

Lua Scripting

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Lua Scripting Overview

Lua scripting is an advanced topic. eGauge Support cannot review code and has limited support for troubleshooting Lua scripts.

Introduction

Support for eGauge Script (eScript) was introduced in firmware v1.1, allowing limited scripting through the use of [formula registers](#). eScript was designed for calculating basic and common mathematical formulas such as basic arithmetic operations, comparisons, and conditionals, along with the ability to call library routines (functions).

Firmware v4.1 introduced [Lua v5.3](#) support. To ensure safe operation, Lua execution is guarded with timeouts to protect against infinite loops or unacceptably long execution times. Additionally, a restricted set of standard libraries is supported.

To maintain backwards compatibility, firmware transparently translates eScript expressions to Lua scripts before execution and the Lua execution environment provides all the functions available within eScript.

Lua Primer

Lexical Conventions

Names may consist of any letters, digits, or underscores but may not start with a digit. Numeric values use the same conventions as in most other languages, including the ability to write hexadecimal values with a prefix of `0x`. The two boolean literal values are `true` and `false`. A variable with an undefined value is `nil`. Strings may be enclosed in double or single quotes. Characters within a string may be escaped with a backslash. Comments start with a double-dash (`--`) and extend to the end of the line. Statements may be terminated with a semicolon but, generally, semicolons are not required (even when there are multiple statements on a single line). The only exception to this rule is that a semicolon is required if the following statement starts with a left parenthesis.

Variables

Variables are *global* unless explicitly declared as local. For example:

```
x = 10      -- global variable
local y = 42 -- local variable
```

Operators

Lua provides a normal set of operators for arithmetic operations and comparisons. A bit unusual is that the inequality operator is `~=` rather than the more typical `!=`. Logical operators use keywords like in Python:

and, **or**, and **not**. The length of a string or a table (see [Structured Data](#)) is obtained by prefixing the string or table name with a hash mark. `#'hi'` would return 2, for example. Strings can be concatenated with the double-dot operator. `'yell'..'ow'` would yield `'yellow'`, for example.

Control Structures

The syntax for the various control structures is:

```
for index=initial,step,final do block end -- numeric for loop
```

```
for var in iterator do block end -- iterator for loop
```

```
while cond do block end -- while loop
```

```
repeat block until cond -- do while loop
```

```
if cond then block else block end -- conditional statement
```

You can use **break** to exit a loop but, unlike in C and other languages, there is no `continue` that would allow you to skip to the next iteration.

Structured Data

Lua uses tables to represent both arrays and hash tables (Python dictionaries, Javascript objects). For example:

```
local a = {'a', 'b', 'c'}
```

assigns an array containing the strings `'a'`, `'b'`, and `'c'` to local variable `a`. Unlike in most other languages, the array base index is 1, so `a[1]` would yield the first element or `'a'` in our example.

Dictionary literal values can be written like this:

```
local d = {[ 'k1' ]='v1', [ 'k2' ]='v2'}
```

and indexed with square brackets such that `d['k2']` would yield `'v2'`, for example. If the keys for a dictionary happen to be valid Lua names, the square brackets and quotes around the key strings can be omitted. For example, the above example could be simplified to:

```
local d = {k1='v1', k2='v2'}
```

For such key values, it is also possible to access their values using member-name syntax. For example, `d.k1` would yield `'v1'`, just as `d['k1']` would.

Migrating from eScript to Lua

Most of eScript has a direct equivalent in Lua. eScript has full support for a single numeric type (IEEE754 double precision float) and limited support for strings. As configured for the eGauge firmware, Lua has the same numeric type but also supports 32-bit integers and has full support for strings, boolean values, and tables.

The most important differences between eScript and Lua are as follows:

- In eScript, the value of a register is obtained with `$"register_name"`, whereas in Lua, the equivalent expression is `__r("register_name")`.
- Lua boolean values cannot directly be used as numeric values, whereas eScript uses 0 to represent false and any non-zero value for true.
- Lua does not provide a direct analog for the conditional operator

```
cond ? if_true_expr : if_false_expr
```

Instead, Lua uses the logical expression

```
cond and if_true_expr or if_false_expr
```

This works quite similarly to the eScript conditional because of the way the `and` and `or` operators are defined. Specifically, `and` returns `false` if the left-hand side is `nil` or `false` or the right-hand side's value otherwise. Operator `or` returns the value of the left-hand side if it is not `nil` or `false` and the value of the right-hand side otherwise. Both operators short-circuit evaluation and operator `and` has higher precedence than `or`.

