# rt.buffer Reference Manual

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| Data | Author | Release |
|---|---|---|
| 2017-10-11 | MP | For firmware 1.00 |
| 2017-10-27 | MP | For firmware 1.01 |
| 2017-11-10 | MP | For firmware 1.02 |
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# Introduction

See also the "rt.buffer Getting Started Manual".

Lua 5.1.5 has been chosen, along with numerous patches and extensions that allow it to run in a very resource-constrained environment.

Lua in the rt.buffer has about 80k bytes of memory available to it, and this has required using short names for functions and variables (because even though code is compiled into p-code, the tables and functions are still referred to by their string name).

A combination of event-driven (aka "Reactor Pattern") programming and loop programming allows for a flexible combination of ultra-low-power operation, and ease of programming for sequential transmit/receive style operations.

A real-time-operating system (RTOS) provides multi-tasking support, and Lua is called from three different tasks in the RTOS.

1. `Main Lua Loop` Task
2. `Event Callback` Task
3. `Modem Cellular Delivery` Task

Think of the 'Event Callback` Task as an "interrupt handler" in traditional coding.

It is important to be aware that the Event Callback Task must NEVER perform long-running operations. If you try, they will be aborted. Instead, callbacks issued from within this task should signal to the Main Lua Loop Task (or otherwise queue up requests in a Lua table).

There are also callbacks that occur within the Modem/3G Delivery Task — and these can take a reasonable time (minutes). However, the task can still choose to abort the running Lua callback.

Most of the system architecture has been designed to be completely flexible. Consequently, the process of designing a suitable Lua-based App may take some time and skill to be successful.

This document aims to provide a reference for the many Lua library extensions that have been written to complement the Lua core.

# Useful Bookmarks

These links may be helpful:

- USB and Terminal
  - Terminal Commands
  - BootLoader Terminal Commands
- `c.` and `i.` values
  - Configuration Variables
  - Information Variables
- Scheduling
  - Job Schedule Strings
  - Schedule Examples
- LED Sequences

# IoT Operations

"Internet-of-Things" methods.

Primarily the IoT core provides services to push collected data and alerts to your central servers. Additionally, the the rt.buffer can be managed remotely through the Update Mechanism - allowing firmware upgrades, diagnostic gathering, etc, to be handled centrally and remotely.

A [User Process] can also be glued in, so that special actions can occur on a specific event (like the magnet triggering).

This section outlines some key details for using these services.

See also:

- Configuration Variables:
  - `c.cell` - for connection details and modem timings
  - `c.iot` - for server details
  - `c.user` - for the [User Process] settings
- Lua Library Extensions
  - `iot.*` - for IoT actions
  - `gps.time` - for the GPS service timing setting
  - `sms.rxt` - for the SMS service timing setting

# Update Mechanism

The update mechanism works by pulling an `update.txt` file from the IoT server, and parsing the lines of the ASCII file.

When completed, the `update.txt` file will be renamed on the server as `update.YYYYMMDDHHMMSS.txt` (using the rt.buffer's UTC time that the update was completed).

The commands and available options are listed below.

## update.txt Keywords

> If the `c.iot_gz=0`, then the following transfers will not use gzip compression, and will not use the .gz extension.

### `cellinfo`

Perform a cellular survey and post the results to the IoT server.

The file will be named `cellinfo.{i.rt_sn}.txt.gz`

### `diag`

Post a diagnostics dump file onto the IoT server.

The diag file will be named `diag.{i.rt_sn}.txt.gz`

### `COMMAND`

`COMMAND:Lua expression`

Execute a Lua command. This is syntactically the same as the USB command `lx`. However, the results of the Lua command will be thrown away.

Complex expressions can be executed, with a line length up to 128 characters.

```
lx job.utc(os.time()+6000, function() iot.go('user') end)
```

If an App has utility functions, for example to make configuration changes to the connected device, you can call these too. They will be executed from the context of the modem task.

```
lx CallMyFunction(10.34, 34.56)
```

### `getfile SOURCE,TARGET`

`SOURCE`:The full path and name of the file on the rt.buffer

`TARGET`:The (path and) filename of where to save the file on the IoT server

Post a file from the flash file system onto the IoT server.

*Listing 1. gz will be added to the target filename, if appropriate.*

```
getfile /Logs/system.log,/temp/system.log
```

### `setfile SOURCE,TARGET`

`SOURCE`: Source filename to ask from the IoT server

`TARGET`: The full path of where to save the file on the rt.buffer

Pull a file from the IoT server and save into the flash file system.

The source file cannot be gzip or zlib compressed. The rt.buffer does not have the RAM to decompress data.

```
setfile /temp/config.mine.txt,/Config/config.txt
```

If updating the `/Config/config.txt` file be **very** careful you do not change the IoT settings, or break the cellular settings… otherwise you could lose control of the rt.buffer!

### `NAME.blf`

`NAME`: Filename (and path) on the IoT server to pull

Pulls a firmware image from the IoT server and burns.

```
../rt.buffer.Lua.1.02.blf
```

### `c.KEY = VALUE`

`c.KEY`: Config parameter

`VALUE`: Config value

Make a configuration change = User Process

The user process is typically triggered by the magnet.

The rt.buffer will connect to the IoT server and repeatedly send the config and info sets. This should enable a back-end process to present the data to a live web-page, so any engineer can view the current information on a phone, tablet or PC.

The process will pause, by default 15s, and send again. This will continue for a default time of 10 minutes. The settings `c.user_ins` & `c.user_onm` override the values.

# Configuration Options

The process will post the data to a file named `"user.{i.rt_sn}.txt.gz"` in the folder specified by `c.iot_url`
`c.iot_user`.

If the `c.iot_user` value is not present, then `"Update/{c.site_name}"` is used (same logic as the `c.iot_upd` value).

The function `"doUser"` will be called on each loop, allowing the Lua App to include additional values (like live ADC readings) in the information tree.

# Stopping the User Process

The back-end process can abort the user mechanism by leaving a file named: `"user.{i.rt_sn}.stop"`

When the rt.buffer detects this file, it deletes it and quits the User Process.

# Lua Modifications

This section documents the additions to the standard Lua core that provide the functionality required for the {rpbuffer} product.

## Lua Compiler and Virtual Machine changes

There are some basic internal changes to the Lua core, including:

1. Reading from a table that doesn't exist returns NIL, and does not generate a run-time error. Attempting to write to a NIL table will still generate a run-time error.
   - `lvm.c` modified
2. C/C++ style comments are supported with the `//` tag and `/…/` tag. This is in addition to the regular Lua comment marker `--`.
   - `llex.c:llex` function modified
3. Strings can use the C/C++ hex markers. e.g. `'\xee\ff'` is 0xee + 0xff.
   - `llex.c:read_string` modified
4. The os functions `execute`, `exit`, `getenv`, `setlocale`, and `tmpname` removed.

## Lua "Basic Functions"

Fully included.

## Coroutine Manipulation - `coroutine`

Fully included

## Modules - `package`

NOT included. The memory requirements were too large.

However, you can still use Lua's `loadfile` and `loadstring`.

## String Manipulation - `string`

Fully included.

# Table Manipulation - `table`

Fully included.

# Mathematical Functions - `math`

Fully included, using double-precision floating point internally.

# Input and Output Facilities - `io`

Mostly included.

## Not included

- `io.popen`
- `io.tmpfile`
- `file:setvbuf`

# Operating System Facilities - `os`

Mostly included.

## Not included

- `os.execute`
- `os.getenv`
- `os.tmpname`

## Added

### `ok = os.move(fromfile, destfile)`

`Move a file`

**Parameters**

- `fromfile`: Filename of existing file
- `destfile`: Filename of target

**Returns**

- `ok`: True if successful

**Description** Move a file

See the more flexible `fc.move` function (which supports wildcard operations).

# Debug Library - `debug`

NOT included.

# `boot.lua`

If the file `/Lua/boot.lua` exists, the rt.buffer will execute this file before loading the application Lua file.

> **!** Be careful what you code you put in this file!

# Lua Library Extensions

There is a large set of Lua library extensions embedded in the firmware. The libraries and their functions are constantly being improved and added to.

Many of the libraries have default behaviour that can be overridden using tables, variables, and function overrides.

# Library adc : ADC Library

This library provides a coroutine-friendly way to take multiple ADC measurements, and average them.

## adc.def() v3.00

Set ADC default parameters

**Parameters** None

**Returns** None

**Description** Sets the default parameters of 1 sample and no 'off' measurement.

## done,n,tot = adc.done() v3.00

Check for complete

**Parameters** None

**Returns**

- done: Whether complete (boolean)
- n: Number of samples taken
- tot: Total number of samples to take

**Description** Checks whether the ADC sequence has completed.

You can create a loop if needed, or use the onAdc callback:

```
while not adc.done()
do coro.w(100)
end
```

## `uv,ts,ouv = adc.get([m, [c, [raw]]])` v3.00

Get ADC sample

**Parameters**

- `m`: Slope for the ADC value
- `c`: Offset for the ADC value
- `raw`: Whether to use raw ADC values (true), or microvolts (false=default)

**Returns**

- `uv`: Microvolts.
  Range ±0-1500000uV (±0 to 1.5V)
  (3.0V is the reference voltage)
- `ts`: Timestamp of the first sample
- `ouv`: Microvolts when the power was off.

**Description** Get average pressure reading in microvolts, optionally calculating $y=mx+c$

> The ADC is LTC2485, 24-bit delta-sigma, that has V-REF = 3.0V.

## `adc.go()` v3.00

Start ADC

**Parameters** None

**Returns**

- `ok`: Whether sampling started

**Description** Starts the ADC measurement process.

Each sample takes 170ms, so an 8-sample average will take 1.36s to complete.

### `n,moff = adc.set([n], [moff])` v3.00

Set or get ADC parameters

**Parameters**

- `n`: Number of samples to average (default=1)
- `moff`: True to measure the 'off' reading as well

**Returns**

- `n`: Number of samples to average
- `moff`: True to measure the 'off' reading as well

**Description** Set or get the ADC parameters.

When triggered, the ADC task will read `n` samples. If `moff` is true, then before enabling the ADC power an 'off' reading will be taken.

# ADC Callback

### `function onAdc()` v3.00

ADC completion callback

**Parameters** None

**Returns** None

**Description** Called when the ADC completes all readings.

> You will need to enable the callback event with `evt.en('onAdc')`

# Library `alm` : Alarm Library

The alarm library allows for tracking counts on 32 distinct alarms. The alarms can be updated with bitfields, or individually.

```
alm.clr(n)
alm.clr( {bitfield} )
```

Alarm clear

**Parameters**

- `n`: Alarm number, 1-32
- `bitfield`: The bitfield number is placed in the first element of a table

**Returns** None

**Description** Clear the Counts.

```
aa, at = alm.get(n)
ab, at = alm.get( {bitfield} )
```

Alarm get

**Parameters**

- `n`: Alarm number, 1-32
- `bitfield`: The bitfield number is placed in the first element of a table

**Returns**

- `aa`: Alarm active (true if active)
- `ab`: Alarm bits that are active
- `at`: Alarm table of values

**Description** Returns a table with the alarm parameters and counts for each alarm specified.

```
local ab, at = alm.get( {0x3} )
-- ab = 1
-- at = {1={co=2,cf=0,lo=2,lf=1,alm=true}, 2={co=0,cf=0,lo=2,lf=1} }
```

### `ao = alm.new()` v3.43

Create alarm object

**Parameters** None

**Returns**

- `ao`: Alarm object

**Description** Return a new alarm object.

Alarm objects are Lua tables with metamethods for method functions.

### `alm.set(n, limiton, limitoff)`<br>`alm.set( {bitfield}, limiton, limitoff)`<br>`alm.set(n, limiton, limitoff, valueon, valueoff)` v3.42

Alarm set

**Parameters**

- `n`: Alarm number, 1-32
- `limiton`: Number of sequential 'ons' before alarmed
- `limitoff`: Number of sequential 'offs' before inactive.
- `bitfield`: The bitfield number is placed in the first element of a table
- `valueon`: The floating point value for the alarmed state. value >= valueon
- `valueoff`: The floating point value for the idle state. value < valueoff

**Returns** None

**Description** Set the parameters for an individual alarm 'n', or a range of alarms '{bitfield}'

When using `valueon` and `valueoff` the code will handle both positive and negative slopes (in which case it becomes `value ⇐ valueon` and `value > valueoff`).

```
alm.set( {0xff}, 10, 1) -- set alarms 1-8
alm.set( 10, 2, 2) -- set alarm 2 only
```

### `txt=alm.txt(n)`

Alarm get text

**Parameters**
- `n`: alarm number

**Returns**
- `txt`: text

**Description** Return the text for the alarm, as set in c.alm_txt##

e.g. `alm.txt(2)` will return the value from *c.alm_txt02*

### `alm.upd(n, ison)`
### `alm.upd( {bitfield, bitvalues} )`
### `alm.upd(n, value)` v3.42

Alarm update

**Parameters**
- `n`: Alarm number, 1-32
- `ison`: Boolean indicating whether on or off
- `bitfield`: The bitfield number is placed in the first element of a table
- `bitvalues`: A bitfield representation of the alarms covered by bitfield, where 0=off, 1=on
- `value`: Floating point value to compare. See `alm.set`

**Returns** None

**Description** Update the alarm counters, and trigger the alarm callbacks as required.

```
alm.upd(2, true)
alm.upd( {0xff, 0x5a} )
```

## `alr,hys = alm.val(n)` v3.43

Alarm value

**Parameters**

- `n`: Alarm number, 1-32

**Returns**

- `alr`: true if active/alerted; false if inactive
- `hys`: true if co>0; false if cf>0; nil if in hystersis zone

**Description**

Returns state details about the specified alarm.

# Alarm Table 'at'

As returned by alm.get(...)

- `.co` = Counts on
- `.cf` = Counts off
- `.lo` = Limit on
- `.lf` = Limit off
- `.alm` = true if in the alarmed state
- `.vo` = Value on (v3.42)
- `.vf` = Value off (v3.42)

# Alarm Callbacks

There are two types of callbacks made from the library:

### `function onAlm##(state)`

Alarm individual callback function

**Parameters**
- `state`: true if alarmed, false if inactive

**Returns** None expected

**Description** Callback for an individual alarm, where `##` is the two-digit decimal number of the alarm:

```
function onAlm02(state)
 if state
 then -- do something
 else -- do something else
 end
end
```

## `function onAlm(n, state)`

`Alarm global callback function`

**Parameters**

- `n`: Alarm number, 1-32
- `state`: true if alarmed, false if inactive

**Returns** None expected

**Description** A callback for all alarms. For each alarm, the `onAlm##` is called first, followed by the `onAlm` callback (allowing a mix of specific and general handling).

You can use the function `alm.txt(n)` within the callback to pick out a name for the alarm.

# Library `alm` | `ao` : Alarm Objects

The alarm objects are Lua tables that contain the alarm state and settings.

They have the same field names as the Alarm Table 'at' but include some additional fields that hold functions for callback and compare.

- `ao.lo` = Limit on
- `ao.lf` = Limit off
- `ao.co` = Counts on
- `ao.cf` = Counts off
- `ao.vo` = Value on
- `ao.vf` = Value off
- `ao.v` = last number value passed to `ao:upd`
- `ao.alm` = true if in the alarmed state; false unalarmed; nil initial state
- `ao.fc` = function callback
- `ao.cmp` = compare function

Added in firmware 3.43

## `ao:clr()`

Alarm Object clear

| | |
|---|---|
| **Parameters** | None |
| **Returns** | None |
| **Description** | Clear the Counts. i.e. `ao.co=0` & `ao.cf=0` |

## `ao:set(limiton, limitoff, [valueon, [valueoff]], [fc])`

Set Alarm Object values

**Parameters**

- `limiton`: Number of sequential 'ons' before alarmed
- `limitoff`: Number of sequential 'offs' before inactive.
- `valueon`: The floating point value for the alarmed state. value >= valueon
- `valueoff`: The floating point value for the idle state. value < valueoff
- `fc`: Function callback

**Returns** None

**Description** Sets the parameters for the alarm.

This is really just a syntactic helper to give compatibility to the original `alm.set` method.

The table fields of `ao` will be assigned the various values passed as parameters.

> If a parameter is `nil` then the table field assignment is skipped.

## `sc,alm = ao:upd(ison)`<br>`sc,alm = ao:upd(value)`

Alarm Object update

**Parameters**

- `ison`: Boolean indicating whether on or off
- `value`: Floating point value to compare. See `ao:set`

**Returns**

- `sc`: State Change > +1=alarmed, 0=nochange, -1=unalarmed
- `alm`: Alarm state > true=alarmed, false=unalarmed

**Description** Update the alarm counters, and trigger the alarm callback (`ao.fc`) as required.

## `alr,hys = ao:val()`

Alarm Object value

**Parameters** None

**Returns**

- `alr`: true if active/alerted; false if inactive
- `hys`: true if ao.co>0; false if ao.cf>0; nil if in hystersis zone

**Description** Returns state details about the alarm object.

## `ao.fc = function(ao, st)`

Alarm Object state callback

**Parameters**

- `ao`: The alarm object is passed to the function
- `st`: The state (boolean)

**Returns** None

**Description** The function `ao.fc` is called in the context of `ao:upd` when the alarm state changes.

```
function mycb(ao, state)
 if state
 then -- do something urgent
 end
end

local ao = alm.new()
...
-- various ways to set ao.fc:
ao:set(5, 10, mycb)           -- Boolean type alarm
ao:set(5, 10, 0.5, 0.3, mycb) -- Value type alarm
ao.fc = mycb                  -- Manual assignment
```

## ao.cmp = function(ao, v)

Alarm Object compare function

**Parameters**

- ao: The alarm object is passed to the function
- v: The value (number)

**Returns**

- ac: Alarm change > +1 increments ao.co; -1 increments ao.cf; 0 no change

**Description**

The function ao.cmp is called when using ao:upd(NUMBER) to decide how to adjust the alarm counters.

The function should return +1/0/-1 to consider the alarm 'on'/'nochange'/'off'.

```
-- Emulates the default behaviour in pure Lua:
function mycmp(ao, v)
 if ao.vo > ao.vf
 then
  if v >= ao.vo
  then return 1
  elseif v < ao.vf
  then return -1
  else return 0
  end
 else
  if v <= ao.vo
  then return 1
  elseif v > ao.vf
  then return -1
  else return 0
  end
 end
end

local ao = alm.new()
...
ao.cmp = mycmp  -- Override default firmware compare
```

# Library `app` : Application Utilities

The `app` library provides some helpful functions related to the Lua app.

## Memory efficient dynamic blocks

You can add special commented markers within the Lua app file, and dynamically retrieve these at runtime.

The tags are in the form:

```
--[[TAG]text--]]--

--[[TAG]
multi-line text
is here
--]]--
```

**`rv,··· = app.eval(tag)`** v2.00

App evaluate block

**Parameters**
- `tag`: Tag name

**Returns**
- `rv`: Lua return values...

**Description** Find the `tag` and evaluates, equivalent to `return app.txt(tag)`

### `rv,… = app.exec(tag)` v2.00

App execute block

**Parameters**
- `tag`: Tag name

**Returns**
- `rv`: Lua return values…

**Description** Find the `tag` and execute, like Lua's `dostring`.

Useful for dynamic function definitions.

### `tb = app.lines(tag)` v2.00

App fetch lines

**Parameters**
- `tag`: Tag name

**Returns**
- `tb`: Table of strings

**Description** Find the `tag` and return as a table of strings.

Useful for internationalisation strings.

### `txt = app.txt(tag)` v2.00

App fetch text block

**Parameters**
- `tag`: Tag name

**Returns**
- `txt`: Text block, if found.

**Description** Find the `tag` and return as a raw string.

# Library `bit` : Logical Bit Functions

The bit module provides useful bit operation functions.

Bit functions by Reuben Thomas <rrt@sc3d.org>
http://luaforge.net/projects/bitlib
(Extensions for bit-wise string handling and nibble/byte swap added by Scannex.)

```
v = bit.ar(a,b)
v = bit.arshift(a, b)
```

Bit arithmetic shift right

**Parameters**
- `a`: Value to shift
- `b`: Number of bits to shift

**Returns**
- `v`: Result

**Description** Returns `a` right shifted arithmetically `b` places.

```
v = bit.band(v1, ⋯)
v = bit.band(txt)
```

Bitwise AND

**Parameters**
- `v1`: Value 1, etc
- `txt`: String

**Returns**
- `v`: Result

**Description** Returns the bitwise AND of the `v's, or string

```
v = bit.bnot(a)
```

Bitwise NOT

**Parameters**
- a: Value

**Returns**
- v: Result

**Description** Returns one's complement of a.

```
v = bit.bor(w1, …)
v = bit.bor(string)
```

Bitwise OR

**Parameters**
- v1: Value 1, etc
- txt: String

**Returns**
- v: Result

**Description** Returns the bitwise OR of the `v's, or string

```
v = bit.bxor(w1, …)
v = bit.bxor(string)
```

Bitwise XOR

**Parameters**
- v1: Value 1, etc
- txt: String

**Returns**
- v: Result

**Description** Returns the bitwise XOR of the `v's, or string

```
v = bit.cast(a)
```

Bit cast

**Parameters**
- a: Value

**Returns**
- v: Result

**Description** Cast a to the internally used integer type.

```
v = bit.ls(a, b)
v = bit.lshift(a, b)
```

Bitwise left shift

**Parameters**
- a: Value to shift
- b: Number of bits to shift

**Returns**
- v: Result

**Description** Returns a left shifted b places.

```
v = bit.rs(a, b)
v = bit.rshift(a, b)
```

Bitwise right shift

**Parameters**
- a: Value to shift
- b: Number of bits to shift

**Returns**
- v: Result

**Description** Returns a right shifted b places.

## `v = bit.swap16(a)`

`Bit swap bytes`

**Parameters**
- `a`: Value

**Returns**
- `v`: Result

**Description** Returns `a` with the LSB and MSB bytes exchanged.

## `v = bit.swap32(a)`

`Bit swap`

**Parameters**
- `a`: Value

**Returns**
- `v`: Result

**Description** Returns `a` with each of the four bytes reversed.

## `v = bit.swap8(a)`

`Bit swap nibbles`

**Parameters**
- `a`: Value

**Returns**
- `v`: Result

**Description** Returns `a` with the nibbles exchanged.

# Library cfg : Configuration

The cfg Library provides helpful routines for reading and writing values into the configuration tree.

## v = cfg.get(key, [t], [d]) v1.00

Config get

**Parameters**

- key: Config key name
- t: (optional) table for replacing the # characters in key
- d: (optional) default value

**Returns**

- v: Result

**Description** Reads a value from the config tree.

The 'c.' prefix is not required, and will be ignored if supplied.

If key contains hash (#) characters then each hash is replaced with a value from the table t.

If d is supplied, and the config tree does not have the key named, then v=d.

v will be NIL, a string, or a number (i.e. its natural type).

```
local t = cfg.get('adc_c', 0.001)
local t = cfg.get('d_#_#', {1, 'm'}) -- returns value of c.d_1_m
```

## `v = cfg.getb(key, [t], [d])` v1.00

Config get boolean

**Description** As cfg.get, but converts to boolean (or nil).

## `v = cfg.getn(key, [t], [d])` v1.00

Config get number

**Description** As cfg.get, but converts to number (or nil).

## `v = cfg.gets(key, [t], [d])` v1.00

Config get string

**Description** As cfg.get, but converts to string (or nil).

## `ok = cfg.set(key, [t], v)` v1.00

Config set

**Parameters**

- `key`: Config key name
- `t`: (optional) table for replacing the # characters in key
- `v`: Value to set

**Returns**

- `ok`: True if succeeded

**Description** Sets `c.key`=v

If `key` contains hash (#) characters, then each hash is replaced with a value from the table `t`.

```
cfg.set('d_#_#', {1, 'm'}, 'Testing')
cfg.set('adc_c', 1.234)
```

### v = cfg.table(key, [t, [d]]) v1.00

Config read as table

**Parameters**

- key: Config key name
- t: (optional) table for replacing the # characters in key
- d: (optional) default table

**Returns**

- v: Resulting table, or NIL

**Description** Reads a config sub-tree as a Lua table.

If key contains hash (#) characters, then each hash is replaced with a value from the table t.

If d is supplied, then this forms the starting point of the v result. The table d is "deep-copied" to v, and then any values within the config sub-tree will replace the entries within v - effectively combining the two.

```
local t = cfg.table('') -- gets the whole tree
local t = cfg.table('adc', {}, {m=1,c=0})
```

# Library cfg.key Secret Keys

The cfg.key library provides control over write-only keys that are used for cryptographic functions.

Keys are stored in a hidden directory /_keys. However, the keys themselves are encrypted with a device-specific key. The files cannot be used in any other device.

Added in firmware v3.00

### `ok = cfg.key.chk(kn)` v3.00

Check a secret key

**Parameters**
- `kn`: Key name

**Returns**
- `ok`: True if a key has been set

**Description** Checks existence of a key.

### `cfg.key.set(kn, txt)` v3.00

Set a secret key

**Parameters**
- `kn`: Key name
- `txt`: Plaintext secret

**Returns** None

**Description** Saves the key.

### `cfg.key.wipe(kn)` v3.00

Erase a secret key

**Parameters**
- `kn`: Key name

**Returns** None

**Description** Erases the key.

## Key names

- `iot` : The IoT secret for http locking
- `toa` : The Terminal Over-the-Air shared secret

# Library coro : Coroutine Extensions

Lua includes a mechanism to run 'coroutines' - also known as cooperative multi-tasking. The rt.buffer firmware extends that library to make it simple to run scheduled tasks.

Any of the `onXXX` callback functions and the UI functions absolutely require that code runs very quickly. The `coro` library provides a very convenient way to queue longer running tasks and execute them in the context of the Lua Loop task.

Up to 16 coroutine functions can be queued at any one time.

Depending on how the functions are written, they will execute strictly sequentially, or can cooperatively multitask (if you use the `coro.w()` or `coro.yld()` functions).

