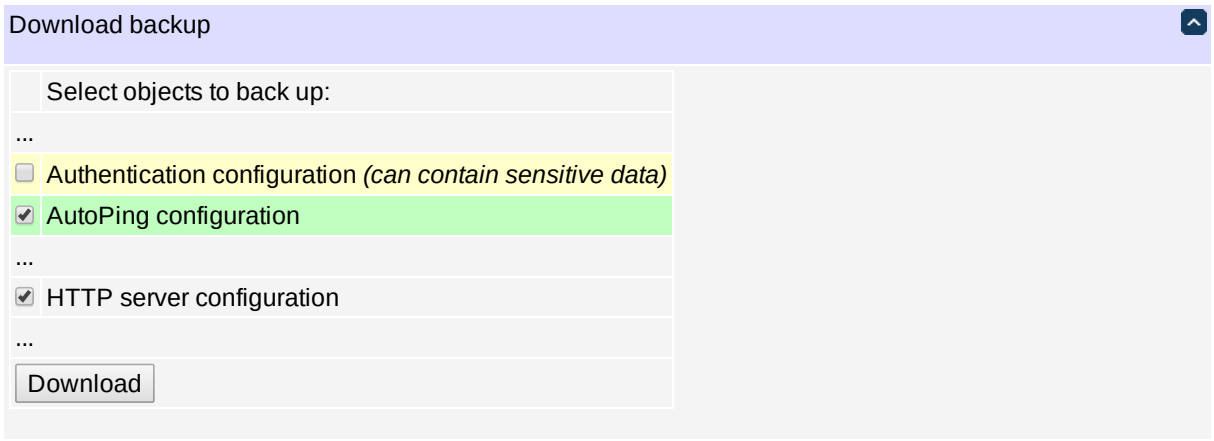
Submit

Modbus/TCP custom holding register settings

See the `default.modbus_demo`, `default.modbus_advanced_demo` script snippets for usage examples.

11 Backing up settings

The setting backup/restore system operates on a file level. It allows saving and restoring most configuration items, including those which have been done manually, e.g. via SSH. Settings can be backed up and restored selectively.



Backup setting selection (sample)

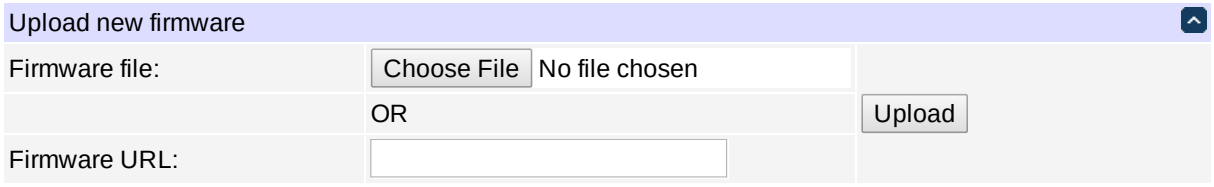
Modified files are highlighted in green. Choose the setting files you want to save (unknown files are shown as "File "+filename) and click "Download".

You may protect the security-sensitive parts of the configuration from being stored in a backup. Pressing the hardware reset button will be required to unlock.

12 Firmware upgrade

The controller's firmware can be upgraded to a newer version by first uploading it, and the committing the upgrade.

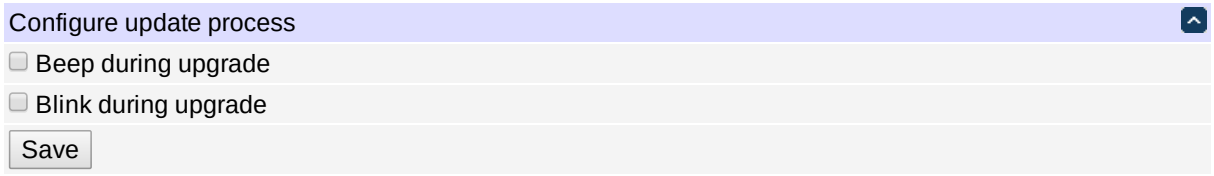
12.1 Uploading the firmware



Firmware upload page

You can upload a file or specify a URI where it can be downloaded from. Be sure to disable the same subnet restriction if you intend to download firmware from a server not in your local network.

By default, the unit beeps and blinks during update. You can disable this using the following form.



Firmware update configuration page

You may protect the current firmware from modification. Pressing the hardware reset button will be required to unlock.

12.2 Committing the firmware upgrade

After the firmware has been uploaded, you are presented with a form to perform the upgrade.

```
Firmware check OK
Upgrading from 1.7.1.0 to 1.7.2.0.
```

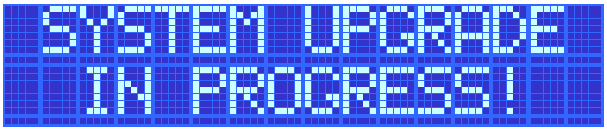
Perform firmware update

Update Cancel

Firmware upgrade page

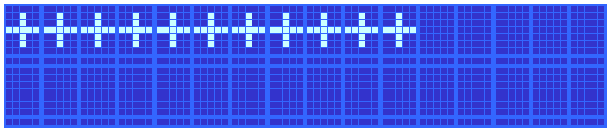
You can double-check the firmware version. If you wish to cancel the upgrade, it's best to explicitly press 'cancel' in the form so that the uploaded file could be cleaned up.

When you start an upgrade, a message about this briefly appears on the LCD.