- eScript automatically propagates NaN (Not-a-Number) values. For example, if any function is called with a NaN value, the returned result is also NaN. Similarly, if the condition of the

conditional operator is NaN, then the result of the conditional expression is also NaN.

Given the similarities between eScript and Lua, most eScript expressions trivially translate to Lua. The non-trivial translations are shown in the table below:

eScript expression	Lua equivalent
<code>a < b</code>	<code>__lt(a, b)</code>
<code>a <= b</code>	<code>__le(a, b)</code>
<code>a > b</code>	<code>__gt(a,b)</code>
<code>a >= b</code>	<code>__ge(a,b)</code>
<code>a = b</code>	<code>__eq(a,b)</code>
<code>c ? a : b</code>	<pre>(function(__c) if __c ~= __c then return __c end return __c~=0 and (a) or (b) end)(c)</pre>

In words, the comparison operators get translated to calls to helper functions `__lt()`, `__le()` and so on. These helper functions check if either `a` or `b` is a NaN and return NaN, if so. If not, they perform the comparison and return 0 for false and 1 for true. The translation of the conditional operator is more complicated because care has to be taken to handle NaN properly and to evaluate `a` and `b` only when necessary. This is accomplished in Lua with the help of an anonymous inline function which checks whether the condition is NaN and returns NaN if that is the case. Otherwise, the function checks if the condition has a non-zero value and, if so, returns the value of `a`. Otherwise, it returns the value of `b`.

Lua Environment provided by eGauge Firmware

Standard Environment

For safety reasons, the eGauge firmware provides a restricted Lua environment (the Lua sandbox). Basic functions and variables are limited to the following subset (see [Lua 5.3 manual](#) for a detailed description):

```
_VERSION, assert, error, getmetatable, ipairs, load, next, pairs, pcall,
print, rawequal, rawget, rawlen, rawset, select, setmetatable, tonumber,
tostring, type, xpcall
```

The following standard Lua libraries are available:

[string](#), [math](#), [table](#)

Additions Provided by eGauge Firmware

Basic and Alert functions

All functions available to eScript are also available to Lua scripts. See the online documentation of an eGauge meter for a complete list (**Help ? Basic functions** or **Help ? Alert functions**). When these functions are called from Lua, they will also propagate NaN values, just like for eScript. That is, if any of the functions are called with a NaN argument, the return value will also be NaN.

Module **json**

This module provides the ability to encode a Lua object to a string and safely convert a string back to an object again.

```
string = json.encode(value):
```

This function accepts a Lua value and serializes it to the corresponding JSON string, which it returns. Tables that contain cyclical references cannot be JSON-encoded and will result in an error. The maximum size of the JSON-encoded string is currently limited to 4095 bytes. Lua tables may be indexed by a mix of number, boolean, and string values, whereas JSON objects are always indexed by strings. This function converts Lua tables that are not empty and whose indices consist entirely of numbers in the range from 1 to N (where N is the length of the table) to JSON arrays and everything else to JSON objects. In the latter case, numeric and boolean indices are converted to their equivalent strings.

```
value = json.decode(string):
```

This function accepts a string and deserializes it to the corresponding Lua object. Only double-quotes are allowed for string quoting. White space consisting of blanks or tabs is ignored.

Module **persistent**

This module provides variables whose values persist across power outages and device restarts.

```
obj = persistent:new(name, initial, description):
```

Declares a persistent variable with the specified *name*. Unlike Lua names, this name can be an arbitrary string. The name must be unique as any Lua script declaring a persistent variable of the same name will access the same underlying object. If this is the first time the persistent variable has been declared, its value is set to *initial*. The purpose of the variable must be described by the string passed for *description*. The return value is an object representing the persistent variable.

```
obj:get()
```

Returns the current value of the persistent variable represented by object *obj*.

```
obj:set(value)
```

Sets the value of the persistent variable represented by object *obj* to *value*. Any value acceptable to **json.encode()** may be set.