Added in firmware v2.00

Lua library functions that delay or wait, such as the serial routines or `rt.ms`, will block **all** coroutines from running during the delay. Once the Lua library function returns then it is possible to call `coro.w` or `coro.yld` to allow other coroutines to run.

```
ok = coro.add([dup], func, [user])
ok = coro.add([id], func, [user])
```

Coro add function to queue

**Parameters**

- `dup`: True to allow multiple instances of func
- `id`: Identifier for the function
- `func`: Lua function
- `user`: User value (string, number, or table) that is passed to `func`

**Returns**

- `ok`: True if added to the queue

**Description** Adds a Lua function, using the supplied id (or the function itself).

By default, the function will not be queued again if it is already pending or running. e.g. `coro.add(MyFuncName)` will only allow a single run of `MyFuncName` at a time.

The `id` is useful to associate the same function with different activities. So, the id could be a string, or a number. You could use the id for a process name, e.g. `smp`, or `prog` - so that one function can be queued for each particular activity.

The `user` value can be used to queue up parameters for the function. So, for example, the function may reconfigure a connected device, and the `user` parameter may be a table of values that are used to reconfigure. This approach allows a single function to perform variable actions.

```
v = coro.id()
```

Coro get ID

**Parameters** None

**Returns**

- `v`: RTOS task and Lua coroutine identifier

**Description** Helpful function that can differentiate different Lua tasks and RTOS tasks.

The locking functions rely on this id value.

```
n = coro.kill()
n = coro.kill(idfn)
```

Coro kill routine

**Parameters**

- `idfn`: The specific `idfn` of the coroutine to kill. (function or ID name as passed to `coro.add`)

**Returns**

- `n`: Number of coroutines that were terminated

**Description** Abort all coroutines, or the specified routine.

```
n = coro.n()
n = coro.n(fn)
```

v3.00

Coro number of routines running

**Parameters**

- `fn`: Function

**Returns**

- `n`: Number of queued coroutines

**Description** Return the number of coroutines currently queued.

If `fn` is defined, then `n` is the number of iterations of `fn` that are still running.

## `coro.yld()`
## `coro.w(ms)`

`Coro yield or wait`

**Parameters**
- `ms`: Milliseconds to wait

**Returns** None

**Description** Yields the current coroutine, allowing the next coroutine task to execute immediately. If `ms` is provided, the current coroutine will not resume until the delay has expired.

If there are no other pending coroutines, the `coro.yld` will return immediately and execution will continue.

The actual delay may be *longer* than the `ms` value.

`coro.yld` and `coro.w` are identical.

v3.00 allows `coro.w` to be called from the main Lua context (e.g. the terminal). In this case it will execute `rt.ms` automatically.

Don't use `coro.w` inside a function referenced by `rt.call`. Use the `coro.except` instead.

## r = coro.wu(ti, [ft], func) v3.31

Coro wait until

**Parameters**

- ti: Millisecond interval to wait
- ft: Future time (as returned by rt.msf)
- func: Function to call each loop

**Returns**

- r: Not false means quit the loop

**Description** Provides a simple way of waiting until something happens in a coro-friendly way.

If the func returns non-null & non-zero then the coro.wu returns the result, allowing you to quit a simple while..do..end loop.

```
-- 500ms intervals, checking received data
while not coro.wu(500, function() return dp:rxw() > 10 end) do end

-- Max 30s with 200ms intervals, calling MyTest
function MyTest(ti,ft)
 -- (ti and ft are passed into the function)
 if dp:rxw() > 10 then return 'yes' end
 return false
end

local ft = rt.msf(30000)
while not coro.wu(200, ft, MyTest) do end
```

```
local onErr = coro.except(func, v)
local onKill = coro.except(func, v)
local onErr,onKill = coro.except(func, v) v3.31
```

Coro exception object

**Parameters**

- `func`: Lua function to call
- `v`: Parameter to pass

**Returns**

- `onErr`: Exception for error handling
- `onKill`: Exception for `coro.kill` on this coroutine

**Description** Creates a special Lua exception handler that **must** be saved local.

The exception handler gives your code a chance to tidy up on exceptions.

If there is a Lua error, the `onErr` will be called after the firmware error handling. If `coro.kill` causes this routine to abort, then `onKill` will be called.

`onKill` is only called as a result of `coro.kill`. For normal exit of a coroutine you must manually call.

Version 3.31 returns two copies of the handler, allowing a single line assignment to both local variables.

```
function OnMyExcept(func, user, cause)
  -- Cleanup
  -- cause == 1 means error
  -- cause == 2 means killed
end

function MyCoro(v)
 local onErr,onKill = coro.except(OnMyExcept, v)
 -- do stuff
end

coro.add(MyCoro)
```

# Library `crc` : CRC Calculations

CRC calculations for CRC-8 (c8), CRC-16 (c16), CRC-32 (c32), and CRC-Xmodem (xm), and custom CRC values.

```
cv = crc.c8(txt) / crc.c16(txt) / crc.c32(txt) / crc.xm(txt)
```
CRC calculate

**Parameters**
- `txt`: String to CRC

**Returns**
- `cv`: CRC value

**Description** Perform CRC-8, CRC-16, CRC-32, or CRC-Xmodem on a string.

Short-hand for using crc.new / crc.upd / crc.fin

```
local v = crc.c32('Testing')
```

```
ct = crc.new(size)
ct = crc.new(txt)
ct = crc.new(ci, ref, polyrev, xor)
```
CRC new object

**Parameters**
- `size`: Number of bits = 8, 16, 32
- `txt`: Name of crc, e.g. 'xmodem', 'crc32'
- `ci`: Initial CRC value
- `ref`: Boolean value. True to reflect the bits
- `polyrev`: Bit-reversed polynomial
- `xor`: Final XOR value

**Returns**
- `ct`: CRC table structure

**Description** Initialise a new CRC object table.

```
--[[ Sample CRC Custom Values
CRC-32: crc.new(0xffffffff, false, 0xedb88320, 0xffffffff)
CRC-16/Modbus:crc.new(0xffff, false, 0xa001, 0)
CRC-16/SDI-12:crc.new(0, false, 0xa001, 0)
CRC-16: crc.new(0xffff, true, 0x8408, 0)
CRC-16/Xmodem:crc.new(0, true, 0x8408, 0)
CRC-16/Kermit:crc.new(0, false, 0x8408, 0)
CRC-16/DNP: crc.new(0, false, 0xa6bc, 0xffff)
]]--
```

## `cv = ct:fin()`

CRC finalise

**Parameters** None

**Returns**

- `cv`: CRC value

**Description** Finish CRC and return CRC value.

```
local c = crc.new('xmodem')
c:upd('Testing')
local v = c:fin()
```

## `ct:upd(txt)` `ct:upd(fhandle, [length])`

CRC update

**Parameters**

- `txt`: String to CRC
- `fhandle`: File handle
- `length`: Optional number of bytes (otherwise does all)

**Returns** None

**Description** Update CRC.

```
local c = crc.new(32)
c:upd('Testing')
```

# Library dpc : Digital Pulse Counters

## `pc1,pc2 = dpc.dis()`

Digital pulse disable

**Parameters** None

**Returns**

- `pc1`: Pulse count 1 before disabled
- `pc2`: Pulse count 2 before disabled

**Description** Disable pulse counter input.

## `l1, l2 = dpc.lvl()` v1.00<br>`l = dpc.lvl(n)` v3.00

Digital pulse current level

**Parameters**

- `n`: Which input - 1 or 2

**Returns**

- `l1`: True if Pulse 1 is at 0V/GND
- `l2`: True if Pulse 2 is at 0V/GND
- `l`: Level (when n>0)

**Description** Return the current level of the digital pulse inputs.

```
pc1,pc2 = dpc.rst()
pc = dpc.rst(n) v3.00
```

Digital pulse reset

**Parameters**
- `n`: Which input - 1 or 2

**Returns**
- `pc1`: Pulse count 1 before reset
- `pc2`: Pulse count 2 before reset
- `pc`: Pulse count (when n>0)

**Description** Reset digital pulse counts (and enables).

```
pc1,pc2 = dpc.val()
pc = dpc.val(n) v3.00
```

Digital pulse get value

**Parameters**
- `n`: Which input - 1 or 2

**Returns**
- `pc1`: Pulse count 1
- `pc2`: Pulse count 2
- `pc`: Pulse count (when n>0)

**Description** Query the pulse count values.

# Library evt : Event Library

## evt.en(evts)
## evt.di(evts)

Event enable or disable

**Parameters**
- evts: Event name strings

**Returns** None

**Description** Enable or disable event callbacks.

A group of the events are always enabled, and cannot be disabled.

```
evt.en('onDevRx,onPL1')
```

## evt.init(evts) v3.10.0171

Event initialise

**Parameters**
- evts: Event name strings (blank = all)

**Returns** None

**Description** Fires the events if they're active. Useful to kick off an event on Lua script start, etc.

Applies to onPL2, onPL1, onDevCon, onEngCon, onDevCts, onEngCts, and onMag only

## `evt.lsig()`

Event signal

**Parameters** None

**Returns** None

**Description** Signal the event loop.

It is important that the main Lua Loop Task is asleep for most of its life. The evt.lsig() can be called from an event callback function to wake up a sleeping loop process.

> ⚠ If you use the `coro` library, do NOT use `evt.lwait` or `evt.lsig` (they are used by the library internally)

## `ok = evt.lwait([timeout])`

Event wait

**Parameters**

- `timeout`: Number of milliseconds to wait. If NIL, then waits forever.
- `ok`: True if signalled. False if timed-out

**Description** Wait for the signal from the event callbacks.

It is important for power-consumption that the main Lua Loop Task is asleep for most of its life. The evt.lsig() can be called from an event callback function to wake up a sleeping loop process that has called evt.lwait()

> ⚠ If you use the `coro` library, do NOT use `evt.lwait` or `evt.lsig` (they are used by the library internally)

## `evt.sig(evts)`

`Event signal trigger`

**Parameters**

- `evts`: Event name strings

**Returns** None

**Description** Trigger a callback (for testing and development).

# Event Callback Functions

Event callbacks are run in a separate Lua Events Task inside the rt.buffer. To make use of a callback, you must declare a function within the App, and enable the named function with evt.en(…)

The callbacks are passed three parameters:

```
function eventcallbackname(name, idx)
```

Event callback function

**Parameters**

- `name`: Event name, e.g. "onSec"
- `idx`: Event index number, 1-32

**Returns** None expected

# Event Callback Names

- For time-based callback events, use the job library.
- Always enabled
  - `onMag` - magnet is closed (default is iot._onMag)
  - `onMagOff` - magnet is released
  - `onConfig` - configuration change occurred
  - `onEngCon` - engineer port is connected or disconnected
  - `onDevCon` - device port is connected or disconnected
  - `onUnload` - called when the script is being unloaded v1.00
- Require enabling
  - `onEngCts` - Engineer CTS line changed
  - `onDevCts` - Device CTS line changed
  - `onEngRx` - data is being received
  - `onDevRx` - data is being received
  - `onPL1` - digital pulse input 1 is low
  - `onPL2` - digital pulse input 2 is low
  - `onPH1` - digital pulse input 1 is high
  - `onPH2` - digital pulse input 2 is high

> Note that some of the events (like the digital pulse events) will dramatically increase power consumption if used with high-frequency devices.

i.e. do not enable the pulse events unless they will occur relatively infrequently (e.g. door closure contacts, etc)

# Event Callback Examples

```
function onMag()
 -- Magnet triggered!
 iot._onMag() -- call the original default
 -- Do some other things
end

function onDevCon(n,idx,v)
 if ser.dev():okr()
 then
 -- connected!
 else
 -- disconnected :-(
 end
end

evt.en('onMag,onDevCon') -- enable these two (onMag already on)
```

# Library `fc` : File Controls

## `name = fc.add(filename, ext1, [ext2···])`

`File add extension`

**Parameters**

- `filename`: Base filename
- `ext1`: Extension to add
- `ext2`: ...More extensions (if required)

**Returns**

- `name`: Full filename

**Description** Add extension(s) to filename (dots not required)

## `nb = fc.append(fhandle, filename, [txt])`

`File append contents`

**Parameters**

- `fhandle`: File handle
- `filename`: Filename of existing file to append to fhandle
- `txt`: optional string to add after the file is appended

**Returns**

- `nb`: Number of bytes added to fhandle

**Description** Writes the contents of filename to the filehandle (at the current position).

## `nb = fc.cache([blocks, [mode]])` v1.00-2.xx

File set cache

**Parameters**

- `blocks`: Number of blocks (2112byte) cache to assign
- `mode`: Cache mode string:
  `'r'` = Read,
  `'w'` = Write-back,
  `'t'` = Write-Thru

**Returns**

- `nb`: Number of bytes allocated to the cache

**Description** Sets up the file system cache.

`'w'` is the mode usually required - where data is lazy written to the volume.

The default is a single block of write-back cache to speed up writing.
i.e. `fc.cache(1, 'w')`

Memory is taken from the Lua memory area.

## `fc.chkupd()` v1.00

File check update

**Parameters** None

**Returns** None

**Description** Triggers a check on the config.txt and Lua App files.

## `fc.clean([blocks, [sectors]])` v1.00

File clean flash

**Parameters**

- `blocks`: =2 (optional) Number of flash blocks to clean
- `sectors`: =0 (optional) Number of sectors

**Returns** None

**Description** Prepare the flash file system for faster writing. The call does internal housekeeping to free up the requested number of blocks/sectors.

> This is helpful when you expect a large file write to take place that must occur without stopping.

```
fc.clean(2, 0) -- make space for about 200k
```

## `ok = fc.copy(fname, tname)` v1.00
## `ok,count,total = fc.copy(fwildcard, twildcard)` v3.20

File copy

**Parameters**

- `fname`: Source file name
- `fwildcard`: Source file using `*` and/or `?` wildcards
- `tname`: Target file name
- `twildcard`: Target directory or `wildcarded path - the` is replaced by each found filename.

**Returns**

- `ok`: True if copied
- `count`: Number of files copied successfully
- `total`: Number of files found.

**Description** Copies a file or files.

## `fc,fs = fc.del([compare], dirpattern, [isdir], [UTCfrom, [UTCto]], [func])`

File delete

**Parameters** compare: dirpattern: isdir: UTCfrom: UTCto:

- `func`: Same structure as `fc.find`

**Returns**

- `fc`: filecount
- `fs`: filesize (if isdir==false)

**Description** Deletes selected files from the directory.

## `ext,name = fc.ext(filename)`

File split extension

**Parameters**

- `filename`: Full filename string

**Returns**

- `ext`: Extension (without the dot)
- `name`: Filename

**Description** Remove first extension from filename (without the dot).

## `n = fc.find([compare], dirpattern, [isdir], [UTCfrom, [UTCto]], [func])`

File find

**Parameters**

- `compare`: How to compare the files `'='` first file that matches (default) `'=='` last file that matches `'!'` first file that does not match `'!!'` last file that does not match
- `dirpattern`: Filename and pattern, e.g. '/Send/*.txt'
- `isdir`: boolean. Set to true to find directories rather than files. (Files are default) UTCfrom:
- `UTCto`: Also adds file's modified time to comparison, such that: UTCfrom ≤ filemodtime < UTCto
- `func`: optional Lua function that's called for each found file (to allow for moving, table creation, etc)

**Returns**

- `n`: Filename of found file

**Description** Finds the file or directory in directory that conforms to the wildcard pattern.

```lua
-- template for fc.find's func parameter:
function fc_find_func(filename, dir, creation, modified, filesize, attribs)
  -- do something, e.g. populate table etc
end

-- e.g.
t = {}
fc.find('/Lua/*e*.lua',
  function(fn,dir,ct,mt,fs,attr)
    t[fn] = fs
  end) -- Collects filesizes into table
```

## `sc,so = fc.gz(fname, [tname], [del])` v3.43

File gzip

**Parameters**

- `fname`: Source file name
- `tname`: Target file name (optional)
- `del`: Delete source (optional, default=false)

**Returns**

- `sc`: Size of compressed file
- `so`: Size of original file

**Description** Compresses a file with gzip.

Adds `.gz` to the target filename.

It is not possible to decompress inside the rt.buffer - it does not have enough RAM.

## `ok = fc.js()` v3.00

Journalling supported

**Parameters** None

**Returns**

- `ok`: True if journalling supported

**Description** Checks whether the internal file system supports journalling.

## `ok,res… = fc.jx(fn, …)` v3.00

Execute with journalling

**Parameters**

- `fn`: Function to call
- `…`: Parameter list

**Returns**

- `ok`: True if ok
- `res`: Results (depending on `fn` return values)

**Description** Calls a function `fn` with journalling begin/end.

This is an advanced function to support special cases. Normally, the default operation will be perfectly fine.

## `ok = fc.lv(fhandle, luavnames, [txt])`

File write Lua value tree

**Parameters**

- `fhandle`: File handle
- `luavnames`: Lua value names
- `txt`: optional string to append after the list

**Returns**

- `ok`: True if evaluated some Lua values

**Description** Outputs the Lua value trees to the filehandle.

(Same syntax as the USB `LV` command)

If `txt` is assigned, also writes this afterwards.

```
fc.lv(fh, 'c,i', '\r\n')
```

## `fn = fc.mdf(dir, name)`

`File join dir and file`

**Parameters**
- `dir`: Directory path
- `name`: Filename

**Returns**
- `fn`: Full directory + filename

**Description** Join directory + filename.

## `ok,rc = fc.mkd(dir)`

`File make directory`

**Parameters**
- `dir`: Directory to create

**Returns**
- `ok`: True if success
- `rc`: Internal result code

**Description** Create a directory, and all sublevels if required.

## `ok = fc.move(fname, tname)` v3.20
## `ok,count,total = fc.move(fwildcard, twildcard)` v3.20

`File move`

**Parameters**
- `fname`: Source file name
- `fwildcard`: Source file using ` * ` and/or ` ? ` wildcards
- `tname`: Target file name
- `twildcard`: Target directory or ` * ` wildcarded path - the ` * ` is replaced by each found filename.

**Returns**
- `ok`: True if copied
- `count`: Number of files copied successfully
- `total`: Number of files found.

**Description** Moves a file or files.

### `ok,rc = fc.rmd(dir)`

`File remove directory`

**Parameters**
- `dir`: Directory to remove

**Returns**
- `ok`: True if success
- `rc`: Internal result code

**Description**
Remove a directory and all contents (can take a long time to run if there are lots of contents).

### `dir,name = fc.sdf(filename)`

`File split dir and file`

**Parameters**
- `filename`: Full filename

**Returns**
- `dir`: Directory path
- `name`: Just filename and extensions

**Description**
Separate directory and filename.

### `fc.sfwm(safe)` v1.00-2.xx
### `fc.sfwm(mode)`

`File set file write mode`

**Parameters**
- `safe`: Boolean.
  true = safe and slow
  false = medium
- `mode`: Mode string. `'fast'`, `'med'`, `'safe'`

**Returns**
None

**Description**
Scannex debug facility to set the file volume's file write mode.

The default mode is `'safe'`.

> Do not use this unless necessary! Using non-safe file system could corrupt data!

## `fc.sync()` v1.00

File sync to flash

**Parameters** None

**Returns** None

**Description** Scannex debug facility to synchronise and flush the NAND file system.

## `utc = fc.utc(filename)`

File get UTC creation

**Parameters**

- `filename`: Filename of existing file

**Returns**

- `utc`: Integer UTC file creation time.

**Description** Returns the creation date of the filename or directory.

```
local s = utc.txt( fc.utc('/Config/config.txt') )
```

## `ok = fc.wc(filename, pattern)`

File wildcard compare

**Parameters**

- `filename`: Filename to compare against
- `pattern`: Wildcard pattern

**Returns**

- `ok`: true if filename matches the pattern

**Description** Does a wildcard compare.

# Library float : Floating Point Utilities

The float library provides conversion between Lua's numbers and IEEE-754 binary representations. Both single precision (32-bit) and double precision (64-bit) numbers are supported, in integer and ASCII formats.

> Be aware that converting from single to double, and vice-versa, can introduce apparent 'errors'. There are helpful articles on the Internet that highlight the technical reasons why this happens. Lua is double-precision (64-bit) internally.

## `iv = float.d2v(fp)`

Double to integer

**Parameters**
- `fp`: Floating point that needs converting

**Returns**
- `iv`: Integer 64-bit IEEE-754

## `ah = float.d2x(fp)`

Double to hex

**Parameters**
- `fp`: Floating point that needs converting

**Returns**
- `ah`: ASCII-Hex representation of 64-bit IEEE-754

**Description** Convert from Lua number to 64-bit float

## `fp = float.dp(fv, tv)` v3.42

Trim float value

**Parameters**

- `fv`: Floating point that needs trimming
- `tv`: Trim value. e.g. 0.001 trims to 3dp

**Returns**

- `fp`: Floating point result.

**Description** Trims and rounds a floating point number.

```
local v = float.dp(123.456, 0.01) -- > 123.46
local v = float.dp(123.456, 10)   -- > 120
```

## `iv = float.f2v(fv)`

Float to integer value

**Parameters**

- `fv`: Floating point that needs converting

**Returns**

- `iv`: Integer 32-bit IEEE-754

**Description** Convert from Lua number to 32-bit integer

## `ah = float.f2x(fv)`

Float to hex

**Parameters**

- `fv`: Floating point that needs converting

**Returns**

- `ah`: ASCII-Hex representation of 32-bit IEEE-754

**Description** Convert from Lua number to 32-bit ASCII-hex float

## `ok = float.isfin(fv)` v3.42

Check if finite

**Parameters**
- `fv`: Value to check

**Returns**
- `ok`: True if finite

**Description** Compare with C library `isfinite`

## `ok = float.isinf(fv)` v3.42

Check if infinite

**Parameters**
- `fv`: Value to check

**Returns**
- `ok`: True if infinite

**Description** Compare with C library `isinf`

## `ok = float.isnan(fv)` v3.42

Check if a number

**Parameters**
- `fv`: Value to check

**Returns**
- `ok`: True if NaN

**Description** Compare with C library `isnan`

## `ok = float.isnor(fv)` v3.42

Check if a normal number

**Parameters**
- `fv`: Value to check

**Returns**
- `ok`: True if a normal number

**Description** Compare with C library `isnormal`

## `ave,var,std,skw,kur,count = float.mean(v,[tbl]···)` v3.42

Get running statistics values

**Parameters**
- `v`: Value
- `tbl`: Table of values

**Returns**
- `ave`: Mean average
- `var`: Variance
- `std`: Standard Deviation
- `skw`: Skewness
- `kur`: Kurtosis
- `count`: Number of sample

**Description** Calculates mean, variance, etc from a set of values and/or table-of-values.

## `mpco = float.mpc(tx, ty)` v2.00
## `mpco = float.mpc(tx, ty, [uv], [ov])` v3.41

Create multi-point-conversion object

**Parameters**
- `tx`: Table of x-values
- `ty`: Table of y-values
- `uv`: Under value (y when x is too low)
- `ov`: Over value (y when x is too high)

**Returns**
- `mpco`: Multi-Point-Conversion object

**Description** Creates a new MPC object that can be called to perform a conversion.

See: [mpco:y]

Stores the `tx` and `ty` in a memory-efficient C structure in the Lua RAM area.

Use `float.rf` or `float.rd` to load raw IEEE values from a file.

## `polyo = float.poly(m0,m1,m2⋯)` v2.00

Calculate n-order polynomial object

**Parameters**
- `m0,m1,m2⋯`: polynomial multiplers

**Returns**
- `polyo`: Polynomial-Conversion object

**Description** Creates a new polynomial object that can be called to perform a conversion. You can use any number of values.

e.g. `float.poly(5, 0.5, 0.1)` = `5 + 0.5x + 0.1x^2`

See: [polyo:y]

Stores the values in a memory-efficient C structure in the Lua RAM area.