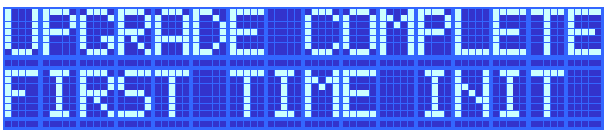
Firmware upgrade start indication

Further activity is indicated by a cycling pattern of + signs.



Firmware upgrade progress indication

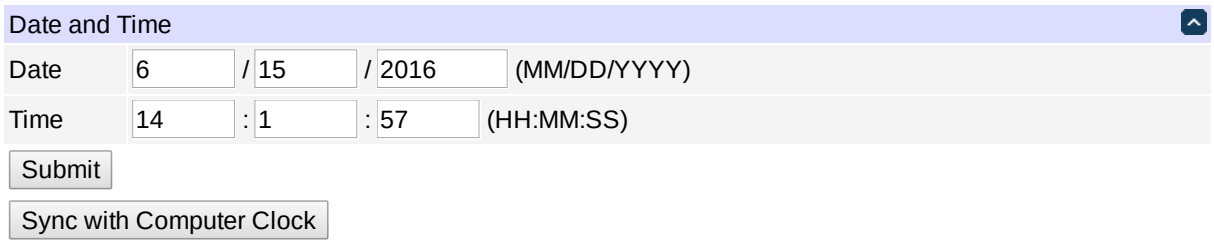
After an upgrade has been completed, the unit is rebooted. The first boot may take longer than usual due to configuration updates.



Post-firmware upgrade initialization indication

13 Date/time

The Date / Time page allows the administrator to set the internal clock and time zone. The clock may be set within the browser or synchronized with an NTP server.



Date/time

The default OpenWrt configuration is to use the NTP servers `(0|1|2|3).openwrt.pool.ntp.org`. See Scripting scripting to perform manual synchronization.

Correct time is restored automatically after power loss in products with the battery powered Real Time Clock.

The preferred time zone can be customized as well.

Timezone

The selected timezone is used for header date/time display and formatting time in plots.

Internally, the time zone is stored in a format different from the display (it has a different meaning for + and −). You should take that into account when interpreting related REST API values and log output.

14 AutoPing

AutoPing can monitor a network device and perform a task if the device stops responding. It can also monitor a group of devices, the task will be executed if none of the group members respond. The task is either a list of relays to reboot or a script to execute.

14.1 Common configuration

AutoPing Properties		
Enable AutoPing:	☑	
Time between pings:	30	seconds. (2-3600)
Ping timeout to reboot:	150	seconds. (2-3600)
Ping responses to enable AutoPing:	5	pings. (0-100)
Times to attempt reboot consecutively:	5	tries. (1-255, or 0 for no limit)
Total times to attempt reboot:	0	tries. (1-255, or 0 for no limit)
Device reboot delay:	120	seconds. (1-43200)
Handle failures immediately instead of waiting for timeout:	☐	
Activate enabled entries without trial on service restoration:	☐	

Apply

Common AutoPing settings

Be sure to enable AutoPing operation by ticking the "Enable AutoPing" checkbox. Certain reset procedures may turn it off automatically.

The following parameters are used for AutoPing operation:

- Time between pings: This is the time between each ping check of an address. 60 seconds should be useful for most applications.
- Ping timeout to reboot: This sets the maximum time that sequential communication attempts may fail. Any failure beyond this time limit will cause the task to be executed. For example, when set to 300 seconds and a time between pings is 30 seconds, if a target system fails to any pings for 330 seconds, the task will be executed. The ping that occurred after 300 seconds came at 330 seconds and still failed. Since occasional network overloads and missed packets can occur during normal network operation, be sure to choose a reasonable time. AutoPing may handle certain failures immediately instead of waiting for the timeout if configured to (see below).
- Ping responses to enable AutoPing: To ensure a reliable connection, AutoPing will only be enabled after this many successful pings. We do not recommend changing this (10 is default) unless you must configure your controller before connecting it to the target devices.
- Times to attempt reboot consecutively: If you have an unreliable target device, limit the number of times it will be rebooted by entering that value here. For example, entering 5 will execute the task up to 5 times before giving up. A successful ping will reset the counter.
- Total times to attempt reboot: similar to above, but limit the total number of times the device will be rebooted, even with successful pings in between.

- Device reboot delay: After rebooting a device with a cold-boot power-off, a waiting period should occur before the IP address is re-checked by AutoPing. This delay allows the device to reboot. Windows and Linux servers can force automatic file system checks which may take several minutes to complete. Enter a safe value here, for example entering 600 would cause the power controller to start checking the server for normal operation 10 minutes after reboot. If a script is to be triggered, any delays contained in the code being executed should be considered in determining the delay setting here so that the thread completes before the delay elapses. This timer starts at the execution of the thread started.

- Handle failures immediately instead of waiting for timeout: Enabling this feature may make sense for handling certain AutoPing target types which may return an explicit error (TCP RST, HTTP 500, etc.) by invoking the task immediately instead of waiting for the timeout to pass (during which the error condition could have disappeared and no action would have been taken). Consider the setup and AutoPing action when enabling this option (e.g. you shouldn't enable it if the AutoPing action is to power cycle a server, you need to shut one of its services down temporarily for maintenance and it's the only target of the AutoPing entry).

- Activate enabled entries without trial on service restoration: By default enabled entries still need to wait for a certain number of successful ping responses on initial power-up before AutoPing actions are taken to make sure the targets have come online as well (in the assumption that they might have suffered a power failure as well and may need time to recover). This option can be used to disable this additional check.

14.2 Ping target configuration

To actually use AutoPing, add one or more AutoPing targets (IP addresses) to the list. The button is used to remove a target from the list.