Lua Environment for Control Scripts

Control scripts have access to the standard environment available as described in the previous section. They also have access to all basic and alert functions as well as to the [coroutine](#) library. Several low-level functions as well as several convenience modules are available as well, as described below.

Low-level Functions

Most of these functions are normally not used directly. They provide the low-level mechanisms required to implement the higher-level abstractions provided by the modules described in the sections below.

```
tid, err = __ctrl_submit(attrs, method, args...)
```

Submit a call to the method named *method* on the device identified by *attrs*, passing arguments *args*. The method name must be a string, *attrs* a table of name/value pairs, and *args* must be a sequence of zero or more Lua argument values that are compatible with the argument types expected by the named method. The method name may be a fully qualified method name consisting of an interface name, immediately followed by a dot (*.*), immediately followed by the proper method name or a proper method name on its own. In the latter case, the method is invoked through the first interface registered for the device that implements the named method. Otherwise, the method is invoked through the named interface.

`__ctrl_submit` returns two values: a transaction id *tid* and an error string *err*. On success, *tid* is a non-negative number which uniquely identifies the newly created call object and *err* is *nil*. On error, *tid* is a negative error code (see `ctrl.Error` below) and *err* is an optional string that may provide an explanation of why the call failed. The error string, if provided, is typically translated to the locale set on the meter.

```
status, result = __ctrl_result(tid):
```

Get the result for the method call identified by transaction id *tid*. The *tid* must be non-negative and must have been returned by a previous call to `__ctrl_submit`.

`__ctrl_result` returns two values: an integer *status* and *result*. The *status* is zero on success, in which case *result* is the result returned by the method call, converted to a Lua value. On error, *status* is a negative error code (see `ctrl.Error` below) and *result* is *nil*. In particular, if a method call is still in progress, error code `ctrl.Error.AGAIN` (-8) is returned. In this case, the caller should wait for a little bit and then retry the `__ctrl_result` call again until it succeeds.

```
status, err = __ctrl_cancel(tid):
```

Attempt to cancel the method call identified by transaction id *tid*. This *tid* must be non-negative and must have been returned by a previous call to `__ctrl_submit`.

`__ctrl_cancel` returns two values: an integer *status* and an optional error string *err*. The *status* is zero on success, in which case *tid* is guaranteed to be an invalid transaction id, until it is reused and returned by another call to `__ctrl_submit`. On error, *status* is a negative error code (see `ctrl.Error` below) and *err* is an optional string that may provide an explanation of why the call failed. The error string, if provided, is typically translated to the locale set on the meter.

```
ret, err = __ctrl_get_devices(attrs):
```

Get a list of devices that match the optional attributes specified by table *attrs*. If the *attrs* is omitted or *nil*, a list of all known (registered) devices is returned.

`__ctrl_get_devices` returns two values: table *ret* and an optional error string *err*. On success, *ret* is a list of tables and *err* is *nil*. Each table in the returned list corresponds to a matching device in no particular order. The table contains the name/value pairs registered for that device.

On error, *ret* is *nil* and *err* may be a non-*nil* string explaining what went wrong, typically translated to the locale set on the meter.

```
ret = __ctrl_get_interface(name):
```

Get a particular interface or a list of all known interfaces. Argument *name* must be a string that names the desired interface or omitted or *nil* to get a list of all interfaces.

`__ctrl_get_interface` returns a single value *ret*. If there was an error or if the requested interface cannot be found, *nil* is returned. Otherwise, *ret* is a single interface (if *name* was specified) or a list of interfaces (if *name* was omitted or *nil*). Each interface is described by a table with the following members:

- *name*: The name of the interface as a string.
- *methods*: A list of methods implemented by the interface.