### t = float.rf(fh, n) v2.00
### t = float.rd(fh, n) v2.00

Read floats/doubles from file

**Parameters**
- `fh`: File handle
- `n`: Number of values to read

**Returns**
- `t`: Table of floating numbers

**Description** Reads raw IEEE single float 4-byte (`rf`) or double float 8-byte (`rd`) into a table.

### rro = float.regr() v3.42

Create a running regression object

**Parameters** None

**Returns**
- `rro`: Running Regression Object

**Description** Creates an object that can calculate slope, intercept, and correlation on X,Y.

See: https://www.johndcook.com/blog/running_regression/

```
local mo = float.regr()
local t = {5,8,4,5}
mo:push(2,5)
mo:push(6,1)
mo:push(t)
print(mo:get()) -- -0.54,7.06,-0.32,4
```

Because many methods return the object itself you can chain calls:

```
local mo = float.regr()
local t = {5,8,4,5}
print(mo:push(2,5):push(6,1):push(t):get()) -- -0.54,7.06,-0.32,4
```

## `rso = float.stat()` v3.42

Create a running statistics object

**Parameters** None

**Returns**

- `rso`: Running Statistics Object

**Description** Creates an object that can calculate mean, variance, standard-deviation, skewness, and Kurtosis.

See: https://www.johndcook.com/blog/skewness_kurtosis/

```
local mo = float.stat()
local t = {5,8,4,5}
mo:push(2,5,6)
mo:push(1)
mo:push(t)
print(mo:get()) -- 4.25,5.07,2.25,0.15,-0.79,8
```

Because many methods return the object itself you can chain calls:

```
local mo = float.stat()
local t = {5,8,4,5}
print(mo:push(2,5,6):push(1):push(t):get()) -- 4.25,5.07,2.25,0.15,-0.79,8
```

```
fp = float.v2d(iv)
```

Integer to double

**Parameters**

- `iv`: Integer 64-bit IEEE-754 value

**Returns**

- `fp`: Floating point value

```
fp = float.v2f(iv)
```

Integer value to float

**Parameters**

- `iv`: Integer 32-bit IEEE-754 value

**Returns**

- `fp`: Floating point value

**Description** Convert from 32-bit integer to Lua number

```
n = float.wf(fh, t)
```
v2.00

```
n = float.wd(fh, t)
```
v2.00

Write floats/doubles to file

**Parameters**

- `fh`: File handle
- `t`: Table of numbers

**Returns**

- `n`: Count of values written

**Description** Writes raw IEEE single float 4-byte (`wf`) or double float 8-byte (`wd`) into a file.

## `fp = float.x2d(ah)`

Hex to double

**Parameters**
- `ah`: ASCII-Hex 64-bit string

**Returns**
- `fp`: Floating point value

**Description** Convert from 64-bit ASCII-hex float to Lua number

## `fp = float.x2f(ah)`

Hext to float

**Parameters**
- `ah`: ASCII-Hex 32-bit string

**Returns**
- `fp`: Floating point value

**Description** Convert from 32-bit ASCII-hex float to Lua number

## `mpco:oob(uv,ov)` v3.41

Multi-point - set out-of-bound values

**Parameters**
- `mpco`: Multi-Point-Conversion Object (returned from `[float.mpc]`)
- `uv`: Under value
- `ov`: Over value

**Returns** None

**Description** Sets the under and over values.

## `count,uv,xf,yf,xl,yl,ov = mpco:range()` v3.41

Multi-point - get range

**Parameters**

- `mpco`: Multi-Point-Conversion Object (returned from `[float.mpc]`)

**Returns**

- `count`: Number of x,y pairs in the object
- `uv`: Under value
- `xf`: First x-value
- `yf`: First y-value
- `xl`: Last x-value
- `yl`: Last y-value
- `ov`: Over value

**Description** Returns some key details about the `mpco` object.

## `x,y = mpco:xy(index)` v3.41

Multi-point - get x,y pair

**Parameters**

- `mpco`: Multi-Point-Conversion Object (returned from `[float.mpc]`)
- `index`: Index of x,y set (1-based)

**Returns**

- `x`: x value
- `y`: y value

**Description** Returns a single x,y pair from the set.

> If `index < 1` then `x = xf-1` and `y=uv`

> If `index > count` then `x = xl + 1` and `y=ov`

## `xt,yt,uv,ov = mpco:xyt()` v3.41

Multi-point - get x and y tables

**Parameters**

- `mpco`: Multi-Point-Conversion Object (returned from `[float.mpc]`)

**Returns**

- `xt`: Table of x-values
- `yt`: Table of y-values
- `uv`: Under value
- `ov`: Over value

**Description** Returns the two tables that were used to create the object.

## `yv,idx = mpco:y(xv)` v2.00

Multi-point - Convert from x to y

**Parameters**

- `mpco`: Multi-Point-Conversion Object (returned from `[float.mpc]`)
- `xv`: X-value to convert

**Returns**

- `yv`: Y-value conversion
- `idx`: Index (effectively insertion point of xv)

**Description** Finds the pair of X-values that `xv` is within, and performs linear slope conversion to find `yv`.

Returns nil if `xv` is out-of-bounds, or the `uv` or `ov` values (if set in `mpco:oob`)

Uses the `tx` and `ty` tables passed to `[float.mpc]`.

```
local m = float.mpc( {10,20,30}, {100,200,300} )
local y = m:y(15)  -- > 150
local y = m:y(1)   -- > nil
local y = m:y(301) -- > nil
```

## `m = polyo:c(idx)` v3.41

Polynomial - return coefficient

**Parameters**

- `polyo`: Polynomial-Conversion Object (returned from `[float.poly]`)
- `idx`: Index of coefficient, >=1

**Returns**

- `m`: coefficient value

**Description** Returns the coefficient.

## `m0,m1,m2,m3··· = polyo:terms()` v3.41

Polynomial - return terms

**Parameters**

- `polyo`: Polynomial-Conversion Object (returned from `[float.poly]`)

**Returns**

- `m0···`: coefficient values

**Description** Returns the coefficients as a set.

## `yv = polyo:y(xv)` v2.00

Polynomial - convert x to y

**Parameters**

- `polyo`: Polynomial-Conversion Object (returned from `[float.poly]`)
- `xv`: X-value to convert

**Returns**

- `yv`: Y-value conversion

**Description** Performs the n-order polynomial converion of `xv`

```
local p = float.poly(5, 1, 0.5, 0.01) -- 5 + x + 0.5x^2 + 0.01x^3
local y = p:y(123)  -- > 26301.17
```

## `rro = rro:add(rro2)` v3.42

Add running regression objects

**Parameters**
- `rro2`: Running regression object

**Returns**
- `rro`: Running Regression Object

**Description** Effectively pushes the information from `rro2` to the `rro` object.

## `rro = rro:clear()` v3.42

Clear running regression object

**Parameters** None

**Returns**
- `rro`: Running Regression Object

**Description** Clears the regression object.

## `ave,var,std,skw,kur,count = rro:get()` v3.42

Get running statistics values

**Parameters** None

**Returns**
- `ave`: Mean average
- `var`: Variance
- `std`: Standard Deviation
- `skw`: Skewness
- `kur`: Kurtosis
- `count`: Number of sample

**Description** Pulls the current set of statistics from the running object.

```
rro = rro:push(x,y, [x,y]⋯) v3.42
rro = rro:push(tbl, ⋯) v3.42
```

Push values into running regression object

**Parameters**
- `x,y`: Values for x & y
- `tbl`: Table of values

**Returns**
- `rso`: Running Regression Object

**Description** Updates the `rro` object with X,Y pairs.

Can include a mixture of tables and value as parameters.

```
rso = rso:add(rso2) v3.42
```

Add running stats objects

**Parameters**
- `rso2`: Running stats object

**Returns**
- `rso`: Running Statistics Object

**Description** Effectively pushes the information from `rso2` to the `rso` object.

```
rso = rso:clear() v3.42
```

Clear running stats object

**Parameters** None

**Returns**
- `rso`: Running Statistics Object

**Description** Clears the statistics.

### `slo,itr,cor,count = rso:get()` v3.42

Get running regression values

**Parameters** None

**Returns**

- `slo`: Slope
- `itr`: Intercept
- `cor`: Correlation
- `count`: Number of sample

**Description** Pulls the current set of statistics from the running regression object.

### `rso = rso:push(v, v…)` v3.42
### `rso = rso:push(tbl, …)` v3.42

Push values into running stats object

**Parameters**

- `v`: Value
- `tbl`: Table of values

**Returns**

- `rso`: Running Statistics Object

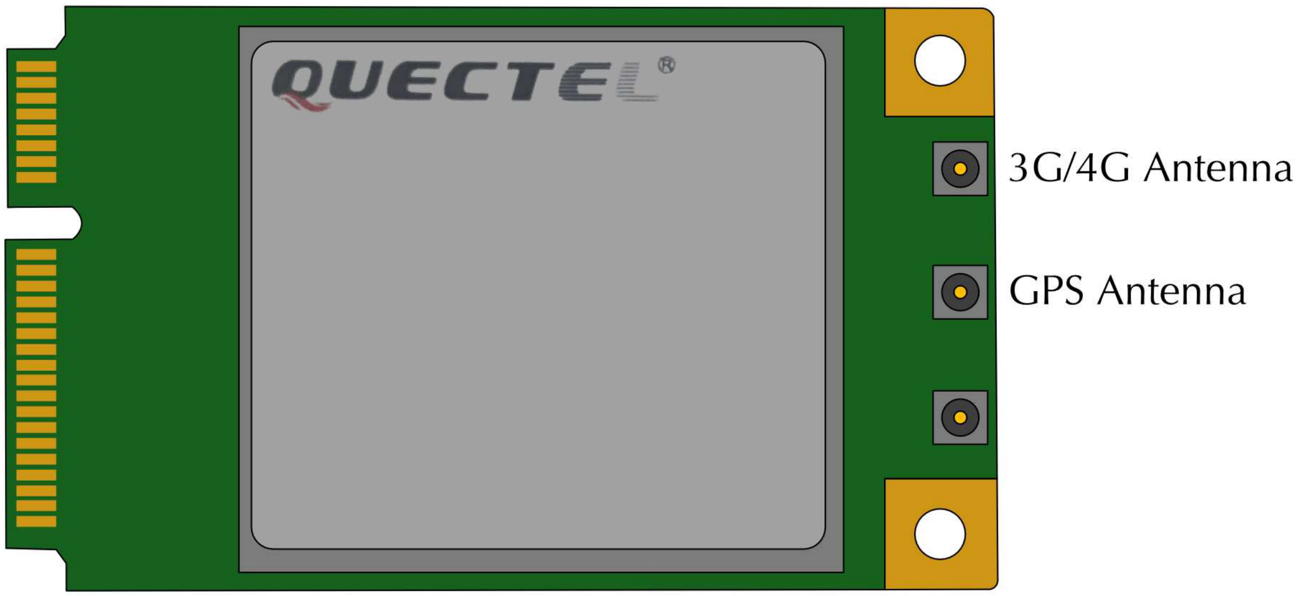
**Description** Updates the `rso` object.

Can include a mixture of tables and value as parameters.

# Library `gps` : GPS/GNSS Library

This library provides an interface to the GPS/GNSS location hardware in the Quectel module modem.

You must connect a suitable GPS/GNSS/GLONASS antenna to the modem.




`en,st = gps.act()` v3.10

Get GPS activity

**Parameters** None

**Returns**

- `en`: True if enabled
- `st`: State = 0:idle, 1:waiting, 2:querying

**Description** Get the GPS status.

## `d = gps.dist([d])` v3.10

Set/Get GPS fix distance

**Parameters**
- `d`: Fix distance, in meters (default: 50)

**Returns**
- `d`: Fix distance in meters

**Description** Sets or gets the fix distance.

## `t = gps.fixt([t])` v3.10

Set/Get GPS fix time

**Parameters**
- `t`: GPS fix maximum time, in seconds (default: 30)

**Returns**
- `t`: GPS fix maximum time.

**Description** Set or get the GPS fix maximum time.

## `t = gps.gap([t])` v3.10

Set/Get GPS interval

**Parameters**
- `t`: Interval time, in seconds (default: 15)

**Returns**
- `t`: Interval time, in seconds

**Description** Set or get the interval time between GPS location queries.

## `gps.go()` v3.10

Start GPS

**Parameters** None

**Returns** None

**Description** Starts the GPS modem process.

Equivalent to `iot.go('gps cho')`

## `gtb = gps.loc()` v3.10

Get GPS location

**Parameters** None

**Returns**

- `gtb`: Table of values

**Description** Get the last GPS location data.

## `lc = gps.rst()` v3.10

Reset the GPS counter

**Parameters** None

**Returns**

- `lc`: Last count

**Description** Reset the count, so the next value of `gtb.idx` will be `1`.

## `t = gps.time([t])` v3.10

Set/Get overall GPS duration

**Parameters**
- `t`: Time, in seconds (default: 120)

**Returns**
- `t`: Time, in seconds

**Description** Set or get the overall time the GPS module should be alive.

A value of -1 will indicate to keep the GPS running all the time the modem is connected.

It usually takes about 45 seconds to obtain a first GPS location.

# GPS Location `gtb`

As returned by alm.get(…)

- `.idx` = Index of the reading (see `gps.rst()`)
- `.utc` = UTC sent by GPS satellite
- `.alv` = rt.buffer alive time of this reading
- `.sat` = Number of satellites
- `.lon` = Longitude
- `.lat` = Latitude
- `.alt` = Altitude (in meters)
- `.hdop` = Horizontal dilution of precision (lower numbers better)
- `.cog` = Ground heading based on true north (ddd.mm)
- `.spkm` = Speed over ground (km/hr)

# GPS Callback

```
function onGPS() v3.10
GPS location available callback
```

**Parameters** None

**Returns** None

**Description** Called when a GPS location has arrived.

> The event is always enabled.

# Library hash : Hash Calculations

Performs MD5, SHA1, SHA256, and HMAC-SHA256 hash functions of text or file contents.

```
hv = hash.md5(txt)
hv = hash.sha1(txt)
hv = hash.sha256(txt)
hv = hash.hmac256(txt, secret) v3.00
hv = hash.hmac256(txt, secret, keyname) v3.31
Hash string immediately
```

**Parameters**

- `txt`: String to hash
- `secret`: Secret string for HMAC-SHA-256 v3.00
- `keyname`: Name of the key that stored `cfg.key.set`

**Description** Calculate hash of direct string.

> The HMAC-SHA-256 function will use concatenate the `secret` text with the value of the `keyname`.

```
ht = hash.new(method, secret, [keyname])
Create new hash object
```

**Parameters**

- `method`: Which hash = `'sha1'`, `'sha224'`, `'sha256'`, `'md5'`, `'hmac256'`
- `secret`: Secret string (for `hmac256`)
- `keyname`: Name of the key that was stored with `cfg.key.set` (for `hmac256`) v3.31

**Returns**

- `ht`: Hash table structure

## `ha = hash.txt(hv, [gap])`

`Convert hash value to text`

**Parameters**

- `hv`: Hash Value, as returned from ht:fin()
- `gap`: optional gap string. Default is a colon ':'

**Returns**

- `ha`: ASCII representation

**Description** Convert hash value into a human-readable format.

## `hv = hash.val(ha)`

`Convert hash string to value`

**Parameters**

- `ha`: ASCII representation of hash (non-hex digits are ignored)

**Returns**

- `hv`: Hash Value.

**Description** Converts ASCII hex to string

## `hv = ht:fin()`

`Hash finalise`

**Description** Produces hash value.

Use `hash.txt(hv)` to convert to ASCII

```
ht:upd(txt)
ht:upd(fileobject, [length])
```

Hash update

| | |
|---|---|
| **Description** | Updates the hash with text or file contents |

# Hash Table Structure

The hash table is returned from a call to hash.new.

There should not be any real need to use the table directly in an app.

- `m` = Method (1, 5, 224, 256, -256 = HMAC-SHA-256)
- `c` = Context for hash (opaque internal value)
- `b` = Number of bytes processed
- `op` = OPAD for HMAC-SHA-256

```
local h = hash.new('sha1')
h:upd('Testing')
local v = h.b -- should be 7
```

# Library `hydrins` : HydrINS Support

```
res, txt = hydrins.cmd(cp, cmdtxt, [timeout])
res, txt, ht = hydrins.cmd(cmdtxt, [timeout]) v3.20
```

Send command to HydrINS

**Parameters**

- `cp`: Com Port Object
- `cmdtxt`: The command to send (# is not required)
- `timeout`: Timeout in milliseconds

**Returns**

- `res`: True if ACK'd by the HydrINS
- `txt`: Response string
- `ht`: HydrINS type (20 or 21)

**Description** Send a command to HydrINS.

```
...
if hydrins.wake(dp, 10, 20)
then
 hydrins.cmd(dp, '086;966')
end
```

```
ht = hydrins.parse(txt)
ht = hydrins.parse(txt, [prm]) v2.00
```

HydrINS parse text

**Parameters**

- `txt`: The received HydrINS data. MUST include the 6-byte binary header. The "W" wakeup character is optional.
- `prm`: The #086 value. When present, parses HydrINS v1 format.

**Returns**

- `ht`: HydrINS table as described

**Description** Parse a HydrINS line into a table.

```
res = hydrins.run(cp)
res, ht = hydrins.run() v3.20
```

Tell HydrINS to run

**Parameters**
- `cp`: Com Port Object

**Returns**
- `res`: True if ACK'd
- `ht`: HydrINS type (20 or 21)

**Description** Issues the #028 command to put into run mode.

Short-hand for:

```
hydrins.cmd(cp, '028')
```

```
ht = hydrins.rx(cp, [timeout])
ht = hydrins.rx(cp, [timeout], [prm]) v2.00
ht = hydrins.rx([timeout], [prm]) v3.20
```

HydrINS receive

**Parameters**
- `cp`: Com Port Object (as returned by ser.dev() )
- `timeout`: Optional timeout, in milliseconds
- `prm`: The #086 value. When present, parses HydrINS v1 format.

**Returns**
- `ht`: HydrINS table of values, or NIL if not received

**Description** Read and parse a HydrINS record from the Com Port.

```
res = hydrins.wake(cp, [delaysec, [trysec]])
res, ht = hydrins.wake([delaysec, [trysec]]) v3.20
```

Wake up HydrINS

**Parameters**

- `cp`: Com Port Object
- `delaysec`: Number of seconds to delay before starting (default 0)
- `trysec`: Number of seconds to keep trying (default 130s)

**Returns**

- `res`: True if successfully woke up the HydrINS into command mode and received an ACK.
- `ht`: HydrINS type (20 or 21)

**Description** Try and wake up the HydrINS.

You can make use of the ht.cycle value to work out a suitable combination of delaysec + trysec:

```
local ht = hydrins.rx(dp)
...
if ht
then
 if hydrins.wake(dp, ht.cycle-2, 4) -- 2s before next cycle
end
```

# Hydrins Table `ht`

- `ht.ver` = Hydrins version (1, 2 or 2.1)
- `ht.params` = Parameters 16-bit field
- `ht.alarms` = Alarms 16-bit field
- `ht.cycle` = Cycle time, in seconds
- `ht.tests` = Self tests 16-bit field (for Hydrins 2.1)
- `ht.water` = True if in water
- `ht.air` = True if in air
- `ht.PULSES` = HydrINS pulse count value
- `ht.VPAV` / `.VPAVu`
- `ht.SPV` / `.SPVu`
- `ht.VMAV` / `.VAMVu`
- `ht.SMV` / `.SMVu`
- `ht.FAV` / `.FAVu`
- `ht.SVG` / `.SVGu`
- `ht.TOTp` / `.TOTpu`
- `ht.TOTm` / `.TOTmu`
- `ht.TOTn` / `.TOTnu`
  - For each, there is a value and optional units. i.e. `ht.TOTm` is the value, and `ht.TOTmu` is the unit string.
- `ht.B1p` = Battery 1 percentage
- `ht.B1v` = Battery 1 voltage (if present)
- `ht.B2p` = Battery 2 percentage (if present)
- `ht.B2v` = Battery 2 voltage (if present)
- `ht.BU` = Batteries used (if present)
- `ht.BF` = Batteries fitted (if present)
- `ht.TEMP` / `ht.TEMPu` = temperature & units (for Hydrins 2.1 if enabled)
- `ht.NAMUR` = (for Hydrins 2.1 if enabled)

# Library `iot` : Internet Of Things

The iot library provides utilities for sending data via FTP, and FTPS to the central IOT server.

- FTP default port is 21;
- FTPS (**implicit** TLS/SSL) default port is 990.
- *You can override the port number with the standard □:xxx□ in the URL.*

## `txt = iot.abort([reasons])`

`IoT abort modem requests`

**Parameters**
- `reasons`: String containing text (as in iot.go)

**Returns**
- `txt`: String representation of reasons that are still outstanding.

**Description** Cancel the modem requests.

> Use with CAUTION. You may prevent the rt.buffer from ever connecting to the IoT server!

## `ok = iot.arch(filename, [archive])` v3.20

`Archive file`

**Parameters**
- `filename`: Filename to archive
- `archive`: True to archive. False to just delete. Default is `true`

**Returns**
- `ok`: True if successful.

**Description** Archive a file.

> Does not currently support wildcard filenames.

## `iot.aup()`

IoT abort user process

**Parameters** None

**Returns** None

**Description** Abort the User Process (if active).

## `min = iot.azt([min])` v3.10

Set modem anti-cell-zombie timeout

**Parameters**

- `min`: Anti-cell-zombie time, in minutes (default: 720 = 12hrs)

**Returns**

- `min`: Time, in minutes.

**Description** Set/Get the modem's anti-cell-zombie timer value.

Many cells will 'zombie' a device if it has been connected for a while.

Going through a brief disconnect-connect phase periodically ensures the cell keeps the Internet connection available.

See also `iot.scmv - to keep modem online permanently.

## `txb,rxb,nssl = iot.bytes([reset])` v3.40

IoT get byte counts

**Parameters**

- `reset`: Pass `true` to reset the counters

**Returns**

- `txb`: Number of plaintext transmitted bytes
- `rxb`: Number of plaintext received bytes
- `nssl`: Number of ssl connections

**Description** Returns TX and RX byte counters for the modem.

> These are *plaintext* byte counts sent to the modem module for TCP connections, so the over-the-air byte count can be larger if using SSL, which will be dependent on certificate sizes, crypto settings etc. `nssl` can help estimate total over-the-air count.

### `ok = iot.cert(cafile, [certfile, keyfile])` v1.00<br>`ok = iot.cert([use])`

IoT set PKI certificate

**Parameters**

- `cafile`: Local filename of the CA.pem file
- `certfile`: (optional) Local filename of the client certificate
- `keyfile`: (optional) Local filename of the matching client private key
- `use`: Passing 'false' will erase the CA, cert, and key

**Returns**

- `ok`: If successful

**Description** Copies the local file to the modem for use as a CA certificate check, and optionally uploads the client certificate and key.

(Can only be called within the context of the modem task.)

```
iot.cert('/config/ca.pem')
iot.cert('/config/ca.pem', '/config/client.pem', '/config/client.key')
iot.cert(false) -- stop using CA/Cert/Key
```

### `iot.cho()`

IoT clear hold off

**Parameters** None

**Returns** None

**Description** Clear hold off.

Use this sparingly to avoid over-use of modem.

## ok = iot.diag([target], [opts])

Send diagnostics info to IoT server

**Parameters**

- target: Optional target filename
- opts: String containing options of what is to be sent:
  'info'= Information tree
  'config'= Configuration tree
  'app' = Lua App source code

**Returns**

- ok: Whether ok

**Description** Sends the diagnostics dump to the IoT server.

```
iot.diag() -- everything
iot.diag('my-file.diag')
iot.diag(_, 'config app') -- not info
```

## ok = iot.dorun()

IoT allowed to run

**Parameters** None

**Returns**

- ok: Whether modem can still remain online

**Description** Check whether we should still be online, or whether we are about to hangup.

## `txt = iot.flg()`

Get IoT reason string

**Parameters** None

**Returns**

- `txt`: String containing the outstanding reasons for connecting to IoT

**Description** Returns a string compatible with iot.go values.

## `ht = iot.gho()`

IoT get hold off

**Parameters** none

**Returns**

- `ht`: The hold-off time in seconds

**Description** Return the current hold off time, in seconds

## `iot.go([reasons])`

Trigger IoT connection

**Parameters**

- `reasons`: optional reasons for triggering IoT
  `'info'` = perform cellular survey v1.01
  `'data'` = send data
  `'update'` = perform update process
  `'time'` = synchronise time
  `'ntp'` = (same as 'time')
  `'user'` = perform user actions (like magnet)
  `'term'` = connect terminal OTA v1.10
  `'toa'` = connect terminal OTA v1.10
  `'test'` = test delivery
  `'diag'` = send diag on update v3.00
  `'sms'` = SMS transmission v1.10
  `'data time update'` = default options

**Returns** None

**Description** Trigger connect and send.

> The survey results are saved in `/Logs/cellinfo.txt`. This process may take between 2 and 5 minutes (perhaps longer if there is no SIM installed).

The modem may be in a 'hold-off' period, but will connect when that period expires.

## iot.hum([kill])

IoT hang up modem

**Parameters**
- `kill`: true to perform nasty, immediate, power kill.

**Returns** None

**Description** Hang up the modem. Without the 'kill' option, the modem handler will let all tasks close down gracefully.

With the `kill` option, the modem power is cut immediately, and it can take a few minutes for the modem handler to timeout and clean up.

## stop = iot.isf(name)

IoT is there a stop file

**Parameters**
- `name`: Root name of the file to look for

**Returns**
- `stop`: True if there is a '.stop'

**Description** Check whether there’s a request to stop from the IoT server.

If found, the file is deleted from the server.

```
local stp = iot.isf('mine') -- looks for 'mine.{i.rt_sn}.stop'
```

## `ok,txt = iot.modem(cmd, [timems])` v3.31
## `ok,txt = iot.modem(cmd, [table])` v3.31

Send modem command

**Parameters**

- `cmd`: AT command string to send (without the 'AT')
- `timems`: Wait time in milliseconds
- `table`: Table of options
  `.time` = timems
  `.look` = (string) prefix to look for
  `.case` = (boolean) case sensitive
  `.xok` = (boolean) expecting OK
  `.prompt` = (boolean) expecting '> ' (special case)

**Returns**

- `ok`: Whether successful
- `txt`: Result string

**Description** Allows sending additional 'AT' commands to the modem during configuration.

> Can only be called within the context of `iotInit` or other `iotXXX` callbacks.

## `mv = iot.scmv([mv])` v3.10

Set modem stay-connected millivolt

**Parameters**

- `mv`: Millivolt setting to keep modem alive (default: 0)

**Returns**

- `mv`: Millivolt level

**Description** Setting `iot.scmv` with a non-zero value will keep the modem alive and ignore the `c.cell_mto`, all the time the power supply is >= `mv`.

As soon as the power supply drops below `mv` then the timings in `c.cell_mto` are followed.

> The modem will still disconnect after the 'anti-cell-zombie' timeout (see `iot.azt`). However, if `sms.rxt(-1)` or `gps.time(-1)` then the modem will reconnect after a short pause.

```
iot.scmv(10000) -- keep online while above 10V
iot.azt(720)    -- 12hr anti-cell-zombie time
sms.rxt(-1)     -- keep SMS reception going
```

## `fc,fs = iot.send(srcptn, [options, [arch]])`

Send files to IoT server

**Parameters**

- `srcptn`: File path pattern (wildcarded) for choosing what to send
- `options`: optional overrides for the transfers
  `''` = send plain
  `'tfr'` = use temp-file-rename process
  `'gz'` = use .gz compression
  `'zlib'` = use .zlib stream compression
  _ (NIL/not present) = send using tfr + gz
- `arch`: Whether to archive the file when sent (default = true)

**Returns**

- `fc`: Count of files sent
- `fs`: Number of bytes sent

**Description** Transfer files from the rt.buffer directory area that match the filename pattern.

Copies according to source ASCII-sort name.

- MUST only be called within the context of the modem process, within the iotData callback function.

```
iot.send('/Send/*.mine.txt')
iot.send('/Send/*.more.dat', '') -- no compression, direct
```

## iot.set(uri)

Set IoT server URL

**Parameters**

- `uri`: Absolute or relative URL for the server

**Returns** None

**Description** Sets the address relative to the previous call to iot.set (i.e. appends this path to the previous full URL).

```
iot.set('ftp://user:pass@ftp.scannex.com:21/target')
-- or --
iot.set('/NewDirectory/Here')
```

Uses the scheme and server details from the previous call to iot.set

```
iot.set('Relative/Path/Here')
```

This function makes use of [rt.exp] to provide for Lua variable expansion:

```
-- include the Site Name and Serial Number:
iot.set('Relative/Path/{c.site_name}-{i.rt_sn}')
```

See [rt.exp] for details on the expansion mechanism.