Below is an example AutoPing configuration with four targets:

AutoPing

	IP(s)	Reboot Outlets 1	2	3	4	5	6	7	8	Script	Action	Stats TX	RX	HIT
☑	74.125.87.103	☑	☐	☑	☐	☐	☑	☐	☐	switch_off		790	578	
☑	67.122.199.250											642	583	2
												0	0	
☐	192.168.0.92	☐	☐	☑	☐	☑	☑	☐	☐	[Cycle]		215	41	5
												0	0	
☑	192.168.0.93	☐	☐	☐	☐	☐	☐	☐	☐	toggle_stuff_and_log		823	822	0
												0	0	
☐		☐	☐	☐	☐	☐	☐	☐	☐	[Cycle]		0	0	0

Individual AutoPing settings

The checkbox to the left of the IP address is used to start/stop target monitoring. Confirm your action with button. This button is also used to link a list of relays or a script line to the AutoPing target.

The current AutoPing item and target state is indicated as follows:

☐	192.168.0.1	No checkmark indicates that the AutoPing item is not enabled.
☑	192.168.0.2	Checkmark indicates that the AutoPing item is enabled and operating normally.
☑	192.168.0.3	Red border around the AutoPing target indicates that it is awaiting a response (that a response has not been received for at least one ping within the "Ping timeout to reboot" period).
☑	192.168.0.4	Yellow background indicates that the AutoPing item is undergoing testing before becoming initially enabled.
☑	192.168.0.5	Orange background indicates that the AutoPing item has failed and the related action is being performed.
☑	192.168.0.6	Green background indicates that the AutoPing item is undergoing testing before being enabled after a power-on or service restart.

AutoPing target and item state indication

You can select the relays to perform trigger action on by ticking their respective checkboxes.

You can select a scripting action to perform when the AutoPing item triggers (by default the selected relays are cycled). The action must be a function defined in the scripting server, like

```
function action_to_perform()
    .
    .
    .
end
```

or e.g.

```
function action_to_perform(selected_outlets)
    .
    .
    .
end
```

In the second form the argument `selected_outlets` (any other name will do) will receive a table of the 1-based indices of relays selected (e.g. `{1,3,6}`). The order of relays in the table is unspecified; use `table.sort` in the script function if you rely on a particular order.

The stats column shows some statistics:

- *TX* — the number of pings sent to the target IP address;
- *RX* — the number of pongs received back so far;
- *HIT* — the number of times the trigger action was executed.

On the sample image, three targets are being monitored (74.125.87.103, 67.122.199.250, and 192.168.0.93). 192.168.0.93 seems to be a very reliable/well-connected device: 823 pings were sent to it and 822 pongs received back. Chances are very good, the 823rd pong will arrive soon. The reboot task (script function `toggle_stuff_and_log`) was never executed.

Looks like 192.168.0.92 failed hard. The task (cycle relays 3,5,6) was executed 5 times in a row but the target did not respond. Monitoring was automatically disabled.

74.125.87.103 and 67.122.199.250 form a group, the trigger task will be performed if they both lose 5 sequential packets simultaneously. This has happened 2 times so far. Monitoring a group of several external spatially separated reliable IP addresses (in this example they belong to Google and Digital Loggers respectively) may become very useful to detect a stuck ADSL modem or some other no-Internet condition.

14.3 Action on local network failures

AutoPing is designed to control operation of remote hosts. You usually don't want to e.g. cycle power to all servers if you turn on same subnet restriction. So AutoPing tries not to trigger if there might be a problem local to the unit itself. For example, if you detach the Ethernet cable from the unit, you'll see messages similar to the following:

```
kernel: eth0: link down
config.net: Interface "eth0" is down
autoping: ping x.y.z.t: no usable route to host, ..., not considered a failure
```

and no actions will be performed. A similar situation will occur if you reconfigure the controller to use a new IP network from which old addresses are unreachable.

Use the `link://` scheme to check for local link loss.

14.4 Advanced ping targets

AutoPing targets don't have to be IP addresses. If you enter a hostname, it will be resolved before sending each request. If the name resolution fails, it is assumed to be a local error and, as described above, no action is taken. If a name is resolved to multiple IP addresses, a random one is chosen.

AutoPing defaults to checking targets using the ICMP protocol by default. A variety of other ping target kinds can be used if you specify a URL instead of simply an IP address or hostname. Supported URL schemes include:

- `icmp` — this is explicit specification of the "regular" ping protocol, e.g. `icmp://192.168.0.1` is equivalent to `192.168.0.1` (note that no trailing slash is used);
- `link` — this allows to check if the physical link is present on the wired (`link://eth0`) or wireless (`link://wlan0`) interface (which is useful as higher-level targets will usually ignore link loss);
- `tcp` — this causes AutoPing to try to establish a TCP connection to the given port, e.g. `tcp://192.168.0.1:22` can be used to check that there's a service listening on TCP port 22 (usually SSH) of `192.168.0.1` (note that no trailing slash is used);
- `http` and `https` — this causes AutoPing to perform a HTTP/HTTPS GET request for the given URL, e.g. `http://www.digital-loggers.com/index.html` can be used to check that the web server is responding and can serve its main page.

14.5 AutoPing events

The most often encountered AutoPing events are:

- `pinging ... (timeout)`
- `ping ... succeeded (time)`
- `ping ... failed (time)`

The time is request round-trip time, in seconds. Note that it's purely informative and can't be used as a measure of target response time unless it has order of hundreds of milliseconds and above.