Each method is described by a table with the following members:

- *name*: The name of the method as a string.
- *arg_types*: The DBus type signature of the arguments as a string.
- *ret_type*: The DBus type signature of the return value as a string.
- *doc*: A description of what the method does as a string. This string may contain references to the arguments which are enclosed in `<arg>/</arg>` tags. For example, the string "`<arg>foo</arg>`" would refer to the method argument named "foo".
- *arg_names*: A string of comma-separated argument names, in order of appearance. This is used only for documentation purposes as, other than in the *doc* string, the argument names have no significance. For example, the string "`foo,bar`" would indicate that the method expects two arguments, which are referred to in the *doc* string as argument names *foo* and *bar*, respectively.


```
ret = __sleep(time):
```

Suspend execution of the call for *time* seconds. The specified time may be a fractional amount, not just an integer amount. If the Lua program calling `__sleep` has other runnable coroutines, the other coroutines are executed. If there are no runnable coroutines left, execution of the program is suspended for the minimum amount of time required until the first coroutine becomes runnable again.

The function returns an integer *ret* which is zero on success or negative if an error occurred.

```
ret = sleep(time):
```

This is an alias for `__sleep` and may be used by end-user Lua programs as a convenience.

Libraries should always call `__sleep` instead to ensure the intended function is executed even if a Lua program redefines the name `sleep` to another value.

Module `ctrl`

This module provides a higher-level interface to invoke control methods. It is generally preferable to use this module rather than the low-level functions documented by the previous section.

```
dev = ctrl:dev(attrs, obj):
```

Create a control device object with attributes *attrs*. The optional *obj* argument could be specified to implement an extended control device class, but is usually omitted (or you could pass `nil` to it) to create a new object. This operation does not communicate with the remote device identified by *attrs* and therefore returns immediately.

```
iface = dev:interface(name):
```

Create an interface object for the interface identified by *name* of device *dev*. The returned interface object will contain a proxy method for each method defined by the named interface. The proxy methods can be called like any other method and automatically forward the call to the control device and then wait for the result to become available from the device. As such, these operations can take a long time to complete and will call `__sleep()` as needed. Because of this, other coroutines may be executed while a proxy method call is in progress.

```
status, result = dev:call(method, args...)
```

Call the method named *method* on device *dev*, passing arguments *args* to it and return the result. The method name must be a string and *args* must be a sequence of zero or more Lua argument values that are compatible with the argument types expected by the named method. The method name may be a fully qualified method name consisting of an interface name, immediately followed by a dot (`.`), immediately followed by the proper method name or a proper method name on its own. In the latter case, the method is invoked through the first interface registered for the device that implements the named method. Otherwise, the method is invoked through the named interface.

Two values are returned: an integer *status* and *result*. The *status* is zero on success, in which case *result* is the result returned by the named method, converted to a Lua value. On error, *status* is a negative error code (see `ctrl.Error` below) and *result* is `nil`.

Error:

This table declares symbolic names for various control errors, namely:

- UNSPEC (-1): An unspecified error occurred.
- INVALID (-2): An invalid or incompatible argument was passed to a method.
- NODEV (-3): The device attributes specified an invalid device path.
- ATTRS (-4): The attributes do not match the selected device.
- NOMETHOD (-5): The method name could not be found.
- NOENT (-6): The specified transaction id could not be found.
- BUSY (-7): The device is busy (too many pending calls).
- AGAIN (-8): The call is still pending.

Module **tasks**

This module provides a convenient interface for creating several tasks that may be run quasi concurrently and then executing them until they have all completed.

`tasks:add(fun, args...):`

Add a task which, when executed, runs function *fun* with arguments *args* until the function returns. The function may call `__sleep` or `coroutine.yield` to suspend execution temporarily and give other tasks a chance to execute.

`tasks:run():`

Execute previously added tasks until they have all completed.

Creating and Using Lua scripts

Lua scripting is an advanced topic. eGauge Support has limited support for troubleshooting Lua scripts and cannot review Lua code.

Use caution and test extensively when using Lua scripts for automated control of remote devices to prevent unexpected operation or damage to connected equipment.