## `iot.sho(value)`

IoT set modem hold off

**Parameters**
- `value`: The hold off time required in seconds.

**Returns** None

**Description** Set modem hold off. Only applies if the current hold off is less that value.

## `ok = iot.trim()` v3.20

Trim archive folder

**Parameters** None

**Returns**
- `ok`: True if successful.

**Description** Trim the archive folder, using the `c.arc_fc` and `c.arc_kb` values.

# Default Functions

## function iot._test

IoT default test callback

**Description** Default IoT Test function. Effectively:

```
function iot._data()
 iot.set(c.iot_data)
 iot.send('/Config/*.tst')
end
```

## function iot._onJob11

IoT default Job11 callback

**Description** Default onJob11 function. Effectively:

```
function iot._onJob11()
 iot.go('update time')
end
```

## function iot._onJob12

IoT default Job12 callback

**Description** Default onJob12 function. Effectively:

```
function iot._onJob12()
 smp.cut()
 iot.go('data')
end
```

## function iot._data

IoT default data callback

**Description** Default IoT Data function. Effectively:

```
function iot._data()
 iot.set(c.iot_data)
 iot.send('/Send/*')
end
```

## function iot._user

IoT default user callback

**Description** Default IoT User function.

## function iot._onMag

IoT default magnet callback

**Description** Default Magnet event handler. Effectively:

```
function iot._onMag()
 iot.go('user update')
 iot.cho()
end
```

# IoT Callbacks

The IoT callbacks are suitable for transferring data using the `iot` library commands. You can also use these commands to interact with the modem (e.g. issuing AT commands via the `modem` library commands).

## `function iotData()`

IoT data callback

**Description** Called when the rt.buffer should send data to the central server.

If this function is not defined, then all files within the /Send directory are sent.

- Within this callback you should make use of iot.set and iot.send (and not much else).

```
function iotData()
 iot.send('/Send/*.dat')
 iot.set('Another/Path')
 iot.send('/Send/*.csv')
end
```

## `function iotIdle()` v3.40

IoT Modem Idle callback

**Description** Called in between jobs while the modem is powered.

## `function iotInit()` v3.31

IoT Modem Initialise callback

**Description** Called when the modem is powered, but before the SIM is initialised, allowing for additional configuration sequences using `iot.modem` or `modem.XXX`.

## `function iotOff()` v3.40

IoT Modem Complete callback

**Description** Called just *before* powering off.

## `function iotOffline()` v3.40

IoT Modem Offline callback

**Description** Called just *before* going offline.

## `function iotOnline(ok)` v3.40

IoT Modem Online callback

**Description** Called when online connection has finished. `ok` is a boolean defining whether successful.

## `function iotReg(ok)` v3.40

IoT Modem Initialise callback

**Description** Called when registration has finished. `ok` is a boolean defining whether successful.

## function iotSetup() v3.40

IoT Modem Starting callback

**Description** Called when the modem is powered and SIM initialised allowing for additional configuration sequences using `iot.modem` or `modem.XXX`

## function iotTest()

IoT test callback

**Description** Called when the rt.buffer should send test file(s) to the central server.

If this function is not defined, then all *.tst files in /Config directory are sent, and not archived.

## function iotUpd()

IoT update callback

**Description** Called within the context of the Update mechanism.

This Lua callback occurs *after* the firmware has performed its processes.

## function iotUser()

IoT user callback

**Description** Called when the rt.buffer should perform the user interaction (e.g. when the magnet is triggered).

The default function repeatedly sends a diagnostic dump to 'user.SERIAL.txt' in the c.iot_user directory (which is the c.iot_url by default). It checks for a 'user.SERIAL.stop' file - if this exists it will delete the file on the server and quit the loop. Otherwise, it will pause 15s, and loop.

The pause can be set with c.user_ins, and the total loop time set with *c.user_onm*.

Something like this:

```
function iotUser()
 local et = (c.user_onm or 2) * 60 + i.rt_alv
 local iv = (c.user_ins or 15)
 while (i.rt_alv < et) and iot.dorun()
 do
  iot.diag( rt.exp('user.{i.rt_sn}.txt'), 'config info' )
  if iot.isf('user') then break end
  rt.ms(1000 * iv)
 end
end
```

# Library `job` : Job Scheduler

The job scheduler provides an efficient mechanism to handle repeat events - like sampling, triggering delivery etc.

There are 12 jobs, and each job can have up to 8 time slots (so that different times of the day, and/or days of the week, can have different frequencies).

When the job needs running, the Lua Event Task will execute onJob#. e.g. Job 1 will execute the Lua callback function `onJob1`.

`Job12` is reserved for the Data Delivery schedule, and defaults to 23:00:00 each day.

`Job11` is reserved for the Update mechanism schedule, and defaults to 23:00:00 each day.

## Job Schedule Strings

The rt.buffer has a flexible job scheduler that is used throughout the firmware. There are up to twelve jobs that can be used for different purposes (e.g. deliver data; contact update server). Each job can have eight different time slots (e.g. for different times throughout the week).

A schedule is programmed with a string that has the following structure:

- The primary value is the interval (default is 24 hours)
  - `00:00:15` = every 15 seconds
- The `@` specifies a time range (default start time is 00:00:00, and default end time is 24:00:00)
  - `@23:00` = at (or from) 11 pm
  - `@6:00-23:30` = between 6:00am (inclusive) and 11:30pm.
- The `#` specifies the day bit-field
  - Where: 1 = Sunday, 2 = Monday, 4 = Tuesday, 8 = Wednesday, 16 = Thursday, 32 = Friday, 64 = Saturday
  - `#62` = weekdays
  - `#65` = weekends
  - `#d` = weekdays, Mon-Fri
  - `#e` = weekends, Sat+Sun
  - `#a` = all days (#127)
- A comma (,) separates the entries

The end time is *exclusive*. So, for example, `2:00@12:00-18:00` will fire at 12:00, 14:00, and 16:00 only. This method allows for clarity when changing the interval, say to 0:00:01.

# Schedule Examples

- `00:00:30@8-18, 00:05:00`
    - every 30s between 8am and 6pm, and 5 minutes outside those times
- `00:00:30@8-18#2,00:00:45@8-18#60,00:05:00`
    - every 30s between 8am and 6pm on Monday; every 45s between 8am and 6pm on Tue-Fri, and 5 minutes otherwise.
- `4@8-18,12`
    - every 4 hours between 8am and 8pm, and every 12hrs otherwise (00:00:00 & 12:00:00)
- `@12:30`
    - an event that occurs each day at 12:30pm

# Scheduled Jobs

## job.set(jobn, txt, [variance])

Set job schedule

**Parameters**

- `jobn`: Job number, 1-12
- `txt`: The job schedule string
- `variance`: Set to true to apply delivery variance to the schedule.

**Returns** None

**Description** Sets the parameters for a job. Not all parameters are required for an entry, and you may have up to 8 time slots defined for each job. Spaces are optional, as are leading zeroes.

## `txt,var = job.txt(jobn)`

Get job schedule

**Parameters**

- `jobn`: Job number, 1-12

**Returns**

- `txt`: Job schedule string (long-hand format)
- `var`: Whether variance applied

**Description** Returns the textual representation and whether variance is applied for the job.

## `var = job.var(jobn, [variance])`

Set or get job variance

**Parameters**

- `jobn`: Job number, 1-12
- `variance`: If present, sets the variance flag for the job

**Returns**

- `var`: Whether variance is applied on this schedule.

**Description** Sets or queries the variance flag for a job.

# Scheduled Job Callbacks

```
function onJob##(jobn, utc, utcj)
```

Job callback prototype

**Parameters**

- `jobn`: The job number, 1-12
- `utc`: The actual UTC time value. Note that this may be slightly behind the current UTC time if there has been a backlog of jobs.
- `utcj`: The UTC the job sees (if variance is applied)

**Returns** None

**Description** This is the function prototype of the job callback, i.e. for onJob1 etc.

The function name should match the job number:

```
function onJob1(n, u, j)
 -- n = 1
 -- u + j = time
 -- do stuff here...
end
```

However, with Lua, the following is also possible:

```
function Foo(n,u,j)
 -- stuff
end

onJob1 = Foo
onJob2 = Foo
```

# UTC Based Jobs

The UTC based jobs are useful for one-time events that need to occur at a certain time, such as triggering a rendezvous to base at a certain time.

There are 16 UTC slots that can be used.

## `job.utc(jobu, utc)`

Set a UTC based job

**Parameters**

- `jobu`: Job number, 1-16
- `utc`: Time the job should run

**Returns** None

**Description** Sets the Job UTC slot to the UTC time provided

Calls the function defined for the job number:

```
onJobU##( ) ①
```

① where `'##'` is the jobu number

```
function onJobU5()
-- do something
end

job.utc(5, utc.cvt('2017-09-01 16:00'))
```

## `jobu = job.utc(utc, function)`

Set a UTC based job function

**Parameters**

- `utc`: Time the job should run
- `function`: Lua function that is called at utc

**Returns**

- `jobu`: The job number assigned, or NIL if no free jobs

**Description** Find a spare UTC job slot, and glue the supplied function to the onJobUxx event

e.g. Assuming slot 5 is free, the function will be linked to onJobU5. On execution, the onJobU5 function is unlinked, and therefore the function originally provided may be garbage-collected (i.e. if it was an unnamed function).

```
job.utc(os.time()+120, function() --[[ do stuff ]]-- end)
job.utc(os.time()+120, MySpecialFunction)
```

## `utc,tmp = job.utc(jobu)`

Query UTC job slot

**Parameters**

- `jobu`: Job number, 1-16

**Returns**

- `utc`: The time the job is scheduled for, or NIL if blank.
- `tmp`: True if the job is a temporary one (see [job.utc](utc, function) )

**Description** Query Job UTC slot number.

# UTC Based Job Callbacks

## function onJobU##()

UTC Job callback prototype

**Parameters** None

**Returns** None

**Description** Called when the UTC job runs.

e.g.

```
function onJobU4()
 -- do something
end
```

The name of the function must match the UTC job number, 1-16

# Library `jobq` : Job Queue

The job queue library provides a useful way to schedule functions to run sequentially.

Added in firmware v3.43

This is useful when devices need data extracting, configuration changes, and diagnostics to be run. Other tasks can post to the job queue and the function callbacks will be run strictly in order.

There is also a global job queue `JQ` that can be used in situations where you might need a simple function call: e.g. `coro.add(jobq.run)` — will run all jobs in JQ as a coroutine. To use this global queue, call the `jobq.XXX` functions without the first table parameter. (You don't need to use `job.new` for the global one - it is created automatically.)

The job queue is atomic - you can safely add and pop from any job queue in any Lua context.

## `jqo = jobq.new()`

Create a new Job Queue Object

**Returns**

- `jqo`: Returned Job Queue Object

**Description** Creates a new job queue.

You can have multiple job queue objects that are serviced by different parts of your Lua app.

A Job Queue Object is just an indexed table with metamethods. Consequently you can count the number of pending jobs with with the standard Lua '#'' operator. e.g. `count = #jqo`

# Typical usage

Generally, you will use the methods `jobq.new` and `jqo:run`

```
mjq = jobq.new()

function MyJob1(a1,a2)
  -- so something with a1 & a2
end

function MyJob2()
  -- do work
end


...
mjq:add(MyJob1, {42, 'Interesting'})
mjq:add(MyJob2)


...
mjq:run() -- runs all jobs
```

Of course, you can wrap the run into a coroutine:

```
coro.add( jobq.run, mjq ) -- effectively runs jobq.run(mjq) === mjq:run()
```

# Using the global job queue

You can use the global job queue `JQ`:

```
jobq.add(MyJob1)
jobq.add(MyJob2)
...
coro.add( jobq.run )
```

Note the subtle difference of '.'' vs ':'!)

# Library jobq | jqo : Job Queue Objects

```
ok = jqo:add(func, argt, [always])
```

Add callback to job queue

**Parameters**

- `func`: Lua function
- `argt`: Table of arguments that will be passed to `func`
- `always`: true means always add. Default is `false` (ie only add if not already in the queue)

**Returns**

- `ok`: True if added to the queue

**Description** Scans the `jqo` for a matching `func` + `argt` set.

The callback is queued if the combination is not already in the queue, or if `always` is `true`.

```
count = jqo:del()
count = jqo:del(func, all)
count = jqo:del(func, argt)
```

Delete jobs from the queue

**Parameters**

- `func`: Lua function
- `argt`: Argument table
- `all`: (bool) whether to remove all instances of `func`

**Returns**

- `count`: Number of jobs deleted

**Description** Deletes either all jobs (`jqo:del()`), or a specific set of jobs from the queue.

## ok = jqo:is(func, [argt])

Check if callback in job queue

**Parameters**
- `func`: Lua function
- `argt`: (optional)Table of arguments

**Returns**
- `ok`: True if exists in the queue

**Description** Scans the `jqo` for a matching `func` + `argt` set. If `argt` is not provided, then checks if there is any `func` queued.

## foo,argt = jqo:pop()

Pop a job from the queue

**Parameters** None

**Returns**
- `foo`: Function callback
- `argt`: Argument table

**Description** Pops a job from the queue.

Use `unpack` to convert `argt` into a set of arguments.

```
mjq = jobq.new()
...
local foo,argt = mjq:pop()
if (foo) then foo(unpack(argt)) end
```

## `ok,rv··· = jqo:poprun()`

Pop a job from the queue

**Parameters** None

**Returns**

- `ok`: If the job ran correctly (boolean)
- `rv···`: Set of arguments returned by the function

**Description** Pops a job from the queue and runs it.

This is a simpler way of straight calling one job.

```
mjq = jobq.new()
...
local res = { mjq:poprun() }
-- res[1] has 'ok' return value
```

## `count = jqo:run()`

Run all jobs in the queue

**Parameters** None

**Returns**

- `count`: Number of jobs successfully run

**Description** Pops each job from the queue and runs it, looping until all are run.

```
mjq = jobq.new()
...
local count = mjq:run()
```

# Library `kvc` : Key Value Container

The `kvc` library can be used to save Lua RAM for sets of values. It uses the same internals as the `c` configuration tree.

**`kvco = util.kvc(nb,ni)`** v2.00

Create new key-value container object

**Parameters**

- `nb`: Number of bytes for the data
- `ni`: Number of index entries

**Returns**

- `kvco`: KVC object

**Description**

Return a KVC object. RAM is taken from the Lua memory for the KVC object, the data area, and the index block.

RAM will be recovered during garbage collection when the `kvco` object becomes unused.

```
local k = util.kvc(2048,64)
k.my_value=1.234
k.my_setting='Test'
```

# Library kvc | kvco : Key-Value Container Objects

## nb = kvco:_free v2.00

Query KVC object free bytes

**Parameters** None

**Returns**

- nb: Number of bytes.

**Description** Returns the number of bytes free in the data area of the kvco object.

Not a function, but a pseudo variable.

## nb = kvco:_sizei v2.00

Query KVC object index capacity

**Parameters** None

**Returns**

- nb: Number of bytes.

**Description** Returns the number of bytes used by the index area of the kvco object.

Not a function, but a pseudo variable.

## `nb = kvco:_size` v2.00

Query KVC object byte size

**Parameters** None

**Returns**

- `nb`: Number of bytes.

**Description** The total number of bytes in the data area of the `kvco` object.

> Not a function, but a pseudo variable.

## `ni = kvco:_freei` v2.00

Query KVC object free index entries

**Parameters** None

**Returns**

- `ni`: Number of index entries free

**Description** Returns the number of index entries free in the `kvco` object.

> Not a function, but a pseudo variable.

## `ok = kvco:_load(filename,[clear])` v2.00

Load data from file to KVC object

**Parameters**

- `filename`: Name of the text file to load from
- `clear`: Whether to clear the kvco before loading (default=true)

**Returns**

- `ok`: If successful

**Description** Loads the file into the `kvco` object.

## `ok = kvco:_save(filename)` v2.00

Save data from KVC object to file

**Parameters**

- `filename`: Name of the text file to save to

**Returns**

- `ok`: If successful

**Description** Saves the contents of the `kvco` object into the text file.

# Library `modbus` : MODBUS functions

The MODBUS library provides raw frame transmission and reception, as well as a higher-level command processor that can frame and de-frame data.

Only supports MODBUS RTU on serial - either RS-232 or RS-485 (with an adapter).

## `rt,txt = modbus.cmd(cp, adr, fnc, [tfmt, ttab, [rfmt, ms]])`

Send MODBUS command

**Parameters**

- `cp`: COM Port object
- `adr`: Slave address
- `fnc`: Function number
- `tfmt`: Transmit format string
- `ttab`: Transmit data table
- `rfmt`: Receive format string
- `ms`: Receive time out

**Returns**

- `rt`: Table of values (as specified by rfmt)
- `txt`: Remaining string (if any)

**Description** Send a MODBUS RTU request, and read the reply.

The indexed table 'ttab' is used, along with tfmt, to create a data string that is passed to modbus.tx, The reply formatting is optional.

For example to write to register 1000:

```
modbus.cmd(dp, 1, 16, 'WWBW', {1000, 1, 2, 7878})
-- register 1000 will have 2 bytes written = 7878
```

Modbus.rx is called, and any reply is pulled apart using the rfmt specifiers to create a list of results.

For example, the Read Holding Registers (0x03) function will return a byte-count, followed by n × 16-bit values (rfmt = 'BWWW' for 3 values):

Use `modbus.rhr` for Read Holding Registers. This example provided for instruction only.

```
t = modbus.cmd(dp, 1, 3, 'WW', {2, 3}, 'BWWW')
if t
then
 -- t[1] = Number of bytes
 -- t[2] = register 0002
 -- t[3] = register 0003
 -- t[4] = register 0004
 reg1, reg2, reg3 = unpack(t)
end
```

Note the use of Lua's `unpack(t)` to turn a table into a list of values.

## `tab = modbus.fs2t(tfmt, txt)` v1.00

Unpack string to table

**Parameters**

- `tfmt`: Format string
- `txt`: Binary block of ModBus data to unpack

**Returns**

- `tab`: Lua table of values

**Description** Utility function (used by modbus.cmd etc) to unpack a binary block received by ModBus and convert to a table of values.

## `txt = modbus.ft2s(tfmt, ttab)` v1.00

Pack table to string

**Parameters**

- `tfmt`: Format string
- `ttab`: Table of values to pack

**Returns**

- `txt`: ModBus packed block to send

**Description** Utility function (used by modbus.cmd etc) to pack a set of values into a binary string block ready to send.

## `modbus.rdi(cp, adr, fc, nc, [ms])` v1.30

Read discrete inputs

**Parameters**

- `cp`: COM Port object
- `adr`: Slave address
- `fc`: First coil to read
- `nc`: Number of coils to read
- `ms`: Receive time out

**Returns**

- `tab`: Table of booleans (one for each input)
- `err`: ModBus error

**Description** Read discrete inputs (function 02)

## `tab = modbus.rhr(cp, adr, regs, regc, [rfmt, [ms]])` v1.00

Read MODBUS holding registers

**Parameters**

- `cp`: COM Port object
- `adr`: Slave address
- `regs`: First register to read
- `regc`: Count of registers to read
- `rfmt`: Receive format string
- `ms`: Receive time out

**Returns**

- `tab`: Table of values

**Description** Wrapper function for modbus.cmd that performs a ModBus **Read Holding Registers** ($3_{dec}$ / 0x03) function.

```
local t = modbus.rhr(dp,1,28,6,'W+') -- read DVP readings
```

## `tab = modbus.rir(cp, adr, regs, regc, [rfmt, [ms]])` v1.30

Read input registers

**Parameters**

- `cp`: COM Port object
- `adr`: Slave address
- `regs`: First register to read
- `regc`: Count of registers to read
- `rfmt`: Receive format string
- `ms`: Receive time out

**Returns**

- `tab`: Table of values

**Description** Read Input Registers (function 04).

Same format as `modbus.rhr` function 03.

## `tab, err = modbus.rmc(cp, adr, fc, nc, [ms])` v1.30

Read multiple coils

**Parameters**

- `cp`: COM Port object
- `adr`: Slave address
- `fc`: First coil to read
- `nc`: Number of coils to read
- `ms`: Receive time out

**Returns**

- `tab`: Table of booleans (one for each coil)
- `err`: ModBus error

**Description** Read multiple coils (function 01)

## `dt,err = modbus.rsid(cp, adr, fmt, [ms])` v1.30

Read server ID

**Parameters**

- `cp`: COM Port object
- `adr`: Slave address
- `fmt`: In format string
- `ms`: Receive time out

**Returns**

- `dt`: Data table of results (or string if `fmt` not defined)
- `err`: ModBus error

**Description** Read Server ID (function 17/0x11)

## `ok,adr,fnc,data = modbus.rx(cp, [ms])`

Receive MODBUS RTU frame

**Parameters**

- `cp`: COM Port object
- `ms`: Optional timeout (default 250ms)

**Returns**

- `ok`: Whether the frame response is CRC'd ok
- `adr`: Address sent by the slave
- `fnc`: Function number sent by the slave
- `data`: String of remaining data (not including the CRC)

**Description** Receive a MODBUS RTU frame.

## `modbus.set(cp, bps, [rs485])`

Setup MODBUS on COM port

**Parameters**

- `cp`: COM Port object, e.g. from ser.dev()
- `bps`: Baud and Protocol string
- `rs485`: true or '485' = RS-485, false or '232'=RS-232

**Returns** None

**Description** Sets the baud-rate and protocol for the MODBUS.

```
local dp=ser.dev()
modbus.set(dp, '19200e8')
```

## `rxt,txt = modbus.time()`

Return MODBUS timings

**Parameters** None

**Returns**

- `rxt`: Time spent receiving packet (ms)
- `txt`: Time spend transmitting packet (ms)

**Description** Debug function to return the last timings.

## `modbus.tx(cp, adr, fnc, d1, d2…)`<br>`modbus.tx(cp, adr, fnc, str)`

Transmit MODBUS RTU frame

**Parameters**

- `cp`: COM Port object
- `adr`: Slave address 1-127
- `fnc`: Function number
- `d1,d2`: Data bytes
- `str`: String

**Returns** None

**Description** Sends a CRC'd MODBUS RTU frame on the COM port 'cp'.

```
modbus.tx(dp, 1,3, 0,1, 0,2) -- read two registers from reg 0001
```

## `tab,txt = modbus.wmr(cp, adr, regs, tfmt, ttab, [ms])`

Write MODBUS multiple registers

**Parameters**

- `cp`: COM Port object
- `adr`: Slave address
- `regs`: First register to read
- `tfmt`: Transmit format string
- `ttab`: Transmit data table
- `ms`: Receive time out

**Returns**

- `tab`: Table of values returned (should be just start register and count)
- `txt`: Remaining string (if any)

**Description** Wrapper function for modbus.cmd that performs a ModBus **Write Multiple Registers** ($16_{dec}$ / 0x10) function.

```
modbus.wmr(dp,2,19,'W',{5}) -- sets OverFLO average length=5
```

## `rt,txt=modbus.wsr(cp, adr, rno, rv, [ms])` v1.30

Write single register

**Parameters**

- `cp`: COM Port object
- `adr`: Slave address
- `rno`: Register Number
- `rv`: Register Value
- `ms`: Receive time out

**Returns**

- `rt`: Table of values (like `modbus.cmd`)
- `txt`: Remaining text, if any (like `modbus.cmd`)

**Description** Write Single Register (function 06)

# modbus.cmd `tfmt` & `rfmt` Format Strings

The format strings tell the command processor how to package data, and how to parse it.

- `B` = 8-bit unsigned byte
- `b` = 8-bit signed byte v1.30
- `C` = 8-bit character v1.30
- `W` = 16-bit unsigned word
- `w` = 16-bit signed byte v1.30
- `D` = 32-bit double unsigned word v1.00
- `d` = 32-bit double signed word v1.30
- `F` = 32-bit IEEE-754 floating point value v1.00
- `S` = string
- `SN` = string with length 'N' v1.30
- `+` = keep using the last parameter until no more data (only applicable at the end of the string) v1.00

# Library modem : Modem interaction

The modem library includes commands to interact with the modem. All the commands must be run within the context of the modem task. Therefore, they should only be used within the iotXXX callback functions (e.g. iotStart)

## clr = modem.clearfplmn([clr]) v3.40

Request Clear Forbidden PLMN List

**Parameters**

- clr: Set to false to *not* clear the fPLMN list. (Optional)

**Returns**

- clr: True if the clear request is pending.

**Description**

Request that the modem handler query and clear the fPLMN during the next iotSetup phase.

If there is a non-blank fPLMN list in the SIM a log entry is created:

```
mdm   fPLMN cleared (32F40132F42332F40232F403)
```

(Showing the original fPLMN value)

## ok,txt = modem.cmd(cmd, [timems]) v3.40
## ok,txt = modem.cmd(cmd, [table]) v3.40

Send modem command

**Parameters**

- cmd: AT command string to send (without the 'AT')
- timems: Wait time in milliseconds
- table: Table of options
  .time = timems
  .look = (string) prefix to look for
  .case = (boolean) case sensitive
  .xok = (boolean) expecting OK
  .prompt = (boolean) expecting '> ' (special case)

**Returns**

- ok: Whether successful
- txt: Result string

**Description**

Allows sending additional 'AT' commands to the modem during configuration.

Same as the iot.modem function

## `txt,blnk = modem.fplmn([clr])` v3.40

Read/Clear Forbidden PLMN List

**Parameters**
- `clr`: Set to `true` to clear the fPLMN list. (Optional)

**Returns**
- `txt`: The fPLMN value (before clearing)
- `blnk`: (boolean)`true` if `txt` is only `'F'` characters (i.e. blank)

**Description** Manages the SIM card's Forbidden Public Land Mobile Network list.

The firmware function queries the SIM STATUS for fileid 28539 and extracts the length. It then reads the binary file data and returns it.

If `clr` is `true` then the firmware function will update the SIM card EF with `F`s if the fPLMN list is not blank.

This function does not normally need to be used. Just use the `modem.clearfplmn()` function.

```
function iotSetup()
 if DoClearFPLMN ①
 then
  local txt,blnk = modem.fplmn(true)
  if not blnk
  then rt.log('fPLMN',txt) ②
  end
  DoClearFPLMN = nil
 end
end
```

① In a job set DoClearFPLMN=true so this will be called periodically on demand

② If the value is not blank then we log it to the /Logs/system.log file

This mechanism is already coded in firmware using the `modem.clearfplmn()` call.