Several failures in a row trigger AutoPing actions which are reported with corresponding events:

- `item ... (addresses...) failed [failures/max]`
- `item ... (addresses...) failed over (max) times in a row, disabling`

As described above, local network failures don't count toward failure count, but generate these notifications instead:

- `no usable route to host, possibly due to local network outage, not considered a failure` (when a request isn't being sent)
- `ping ... not received (time), possibly due to local network outage, not considered a failure` (when an outage occurred after a request has been sent)

The events associated with item trial before enabling are self-explanatory:

- `item ... (addresses...) enable approved`
- `item ... (addresses...) enable cancelled`
- `item ... (addresses...) trial restarted due to address list changes`

15 Energy monitor

The energy monitor page displays values of measurements in different forms.

The image format can be configured on the setup page.

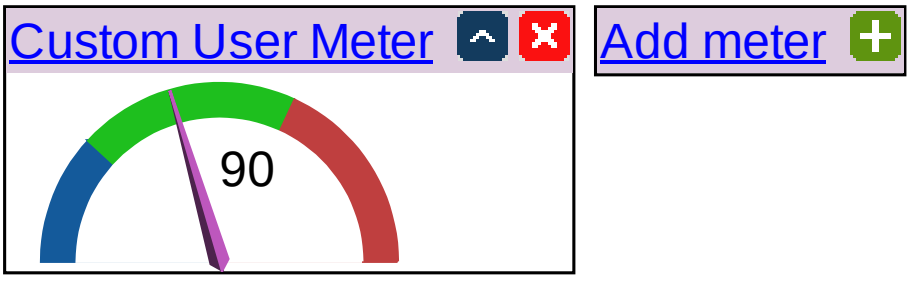
Currently measured values

The rest of the page is occupied by user-configurable meters and plots. You can use the icon to add a new meter or plot, or the icon to delete an existing one.

Use the / icon to toggle visibility of a plot or meter. The setting persists (unlike visibility of configuration blocks).

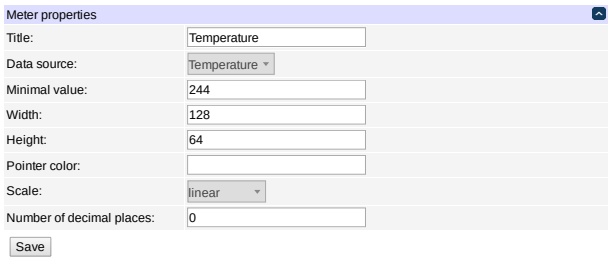
Plots and meters can be configured in detail by clicking on them.

15.1 Meters



Meters

Clicking on a meter allows to configure it.



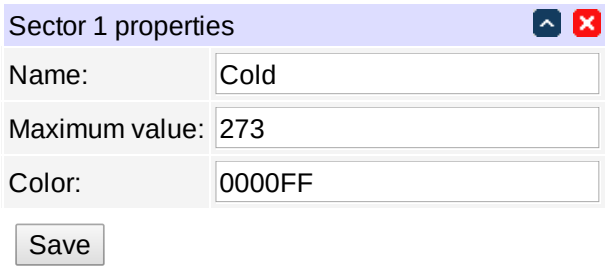
Basic meter configuration

The basic meter properties include:

- the title;

- the width in pixels;
- the height in pixels;
- the main color of the pointer, in hex web notation without '#';
- the minimum (leftmost) value to display;
- the gauge's scale (linear or logarithmic);
- the number of digits to display after decimal point;
- the data source.

A meter should have one or more sectors, which define different ranges of the value to indicate. The end of one sector's range is the beginning of the next one's range; for the start of the first sector's range, the "minimum value to display" setting is used.