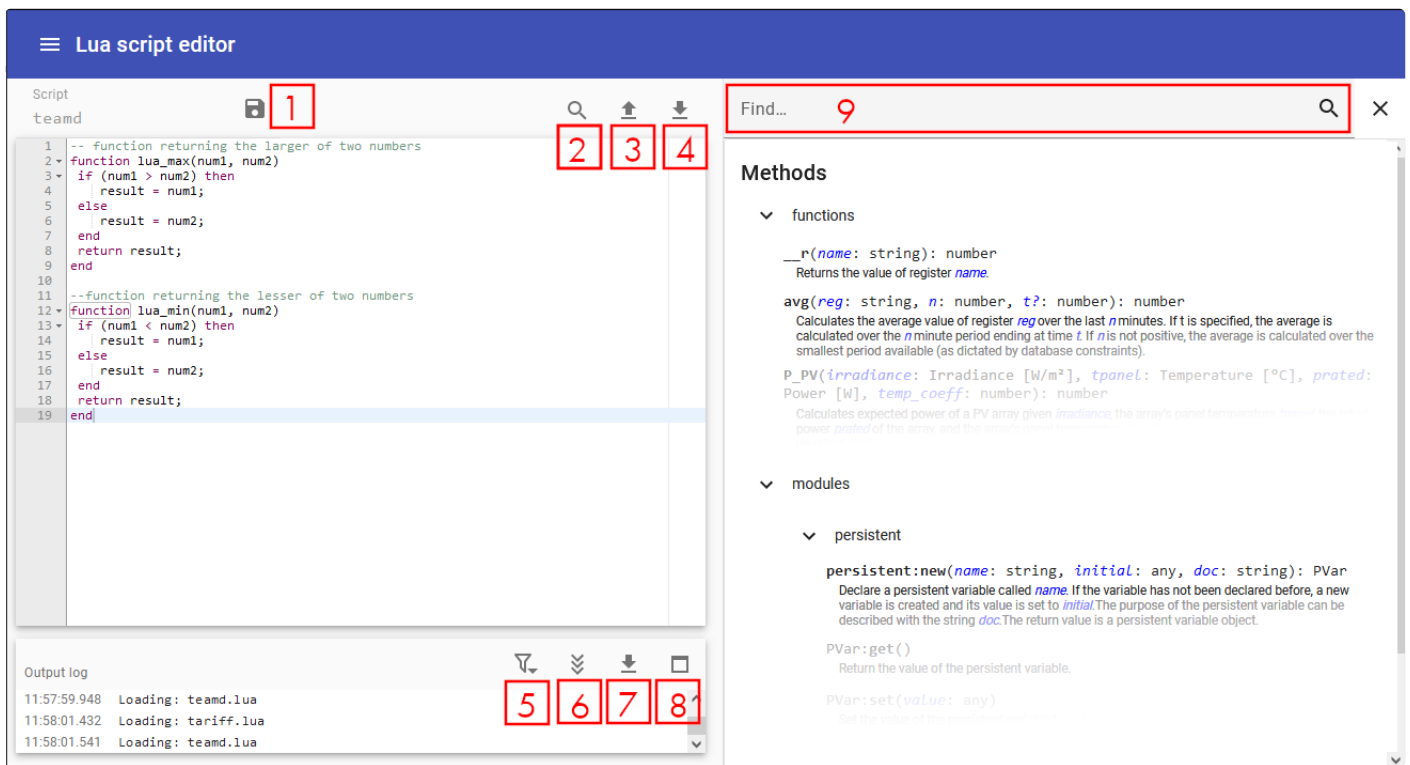
Use the latest firmware: Lua support was added in eGauge meter [firmware version 4.1](#). However, bug fixes and new features this article refers to may have been added in newer firmware versions. [Click here](#) for information about checking and updating a meter's firmware.

Introduction

eGage meters have a [Lua](#) scripting environment that allows for creation of advanced formula register and alert functions, as well as automated control of supported devices such as the [eGauge PRM3 Power Relay Module](#).

Refer to the [Lua Scripting Overview](#) article for a general Lua primer and additional modules provided by the eGauge firmware.

Lua scripting interface



Several keyboard shortcuts are displayed when the interface is loaded:

- **F1**: Open the keyboard shortcuts menu
- **F2**: Toggle the sidebar on the right
- **Ctrl-L**: Toggle auto-complete
- **Ctrl-,**: Open the GUI settings menu

When using Mac, use the **⌘** key instead of Ctrl.