## `modem.kill()` v3.40

Kill modem

**Parameters** None

**Returns** None

**Description** Forces the modem to be powered off.

## `txt = modem.simrb(fileid, [offset], len)` v3.40

Read SIM FileID Binary

**Parameters**

- `fileid`: The decimal FileID (e.g. 28539) to read from the SIM card
- `offset`: Optional offset
- `len`: Length of the file to read

**Returns**

- `txt`: The ASCII-hex value returned from the SIM (e.g. 'FFFFFFFFFFFFFFFFFFFFFFFF')

**Description** Returns the results from the `AT+CRSM=176,fileid,offseth,offsetl,len` command.

## `tbl,len,orig = modem.sims(fileid)` v3.40

Read SIM FileID STATUS

**Parameters**

- `fileid`: The decimal FileID (e.g. 28539) to read from the SIM card

**Returns**

- `tbl`: The status array as a table. See `modem.stot`
- `len`: The integer value of the Tag '80' (decimal 128)
- `orig`: The original string returned

**Description** Returns the results from the `AT+CRSM=192,fileid` command.

> See 3GPP 102.221 specifications

## `ok = modem.simwb(fileid, [offset], txt)` v3.40

Write SIM FileID Binary

**Parameters**

- `fileid`: The decimal FileID (e.g. 28539) to write to the SIM card
- `offset`: Optional offset
- `txt`: The ASCII-hex data to write

**Returns**

- `ok`: Whether successful

**Description**

Returns the results from the `AT+CRSM=214,fileid,offseth,offsetl,len,txt` command.

> The `len` is calculated from the length of the `txt` value.

## `tbl,len = modem.stot(txt)` v3.40

Convert SIM STATUS to table

**Parameters**

- `txt`: The ASCII-hex data to convert.

**Returns**

- `tbl`: The status array as a table. The index is the decimal value of the field. e.g. `tbl[128]='000C'` — length
- `len`: The integer value of the Tag '80' (decimal 128)

**Description**

Iterates the `txt` data and extracts the information based on 3GPP 102.221 specification.

The length field's value is also returned, because this is most frequently needed.

This function is used by `modem.sims`.

# Library `nmea` : NMEA Functions

The NMEA library provides firmware functions that convert from ASCII to Lua table, and from Lua table to ASCII.

## `tab, special, ok = nmea.tab(txt)`

Convert NMEA line to table

**Parameters**

- `txt`: ASCII NMEA line

**Returns**

- `tab`: Lua table of values
- `special`: True if an AIS '!' record
- `ok`: True if the checksum is good

**Description** Convert a line of NMEA data to a table.

```
local tb = nmea.tab('$GPAAM,A,A,0.10,N,WPTNME*32')

--[[
 tb[1] = 'GPAAM'
 tb[2] = 'A'
 tb[3] = 'A'
 tb[4] = 0.10
 tb[5] = 'N'
 tb[6] = 'WPTNME'
]]--
```

## `txt = nmea.txt(tab, [special])`

Convert table to NMEA string

**Parameters**

- `tab`: Table of values
- `special`: True if this is an AIS '!' record

**Returns**

- `txt`: ASCII output, with checksum and CRLF

**Description** Convert Lua table to NMEA string.

```
local tx = nmea.txt( {'PQRS', 12.34, 'TEST'} )
```

# Library `out` : Digital Outputs

The digital output library allows direct control of the four logic outputs on the expansion header HD3.

Additional plug-in PCBs can provide for signalling open-collector outputs, high-current drive outputs, etc - depending on the application.

```
on = out.get(n)  v3.00
v = out.get()  v3.00
```

Read output state

**Parameters**

- `n`: Which output to query (1-4)

**Returns**

- `on`: True if the output is enabled
- `v`: Bit-field integer for all outputs

**Description** Query the output state.

```
out.init([def])  v1.10
```

Initialise outputs

**Parameters**

- `def`: Default values

**Returns** None

**Description** Call this once in the App to initialise the outputs.

If included, 'def' will set the startup state of the outputs. The default value is 0.

## `out.off(n)` v1.10

Turn off output

**Parameters**
- `n`: Which output to turn off (1-4)

**Returns** None

**Description** Turn OFF a selected output.

## `out.on(n)` v1.10

Turn on output

**Parameters**
- `n`: Which output to turn on (1-4)

**Returns** None

**Description** Turn ON a selected output.

## `mp,xp,ep = out.pwo()` v2.00
## `out.pwo(v)` v2.00
## `out.pwo(n,en)` v2.00
## `mp,xp,ep = out.pwo(vs)` v3.21

Control power outputs

**Parameters**
- `v`: Bitfield to set both outputs (D0=main, D1=daughter, D2=engineer)
- `vs`: String defining which outputs to enable ('d'=Device port, 'x'=Expansion port, 'e'=Engineer port)
- `n`: Which output to turn off (1=main,2=daughter,4=engineer)
- `en`: True to enable the output

**Returns**
- `mp`: Mainboard Power status
- `xp`: eXpansion board Power status
- `ep`: Engineer Power status

**Description** Either queries the two power outputs, or controls the power outputs.

Mainboard power output is 3.6V

Expansion power output is 12V with the RS485/switchout convertor PCB.

Engineer power output is 3.3V (with a nominal 0.3V Schottky diode drop), but will rise to 5V when the USB is connected (because it's the same pin!).

Overrides the cp:pwo() function! Use *either* out.pwo or cp:pwo

v3.21 always returns the `mp,xp,ep` set

## out.set(v) v1.10
## out.set(n, ison)

Set outputs

**Parameters**
- `v`: Binary value to output (0-15)
- `n`: Which output to change (1-4)
- `ison`: Boolean value, true/false

**Returns** None

**Description** Set all the outputs, or control an individual output.

```
out.set(2, true) -- turn output #2 ON
out.set(1, false) -- turn output #1 off
```

# Library `pwr` : Power Control

## `pwr.apo(n)`

Control ADC power output

**Parameters**

- `n`: 0 = Power off
  1 = Power on

**Returns** None

**Description** Control power for power outputs for ADC reference.

> The rt.adc command may override the ADC reference power output.

## `bn,mv = pwr.back([bn], [mv])` v3.00
## `bn,mv,rmv = pwr.back([bn], [mv], [rmv])` v3.31

Set backup battery

**Parameters**

- `bn`: Battery for backup (0=none, 1=BATT1, 2=BATT2, 3=EXT)
- `mv`: Minimum millivolts for the other inputs
- `rmv`: Restore millivolt setting

**Returns**

- `bn`: As above
- `mv`: As above
- `rmv`: As above

**Description** Sets which battery is the backup battery, and a minimum voltage.

e.g. for lead acid, `pwr.back(0,10800)` will enter backup mode at 10.8V

e.g. `pwr.back(0, 10800, 11500)` will enter backup mode at 10.8V and resume at 11.5V

> Firmware v3.31 defaults `rmv` to (`mv` + 100mV).

### `pwr.boot()`

Reboot device

**Description** Reboot the rt.buffer.

### `pc = pwr.dpc([mA, [V]])` v1.00

Set the coulomb consumption for device

**Parameters**

- `mA`: Current in milliamps
- `V`: Optional voltage measured at (3.6V default)

**Returns**

- `pc`: Power consumption in milli-coulombs (@3.6V)

**Description** Set or get the Device port power consumption.

To get the current value, pass no parameters.

### `pc = pwr.epc([mA, [V]])` v1.00

Set the coulomb consumption for engineer

**Parameters**

- `mA`: Current in milliamps
- `V`: Optional voltage measured at (3.3V default)

**Returns**

- `pc`: Power consumption in milli-coulombs (@3.3V)

**Description** Set or get the Engineer port power consumption.

To get the current value, pass no parameters.

## `sa,sl,cr,cw = pwr.gpm()`

Get power manager metrics

**Parameters** None

**Returns**

- `sa`: Seconds alive
- `sl`: Seconds in ultra-low power
- `cr`: CPU cycles running
- `cw`: CPU cycles waiting

**Description** Get power manager metrics. Can be used to calculate power consumption:

- Effective CPU freq.cf = (`cr` + `cw`) / (`sa` - `sl`)
- CPU run timert = `sa` * `cr` / (`cr` + `cw`)
- Idle percentageip = (`sa` - `rt`) / `sa` * 100

## `pwr.off()`

Turn off device

**Description** Enter deep sleep / off mode.

Wakes up on USB or Engineer Serial port re-connection.

## `pt,cpu = pwr.rsn()`

Query the power reasons

**Parameters** None

**Returns**

- `pt`: Table of {"section"=count} indicating which power functions are in use.
- `cpu`: CPU frequency, in Hz

## `bc = pwr.sbc([ac, [v]])`

Set battery coulomb capacity

**Parameters**

- `ac`: Battery capacity <200 = A/hr
  >200 = Coulombs
- `v`: Voltage of battery (default is 7.2V)

**Returns**

- `bc`: Battery coulombs

**Description** Set battery capacity for power consumption estimation.

To read the capacity, pass no parameters

```
pwr.sbc(26, 7.2) -- 26Ahr @ 7.2V = 93600C
pwr.sbc(5, 6) -- 5Ahr @ 6V = 15000C (@7.2V)
local c = pwr.sbc() -- read the value
```

## `pwr.scu(c)` v1.00

Set coulombs used

**Parameters**

- `c`: Coulombs used

**Returns** None

**Description** Sets the number of coulombs used. Useful if replacing with a half-full battery.

### `mv,sv,ws,ta = pwr.tmv()` v2.00
### `m1,s1,m2,s2,mE,sE,ta = pwr.tmv(true)` v2.00

Query the transient minimum voltage

**Parameters** None

**Returns**

- `mv`: Minimum voltage (mV)
- `sv`: Start voltage (mV)
- `ws`: Which source. `1`, `2`, or `E`
- `m1,s1`: Minimum and start for Battery 1
- `m2,s2`: Minimum and start for Battery 2
- `mE,sE`: Minimum and start for External power
- `ta`: Time alive of measurement

**Description** Returns the Transient Minimum Voltage.

> This value is obtained each time the modem is powered up. If no measurement has happened, `pwr.tmv` will return `0,0,'?'`

### `pwr.work(ms)`

Allow hard work

**Parameters**

- `ms`: Time to perform hard work (0-2000) milliseconds.
  0 = back to normal (low) power

**Returns** None

**Description** Runs at 96MHz for a time, before falling back to low power, 12MHz, running.

# Development Functions

These functions are for internal testing at Scannex, and are not guaranteed to remain constant between firmware versions.

```
pwr._bv(boost, unboost)
pwr._bv() v1.03
Set the boost values
```

**Description** Set the boost millisecond timers.

Use boost=0 to disable auto-boost Pass no parameters to set the defaults.

```
pwr._iv(min, max)
pwr._iv() v1.03
Set the idle timers
```

**Description** Set the idle timers for ultra-low power mode.

Pass no parameters to set the defaults.

# Library `rt` : rt.buffer Utility Functions

## `rt.print(…)` v1.30
## `print(…)` v1.30

Print string

**Parameters** (As for Lua's print function)

**Description** Print to the USB terminal, the TOA terminal, or USB log.

This is useful for debugging Lua functions when you execute the function from the USB terminal with `lx`.

## `uv,rs = rt.adc([phases], [m, [c]])`

Get ADC reading

**Parameters**

- `phases`: Choice of ADC phase (to save power).
  `''` = do all phases (takes about 170ms)
  `'L'` = lock and power up
  `'l'` = lock, but don't change power
  `'S'` = Start fresh sample
  `'s'` = Start sample
  `'R'` = Read sample
  `'U'` = Un-power and unlock
  `'u'` = Unlock only
- `m`: Slope for the ADC value
- `c`: Offset for the ADC value

**Returns**

- `uv`: Microvolts.
  Range ±0-1500000uV (±0 to 1.5V)
  (3.0V is the reference voltage)
- `rs`: Raw Sample Value

**Description** Get pressure reading in microvolts, optionally calculating *y=mx+c*

Use the new `adc.go()` and `adc.get()` library calls.

The ADC is LTC2485, 24-bit delta-sigma, that has V-REF = 3.0V.

```
local p = rt.adc('LSRU') -- does the default
local p = rt.adc('lSRU') -- measures without powering up
local p = rt.adc(0.001, 500) -- apply m & c
```

## `i. = rt.atom(function, args…)`

Atomic function call

**Parameters**

- `function`: Lua function to execute
- `args`: Arguments that are passed to 'function'

**Returns** Varies (depending on the function)

**Description** Execute the function atomically. Syntactically the same as pcall, but wraps with a mutex so that data writes and file renames can occur atomically.

The function MUST be a short function, with no waits. Ideally it should return in milliseconds. Otherwise much of the rt.buffer will be blocked!

Use cororoutines where possible!

## `str = rt.bin(txt)` v1.00

Convert ASCII hex to binary

**Parameters**

- `txt`: Human-readable ASCII Hex to convert to binary string. Can include separators between hex values

**Returns**

- `str`: Binary string

**Description** Convert a string of ASCII-hex into a binary represenation.

## `b = rt.bool(v, [dflt])` v1.01

Convert boolean value

**Parameters**

- `v`: Value to check
- `dflt`: (optional) default value

**Returns**

- `b`: Boolean result

**Description** Returns true or false based on the value of v.

- If v is a Lua boolean type, then b = v.
- If v is a Lua number, then b = (v != 0)
- If v is a Lua string, then a non-case-sensitive comparison occurs:
  - b = true if v is 'y', 't', or starts with "true" or "yes"
  - b = false if v is 'n', 'f', or starts with "false" or "no"
  - b = dflt or false if v has any other value.
- If v is NIL then b = dflt or false

## `i. = rt.call(function, args…)`

Protected call

**Description** Non-atomic version of rt.atom

The same as Lua's pcall, just presented under the rt group.

## rt.coldboot() v3.42

Reboot device

**Parameters** None

**Returns** None

**Description** Reboots the device as soon as possible.

## v = rt.cyc() v1.03

Get Cortex cycle counter

**Parameters** None

**Returns**

- v: Cortex cycle counter

**Description** Returns the 32-bit CPU cycle counter.

## v = rt.dct(t) v1.00

Deep copy table

**Parameters**

- t: Table to deep copy

**Returns**

- v: Resulting copy of table

**Description** Deep-copies a Lua table. Any changes made to v will therefore be independent of the original table t.

> using the Lua standard v=t will only result in a single table in memory. Any changes to v will affect t as well. Thats why a deep copy is needed to produce a replica of the original table that is independent.

> Only the Lua types: LUA_TNIL, LUA_TBOOLEAN, LUA_TNUMBER, LUA_TSTRING, and LUA_TLIGHTUSERDATA are handled.

## `sn,cn,pn,dt = rt.dev()` v3.00

Get device details

**Parameters** None

**Returns**

- `sn`: Serial number
- `cn`: Company name
- `pn`: Product name
- `dt`: Description text

**Description** Read the device details (as shown in the USB enumeration).

## `ok = rt.dorun()`
## `ok = rt.ok()` v3.31

Still allowed to run

**Parameters** None

**Returns**

- `ok`: True if still keep running.

**Description** Check whether Lua can still run in this task.

> ! Only useful within the context of Lua Loop Task and Modem Task. (i.e. do not use within the Lua Event Task - it will time out!)

## txt = rt.exp(txt)

Expand a string

**Parameters**
- `txt`: String to expand

**Returns**
- `txt`: Expanded string

**Description** Expand string using {..} to evaluate Lua values.

This function forms a key part of the iot.set method.

```
local s = rt.exp('Data-{c.site_name}-{i.rt_sn}.csv')
```

Because the text within the {..} is evaluated and executed within Lua, you can even use expressions:

```
local s = rt.exp('Data-{i.rt_sn * 12345 + 34.56}')
```

## txt = rt.hex(str, [gap]) v1.00

Convert binary to ASCII hex

**Parameters**
- `str`: Binary string to convert
- `gap`: (optional) Gap character

**Returns**
- `txt`: Human readable ASCII hex string

**Description** Convert a binary string into human readable ASCII hex.

## `rt.led(en)` v1.00

Enable debug LED sequence

**Parameters**
- `en`: True to enable the 5/4 LED pulse

**Returns** None

**Description** Scannex debug facility to flash LED in the 5/4 pulse sequence.

## `rt.log(module, txt)`

Write log entry

**Parameters**
- `module`: Module string
- `txt`: Text to log

**Returns** None

**Description** Log to the /Logs/system.log file.

## `rt.luaboot()` v3.42

Reboot Lua

**Parameters** None

**Returns** None

**Description** Reboots Lua as soon as possible.

### `ms,ma,mr = rt.mag([ms])` v2.00.0144

Set magnet delay

**Parameters**
- `ms`: Time the magnet has to be active (milliseconds)

**Returns**
- `ms`: Time the magnet has to be active
- `ma`: True if the magnet is considered on (i.e. onMag has been called)
- `mr`: True if the magnet IO line is active (i.e. the pre-timer value)

**Description** Controls the delay on the magnet before `onMag` is called

### `res = rt.ms(value)`<br>`ms = rt.ms()` v1.00

Delay milliseconds

**Parameters**
- `value`: Delay time in milliseconds

**Returns**
- `res`: Reason - 0=OK, 1=TaskTimeOut, 2=LuaAbort
- `ms`: System millisecond counter

**Description** Delay number of milliseconds. The value is limited to half the Lua timeout value for the calling task.

Or, with no parameters, returns the system time in milliseconds.

> The actual time will be in the range of 'value-1 < actual ⇐ value'. For small delays use `rt.us`

## `fv = rt.msf(offset)` v2.00

Calculate millisecond finish time

**Parameters**
- `offset`: Offset time in milliseconds

**Returns**
- `fv`: Future value, in milliseconds

**Description** Calculate an end time. Use with `rt.msx` to determine when expired.

## `ok = rt.msx(fv)` v2.00

Check millisecond expiry

**Parameters**
- `fv`: Future value - the result from `rt.msf`

**Returns**
- `ok`: True if expired

**Description** Determine when a timeout has expired.

## `b1,b2,ext = rt.mv([id, [smp]])`

Get millivolt readings

**Parameters**
- `id`: (Optional) ID. 0 = all three values
  1 = Battery 1
  2 = Battery 2
  3 = External
- `smp`: (Optional) Set to false to prevent sampling and just read the last reading.

**Returns**
- `b1`: Batt1 Voltage (mV)
- `b2`: Batt2 Voltage (mV)
- `ext`: External Voltage (mV)

**Description** Get millivolt readings

## `mv,which = rt.mvh()` v3.42

Get highest millivolt

**Parameters** None

**Returns**

- `mv`: Highest input (mV)
- `which`: Which input - 1=Batt1, 2=Batt2, 3=Ext

**Description** Get the highest millivolt reading.

## `rt.setblf(filename)` v1.20

Set a BLF file

**Parameters**

- `filename`: name of file to be loaded into the BLF area

**Description** Load a file into the BLF area, ready for the boot-loader to burn. Use `pwr.boot()` to reboot in code.

## `c = rt.temp()` v1.00

Get temperature

**Parameters** None

**Returns**

- `c`: Temperature in degrees Celcius

**Description** Returns the temperature from the LTC2485. Note, this can take 160ms to sample.

## `rt.us(value)` v2.00

Delay microseconds

| | |
|---|---|
| **Parameters** | • `value`: Delay time in microseconds (1 to 5000) |
| **Returns** | None |
| **Description** | Delay number of microseconds. |

# Library `sdi12` : SDI-12 Protocol

The SDI-12 protocol requires a hardware adapter (either internal or external) to provide the SDI-12 signal levels.

The library provides a set of low-level protocol commands, as well as a pair of high-level function (`sdi12.go` and `sdi12.done`) that handle the complete protocol as a state-machine.

Ensure you call `sdi12.set` to setup the Comport before calling other SDI-12 library calls.

Example:

```
dp = ser.dev()
sdi12.set(dp)
dp:pwo(true)

VRS = {{'2I'}, {'2CC'} } -- Get ID and measurements

function QueryExample()
 sdi12.gp(dp, VRS)
 while not sdi12.done(t)
 do
  rt.ms(250)
 end
end

QueryExample()
print(VRS[1].v, VRS[2].v[1])
```

## `res = sdi12.ack(cp, dev)`

Check ACK

**Parameters**

- `cp`: Comport object
- `dev`: Device number

**Returns**

- `res`: Result - false or address

**Description** Use the ACK active command. Returns `false` if the device is not there, else returns the device number.

```
local dn = sdi12.ack(dp, '?') -- Query a single device
```

## `sdi12.brk(cp)`

Send break

**Parameters**

- `cp`: Comport object

**Returns** None

**Description** Outputs a 12ms break sequence.

## `res = sdi12.chg(cp, dev, devto)`

Change device address

**Parameters**

- `cp`: Comport object
- `dev`: Device number
- `devto`: Device address to change to

**Returns**

- `res`: false = failed; else address of device

**Description** Attempt to change the device address

## `ok,txt,crc = sdi12.crc(txt)`

CRC calculation

**Parameters**

- `txt`: String to CRC check

**Returns**

- `ok`: True if the CRC matches
- `txt`: The text without the CRC
- `crc`: The CRC string

**Description** Check, or generate a CRC for SDI-12

```
local _,txt,crc = sdi12.crc('1Testing---') -- calculate CRC
local ok = sdi12.crc('1TestingDU}') -- verify
```

## `ok = sdi12.done(sdit)`

Check whether sequence complete

**Parameters**

- `sdit`: SDI-12 table structure

**Returns**

- `ok`: True if the state-machine is complete

**Description** Polls the SDI-12 protocol state machine to work through the commands in the table.

## `sdit = sdi12.go(cp, sdit)`

Run SDI-12 sequence

**Parameters**

- `cp`: Comport object
- `sdit`: SDI-12 command table

**Returns**

- `sdit`: The table, ready to be passed to `sdi12.done`

**Description** Initialises the SDI-12 protocol table and starts the process.

## `idt = sdi12.id(cp, dev)`

Query ID

**Parameters**

- `cp`: Comport object
- `dev`: Device number

**Returns**

- `idt`: ID table idt[0]: Address idt[1]: SDI Version idt[2]: Company (8 characters) idt[3]: Model (6 characters) idt[4]: Version (3 characters) idt[5]: Serial number

**Description** Queries the ID of the device.

## `sdi12.mrk(cp)`

Send mark

**Parameters**

- `cp`: Comport object

**Returns** None

**Description** Waits the required 8.33ms.

## `ok = sdi12.set(cp, [mb])`

Setup COM port for SDI-12

**Parameters**

- `cp`: Comport object
- `mb`: Mainboard. Set to false if using internal daughter board.

**Returns**

- `ok`: True if ok

**Description** Configures the Comport object to 1200E7 and configures the RTS for direction.

## `txt = sdi12.t(cp, cmd)`

Transparent command

**Parameters**

- `cp`: Comport object
- `cmd`: Command string (the '!' is optional)

**Returns**

- `txt`: Reply (or false if no reply)

**Description** Performs a transparent SDI-12 command.

```
local dp = ser.dev()
local txt = sdi12.t(dp, '2!')
```

# SDI-12 Table Structure

The table starts as an indexed set of tables with commands:

```
sdit = { {'1C5'}, {'2C1'}, {'2C2'}, {'3CC'} }
```

Once `sdi12.go` and `sdi12.done` have completed, there will be additional fields within the table:

- `sdit.c` = Comport object
- `sdit.[#].t` = Millisecond alive time when ready. False if the device did not respond
- `sdit.[#].n` = Number of samples (if a measurement command)
- `sdit.[#].v` = Table of results, or a string result

# Library ser : Serial Ports

```
cp = ser.dev()
cp = ser.eng(prot, [rsmode], [main], [hwflow]) v3.31
```

Get the device COM port object

**Parameters**

- prot: Protocol string, e.g. 19200N8
- rsmode: 232 = RS232, 485 = RS485
- main: true for the mainboard / false for daughterboard
- hwflow: Hardware flow string. rx = RX (RTS) flow, tx = TX (CTS) flow, rxtx = both

**Returns**

- cp: Com Port object

**Description** Return a COM port userdata value for the device serial port.

```
local dp = ser.dev()
dp:tx('Hello!')
```

```
cp = ser.eng([try])
cp = ser.eng(prot, [rsmode], [main], [hwflow]) v3.31
```

Get the engineer COM port object

**Parameters**

- try: Set to true to try and grab the engineer port. If it is in use by the terminal, then cp will be nil.
- prot: Protocol string, e.g. 19200N8
- rsmode: 232 = RS232, 485 = RS485
- main: true for the mainboard / false for daughterboard
- hwflow: Hardware flow string. rx = RX (RTS) flow, tx = TX (CTS) flow, rxtx = both

**Returns**

- cp: Com Port object

**Description** Return a COM port userdata value for the egnineer serial port.

> This implicitly disables the terminal function, unless try is true.

```
local dp = ser.eng()
dp:tx('Hello Engineer!')
```

## `ok,code = ser.exp()` v3.20

Check expansion board

**Parameters** None

**Returns**

- `ok`: Whether expansion board detected
- `code`: Code for board. 0=none, 1=CTS, 2=RX, 3=RX+CTS

**Description** Checks whether an expansion board is present.

- RS485 board returns `true,2`
- LED test board returns `true,3`

## `b = ser.term([en])` v1.00
## `b = ser.term(prot)`

Enable or disable terminal over COM port

**Parameters**

- `en`: (optional) boolean value to control serial terminal
- `prot`: (optional) Enable terminal with the given protocol

**Returns**

- `b`: Boolean result. True if serial terminal enabled.

**Description** Controls the engineer serial port to terminal logic.

When Lua reboots, the engineer serial port defaults to be used by the terminal.

> You must have RX/TX and RTS/CTS connected to work as a terminal! The terminal will not start until RTS is asserted. If RTS is unasserted for 10 seconds the rt.buffer assumes the terminal has disconnected and will de-energise its RS232 port.

To use the engineer serial port for other uses, call:

```
ser.term(false) -- let Lua use the port
ep = ser.eng() -- also lets Lua use the engineer port
--...and the serial port can then be used within Lua.
```

# Library ser | cp : Comport Objects

These functions work on the object returned from ser.dev() and ser.eng().