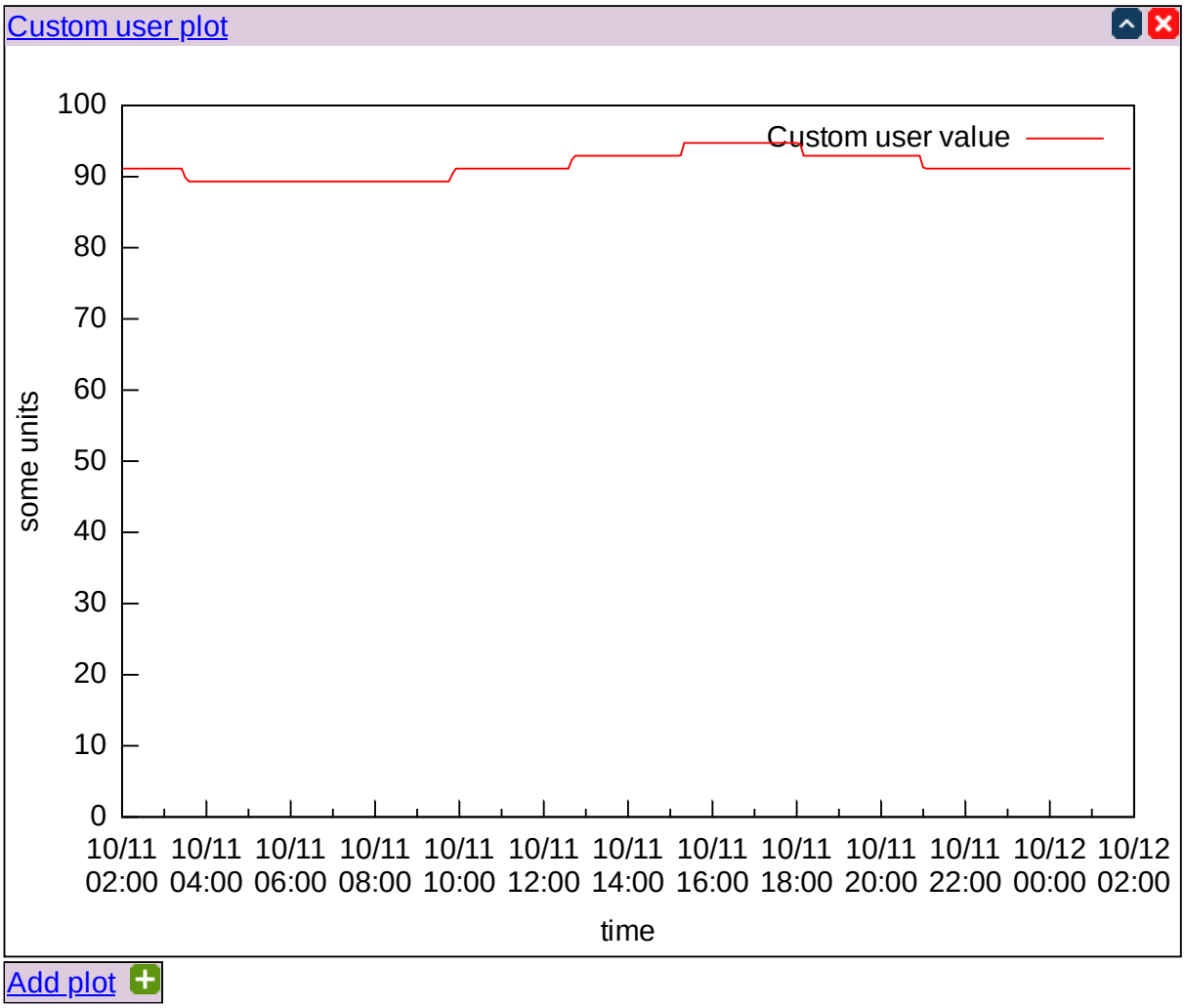


Meter sector configuration

The sector properties include:

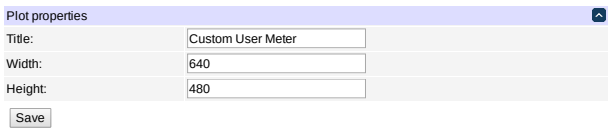
- the name of the sector (currently unused);
- the maximum value for the sector (and also the minimum value for the next sector);
- the sector color, in hex web notation without '#'.

15.2 Plots



Plots

Clicking on a plot allows to configure it.



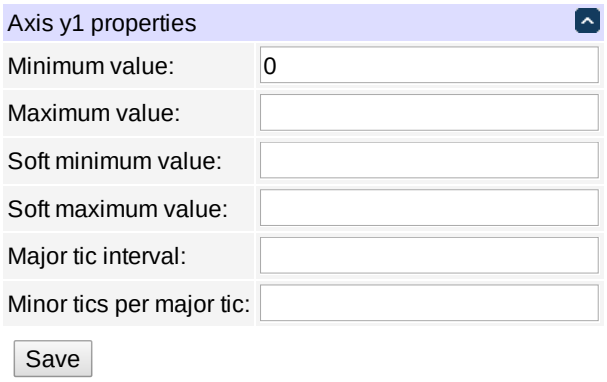
Basic plot configuration

The basic meter properties include:

- the title;
- the width in pixels;
- the height in pixels.

The rest of meter configuration is centered around axes and plot lines which are drawn on them.

There are 4 axes: `x1` and `y1` are the usual ones; `x2` is at the top, and `y2` is at the right side.



Configuration of an axis

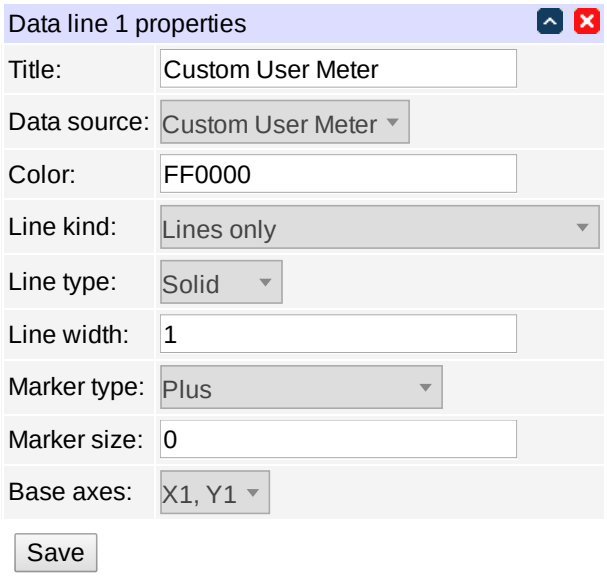
Each axis has the following properties:

- minimum/maximum values: these specify the exact plotting value range;
- soft minimum/maximum values: these specify a range with limits which can be exceeded;
- major tic interval/minor tics per major tic: configure the axis tic behaviour;

The interaction between hard and soft limits is as follows:

- if no limit is specified, the plotting range is determined by the data to be plotted;
- if only a hard limit is specified, it's obeyed;
- if only a soft limit is specified, it's obeyed unless data exceed it, then data are obeyed;
- if both limits are specified, the soft limit (which should be less strict than the hard limit) is obeyed unless data exceeds it, then data are obeyed unless they exceed the hard limit (which should be stricter than the soft limit), then the hard limit is obeyed.

Several plot lines can be drawn on the same plot (they don't have to be proper lines but may have various shapes, see below).



Configuration of a plot line

Each plot line can be one of the following styles:

- lines only;
- markers only;
- lines and markers;
- small dots;
- step lines;
- boxes;
- spline smoothed lines;
- approximated spline smoothed lines;
- Bezier smoothed lines;
- vertical lines.