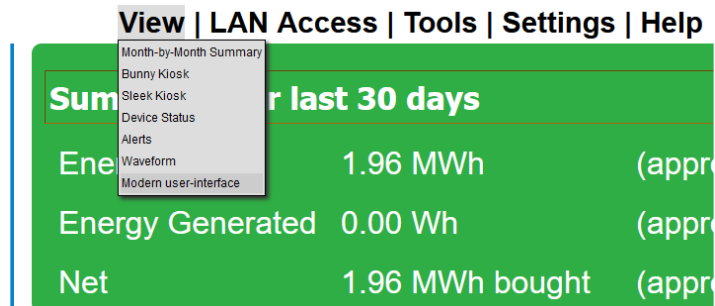
The eGauge web interface has a built-in Lua script editor with 3 panes as shown in the above screenshot.

- **Editor (top left)**— The Lua code editor. There are 4 buttons for this pane:
 - [1] Save: This saves the functions and makes them available for use by the meter.
 - [2] Search: This allows to search for and replace text in the code.
 - [3] Upload: This replaces the current script on the meter with a file upload.
 - [4] Download: This downloads the current script from the meter as a file
- **Output log (bottom left)**— Below the editor, the Lua log is displayed. This will include any script errors or print statements. If there are no custom Lua functions for the script loaded, there may be an error such as "Lua error: cannot open xxx.lua: No such file or directory", and this error may be ignored. There are 4 buttons available for this pane:
 - [5] Filter: Apply a filter to only output log lines containing certain text
 - [6] Autoscroll: Toggles auto-scrolling to the most recent log output
 - [7] Download: Downloads the log file
 - [8] Maximize Window: Maximizes the log output window
- **Sidebar (right)**— the sidebar on the right-hand side provides a method explorer to find and describe all available eGauge-provided functions and modules. The function or module may be clicked on to automatically insert it into the Editor pane to the left. The

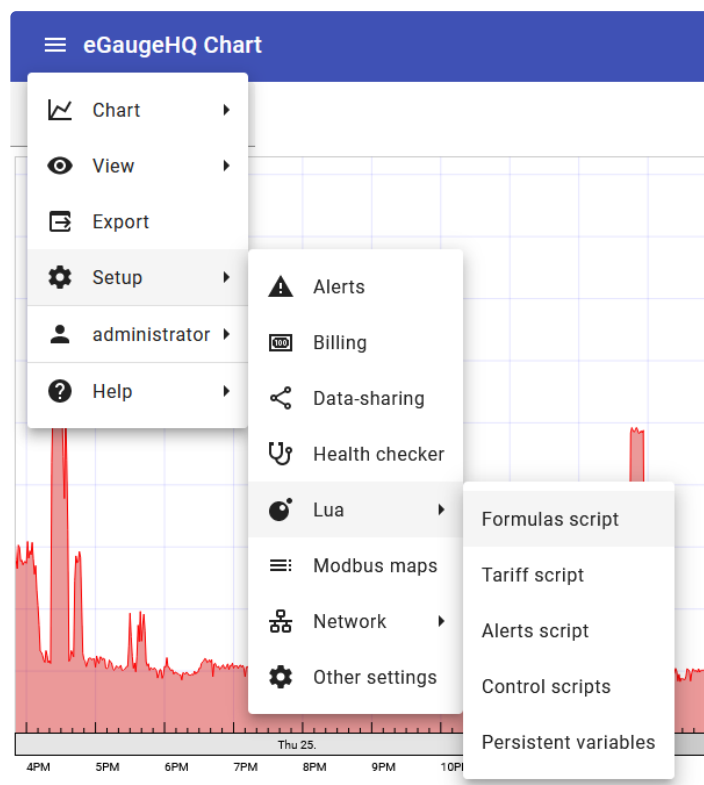
sidebar has a search bar [9] to conveniently search through methods, functions and documentation

Accessing the Lua scripting environment

1. If using the classic interface, click on View → Modern user-interface:



2. Navigate to Setup → Lua and choose the appropriate script type:



Script Types

Click to expand information for the script type:

Formulas script (formula registers)

Creating lua functions in the Formulas script editor will allow the functions to be used in a formula register.