For the sake of documentation, these are shown to refer to 'cp'

```
cp:brk(ms)
```

Send break

**Parameters**

- ms: Number of milliseconds for the break sequence

**Returns** None.

**Description** Send break on the line.

```
nb,ti = cp:cap(file, [ms])
nb,ti = cp:cap(fh, [ms])
nb,ti = cp:cap(file/fh, tab)
```

v1.00

Capture data to file

**Parameters**

- file: Filename to overwrite and create
- fh: File handle to write to
- ms: Time out to close in milliseconds (default 1000)
- tab: Parameter table.
  tab.ms = timeout, in milliseconds
  tab.ft = first byte timeout (default is 2x .ms)
  tab.nb = number of bytes to capture
  tab.hw = set to true to do hardwork at 96MHz

**Returns**

- nb: Number of bytes captured
- ti: Timed out flag

**Description** Captures serial bytes directly to a file. Allows faster capturing than doing this directly in Lua.

The write will occur from the the file handle current position.

## ok,txt,err = cp:cmd([txt], [tab])

Handle a command sequence

**Parameters**

- `txt`: ('\r\n') String to send
- `tab`: Table of values:
  `.pt` = (0) pause time in seconds
  `.ss` = (\r\n) send string (overridden by txt)
  `.wt` = (5000) wait time, in milliseconds
  `.dt` = data time, in milliseconds (default is .wt)
  `.ls` = (>) look for string
  `.es` = (NIL) error string
  `.nt` = (5) number of times to try
  `.tt` = (120) try time, in seconds (.nt must be 0)
  `.re` = (false) Ignore echo of send string

**Returns**

- `ok`: True if we got the device's attention
- `txt`: The text returned (without the prompt)
- `err`: If the error string was found, this return value has the string

**Description** Send a command string to the device until it responds, or times out.

Text is limited to 2048 bytes.

```
local dp = ser.dev()
local ok,txt = dp:cmd('$\r\n', {ls='>', wt=1500, nt=10})

local dp = ser.dev()
local ok = dp:cmd('$\r\n') -- wait for '>' prompt with defaults

local dp = ser.dev()
local t = {ss='$\r\n$\r\n', ls='ERROR\r\n>', tt=240}
local ok,txt = dp:cmd(t)
```

### `value = cp:cts()`

Get CTS line

**Parameters** None

**Returns**

- `value`: True if the CTS line is asserted.

**Description** Return the CTS status

### `nb = cp:fifo([size])`

Set the receive FIFO

**Parameters**

- `size`: Number of bytes for the Serial Port DMA buffer + (min 128)

**Returns**

- `nb`: Number of bytes actually reserved

**Description** Change the buffering for the serial port. The size defaults to 1024 bytes on Lua reboot.

Memory is taken from the Lua RAM area, split into 4 parts. Two parts at a time are queued with the hardware DMA controller. Therefore, the buffer time for a given FIFO size will = size / 2 x character-time. e.g. at 115200 baud, with cp:fifo(4096) will give a time of 4096/2 x 87us = 178ms.

### `ok = cp:lck([ms])` v2.00

Lock the COM port

**Parameters**

- `ms`: Time to keep the lock enabled (default = 10000ms, max=30000)

**Returns**

- `ok`: True if we have locked the COM port.

**Description** Lock the COM port. The lock keeps track of the number of times `cp:lck` was called.

```
dp = ser.dev()

if dp:lck(2000)
then
  -- do stuff short than 2000ms
  dp:ulck()
else
  -- do something else
  -- someone else is using it!
end
```

## ok = cp:okr()

Check whether signals are valid

**Parameters** None

**Returns**

- ok: true if there is a valid signal level on the serial port.

**Description** Check whether the MAX-chip is detecting a valid signal.

```
local dp = ser.dev()
if dp:okr()
then
 dp:tx('You are connected :-)')
end
```

## `txt,baud,par,db,sb = cp:prot([actual])` v3.31

Get the protocol settings

**Parameters**

- `actual`: Pass `true` to return the actual baud rate

**Returns**

- `txt`: Protocol string
- `baud`: Baud rate
- `par`: Parity `N`, `E`, `O`, `S`, `M`
- `db`: Databits
- `sb`: Stop bits

**Description**

Return the current protocol settings for the port

## `ison = cp:pwo(ison)`

Set COM port power output

**Parameters**

- `ison`: true = enable power output
  false = turn off power output

**Returns**

- `ison`: True if the COM port power output is on

**Description**

Set power output on the COM port.

```
local dp=ser.dev()
dp:pwo(true) -- enable the 3.6V output
```

### cp:pwrx(ison, [ms])
### cp:rxpw(ison, [ms]) v3.31

Enable power for receiving

**Parameters**
- ison: true = enable receiving
  false = disable receiving
- ms: Optional time to keep the RX power enabled. Zero disables the timer. (ison is ignored)

**Returns** None

**Description** Set the receive power. Enabling receiving will keep the CPU alive. You MUST disable both pwtx and pwrx for both ports to enter low power sleep mode.

This is only needed if pwtx is not called, but you need to receive on a USART

### cp:pwtx(ison, [ms])
### cp:txpw(ison, [ms]) v3.31

Enable power for transmitting

**Parameters**
- ison: true = enable transmission
  false = disables transmission
- ms: Optional time to keep the TX power enabled. Zero disables the timer. (ison is ignored)

**Returns** None.

**Description** Set the transmit power.

> **!** Enabling transmission on the serial chips requires about 8mA. Only enable the transmit power when absolutely necessary!

```
local dp=ser.dev()
dp:pwtx(0, 250) -- keep TX on for 250ms
-- OR --
dp:pwtx(true) -- use TX
...
dp:pwtx(false) -- finished
```

### mode = cp:rs([mode]) v1.00
### mode = cp:rs([mode], [main]) v1.10
### mode,main = cp:rs([mode], [main]) v3.31

Set the RS232/RS485 mode

**Parameters**
- `mode`: 232 or 485
- `main`: true or false

**Returns**
- `mode`: Current mode - 232 or 485

**Description** Set the RS232 or RS485 mode of the Device COM Port.

The 'main' value defines whether the main PCB electronics are used for serial communications, or whether the add-on PCB is used.

```
local dp = ser.dev()
dp:rs(485, false) -- use add-on board in RS485 mode
dp:rs(485, true) -- use the main PCB in RS485 mode (inline adapter)
dp:rs(232, true) -- default = RS232 on the main PCB
```

### cp:rts(value)

Set RTS line

**Parameters**
- `value`: Boolean or integer value

**Returns** None

**Description** Set the RTS line. 0/false unasserts; 1/true asserts.

> If value is false, this overrides receive flow control. i.e. RTS flow control only operates when value = true.

## `txt,b,to = cp:rx([ms, [nbytes]])`

`Receive data`

**Parameters**

- `ms`: Time to wait, in milliseconds. Default = 5ms
- `nbytes`: Maximum number of bytes to read. Default = 2k. Maximum = 8k

**Returns**

- `txt`: String received
- `b`: Number of bytes in txt
- `to`: true if timed-out

**Description** Wait for receive data.

## `nb = cp:rxe([ms])` v1.00

`Receive and empty data`

**Parameters**

- `ms`: Time to wait, in milliseconds. Default = 100ms

**Returns**

- `nb`: Number of bytes flushed

**Description** Flush receive data.

## `cp:rxf(ison)`

`Set receive flow control`

**Parameters**

- `ison`: True if RTS should unassert when receive buffers are full.

**Returns** None

**Description** Set RX flow control (uses RTS line).

> If ison is true, this also calls :pwtx(true) and :rts(true) Therefore, power will be consumed all the time that :rxf(true) is enabled - because the RS232 chip has to be enabled to assert RTS! And you will see the DeviceTx enabled in the "PMM" terminal command.

## cp:rxto(bits)

Set receive timeout value

**Parameters**

- bits: Number of data bits to consider a receive timeout for the internal DMA controls

**Returns** None

**Description** Set RX time out in bits

## cp:rxtx(ison, [ms]) v3.31

Enable power for receiving and transmitting

**Parameters**

- ison: true = enable receiving & transmiting
  false = disable receiving & transmitting
- ms: Optional time to keep the RX/TX power enabled. Zero disables the timer. (ison is ignored)

**Returns** None

**Description** Sets both the receive & transmit power. Enabling will keep the CPU alive. You MUST disable for both ports to enter low power sleep mode.

## txt,b,ti,fs = cp:rxu(rxut, [ms])

Receive until

**Parameters**

- rxut: Receive Until Table
- ms: Timeout in milliseconds

**Returns**

- txt: The received data
- b: Number of bytes in txt
- ti: true if timed-out
- fs: Find state:
  0=didn't find start
  -1=found start but no end
  1=found end (OK)

**Description** Receive Until.

See the following information the 'rxut' table structure.

### `b = cp:rxw()`

Number of RX bytes waiting

**Parameters** None

**Returns**

- `b`: Number of bytes waiting

**Description** Returns number of bytes waiting on port

### `cp:set(txt)`
### `cp:set(baud, [parity, [databits, [stopbits]]])`
### `cp:set(txt, [rsmode], [main], [hwflow])` v3.31

Setup COM port

**Parameters**

- `txt`: Baud rate and protocol string
  e.g. `'19200n8'`
  stop bits are defined with a suffix:
  '.' = 1, e.g. '19200n8.' ',' = 1.5, e.g. '19200n8,' ':' = 2, e.g. '19200n8:'
- `baud`: Baud rate, from 300-115200
- `parity`: Parity, 'n', 'e', 'o', 'm', 's'
- `stopbits`: 1, 1.5, 2
- `rsmode`: 232 = RS232, 485 = RS485
- `main`: true for the mainboard / false for daughterboard
- `hwflow`: Hardware flow string. `rx` = RX (RTS) flow, `tx` = TX (CTS) flow, `rxtx` = both

**Returns** None

**Description** Set the protocol.

```
local dp=ser.dev()
dp:set('300n8:')
dp:set(300, 'n', 8, 2) -- same as above
```

## `b,to,txt = cp:tx(txt, [ms])`

Transmit data

**Parameters**
- `txt`: The text to send
- `ms`: Timeout for sending

**Returns**
- `b`: Number of bytes sent
- `to`: true if timed-out
- `txt`: Remaining part of txt that is yet to be sent

**Description** Send data.

If you don't see data being output, check whether you have transmit flow control and the CTS line status, and whether cp:pwtx has been enabled.

```
local dp=ser.dev()
dp:pwtx(1)
dp:tx('Welcome!')
dp:wtx(100)
dp:pwtx(0)
```

## `cp:txf(ison)`

Set transmit flow control

**Parameters**
- `ison`: True if CTS should be asserted before data is sent

**Returns** None

**Description** Set TX flow control (uses CTS line).

## `cp:txtg(bits)`

Set transmit time guard gap

**Parameters**
- `bits`: Number of data bits to pause between each transmitted byte

**Returns** None

**Description** Set TX time guard in bits. The time-guard slows down transmission of data for the benefit of slow devices.

## `ok = cp:ulck()`
## `cp:ulck(true)` v2.00

Unlock the COM port

**Parameters**
- `true`: This form will unlock all counts

**Returns**
- `ok`: True if we still owned the COM port (i.e. false indicates the COM port timer has expired, etc)

**Description** Unlock the COM port (before the timeout completes). You will need to call `cp:ulck` the same number of times that `cp:lck` was called in order to unlock before the timeout.

## `to = cp:wtx(ms)`

Wait for TX to complete

**Parameters**
- `ms`: Number of milliseconds to wait

**Returns**
- `to`: true if timed out before data was sent

**Description** Wait for transmission to complete.

# Receive Until Table `rxut`

As used by the cp:rxu method.

- `st = 0`
    - start timeout, in milliseconds, for flushing. If > 0 then the function will wait for a pause until beginning the scanning.
- `ss = ''`
    - start string or table-of-strings
- `bn = 0`
    - minimum number of bytes (the number of bytes before the et/es are started)
- `bx = 256`
    - maximum number of bytes (256 is the largest)
- `et = 0`
    - end timeout in milliseconds.
- `es = ''`
    - end string or table-of-strings.

```
local txt,to = dp:rxu( {ss='begin'} )

local txt,to = dp:rxu( {ss={'this', 'that'} } ) -- waits for this or that
```

## Useful Examples

```
NMEA= {ss='$',es='\r\n',bn=4}
ASCII= {es='\n'} or {es='\r\n'} or {es=\{'\r','\n'}}
HydrINS= {ss='W',es='\r\n',bn=8}
```

# Library `smp` : Sample Data Store

The sample data store library provides a convenient way to handle periodic writes of sample data. The writing is handled 'atomically'. When a sample store reaches a certain size (e.g. 128k), or when it�s time to send what has been saved, the sample store is "cut" and the file moved to the /Send directory.

The sample data store is also suitable for collecting bulk data from a device, and choosing to either save or abandon the data (e.g. on a communication drop-out).

By default, the sample data store works with a single file. However, it is possible to use the table structures defined to save to multiple sample stores - for example where there are multiple connected devices, or where selected data needs to be extracted to a secondary file.

## Structure of `ftable`

- `.n = 'AppName.data.txt'`
  - Filename of the current file (".tmp" is added automatically)
  - Default is 'AppName.data.txt'
- `.f = nil`
  - Current file object (NIL if closed)
- `.r`
  - String or Function for renaming when cutting the file.
  - If this is nil (or not present), then the default function will use the form "YYYYMMDD-HHMMSS-SerialNo-SiteName-data.txt"
- `.h`
  - String or Function for the header of the file
  - `function(ftable, file)` - return nothing, do the writes within the function
- `.t`
  - String or Function for the tail of the file
  - function(ftable, file) - return nothing, do the writes within the function
- `.bx = 131072`
  - Maximum number of bytes for the file
  - 0 means unlimited (not recommended)
  - Default is 128k (131072 bytes)
- `.secret = ''`
  - The prefix for the HMAC-SHA-256 tail function (if used)

- `.cfgkey = 'data'`
  - The name of the key store for the suffix for HMAC-SHA-256 tail function (if used).
  - The HMAC secret becomes `.secret` + value-of(`.cfgkey`)
- `.gz = 0`
  - Set to 1 to gzip the files into the `/Send/` directory.
  - Included in firmware v3.43

# Sample Data Store Functions

## ov = smp.cnt([v])

Set or get counter

**Parameters**
- v: New value for the i.smp.cnt

**Returns**
- ov: The old value

**Description** The i.smp.cnt value is 'hidden' in C++. The value will be incremented and applied to i.smp.cnt on the next call to smp.save.

## txt = smp.csv(valuetable, [inctime])

Convert table to CSV text

**Parameters**
- valuetable: table of values to turn into CSV
- inctime: optional boolean. Set to false to not include the time as the first value.

**Returns**
- txt: returned string in CSV format

**Description** Creates a CSV line with UTC as the first field in the form

"YYYY-MM-DD HH:MM:SS" (default timeformat = '%Y-%m-%d %H:%M:%S')

Strings are quoted with quote (default double quotes)

The line ends with lineend (default [CR][LF])

The CSV values are controlled by a global table `"csv"`. The `valuetable` can also include a field `.csv` to point to an alternative CSV formatting table.

The `valuetable` can also include a field `.fmtf` to perform formatting function callbacks where more complex formatting is needed.

```
local t = {1, 2, 3, i.cell_csq}

smp.save( smp.csv(t) )
```

## `smp.cut([ftable], [killfile])`

Cut the sample file

**Parameters**

- `ftable`: optional. If not present, uses global table `"ft"`
- `killfile`: optional boolean. If true, the cut file will be discarded.

**Returns** None

**Description** Split off the file and rename.

Use the killfile option when downloading bulk data from a device and the process failed.

```
function onJob2() -- do this on a schedule
 smp.cut()
end
```

## `ftable = smp.save([ftable], txt)`

Save sample to flash

**Parameters**

- `ftable`: optional. If not present, uses global table `"ft"`
- `txt`: text to save to the sample file

**Returns**

- `ftable`: table that was passed (for convenience)

**Description** Atomically saves a single block of data to the data store

Also flashes LED to indicate data being stored

```
local t = 'this is a sample\r\n'

smp.save(t)
```

# Prebuilt Function Methods

These functions save you coding them in pure Lua.

## `smp.r_ft`

`Default rename function callback`

**Description** Default rename function

Renames the file according to YYYYMMDDHHMMSS-serial-site_name-filename

(Uses the fc.utc and utc.fn formatting functions to use the file's creation time)

```
ft = {r=smp.r_ft}
```

## `smp.t_crc32`

`Tail function for CRC32`

**Description** Tail function that adds CR/LF+CRC32 of the file on close

```
ft = {t=smp.t_crc32}

ft = {r=smp.r_ft, t=smp.t_md5} - two options
```

## `smp.t_md5`

Tail function for MD5

**Description** Tail function that adds CR/LF+MD5 of the file on close

```
ft = {t=smp.t_md5}
```

## `smp.t_sha1` v3.31
## `smp.t_sha256` v3.31
## `smp.t_hmac256` v3.31

Tail function for hashes

**Description** Tail function that adds secure hash to the end of the file on close.

Each of these add the hash name, a colon, a tab, and the hash string.

e.g. `hmac-sha256: e6:11:f2:e9:53:08:9d:b9:81:d1:f6:aa:a6:4a:9b:81:02:b3:45:b0:9f:1b:68:44:ad:d2:f4:75:ca:81:0f:3c`

the HMAC-SHA-256 function uses the secret that is set by `cfg.key.set('data', XXXX)` for the secret.

# CSV Formatting Table `csv`

The global table 'csv' defines the formatting for the smp.csv function.

- `csv.s = ','`
  - Separator string override.
- `csv.q = '□'`
  - Quote character for strings.
- `csv.tf = '%Y-%m-%d %H:%M:%S'`
  - Time format. If this is blank (i.e. ""), the time is NOT placed at the beginning of the line. You'll need to add the time yourself into the table. Use standard C strftime format strings.
- `csv.le = '\r\n'`
  - Line ending string
- `csv.str` = false.
  - Set to true to represent all fields as strings

# CSV Formatting Callback `.fmtf`

If the table field `.fmtf` is defined, this can point to a function that handles formatting of the table data for CSV output.

The function is passed:

- The original table
- The index value (1-based)
- The value to format

The first return parameter is the value (string or number) for inclusion.

The second return value of the function can control how the CSV quotation is handled. +1 = Use quotation; 0 = use default; -1 = do not quote

```
function myfmt(tbl, idx, v)
  --tbl   = table
  --idx = index (1-based)
  --v   = value, equivalent to tbl[idx]
  -- Can format any way you like...
  -- return values dictate the CSV style:
  -- v,-1 = do not quote
  -- v,0  = use auto/default quote
  -- v,1  = use quote marks
  return v,0
end

local t = {1,2,3,4}
t.fmtf = myfmt
local txt = util.tcsv(t)
```

# Library `sms` : SMS Text Messaging

The SMS library allows for the transmission of 8-bit binary, or 16-bit UCS2 encoded PDU SMS messages, and the reception of 7-bit GSM, 8-bit, and 16-bit UCS2 encoded PDU SMS messages.

Up to 16 SMS messages are queued up while the modem is offline, and the messages are sent when the modem connects. Incoming messages are handled asynchronously, and the rt.buffer can be programmed to remain connected to the network for a minimum time - to allow for delivery of the SMS messages.

## `gsm = sms.ag7(txt)` v3.00

Convert ASCII to GSM-7bit

**Parameters**

- `txt`: ASCII text

**Returns**

- `gsm`: GSM 7-bit encoded

**Description** Encodes ASCII.

## `tv = sms.dec(PDU)` v1.10

Decode SMS PDU

**Parameters**

- `PDU`: Binary PDU block

**Returns**

- `tv`: Table of values
  `.num` = originating number
  `.utc` = UTC time
  `.tzm` = Time zone minute offset
  `.pid` = Protocol identifier
  `.dcs` = data coding scheme (0=7-bit GSM, 4=8-bit, 8=UCS2)
  `.msg` = message ASCII
  `.ucs` = raw UCS2 (if encoding is UCS2)

**Description** Decodes a PDU frame into usable fields.

> This only decodes `SMS-DELIVER` message received through `onSMS` callback. It will not decode the output from `sms.enc`. Use web services, e.g. https://www.smspdu.be to decode.

## `PDU = sms.enc(msg, [number], [options])` v1.10

Encode SMS PDU

**Parameters**

- `msg`: Message string (max 140 octets)
- `number`: (optional) target phone number. If not present, then c.cell_sms is used
- `options`: (optional) table of optional values
  `.mti` = Message Type. 0x01 or 0x11 are acceptable
  `.mr` = Message Reference
  `.vp` = Validity period. e.g. 0xaa = 4-days (See 3GPP TS 123 040 section 9.2.3.12.1)
  `.pid` = Protocol identifier
  `.ucs` = true (sets UCS2 encoding, and msg is assumed to be two-byte Unicode) `.bin` = set to `true` to encode as binary

**Returns**

- `PDU`: Binary output

**Description**

Encodes a simple ASCII or binary message into a PDU frame suitable for sending.

## `fc,mc = sms.free()` v1.10

Check free SMS entries

**Parameters**

None

**Returns**

- `fc`: Number of free messages available
- `mc`: Number of messages currently queued for transmission.

**Description**

Returns the message queue counters.

## `txt = sms.g7a(gsm)` v3.00

Convert GSM-7bit to ASCII

**Parameters**
- `gsm`: GSM 7-bit encoded

**Returns**
- `txt`: ASCII text

**Description** Decodes to ASCII.

## `sms.go([DoItNow])` v1.10

Trigger SMS exchange

**Parameters**
- `DoItNow`: (optional) whether to connect immediately.

**Returns** None

**Description** Tells the modem handler that we need to perform SMS transmission on the next connection phase.

DoItNow is assumed to be true (i.e. clear hold off and dial immediately), so 'sms.go(false)' will just arm the modem handler for the next phase.

## `v = sms.rxt([secs])` v1.10

Set receive timer

**Parameters**
- `secs`: Number of seconds to stay online (minimum). Set to 0 to disable the receive wait process.

**Returns**
- `v`: Current receive time

**Description** Sets, or reads, the receive time. This is the minimum number of seconds the modem will remain registered before powering off. The delay is required to provide time for the cellular base-station to send the messages to the rt.buffer.

A value of -1 will enable SMS all the time the modem is online. `sms.rxt(-1)` v3.10

## `ok = sms.snd(PDU, [DoItNow])` v1.10

Send PDU frame

**Parameters**

- `PDU`: SMS PDU frame. Use sms.enc to encode
- `DoItNow`: Whether to transmit immediately. Pass the value false to simply queue for later

**Returns**

- `ok`: True if the message was queued.

**Description** Queue the PDU frame and connect the modem.

## `ok = sms.txt(msg, [number], [DoItNow])` v1.10

Send text

**Parameters**

- `msg`: ASCII message
- `number`: (optional) target phone number. If not present, uses c.cell_sms
- `DoItNow`: Whether to transmit immediately.
- `Ascii`: (true) Set to false to tell `sms.txt` that `msg` is already UTF-8 encoded

**Returns**

- `ok`: True if the message was queued

**Description** Combined function, similar to sms.snd(sms.enc(msg, number, DoItNow)).

However, msg can be longer than 140 characters - this function will queue up multiple PDUs.

> This sends the message GSM-7-bit characters. For UCS2/UTF-16 you need to use `sms.enc` and `sms.snd`

# SMS Received callback

The SMS callback occurs asynchronously at any time while the modem is registered (i.e. not just during the SMS transmission phase).

The service message center may require the rt.buffer to be connected and registered for some time (e.g. at least 30seconds) in order to send any queued SMS messages. Use the 'sms.rxt' function to enable minimum-waiting-times.

```
function onSMS(smsc, pdu) v1.10
```

SMS callback function prototype

**Parameters**

- `smsc`: The Service Message Center number
- `pdu`: The binary PDU received.

**Description**

You should use 'sms.dec' to decode the received PDU frame and do something meaninful with them.

e.g.

```
sms.rxt(30) -- set the minimum online time
function onSMS(nu, pdu)
 local t = sms.dec(pdu) -- decode the frame into a table
 local s = t.num .. ' : ' .. t.msg -- make a message
 usb.log('SMS:'..s)
end
```

# Library `struct` : Structure Handling

The struct module adds C style packing and unpacking (for byte-wide values, not bits).

See:
http://www.inf.puc-rio.br/~roberto/struct/
https://github.com/dubiousjim/luafiveq/blob/master/src/struct.c
https://github.com/dubiousjim/luafiveq/blob/master/BENEFITS-LUA

## `txt = struct.pack(fmt, d1, d2, …)`

Pack structure

**Parameters**
- `fmt`: Structure Format string
- `d1`: Data
- `d2`: …more data

**Returns**
- `txt`: Packed data

**Description** Returns a string containing the values d1, d2, etc. packed according to the format string fmt.

## `nb = struct.size(fmt)`

Calculate size of format

**Parameters**
- `fmt`: Structure Format string

**Returns**
- `nb`: Number of bytes required

**Description** Returns the size of a string formatted according to the format string fmt. The format string should contain neither the option s nor the option c0.

## `d1,d2,… = struct.unpack(fmt, txt, [idx])`

Unpack structure

**Parameters**

- `fmt`: Structure Format string
- `txt`: Packed data
- `idx`: Start of reading (default is 1)

**Returns**

- `d1`: Data 1
- `d2`: Data 2 etc

**Description**

Returns the values packed in string s according to the format strong fmt. An optional i marks where in s to start reading (default is 1). After the read values, this function also returns the index in s where it stopped reading, which is also where you should start to read the rest of the string.

# Struct format strings

Here are the formatting codes. Initially endianness is set to native and alignment is set to none (!1).

- `">"` use big endian
- `"<"` use little endian
- `"!"` use machine's native alignment
- `"!n"` set the current alignment to n (a power of 2)
- `" "` ignored
- `"x"` padding zero byte with no corresponding Lua value
- `"xn"` padding n bytes
- `"Xn"` padding n align (default to current or native, whichever is smaller)
- `"b/B"` a signed/unsigned char/byte
- `"h/H"` a signed/unsigned short (native size)
- `"l/L"` a signed/unsigned long (native size)
- `"i/I"` a signed/unsigned int (native size)
- `"in/In"` a signed/unsigned int with n bytes (a power of 2)
- `"f"` a float (native size)
- `"d"` a double (native size)
- `"s"` a zero-terminated string
- `"cn"` a sequence of exactly n chars corresponding to a single Lua string. An absent n means 1. The string supplied for packing must have at least n characters; extra characters are ignored.
- `"c0"` this is like "cn", except that the n is given by other means: When packing, n is the actual length of the supplied string; when unpacking, n is the value of the previous unpacked value (which must be a number). In that case, this previous value is not returned.
- `"("` stop capturing values
- `")"` start capturing values
- `"="` current offset

# Struct Examples

## To match a C structure

```
/* C demo structure */
struct Str {
 char b;
 int i[4];
};
```

in Linux/gcc/x86 (little-endian, max align 4), use "<!4biiii"

## To pack and unpack Pascal-style strings

```
sp = struct.pack("Bc0", string.len(s), s)
```

```
s = struct.unpack("Bc0", sp)
```

In the latter command, the length (read by the element "B") is not returned.