Solid/dotted/dashed lines are supported. Data points can be displayed using a variety of markers:

- empty/filled circle;
- empty/filled square;
- empty/filled triangle;
- empty/filled inverse triangle;
- empty/filled rhombus;
- plus;
- dot;
- cross.

Line width and marker size can be configured. Colors have to be specified in hex web notation without '#'.

Each plot line is plotted on a combination of x and y axes. Plot lines which are plotted against the same axis must have matching measurement units along that axis; e.g. if you want voltage and current on the same plot, they need to be plotted against different y axes but can share the same x axis (time).

If spline interpolation is requested and it fails, the line is plotted using Bezier curves instead.

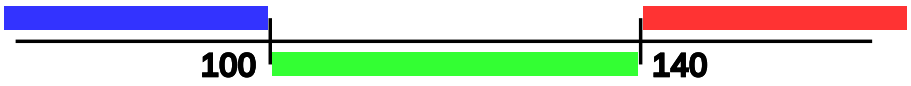
15.3 Alarms

Every measured value can trigger 'alarms' when it is in a certain value interval; those alarms can be made periodic. Alarms carry a 'level', which is an administratively assigned number; the range of these numbers is entirely up to the user; it may be used in notification rule conditions (e.g. 'value_alarm_level>2'); it's intended that alarm levels for different values correspond to the associated severity/risk value so that the notification rules can be made generic (and independent of concrete values).

Configuration of meter value alarms is done not on the notification page, but on the energy monitor page. You can configure a meter value's alarms by clicking the icon next to it. This will open the interval alert configuration page for it.

Every measured value is a just a number, or 'none' for some meters on some devices which are detachable, so it makes sense to say there's no value.

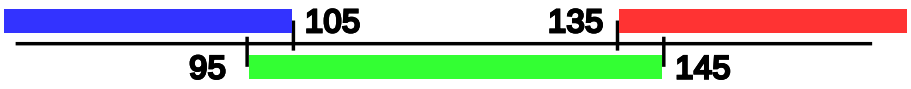
The real line of the possible values can be partitioned into intervals using threshold points: e.g. voltage can be below 100V, between 100V and 140V or above 140V, so there are two points, 100V and 140V, splitting the real line into 3 intervals. The idea is similar to configuring sectors of a meter's visual appearance.



Naive interval configuration

Each of the intervals can be assigned an alarm level, which can then be analyzed by notification server conditions (you can also 'none' if you explicitly wish to send no events for that interval).

It is often desirable to keep some level of hysteresis between two adjacent intervals, so that there is some threshold the value needs to cross before we consider that it has left one interval and entered a different one, to avoid needless notifications. This is accomplished by further splitting the threshold points into the top and bottom values. If a value increases and crosses the interval boundary, we only consider that it has switched intervals after it's above the top value. Likewise, if a value decreases and crosses the interval boundary, we only consider that it has switched intervals after it's below the bottom value. E.g. you could use 95V and 105V for the bottom and top values of the 100V threshold point in the previous examples for a 10V hysteresis.

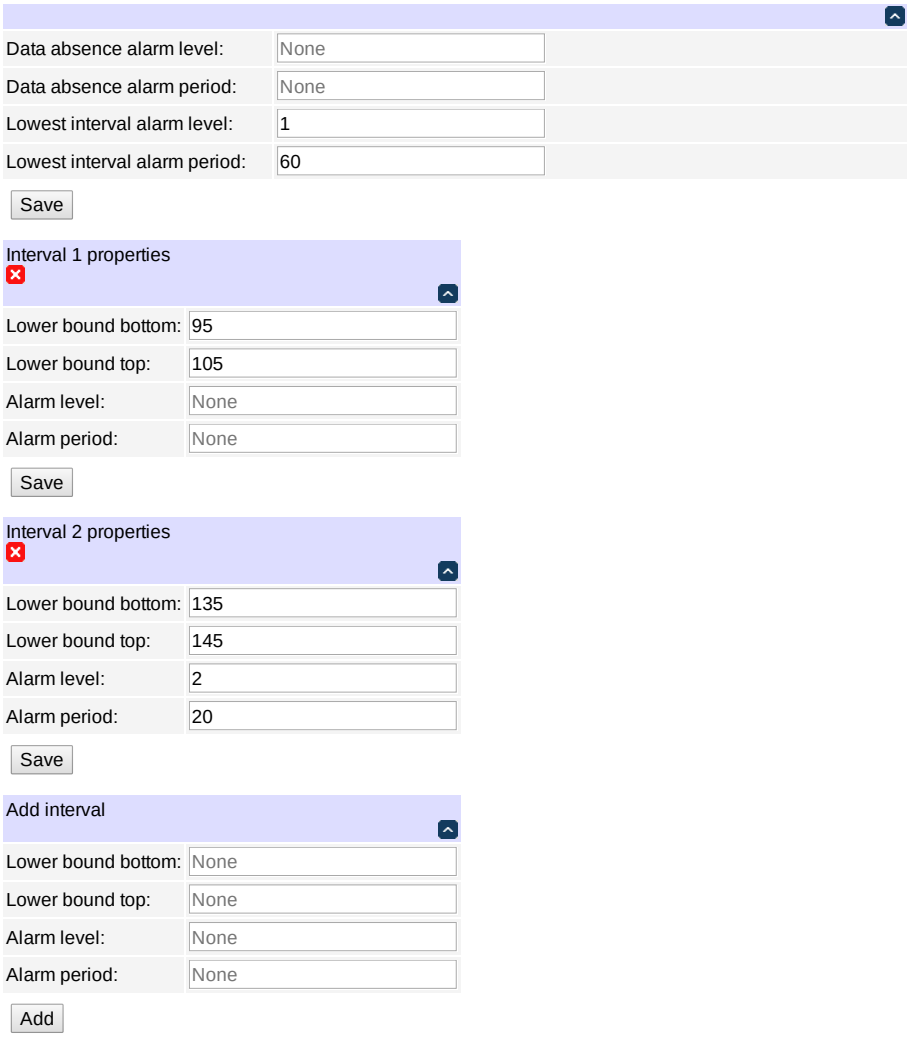


Interval configuration with hysteresis

Each interval is characterized by its lower threshold point (with its bottom and top values), its alarm level and period. The exception is the lowest interval which has no threshold point (but still has a level and a period). The "none" value is considered so distinct from all regular values that no hysteresis is possible, so it is also characterized by a level and a period only.