For example, here are two functions made in the Lua Formulas script editor that will return the min or max of two numbers:

```
-- function returning the larger of two numbers
function lua_max(num1, num2)
  if (num1 > num2) then
    result = num1;
  else
    result = num2;
  end
  return result;
end

--function returning the lesser of two numbers
function lua_min(num1, num2)
  if (num1 < num2) then
    result = num1;
  else
    result = num2;
  end
  return result;
end
```

They may then be used in a formula register:

lua max function	x	=	=	▼	Whole number	▼	lua_max(1,20)
lua min function	x	=	=	▼	Whole number	▼	lua_min(1,20)

And we may see the registers work as defined by the script functions:

1:40:06pm	⬆	⬇	≡+
lua max function	20		
lua min function	1		

Advanced time-of-use and tiered billing may be performed in this Lua script.

A tariff script should provide (at least) a `cost(register, negate, schedule)` function which calculates the incremental cost based on the energy-use recorded by register. *negate* can be set to true if the register's value counts down for power consumption. *schedule* is optional and can be set to the (non-default) name of the schedule to use when calculating the cost.

A formula register of type "monetary" would be used with the `cost()` function.

For an example billing script, from the classic interface:

1. Navigate to Settings → Billing.
2. Choose Xcel Colorado as the tariff provider.
3. Click "OK" to save and go back to the main settings page.
4. Go back to Settings → Billing.
5. Change the tariff providert to "custom"
6. Click the "Customize tariff script" button, which will open a copy of the Xcel Colorado billing tariff in the Lua script editor.

Alert script

Alerts scripts work the same as Formula scripts, but are used in eGauge meter alerts, configured in Settings → Alerts.

Control scripts

See the main [Lua Scripting Overview](#) Control Scripts section for additional Lua Control environment information.

There is risk of damaging external equipment using control scripts. Only skilled Lua developers familiar with the eGauge meter and software should attempt to use Lua control scripts.

Control scripts can be used to confrol supported equipment such as the eGauge Power Relay Module (PRM3).

For example, the following script reads the instantaneous value of a register called "Temperature" and controls a PRM3 relay contact. If the temperature is lower than 21 C, relay number 0 of the PRM3 is closed (activated), otherwise opens (turns off) relay number 0. It then sleeps for 15 minutes before checking again.

In the real world, the control script should be more advanced

```
dev = ctrl:dev({interface='relay'})
relay = dev:interface('relay')

while true do
    print("Temperature is currently: " .. __r("Temperature"))
    if __r("Temperature") < 21 then
        relay:close(0)
    else
        relay:open(0)
    end
    sleep(60*15)
end
```

Persistent variables

See the main [Lua Scripting Overview](#) section on Persistent variables.

Persistent variables are variables that are preserved between reboots or power cycles.

The following Formula script creates and updates a persistent variables with a given name and number passed to it in a formula register, and prints debug to the output log:

```
function persistent_variable_example(name, number)

    obj = persistent:new(name, number, "Variable stored by formula function persistent_variable_example")

    current_value = obj:get()
    print(name .. " currently has value " .. current_value)

    print("updating " .. name .. "to new value " .. number)

    obj:set(number)
end
```

A register is configured to run the formula script:

persistent_formula_test x = Number with 3 decimals persistent_variable_example("variable test 1", time())

This creates or updates a persistent variable called "variable test 1" with the current time.

The Formula script editor shows the print debug as the variable is updated once a second as the formula register is run:

```
15:26:28.168 variable test 1 currently has value 22.0433333333333
15:26:28.168 updating variable test 1 to new value 22.0436111111111
15:26:29.171 variable test 1 currently has value 22.0436111111111
15:26:29.172 updating variable test 1 to new value 22.0438888888889
15:26:30.168 variable test 1 currently has value 22.0438888888889
15:26:30.168 updating variable test 1 to new value 22.0441666666667
15:26:31.168 variable test 1 currently has value 22.0441666666667
15:26:31.168 updating variable test 1 to new value 22.0444444444444
```

While this particular example is rather pointless, persistent variables may be used in any Lua scripts. Control scripts are executed continuously, and a formula register would not need to be created to run it.