## To pack a string in a fixed-width field with 10 characters padded with blanks

```
x = struct.pack("c10", s .. string.rep(" ", 10))
```

# Library `twi` : TWI Hardware Interface

```
a1,a2··· = twi.qy()
ok = twi.qy(addf,[addt])
```

Query TWI bus

**Parameters**

- `addf`: Device address to start
- `addt`: Device address to finish

**Returns**

- `a1`: Addresses
- `ok`: If found

**Description** Queries the TWI bus.

```
res = twi.rd(add,[txt])
res = twi.rd(add,num,[v])
```

Read TWI

**Parameters**

- `add`: Device address
- `txt`: String to send during the read phase
- `num`: Number of bytes to read
- `v`: Output value while reading (default = 0xff)

**Returns**

- `res`: String bytes read. False if fails.

**Description** Reads from the TWI bus.

Use the Lua `string.bytes(···)` to pull the reply apart.

```
res = twi.wr(add,txt)
res = twi.wr(add,b1,b2,b3)
```

Write TWI

**Parameters**
- `add`: Device address
- `txt`: String to write b#: Bytes to send

**Returns**
- `res`: String bytes read. False if fails.

**Description** Writes to the TWI device.

You can mix and match the string and byte parameters.

# Alternative to the TWI `add` parameter for v3.11+

In firmware 3.11+ the `add` address parameter is more flexible, allowing addressing of memory-type TWI/I2C devices.

When `add` is a table it can specify the device address, the internal address and length, as well as timing values for the transfer.

Simplest forms:

- `{add, iad}` = Address device `add` with internal address `iad` and length 1 (addresses 0-255)
- `{add, iad, ial}` = Address device `add` with internal address `iad` and length `ial`

```
twi.wr( {28, 16}, 'Test')
twi.wr( {28, 16, 1}, 'Test')    -- Same as above
```

Alternatively, a named table index can be used with the following details:

- `dev=` I2C device address
- `addr=` Internal device address
- `alen=` Internal device address length (default 1)
- `tw=` Write time (ms)
- `tr=` Read time (ms). Increasing this allows the device more time to gather the data to send back.
- `tb=` Inter-byte time (ms)
- `ts=` Stop-bit time (ms)

Setting the timing values to zero will disable them.

The timing settings will remain in place for the next call to `twi.rd` or `twi.wr`.

```
twi.wr( {dev=28, addr=16, alen=1}, 'test') -- Same as previous example

local t1 = {dev=28, addr=16, ts=200}
twi.wr(t1, 'test')                         -- Same with timing added
```

# Library usb : USB functions

## usb.log([sub], txt)

Send log string to USB

**Parameters**
- sub: Optional sub section string.
- txt: Text to output to USB log stream

**Returns** None

**Description** Output a string for the USB log. Useful for debugging Lua Apps.

## n,vp = usb.on()

Check USB connected

**Parameters** None

**Returns**
- cn: USB Connected (at the protocol level)
- vp: Voltage present on the USB port

**Description** Returns information about the USB port.

# Library `utc` : Time Functions

## `utc = utc.a2utc(alv)` v3.10

Convert alive time to UTC

**Parameters**
- `alv`: Alive time

**Returns**
- `utc`: Converted UTC time.

**Description** Uses the rt.buffer's current clock to convert from an alive-time to UTC.

## `txt = utc.fmt(format, [t])`

Format UTC

**Parameters**
- `format`: C strftime format string
- `t`: UTC time value (integer). Default is now.

**Returns**
- `txt`: Formatted time string.

**Description** Convert time into formatted text.

## `txt = utc.fn([t])`

Filename UTC

**Parameters**
- `t`: UTC time value (integer). Default is now.

**Returns**
- `txt`: String of time in form 'YYYYMMDDHHMMSS'

**Description** Returns a time string that is suitable for filenames.

## `utc.job(···)`

**Description** Convenience function - same as job.utc

## `ok = utc.ok()`

Check if UTC is sensible

**Parameters** none

**Returns**

- `ok`: true if the time is sensible.

**Description** Returns true if the time is sensible (i.e. > 2016-01-01 00:00:00)

Use this to determine when we've got a good time before continuing with data collection.

## `utc.set([utc], [tzm])`

Set UTC time and timezone

**Parameters**

- `utc`: UTC time integer, or string
- `tzm`: optional time zone offset, in minutes

**Returns** None

**Description** Sets the real time clock.

```
utc.set('2017-01-01 10:00:00') -- just the time
utc.set(_, 120) -- just the Timezone (+2hr)
utc.set(1234567, 120) -- integer UTC and timezone
```

## `wd,spm,ds = utc.split(t)`

Split UTC time

**Parameters**
- `t`: Time value (integer) or string

**Returns**
- `wd`: UTC time at 00:00:00 on this day
- `spm`: Seconds past midnight
- `ds`: Days since 1970-01-01

**Description** Split the UTC time value into components.

## `spm = utc.spm(t)`

Get seconds past midnight

**Parameters**
- `t`: Time value (integer) or string (Default is now.)

**Returns**
- `spm`: Seconds past midnight

**Description** Calculate the seconds-past-midnight. i.e. the UTC time value with the day-portion subtracted.

## `txt = utc.txt([t])`

Text of UTC

**Parameters**
- `t`: UTC time value (integer). Default is now.

**Returns**
- `txt`: String of time in form 'YYYY-MM-DD HH:MM:SS'

**Description** Convert time into text.

## `tzom, tzos = utc.tz()`

Get time zone

**Parameters** None

**Returns**

- `tzom`: Time zone offset in minutes
- `tzos`: Time zone offset in seconds

**Description** Returns the time-zone offset (as retrieved by the 3G modem).

## `alv = utc.utc2a(utc)` v3.10

Convert UTC to alive time

**Parameters**

- `utc`: UTC time.

**Returns**

- `alv`: Alive time

**Description** Uses the rt.buffer's current clock to convert from a UTC time to an alive-time.

## `t = utc.val(txt)`

Convert string to UTC

**Parameters**

- `txt`: string time to convert

**Returns**

- `t`: UTC time value

**Description** Convert text to either full date or seconds-past-midnight

```
local v = utc.val('08:00')
local v = utc.val('2017-06-03 12:15:00')
```

## `wd,ds = utc.wds(t)`

`Get whole days`

**Parameters**

- `t`: Time value (integer) or string

**Returns**

- `wd`: UTC time at 00:00:00 on this day
- `ds`: Days since 1970-01-01

**Description**

Calculate the whole-day portion of the UTC time value.

# Library `util` : Utility functions

## `t = util.add(t1, t2, ⋯)`

Add tables

**Parameters**

- `t1`: Table
- `t2`: Table ...

**Returns**

- `t`: combined table

**Description** Combines two or more tables into a single table. If keys in t2 are present in t1, then t2 takes precedence.

Effectively uses Lua's "pairs" on each table in turn. Lua equivalent for each table:

```
--[[ Equivalent Lua
t = {}
for k,v in pairs(t1) do t[k]=v
]]--
```

## `t = util.addi(tv1, tv2, ⋯)`

Add indexed tables

**Parameters**

- `tv1`: Table or value
- `tv2`: Table or value ...

**Returns**

- `t`: Combined table

**Description** Combines two or more tables (or values) into a single table.

Effectively uses Lua's "ipairs" on each table in turn. Lua equivalent for each table:

```
--[[ Equivalent Lua
t = {}
for k,v in ipairs(tv1) do table.insert(t, v)
]]--
```

Example:

```
local t1 = {1,2,3}
local t2 = {5,6,7}
local t3 = util.addi(t1, 4, t2, 8, 9)
-- t3 = {1,2,3,4,5,6,7,8,9}
```

## `u = util.au16(a, [be])` v3.00

Convert ASCII to UTF-16

**Parameters**
- `a`: ASCII text
- `be`: Set to true for Big-Endian encoding (default)

**Returns**
- `u`: UTF-16 encoded text

**Description** Simple conversion into double character sequences.

## `u = util.au8(a)` v3.00

Convert ASCII to UTF-8

**Parameters**
- `a`: ASCII text

**Returns**
- `u`: UTF-8 encoded text

**Description** Simple conversion of 0x00-0x7f and 0x80-0xff into double character sequences.

## `same = util.cmpi(t1, t2)` v3.43

Compare indexed tables

**Parameters**
- `t1`: Table
- `t2`: Table

**Returns**
- `same`: true if they are equivalent

**Description** Compares two indexed tables.

Only compares the first level tables, and not the contents of subtables:

```
xx = {1,2,3}
xy = {1,2,3}
util.cmpi({9,8,7,xx}, {9,8,7,xx}) --> true
util.cmpi({9,8,7,xx}, {9,8,7,xy}) --> false
```

## `cs = util.codesize(MYFUNC)` v2.00
## `cs = util.codesize(nil, true)` v2.00
## `cs = util.codesize(nil, function(cs,fn) print(fn,cs) end)` v2.00

Estimate Lua codesize

**Parameters**
- `MYFUNC`: Function name to profile
- `cs`: Number of bytes (for callback)
- `fn`: Function name (for callback)

**Returns**
- `cs`: Number of bytes

**Description** Calculate the RAM impact of a function, or all top-level functions.

The format `util.codesize(nil, true)` will print the individual function sizes to the console. Providing a function for the second parameter allows customisation of the results.

## `t,rtxt = util.csvt(txt, [opt])` v3.00

Convert CSV text to table

**Parameters**

- `txt`: ASCII line to parse
- `opt`: Optional table of parameters
  `.s` = Separator character (,)
  `.q` = Quote character (") `.str` = Boolean value. If true then all fields treated as string

**Returns**

- `t`: Table of values
- `rtxt`: Remaining text (for incomplete quotation etc)

**Description** This function converts an ASCII text line to a Lua table.

## `t1,t2 = util.cuti(t, idx)`

Cut indexed table

**Parameters**

- `t`: Table that needs cutting in two
- `idx`: Index of first entry to be in second half

**Returns**

- `t1`: First half
- `t2`: Second half

**Description** Cuts a table in half at the 'idx' point.

If idx=1, then t1 will be empty, and t2===t

Idx can be negative to indicate "n-th point from the end", so if idx=-1, then t1==t, and t2 will be empty.

```
local t1 = {1,2,3,4,5,6,7,8,9}
local t2,t3 = util.cuti(t1, 6)
-- t2 = {1,2,3,4,5}
-- t3 = {6,7,8,9}
```

## `v = util.dct(t)` v2.00

Deep copy table

**Parameters**

- `t`: Table to deep copy

**Returns**

- `v`: Resulting copy of table

**Description**

Deep-copies a Lua table. Any changes made to `v` will therefore be independent of the original table `t`.

using the Lua standard □v=t□ will only result in a single table in memory. Any changes to □v□ will affect □t□ as well. That□s why a □deep copy□ is needed to produce a replica of the original table that is independent.

Only the Lua types: LUA_TNIL, LUA_TBOOLEAN, LUA_TNUMBER, LUA_TSTRING, and LUA_TLIGHTUSERDATA are handled.

## `idx,found = util.find(t, v, [func])` v2.00

Find

**Parameters**

- `t`: Table of values
- `v`: Value to find
- `func`: Optional comparison function

**Returns**

- `idx`: Index (effectively the insertion point)
- `found`: Whether found in the list

**Description**

Binary search through the ordered table.

Uses the first entry of the table to determine whether string or number.

```
local idx,found = util.find( {1,2,3,4,5}, 3) -- > 3, true
local idx,found = util.find( {1,2,3,4,5}, 3.1) -- > 3,false
local idx,found = util.find( {'apple','orange','pear'}, 'orang') -- > 2,false
local idx,found = util.find( {'apple','orange','pear'}, 'oranges') -- > 3,false
local idx,found = util.find( {'apple','orange','pear'}, 'oranges',
  function compare(a,b)  ①
    if a<b
    then return -1
    elseif a==b
    then return 0
    else return 1
    end) -- > 3,false
```

① Comparison function

## `n = util.iter(FOO,start,[depth])` v2.00

Iterate table

**Parameters**

- `FOO`: Function to call. `n = FOO(o)` is the prototype.
- `start`: Starting object or table
- `depth`: (optional) table depth. Default = 3

**Returns**

- `n`: Count or total

**Description** The function `FOO` can return a value that is summed to form the total `n`.

## `kvco = util.kvc(nb,ni)` v2.00

Create key-value container object

**Parameters**
- `nb`: Number of bytes for the data
- `ni`: Number of index entries

**Returns**
- `kvco`: KVC object

**Description** Return a KVC object.

See `util.kvc`

## `t = util.remi(t, idx, [last])`

Remove indexed table

**Parameters**
- `t`: Table that needs cutting in two
- `idx`: Entry to remove, or first entry to remove
- `last`: Optional last entry to remove

**Returns**
- `t`: Resulting table

**Description** Returns a table that is 't' minus the entry at idx, or minus entries between idx and last (inclusive)

```
local t1 = {1,2,3,4,5,6,7,8,9}
local t2 = util.remi(t1, 6)
-- t2 = {1,2,3,4,5,7,8,9} (#6 removed)
local t3 = util.remi(t1, 6, -2)
-- t3 = {1,2,3,4,5,9} (#6-8 removed)
```

## `txt = util.tcsv(t)` v3.42

Convert table to CSV text

**Parameters**
- `t`: Table of values
  `.csv` = CSV parameter table
  `.fmtf` = Format function(t, idx, v)

**Returns**
- `txt`: ASCII line

**Description** Converts a table of values to a formatted CSV output.

If present `.csv` can point to a table of alternative CSV format parameters. Otherwise the global `csv` table will be used. See `smp.csv` table definitions.

See the `.fmtf` table information for formatting function callback.

## `ty = util.tia(ta, tb)` v2.00

Append index table

**Parameters**
- `ta`: Table A
- `tb`: Table B

**Returns**
- `ty`: Resultant table

**Description** Append two indexed tables.

```
t = rt.tia({1,2,3},{'A','B'})
---> t = {1,2,3,'A','B'}
```

## `ty = util.tio(ta, tb)` v2.00

OR indexed tables

**Parameters**

- `ta`: Table A
- `tb`: Table B

**Returns**

- `ty`: Resultant table

**Description** OR together two indexed tables.

Useful for applying defaults to a table.

```
t = util.tio({1,_,3},{'A','B','C'})
---> t = {1,'B',3}
```

## `u = util.u16u8(u, [be])` v3.00

Convert UTF-16 to UTF-8

**Parameters**

- `u`: UTF-16 encoded text
- `be`: Set to true for Big-Endian encoding (default)

**Returns**

- `u`: UTF-8 text

**Description** Converts Unicode 16-bit characters with either big or little endianness to UTF-8 encoding.

### `a,ok = util.u8a(u, [d])` v3.00

Convert UTF-8 to ASCII

**Parameters**
- `u`: UTF-8 encoded text
- `d`: Text to replace undefined characters (default `?`)

**Returns**
- `a`: ASCII text
- `ok`: True if the decoding was ok

**Description** Converts Unicode code points 0x0000 to 0x00ff into ASCII.

Invalid UTF-8 code points will return `ok` as false.

### `u,ok = util.u8u16(u, [be])` v3.00

Convert UTF-8 to UTF-16

**Parameters**
- `u`: UTF-8 encoded text
- `be`: Set to true for Big-Endian encoding (default)

**Returns**
- `u`: UTF-16 text
- `ok`: True if the decoding was ok

**Description** Converts UTF-8 to Unicode 16-bit characters with either big or little endianness.

```
v = util.use(fn, [force]) v3.42
u1,u2,⋯ = util.use() v3.42
```

Include Lua library

**Parameters**

- `fn`: Filename of Lua file
- `force`: Force re-load (set to `true`)

**Returns**

- `v`: true if found and loaded; false if already used; nil,error on error
- `u1,u2⋯`: Uses file name entries

**Description** Allows load and run of Lua libraries. Similar to Lua's `require` but designed for embedded use.

`fn` does not need to have a full path. `.lua` is appended if no extension is found. `/Lua` is prefixed if `fn` does not start with `/` (allows for relative module names)

# LCD and User Interface Library Extensions

# Library key : Keyboard Library

The keyboard library provides scripting support for up to 8 push-to-make switches that are connected to an IO-expander on the I2C bus.

```
bf,td = key.get()
v,td = key.get(keyno)
```

Get key state

**Parameters**

- keyno: Which key to check (1-8)

**Returns**

- v: (boolean) whether the key is pressed (if keyno is provided)
- bf: (number) bit-field of the pressed keys (D0 = key #1)
- td: Time keys have been pressed (milliseconds)

**Description** Get the state of an individual key, or all keys as a bitfield.

```
v = key.ign(bf)
v = key.ign(keyno, ign)
```

Ignore keys

**Parameters**

- bf: Number bitfield. If a bit is set then the key is ignored.
- keyno: Key number (1-8)
- inv: Whether to ignore (boolean)

**Returns**

- v: Bitfield of ignore field.

**Description** Set which keys to ignore.

Removed in v3.00

## `ok = key.inj(keyno)` v2.00

Inject keystroke

**Parameters**
- `keyno`: Key number 1-8

**Returns**
- `ok`: True if injected

**Description** Injects a keystroke into the keyboard buffer.

## `v = key.inv(bf)`<br>`v = key.inv(keyno, inv)`

Set key inversion

**Parameters**
- `bf`: Number bitfield. If a bit is set then the key is inverted.
- `keyno`: Key number (1-8)
- `inv`: Whether to invert (boolean)

**Returns**
- `v`: Bitfield of inversion field.

**Description** Set which keys to invert.

## `key.kre(keyno, en)`

Set key repeat enable

**Parameters**
- `keyno`: Key number 1-8
- `en`: Whether to act on key repeats (true=repeat)

**Returns** None

**Description** Set the Key Repeat Enable. If an individual key has repeat enabled, then there will be a callback at the repeat interval all the time the key is kept pressed.

## `rt,it = key.kri(rt,[it])`

Set keyboard repeat idle

**Parameters**
- `rt`: Repeat time (milliseconds)
- `it`: Idle time (milliseconds)

**Returns**
- `rt`: Repeat time (milliseconds) Default = 400ms
- `it`: Idle time (milliseconds) Default = 10000ms (10sec)

**Description** Set the Key Repeat Idle time and repeat interval time.

## `ok = key.ok()`

Check keyboard hardware

**Parameters** None

**Returns**
- `ok`: True if the keyboard hardware was found.

**Description** Check whether the keyboard is connected.

# Key callback functions

## function onKey#(keyno,isdown,t)

Individual key callback prototype

**Parameters**

- `keyno`: Key number 1-8.
- `isdown`: True if the key is pressed.
- `t`: Time, in milliseconds, that the key has been held down for.

**Returns** None

**Description** Callback for an individual key. Called after the `onKey` general callback.

```
function onKey2(kn,id,td)
 -- do something
end
```

## function onKey(keyno,isdown,t)

Key global callback prototype

**Parameters**

- `keyno`: Key number 1-8. Or -1 for the Idle callback.
- `isdown`: True if the key is pressed.
- `t`: Time, in milliseconds, that the key has been held down for.

**Returns** None

**Description** Called when any key is pressed. This function is called first.

When the keyboard is idle, the `onKey` function is called with keyno=0 (allowing for a single function to handle all events). The `onKeyIdle` callback (if defined) is called after this function.

## `function onKeyIdle()`

`Keyboard idle callback prototype`

| | |
|---|---|
| **Parameters** | None |
| **Returns** | None |
| **Description** | Called when the keyboard has been idle. |

See `key.kri` - Idle Time.

# Library `lcd` : LCD Library

> The LCD library was included in firmware v2.00. None of the LCD functions are in previous releases.

The `lcd` library provides low-level functions for displaying text, icons, and graphics.

Two LCD boards are supported (both from Electronic Assembly http://www.lcd-module.com ):

- EA DOGXL-160
  - 160x104 monochome
- EA DOGL-128 or EA DOGM-128
  - 128x64 monochrome

The LCD board is an optional attachment that also includes support for 8 keyboard switches.

See also the `key` library.

> The LCD library will not function unless the keyboard library detects the keyboard chip!

> The coordinate system has (0,0) as the top-left pixel.

> The LCD library is a modified and improved version of the U8G2 library.

# Hardware control

## `ison = lcd.act()`

`Check if the LCD is on`

**Parameters** None

**Returns**

- `ison`: true if the LCD is currently on

**Description** Find out if the LCD is powered.

## `lcd.c(col)`

`Set LCD draw colour`

**Parameters**

- `col`: Colour - 0=WHITE, 1=BLACK

**Returns** None

**Description** Set the current drawing colour.

## `lcd.ers()`

`Erase the LCD buffer`

**Parameters** None

**Returns** None

**Description** Erases the LCD buffer.

## `lcd.go([ison])`

`Display the current LCD buffer`

**Parameters**
- `ison`: Whether to power on the LCD too (default=true)

**Returns** None

**Description** Display the current LCD buffer.

## `w,h = lcd.gss()`

`Get the LCD screen size`

**Parameters** None

**Returns**
- `w`: Width in pixels
- `h`: Height in pixels

**Description** Get the LCD screen size dimensions.

> X-coordinates will be from `0` to `(w-1)`; Y-coordinates will be from `0` to `(h-1)`

## `v = lcd.idle(v)`

`Set or get LCD idle time`

**Parameters**
- `v`: Idle time, in milliseconds

**Returns**
- `v`: Idle time, in milliseconds

**Description** Set, or get, the LCD idle timeout.

> Limited to >1500ms and <120000ms (2 minutes)

## `ok = lcd.init(width, [rot], [eng])`

`Initialise LCD hardware`

**Parameters**

- `width`: Pixel width of LCD, either 160 or 128 (default=160)
- `rot`: Optional rotation 0, 90, 180, 270 (default=0)
- `eng`: True to route LCD to engineer port

**Description** Initialise the LCD hardware.

> RAM for the LCD buffer is taken from the Lua working RAM. The DOGXL160 requires 2k, the DOGL128 requires 1k.

## `lcd.off()`

`Turn off the LCD`

**Parameters** None

**Returns** None

**Description** Turns off the LCD.

## `ok = lcd.ok()`

`Find out if LCD hardware present`

**Parameters** None

**Returns**

- `ok`: true if the LCD hardware was found

**Description** Check whether the LCD and keyboard is connected.

## `lcd.on(ison)`

`Control LCD state`

**Parameters**
- `ison`: true if enabled

**Returns** None

**Description** Turn the LCD on, or off.

> The LCD consumes about 700uA while on.

## `lcd.save(filename)`

`Save the LCD to a bitmap`

**Parameters**
- `filename`: File to save the bitmap to.

**Returns** None

**Description** Save an NetPBM file `P4` style bitmap of the current LCD frame buffer.

> Use the extension `.pbm` to be compatible with Photoshop, etc.

## `lcd.sdc(c)`

`Set LCD display contrast`

**Parameters**
- `c`: Contrast, 0-255

**Returns** None

**Description** Set the display contrast.

# Drawing functions

## `lcd.box(ft, x,y, w,h, [r])`

Draw LCD box

**Parameters**

- `ft`: Fill type:
  - `'f'` = filled
  - `'h'` = hollow
  - `'r'` = rounded hollow
- `x,y`: Starting point
- `w`: Width in pixels
- `h`: Height in pixels
- `r`: Radius, in pixels

**Returns** None

**Description** Draw a box, or a block.

## `lcd.cir(ft, seg, x,y, rx, [ry])`

Draw LCD circle or ellipse

**Parameters**

- `ft`: Fill type
  - `'f'` = filled
  - `'h'` = hollow
- `seg`: Which segments to draw:
  - `'*'` or nil = all
  - `'L'` = upper left
  - `'R'` = upper right
  - `'l'` = lower left
  - `'r'` = lower right
- `x,y`: Centre
- `rx`: Radius for width
- `rh`: Radius for height (=rx if not present)

**Returns** None

**Description** Draw a circle, or ellipse, or segment.

## `lcd.l(x1,y1, x2,y2)`

Draw LCD line

**Parameters**

- `x1,y1`: Starting point
- `x2,y2`: End coordinate

**Returns** None

**Description** Draws a line from (x1,y1) to (x2,y2) in the current drawing colour.

## `lcd.lh(x, y, w)`

Draw LCD horizontal line

**Parameters**

- `x,y`: Starting point
- `w`: Width of line, in pixels

**Returns** None

**Description** Draws a horizontal line in the current drawing colour.

## `lcd.lv(x, y, h)`

Draw LCD vertical line

**Parameters**

- `x,y`: Starting point
- `h`: Height of line, in pixels

**Returns** None

**Description** Draws a vertical line in the current drawing colour.

## `lcd.p(x, y)`

Draw LCD pixel

**Parameters**

- `x`: X coordinate. 0-159
- `y`: Y coordinate. 0-103

**Returns** None

**Description** Set a pixel to the current drawing colour.

## `ok,x,y,w,h = lcd.pbm(x,y, filename, [invert])`

Draw LCD PBM bitmap from file

**Parameters**

- `x,y`: Position (top left corner)
- `filename`: Name of the PBM file
- `invert`: Whether to invert drawing

**Returns**

- `ok`: True if loaded and drawn
- `x,y`: New position (bottom right corner)
- `w,h`: Width and height of the bitmap

**Description** Draw a NetPBM `P4` binary bitmap.

> ℹ Photoshop refers to this as "Portable Bit Map", and saves as a `.pbm` file.