The above sample configuration might look like this:

Interval alert configuration for Custom User Meter



Sample interval alert configuration

Here, we trigger a level 1 alarm every minute if the voltage is below 100V and a level 2 alarm every 20 seconds if the value is above 140V.

16 System log

Most events occurring during controller operation are logged into the system log.

System Log:

```
Fri Jan 1 00:02:31 2018 daemon.info dnsmasq[4061]: started, version 2.78 cachesize 150
Fri Jan 1 00:02:31 2018 daemon.info dnsmasq[4061]: DNS service limited to local subnets
Fri Jan 1 00:02:31 2018 daemon.info dnsmasq[4061]: compile time options: IPv6 GNU-getopt no-DBus no-i18n no-IDN DHCP no-DHCPv6 no
Fri Jan 1 00:02:31 2018 daemon.info dnsmasq-dhcp[4061]: DHCP, IP range 192.168.254.200 -- 192.168.254.248, lease time 12h
Fri Jan 1 00:02:31 2018 daemon.info dnsmasq[4061]: using local addresses only for domain lan
Fri Jan 1 00:02:31 2018 daemon.info dnsmasq[4061]: reading /tmp/resolv.conf.auto
Fri Jan 1 00:02:31 2018 daemon.info dnsmasq[4061]: using local addresses only for domain lan
Fri Jan 1 00:02:31 2018 daemon.info dnsmasq[4061]: using nameserver 192.168.0.1#53
Fri Jan 1 00:02:31 2018 daemon.info dnsmasq[4061]: read /etc/hosts - 2 addresses
Fri Jan 1 00:02:31 2018 daemon.info dnsmasq[4061]: read /tmp/hosts/dhcp - 1 addresses

Fri Jan 1 00:02:31 2018 daemon.info dnsmasq-dhcp[4061]: read /etc/ethers - 0 addresses
Fri Jan 1 00:02:32 2018 user.notice firewall: Reloading firewall due to ifup of wan (wlan0)
Fri Jan 1 00:02:34 2018 user.notice upnp[4136]: Starting...
Fri Jan 1 00:02:39 2018 user.notice www[4291]: Starting...
Fri Jan 1 00:02:46 2018 daemon.info procd: - init complete -
```

System log

Note that the system log buffer has a fixed size, and old entries are removed automatically as new ones appear. The display is periodically updated.

You can use the `logread` command to read the same data in an SSH session. `logread -f` will display new entries in real time.

17 Locking down the controller

17.1 Intended locking use cases

In some cases it's required to grant administrative access to multiple, possibly not completely trusted, parties. The settings described below are designed to somewhat limit what an administrator can do to the device.

17.2 Protection bits

The following operations available to the administrator pose an increased risk and can be protected:

- changing administrator credentials;
- changing networking settings;
- changing notification settings;
- backing up private settings (passwords, keys, etc.);
- restoring settings from backup;
- upgrading firmware;
- entering maintenance mode.

17.3 Protection status indication

Overall protection status is indicated in the top right corner of each page:

-  — no protection bits active;
-  — some protection bits active;
-  — all protection bits active.

Clicking on the icon gives more detailed info:

```
Firmware protection is disabled

Notification settings protection is disabled

Private configuration protection is enabled but ineffective:
SSH is enabled, which could be used to bypass protection
Firmware upload is allowed, specially crafted firmware could be used to bypass protection

Administrator credentials protection is disabled

Maintenance mode lock is enabled but ineffective:
SSH is enabled, which could be used to bypass protection
Firmware upload is allowed, specially crafted firmware could be used to bypass protection

Protection from restore from backup is enabled but ineffective:
SSH is enabled, which could be used to bypass protection
Firmware upload is allowed, specially crafted firmware could be used to bypass protection

Network settings protection is disabled
```

Protection status details

17.4 Unlocking protection

You should use the reset button and select the "Clear lock bits" reset mode to clear protection bits. This, of course, requires physical access to the unit.

18 Resetting settings to defaults

The device's settings can be reset to defaults by pressing the reset button .

You may want to take a backup of your settings first.

The display displays an overview of possible actions with a ticker on the second LCD line. You may interrupt it by pressing ▲ , ▼ or ⟲ .

Use ▲ and ▼ , or short presses of the reset button, to select a reset mode. A description of the currently selected mode is displayed on the second LCD line.

The following reset modes are available:

1. Clear lock bits: Clear protection bits only. Other settings are preserved.
2. Reset network and scripting: Clear protection bits, reset network settings and admin login, disable AutoPing and scripts. Other settings are preserved.
3. Reset network and scripting + enable WiFi: Clear protection bits, reset network settings and admin login, disable AutoPing and scripts, and enable open WiFi access. Other settings are preserved.
4. Complete wipe: Reset all settings to factory defaults and remove any user files. All settings, including contents of the `/storage` directory, will be lost!
5. Complete wipe + enable WiFi: Reset all settings to factory defaults and remove any user files, then enable open WiFi access. All settings are lost!

To activate the selected reset mode, press ⟲ or the reset button and hold it.

If all settings are reset (the two last 'wipe' reset modes), the Subnet Restriction will be enabled to prevent remote access using the default password. ONLY MACHINES IN THE SAME SUBNET WILL BE ABLE TO CONNECT A↩ FTER RESETTING TO DEFAULTS. If connectivity is lost, use a local connection such as a laptop with a crossover cable to restore your original network settings.

19 Specifications

Alert Beeper	73dBa at 12". Programmable.
Applications	Commercial, industrial power distribution and reboot. Indoor use only.
Circuit Breakers	Manual reset, 15A-50A Thermal Supplemental
Clock / RTC	15 year Li battery, under 2 grams
Controls / Display	Reset-to-factory-default switch, 2x16 Backlit LCD w/ PowerSave, 5 button keypad
Enclosure	Steel, double grounded. Vented 4 sides.
Ethernet Interface	10/100 autosensing, Static IP, TCP port selectable, 8 pin RJ-45 w/ internal FCC filtering, WiFi optional
FCC Testing	Part 15 FCC ID 2ACIUDC3
Humidity	8-80% RH Operating.
Input Terminals	Two 50A copper compression lugs
Power Input	2x50A, 12-72VDC, positive or negative ground
Operating Temperature	-30° to 170°F, -34° to 77°C
Options - Factory	Custom breakers. External connectors.
Power Supply Rating	12-72VDC, undervoltage lockout at 11.3V
Password Transmission	Encrypted, base 64 or HTTPS
Power Dissipation	5.9W Typ Max (all on) $<$3 W idle
Power Fail Hold-Over	100ms minimum (all relays on)
Power-Up Modes	Last used settings, all power on or off, sequential on or run user-script $\sim$30s after power-up
Relay Contact Spec	40A AC NO, 1/2HP, 12V DC coil
Surge Protection	3600W Metal Oxide Varistor
Size	1.75 (1RU) x9.0x19.0"
Software Controls	Individual outlets on/off , all on/off /cycle. Net settings, Web UI
Surge Protection	3600W Metal Oxide Varistor
Weight (packed)	Single unit 11lbs 4.8kg.
WiFi	Atheros 9331 2.4G 802.11n RP-SMA

FCC Note:

The DC3 may only be used with

- the manufacturer supplied antenna (Gain: 2.0dBi),or
- a 50 Ohm antenna of equal or lesser gain.

20 Open source code

In compliance with the spirit of the GNU Public License, source code is provided together with the firmware itself (accessible using one of the user-configurable links). Note that it is placed on the read/write firmware partition, so certain operations (like full factory reset) may remove it.

Purchasing a TLA and signing an NDA from Atheros are highly recommended before attempting any custom development; however, they aren't required to build the firmware (only the bootloader).

DLI cannot provide warranty or technical support for modified units; this includes units with custom firmware.

21 Technical support

Please register. Painless on-line registration gets you:

- free tech support,
- access to firmware updates,
- and information when updates and new features become available.

To save time, please have a look at the product FAQ page solutions. You may FAX questions to (408) 541-8459 or email: support@digital-loggers.com.

For phone support, call (408) 330-5599 with the following so we can better serve you:

- The firmware version level installed in the power switch. This information can be found on the lower left corner of the relay control page.
- A description of the Ethernet devices connected to your unit, for example, a 10/100 PC and crossover cable.
- A description of the WiFi devices connected to your unit, i.e. their manufacturers and model numbers.

22 Limited one year warranty

The terms of this warranty may be legally binding. If you do not agree to the terms listed below, return the product immediately in original unopened condition for a full refund. The purchaser assumes the entire risk as to the results and performance of the unit.

DLI warrants this power controller to be free from major defects. No agency, country, or local certifications are included with this unit. It is the responsibility of the user to obtain such certifications if necessary for the customer's application. Buyer acknowledges and agrees that he is solely responsible for proper use, certification and safety testing of components supplied by DLI. DLI's entire liability and exclusive remedy as to defective hardware shall be, at DLI's option, either (a) return of the purchase price or (b) replacement or repair of the hardware that does not meet DLI's quality control standards and has been returned through proper RMA procedures. DLI's liability for repair or replacement is to DLI's customer ONLY.

WARRANTY SERVICE DOES NOT COVER DAMAGE TO SCREW TERMINALS FROM EXCESSIVE TORQUE OR DAMAGE DUE TO EXPOSURE TO WATER OR VIBRATION.

NO SUPPORT IS PROVIDED FOR MODIFIED FIRMWARE. MODIFICATION OF FIRMWARE VOIDS ALL WA↩ RRANTY.

Warranty service requires an original invoice from DLI and an RMA number provided by technical support. RMA material must be shipped prepaid to DLI. RMA numbers are valid for 15 days from date of issue. This warranty does not cover products which are modified (including firmware modifications), subjected to rough handling, or used in applications for which they were not originally intended. Batteries are not covered under warranty. Physical damage caused by customer or in transit to DLI is not covered under warranty. Please insure your shipments.

No oral advice or verbal warranties made by DLI's employees, dealers, or distributors shall in any way increase the scope of this warranty. DLI makes no warranty as to merchantability or fitness for any particular purpose. DLI assumes no liability for incidental or consequential damages arising from the use or inability to use this product. This warranty gives you specific legal rights. You may also have other rights that vary from state to state. Since some states do not allow the exclusion of liability for consequential damages, some of the above limitations may not apply to you. This product is not qualified or intended for mobile, airborne, medical or aerospace use or FDA Class III applications.