## `lcd.tri(ft, x1,y1, x2,y2, x3,y3)`

`Draw LCD triangle`

**Parameters**

- `ft`: Fill type
  - `'f'` = filled
  - `'h'` = hollow
- `x1,y1`: Start corner
- `x2,y2`: Middle corner
- `x3,y3`: End corner

**Returns** None

**Description** Draw a triangle.

## `lcd.xbm(x,y, w,h, txt)`

`Draw LCD XBM bitmap string`

**Parameters**

- `x,y`: Position
- `w`: Bitmap width
- `h`: Bitmap heigh
- `txt`: XBM encoded string

**Returns** None

**Description** Draw a bitmap on the LCD frame buffer.

# Font and Text functions

## `fa,fd = lcd.f(name)`

Set the LCD font

**Parameters**
- `name`: Font name string

**Returns**
- `fa`: Font ascent
- `fd`: Font descent

**Description** Choose a font to write with.

## `lcd.fr(rot)`

Set LCD font rotation

**Parameters**
- `rot`: Rotation angle, 0, 90, 180, 270

**Returns** None

**Description** Set the font rotation angle.

## `lcd.ft(tr)`

Set LCD font transparency

**Parameters**
- `ft`: Whether transparent font. 1=transparent; 0=opaque

**Returns** None

**Description** Set the font drawing method.

### `fa,fd = lcd.gad()`

Get the LCD ascent and descent metrics

**Parameters** None

**Returns**

- `fa`: Font ascent
- `fd`: Font descent

**Description** Get the current font's ascent and descent metrics.

### `lcd.gly(x,y, gn)`

Draw LCD glyph

**Parameters**

- `x,y`: Coordinate
- `gn`: Glyph number

**Returns** None

**Description** Draw a Unicode glyph from the current font.

### `w,fa,fd = lcd.gtw(txt)`

Get LCD text width

**Parameters**

- `txt`: UTF-8 text to measure

**Returns**

- `w`: Width in pixels
- `fa`: Font ascent
- `fd`: Font descent

**Description** Measure the width of a UTF-8 string in the currently selected font.

## `x,y,w,h = lcd.t(x,y, txt)`

Draw LCD text

**Parameters**

- `x,y`: Coordinate for the baseline
- `txt`: UTF-8 text to print

**Returns**

- `x`: Updated x position
- `y`: Updated y position
- `w`: Width of text
- `h`: Height of text

**Description** Draw the `txt` at the position `x,y` with the currently selected font.

You can throw away all, or some, of the return values.

```
local x = 10
x = lcd.t(x, 10, 'Hello ')
x = lcd.t(x, 10, 'world!')

local y,_
y = 10
_,y = lcd.t(10, y, 'Line 1')
_,y = lcd.t(10, y, 'Line 2')
```

# Font names

## Single size

- `"gt"` Glasstown (modified u8g2_font_glasstown_nbp_t_all)

## X11 fonts

- `"4x6"`
- `"5x8"`
- `"6x10"`
- `"6x12"`
- `"7x13"`
- `"7x13b"` Bold
- `"7x13e"` Emphasised
- `"9x15"`
- `"10x20"`

## ProFont

- `"pf10"`
- `"pf11"`
- `"pf12"`
- `"pf15"`
- `"pf17"`
- `"pf22"`
- `"pf29"`

## Icon and special fonts

- `"batt6"`
- `"cell6"`
- `"i1"` OpenIconic x 1
- `"i2"` OpenIconic x 2
- `"i4"` OpenIconic x 4
- `"sk7"` Soft key icons
- `"uf"` Unifont symbols

# Library `ui` : User Interface LCD Library

The LCD library was included in firmware v2.00. None of the LCD functions are in previous releases.

The `ui` library provides high level user interface functions for keyboard and LCD operation.

See also: `lcd` and `key` libraries.

The UI library is designed to be extremely memory efficient. The LCD frame buffer will take just over 2k (for an EA-DOG160XL LCD). Only the currently viewed UI element will be loaded into Lua's RAM - with everything else existing in comments within the Lua App file.

The UI will enter power save after a brief period, and can be instantly woken with a press of a key.

The UI is called from the context of the LuaEvents task. Consequently, ensure any functions do not block - otherwise you will hold up the rest of the system. (Best to trigger flags that are then executed within the Lua Loop task.)

# Boilerplate code

The code here shows the smallest UI code required. Additional information is provided in the following chapters.

```
--[[Mmain1] ①
Nsample
[Main menu]
Welcome!
Alive {i.pwr_alv} sec
]]--

--[[Nsample] ②
my_value
[Choose a value]
Something {2} units
99
-99
]]--

lcd.init(160) ③
ui.go()
ui.push('Mmain')
```

① The UI element for page 1 of `Mmain`

② The UI element for a number editor `Nsample`, with a 2 decimal-place value between -99 and +99

③ The initialisation sequence for an EA-DOG160XL display

# UI Element : Menu

The prefix `M` is for menu. The UI core will try and access `Mname1` to begin with, and pressing the `DOWN` button will sequence through the digits until no more are available in the file.

```
--[[Mname1] ①
Next     ②
  (OR)
/execfunc ②
  (OR)
.         ③
[Title]    ④
CommentText ⑤
Label {%.1f,my_value} ⑥
Label-{c.lua_app} {{%.1f,my_value}} Units ⑦
Label {*%.1f,my_value} Units ⑧
/funcname ⑨
]]-- ⑩
```

① The first menu item for level `name`

② The UI element to push, or Lua function to call, when `SET` is pressed.

③ Use a dot when there is no `Next` or function, and there is no `[Title]`

④ (optional) Title string

⑤ A line that is shown as a comment

⑥ A line that is shown with a label and right-justified small number

⑦ A line with label, formatted value, and units. Note the double `{` to allow `rt.exp` expansion of Label and Units

⑧ The `*` denotes a line with big formatted value.

⑨ A Lua function hook for the line

⑩ The end of the UI element.

## Example

Menu with: * static text on page 1 that leads to a number editor * static text on page 2 that leads to a list picker * dynamic text on page 3 showing two values

```
--[[Mmain1]
Nvalue
[Edit value]
Press SET/RIGHT to edit the value.
]]--

--[[Mmain2]
Litems
[Choose list]
Press SET/RIGHT to choose from the list
]]--

--[[Mmain3]
.
[Display only]
Alive {*%.0f,i.pwr_alv}
Serial {i.rt_sn}
]]--
```

# UI Element : Values with editing

A UI menu that has no `Next` or `/execfunc` can be used to have in-place-editing values, saving several separate pages and glue-code.

> If you accidentally assign a `Next` or `/execfunc` then the UI will never enter the edit mode. (Even if you have assigned the in-place editing write;dps;min;max values)

```
--[[Mname2] ①
.          ②
[Title]    ③
Label {%.1f,my_value;my_value;1;-10} ④
Label {%.1f,my_value;/WriteFunc;1;-100;200} Units ⑤
Label {*%.1f,my_value} Units ⑥
Jump {;>Ltest} ⑦
Call {;/CallFunc} ⑧
]]-- ⑨
```

① The second menu item for level `name`

② Use a dot when there is no `Next` or function, and there is no `[Title]`

③ (optional) Title string

④ Edit value: write to `my_value`; 1 decimal place; minimum=-10

⑤ Edit value: write with function `WriteFunc(VALUE)`; 1 decimal place; minimum=-100; maximum=200

⑥ View only big value.

⑦ A label that will jump to the UI element `Ltest`

⑧ Lua call to `CallFunc(uiname, uilevel)`

⑨ The end of the UI element.

> Using negative decimal places will increment/decrement in tens, hundreds, etc. e.g. -3 will use 1000 as a delta.

# UI Element: Number Editor

The prefix `N` is for number-editor. The number editor can show an optional title, and specify optional maximum and minimum values.

```
--[[Nname] ①
Read ②
  (OR)
Read,Write ②
  (OR)
/readfunc,/writefunc ②
[Title]    ③
Label {dp} Units ④
Maximum ⑤
Minimum ⑥
]]-- ⑦
```

① The UI element name

② Either read; read+write variables. Can also be a Lua function name prefixed with `/`

③ (optional) Title string

④ Label, decimal places, and Units

⑤ (optional) Maximum value

⑥ (optional) Minimum value

⑦ End of the UI element.

## Example 1

Number editor that reads `my_val` and shows to 1 decimal place. When saved, the variable `my_val` is updated:

```
--[[None]
my_val
[Edit my_val]
Value {1} cm
]]--
```

## Example 2

Number editor that reads `my_val` and shows to 1 decimal place. When saved, the variable `other_val` is updated:

```
--[[Ntwo]
my_val,other_val
[Edit my_val, save other_val]
Value {1} cm
]]--
```

## Example 3

Number editor that uses a function `getmyval` to obtain the value. When saved, the function `setmyval`is called to store the value:

```
--[[Nthree]
/getmyval,/setmyval
[Edit with max + min]
Value {1} cm
100
0
]]--

function getmyval()
 return my_val
end

function setmyval(v)
 my_val = v
end
```

# UI Element: List Picker

The prefix `L` is for the list-picker.

```
--[[Lname] ①
Read ②
  (OR)
Read,Write ②
  (OR)
/readfunc,/writefunc ②
[Title]    ③
/listfunc  ④
  (OR)
item1 ④
item2
item3
etc
]]-- ⑤
```

① The UI element name

② Either read; read+write variables. Can also be a Lua function name prefixed with `/`

③ (optional) Title string

④ Either a Lua function name for a software list, or the list of items

⑤ End of the UI element.

## Example1

List picker that reads and writes to the variable `yn_answer`:

```
--[[Lyesno]
yn_answer
[Decide]
No
Yes
]]--
```

## Example 2

List picker that uses functions `getyn` and `setyn` to read and write the values. Also uses a Lua function to generate the list contents - in this example the list is taken from a Lua table.

```
--[[Lsoft]
/getyn,/setyn
[Decide]
/ynlist
]]--

thelist = {"No", "Yes"}

function getyn()
  return yn_answer
end

function setyn(v)
  yn_answer = v
end

function ynlist(n)
  if not n then return #thelist end
  return thelist[n]
end
```

# UI Element: Settings and Hooks

The UI elements can be expanded with additional modifiers. Place these before the `[Title]` value.

### `:hook:funcname`

Draw hook

**Parameters**

- `funcname`: Name of a Lua function

**Description**

Add a draw hook that is called at the end of each LCD update.

You can use this to draw a bitmap for the selected list index, etc.

Example draw hook:

```
function MyDrawHook(name,menuidx,value)
  --name    = UI name, e.g. 'Mtest1'
  --menuidx = UI index
  --value   = value in the UI.
  --          Menu or list index, or Number
end

--[[Mname1] ①
/dothis    ②
:hook:MyDrawHook  ③
:skey:GO!         ④
:skms:2000        ⑤
[Title]   ⑥
Label {%.1f,my_value}
Label {%.1f,my_value} Units
L-{c.somelabel} {{*%.1f,my_value}} {c.someunits}
]]-- ⑧
```

① The UI name

② Lua function call

③ Hook to display

④ The SET button will show `GO!`

⑤ You must hold the SET button down for 2 seconds

## `:skey:text`

SET key override

**Parameters**

- `text`: String to use for the `SET` key

**Description** Override the key text. (See the example in `:hook:funcname`)

## `:skms:time`

SET key milliseconds

**Parameters**

- `time`: The time delay, in milliseconds

**Description** Add a delay to the `SET` key. (See the example in `:hook:funcname`)

## `ui._bar`

Default uiBar handler

**Description** Default `uiBar` handler for the UI.

## `ui._key`

Default onKey handler

**Description** Default `onKey` handler for the UI. This has been made available so the default handler can be intercepted and overridden.

## `ui._cell`

Default uiCell handler

**Description** Default `uiCell` handler for the UI. Draws a large timer and big icons for the status of the cellular modem.

## `ui.box(title, [y])`

Draw UI box

**Parameters**

- `title`: Title text
- `y`: Top y-coordinate

**Description** Draws the optional title box, and main box (according to the UI preferences set).

## `ui.go()`

Start the UI

**Parameters** None

**Description** Start the UI. Applies the defaults, hooks the `onKey` callback, and begins the UI.

## `ui.key(kn,txt,[tfon])`

Draw soft key

**Parameters**

- `kn`: Key number, 1 to 4
- `txt`: String to display
- `tfon`: True if a text font should be used

**Returns** None

**Description** Draw a soft-key (useful in the display hook callback)

## `name = ui.pop()`

Pop UI element

**Parameters** None

**Returns**

- `name`: Element name

**Description** Pops a UI element off the stack.

## `ui.popa([all])`

Pop all UI

**Parameters**

- `all`: True to pop everything, false to pop everything except the top-level

**Description** Pops all UI elements off the stack.

## `ui.push(name)`

Push UI element

**Parameters**

- `name`: Element name

**Description** Push a UI element onto the stack. The element is loaded from either the current Lua App, or to filename set with `ui.set.i8n`.

## `ui.ssk(txt)`

SET key icon

**Parameters**

- `txt`: String to use for the `SET` key

**Returns** None

**Description** Set the text or icon for the `SET` key.

## `name,val,index = ui.top()`

Get the top UI element

**Parameters** None

**Returns**

- `name`: Name of the UI element
- `val`: Value of the stack
- `index`: Stack pointer for the element

**Description** Accesses the top element on the UI stack.

```
txt = ui.txt()
```

Get UI element text

**Parameters** None

**Returns**

- `txt`: The text loaded by `app.txt`

**Description** Provides access to the full text within the UI element.

```
y = ui.val(y, label, value, units, [big])
```

Show values on LCD

**Parameters**

- `y`: Y-position to draw the line
- `label`: The label text
- `value`: The value text
- `units`: The units text
- `big`: True to show large value text

**Description** Draws a single row of label/value/units.

The formatting is different depending on the contents of `value` and `units`.

```
ui.yes()
ui.yes(txt,[fontname]) v3.00
ui.yes(func) v3.00
```

Show YES tick

**Parameters**

- `txt`: Text for the popup
- `fontname`: Font to use (default 'i4')
- `func`: Function to call for drawing

**Returns** None

**Description** Show the UI confirmation 'tick'.

If `func` is used, then the function can perform LCD drawing functions. The screen will already be blank on entry, and be drawn on exit.

# Preference settings

The preferences can control the look and feel of the UI.

```
tc,bc,kc = ui.set.c(tc,bc,kc)
```

Set UI colours

**Parameters**

- `tc`: Title colour
- `bc`: User box colour
- `kc`: Softkey colour

**Returns**

- `tc`: Title colour
- `bc`: User box colour
- `kc`: Softkey colour

**Description** Control the colour of UI elements.

```
fn = ui.set.i8n(filename)
```

Set UI filename

**Parameters**

- `filename`: Filename to load UI elements from

**Returns**

- `fn`: Current filename

**Description** Set the internationalisation file. By default the UI elements are loaded from the current Lua App file.

Make sure the chosen `filename` contains **all** the elements referred to in the App!

## `v = ui.set.idle([n])`

Set UI idle time

**Parameters**
- `n`: Number of seconds the UI should show when idle

**Returns**
- `v`: Current value

**Description** Sets, or gets, the current UI idle time.

Use a time of -1 to show the UI always.

```
ui.set.idle(-1) -- Show always
```

## `ui.set.km(bk,uk,dk,sk)`

Set UI key mapping

**Parameters**
- `bk`: Back key number (1)
- `uk`: Up key number (2)
- `dk`: Down key number (3)
- `sk`: Set key number (4)

**Description** Override the Key Mapping. The soft-keys will be rearranged to match the key assignments.

Key 1 is on the left of the display; Key 4 is on the far right of the display.

```
ui.set.km(4,3,2,1) -- reverse
```

```
ui.set.km(1,3,2,4) -- swap UP / DOWN
```

### `kr = ui.set.kr(kr)`

`Set UI key repeat`

**Parameters**
- `kr`: Key repeat time

**Returns**
- `kr`: Key repeat time

**Description** Set the Key Repeat value.

### `tr,br,kr = ui.set.r(tr,br,kr)`

`Set UI rounded corners`

**Parameters**
- `tr`: Title round value (pixels)
- `br`: User box round value (pixels)
- `kr`: Softkey round value (pixels)

**Returns**
- `tr`: Title round value (pixels)
- `br`: User box round value (pixels)
- `kr`: Softkey round value (pixels)

**Description** Control whether UI elements have rounded corners.

### `ui.set.ui(xt, ft)`

`Set UI font positions`

**Parameters**

- `xt`: Table of X-positions
- `xt.t`: X-pos for Text
- `xt.l`: X-pos for Labels
- `xt.u`: X-pos for Units
- `xt.vl`: X-pos for left justified Values (no units)
- `xt.vr`: X-pos for right justified Values (with units)
- `ft`: Table of Font names
- `ft.t`: Font for Text
- `ft.l`: Font for Labels
- `ft.u`: Font for Units
- `ft.s`: Font for Value small size
- `ft.m`: Font for Value medium size
- `ft.b`: Font for Value big size

**Description** Overrides one, or more, of the X-positions, and/or the fonts used for UI components.

Apply settings **after** calling `ui.go`

# UI Callbacks

## `h = uiBar()`

`uiBar callback prototype`

**Parameters** None

**Returns**

- `h`: Height of the status bar (the default `ui._bar` returns a height of 8 pixels)

**Description** An override callback for the top line status bar.

## `show = uiCell()`

`uiCell callback prototype`

**Parameters** None

**Returns**

- `show`: Return `false` to prevent the call to `lcd.go`. Any other value will show the contents of the LCD buffer.

**Description** An override callback for the cellular status LCD display.

The default `uiCell` function should be sufficient for most requirements.

> You do not have to call `lcd.go` - this is handled in the firmware.

## `uiSmp()`

`uiSmp callback prototype`

| | |
|---|---|
| **Parameters** | None |
| **Returns** | None |
| **Description** | An override callback for the sample LCD display. |

This callback is invoked if `smp.save` is called - allowing you to display important values from the last saved sample.

> You do not have to call `lcd.go` - this is handled in the firmware.

# Configuration Variables

The rt.buffer stores the configuration variables inside an efficient C++ `key=value` memory structure that has about 6k of space.

The contents of this store are saved and read from the file `/Config/config.txt`

The `config.txt` file is updated 500ms after configuration changes have stopped happening. Conversely, editing config.txt through the USB HID interface will trigger a reload of the config.txt into RAM.

However, to make life much easier inside Lua, the values can be queried and modified directly as a Lua global table, called `c`.

Within the C++ structure, the keys are organised in ASCII order, with the underscore (`_`) character representing the branches of a tree. This method enables simple 'wildcard' style erasing and querying of sets of values, and is also compatible with Lua's syntax.

```
c.my_value = 123
c.my_other = 'A string'
c.my_more = 'A complex \r\n string\twith\x00controlcodes' ①

c.mynot = 'Not the same tree'
c.my_other=_ -- erases just one key-value
c.my=_ -- erases all c.my* key-values. But c.mynot remains
```

① See https://en.wikipedia.org/wiki/Escape_sequences_in_C for examples of escaped characters. e.g. '\t' = TAB, '\r' = CR, '\x00' = NULL, etc

Some of configuration names are fixed and used within the firmware. However, your Lua App can choose to make use of additional configuration parameters as needed.

The following sections list the firmware-fixed configuration names and their settings.

# Config `c.alm` : Alarm

```
c.alm_txt01 = ''
c.alm_txt02 = '' …
```

**Description** Text names for the alarms 01-32.

(Developers) Can be retrieved in Lua with `alm.txt(…)` function.

# Config `c.arc` : Archive Parameters

The `/Archive/` folder saves copies of the files that are sent. When the file count is exceeded, or the total bytes is exceeded, the oldest files are removed from the folder.

- The folder is flat - any files that do not begin with `/Send/` are mapped so that the `/` characters are replaced by `^` symbols.
  e.g. `/MyFolder/myfile.txt` is archived as `/Archive/^MyFolder^myfile.txt`

If you create sub-folders within `/Archive/` then these folders will not be scanned, nor curated (i.e. they will stay there and not be pruned).

## `c.arc_fc = 32` v1.00

**Description** Maximum number of files to keep in the `/Archive/` directory.

## `c.arc_gz = 0` v3.43

**Description** Set to 1 to gzip files are they are moved into the `/Archive/` directory.

> There are routes for compressing. See `smp ftable.gz`, and `fc.gz`

## `c.arc_kb = 4096` v1.00

**Description** Maximum number of kilo-bytes to keep in the `/Archive/` directory.

# Config `c.cell` : Cellular

## `c.cell_apn = 'Internet'`

**Description** APN name for the Internet connection

## `c.cell_auth = -1`

**Description** (optional) Override the APN authentication method

- `-1` = Auto (depending on `c.cell_user` + `c.cell_pass`)
- `0` = None
- `1` = PAP only
- `2` = CHAP only
- `3` = PAP/CHAP

## `c.cell_hof = 10`

**Description** (optional) hold off failure time, in minutes.

## `c.cell_hos = 2`

**Description** (optional) hold off success time, in minutes.

### `c.cell_init = ''` v3.31

**Description** (optional) Modem initialisation sequence.

Do not include the "AT", just the command.
Separate commands with a control character, e.g. '\r'

### `c.cell_mto = 15`

**Description** (optional) Maximum time online, minutes.

### `c.cell_pass = ''`

**Description** (optional) Password for the Internet connection

### `c.cell_pin = ''`

**Description** (optional) PIN number for the SIM card

### `c.cell_sms = ''`

**Description** (optional) Default SMS target number. Should be in international format (i.e. starting with "+" and the country code)

### `c.cell_user = ''`

**Description** (optional) Username for the Internet connection

# Config `c.iot` : IoT Parameters

```
c.iot_data = ''
```

**Description** (optional) Data process URL or path.

Uses Lua expansions.

```
c.iot_gz = 1
```

**Description** (optional) Use GZIP compression and naming.

```
c.iot_job = '@23:00'
```

**Description** (optional) Job string for Data delivery (and Update).

> (Developers) Sets both `onJob11` for Update, and `onJob12` for Data delivery, unless `c.iot_ujob` is set - in which case `c.iot_job` does just data.

```
c.iot_ntp = 'time.apple.com'
```

**Description** (optional) NTP server name.

```
c.iot_tfr = 1
```

**Description** (optional) Use Temp File and Rename for FTP.

Set to 0 to disable this method and send the file directly.

> `c.iot_tfr=1` requires the user FTP account support renaming. However, this approach is **STRONGLY** recommended as it ensures files are completely transferred. Just make sure your back-end processes ignore `*.tmp` files (It is also a good idea to purge very old *.tmp files, e.g. over 1 month old.)

### `c.iot_tz = 60` v3.00

**Description** (optional) Timezone override, in minutes.

When set, there is no DST (Daylight Saving Time) applied.

### `c.iot_ujob = _`

**Description** (optional) Update job string. If not present, then *c.iot_job* sets both update and data job strings.

### `c.iot_upd = 'Update/{c.site_name}'`

**Description** (optional) Update URL or path for the update mechanism, relative to c.iot_url (although can be an absolute URL too!)

Uses Lua expansions - see `rt.exp`.

### `c.iot_url = ''`

**Description** (required) Base URL for IOT.

This uses Lua expansions.

Required!

```
c.iot_url = 'ftp://mp:pm@ftp.scannex.com/Upload/{c.site_name}-{i.rt_sn}'
```

```
c.iot_user = ''
```

**Description** (optional) User process URL or path.

Uses Lua expansions.

```
c.iot_var = 3600
```

**Description** Server variance (seconds).

Jobs that are scheduled can be skewed by a combination of c.iot_var and the serial number of the rt.buffer. This ensures that your server does not get 'hit' by many rt.buffer devices all at the same time, but are spread over time.

# Config `c.lua` : Lua Configuration

```
c.lua_app = ''
```

**Description** The App name to run.

This configuration value is **required** for the rt.buffer to work. And the corresponding `.lua` app must already be in the `/Lua` folder.

# Config `c.site` : Site Deployment

```
c.site_loc = ''
```

**Description** Optional Site location details. Can be used by the App.

```
c.site_name = ''
```

**Description** (optional) rt.buffer Site Name.

Used by the smp library for naming the files.

# Config `c.term` : Terminal Controls

### `c.term_epw = 1` v1.00

**Description** (optional) Whether Engineer Serial Port needs a password.

If there is a dedicated MCU connected to the Engineer Serial Port, then this can be set to 0 so that no password is required (but it will be required from the USB still if `c.term_pass` is set).

### `c.term_pass = ''`

**Description** (optional) Terminal password.

Do NOT forget this password - there is no backdoor.

# Config `c.tls` : Security Settings

## `c.tls_csc = 0xffff` v1.00

**Description** (optional) The modem cipher suite code for IoT connections

Recommend either `0x0035` or `0x002f` as a balance between security and server compatibility.

- `0x003D` = TLS_RSA_WITH_AES_256_CBC_SHA256 (Only possible when `c.tls_ver=3` since AES-256/SHA-256 is only available in TLSv1.2)
- `0x0035` = TLS_RSA_WITH_AES_256_CBC_SHA1
- `0x002F` = TLS_RSA_WITH_AES_128_CBC_SHA1
- `0x0005` = TLS_RSA_WITH_RC4_128_SHA1
- `0x0004` = TLS_RSA_WITH_RC4_128_MD5
- `0x000A` = TLS_RSA_WITH_3DES_EDE_CBC_SHA1
- `0xFFFF` = Support all ciphersuites above (default)

## `c.tls_ilt = 1` v1.00

**Description** (optional) Ignore Local Time[2]

- 0 = Care about time checks for certificates
- 1 = Ignore time checks

## `c.tls_ver = 3` v1.00

**Description** (optional) TLS Version

- 0 = SSLv3 (not recommended)
- 1 = TLSv1.0 (not recommended)
- 2 = TLSv1.1
- 3 = TLSv1.2

[1] Checking the time against the certificate requires the local rt.buffer time be valid too!
[2] Checking the time against the certificate requires the local rt.buffer time be valid too!

# Config `c.toa` : Terminal Over the Air settings

The Terminal Over the Air mechanism connects a TCP socket (or TCP+SSL) to an Internet server and provides a full link to the rt.buffer's terminal interface.

## `c.toa_ito = 120` v1.10

**Description** The idle timeout, in seconds, for the terminal.

If nothing is received from the server connection in this time, the rt.buffer will close the connection.

## `c.toa_key = NIL` v1.10

**Description** The shared secret key for HMAC-SHA-256 mutual authentication between the rt.buffer and the server.

This is for the link-level, so any terminal password will still be requested after the link has been established.

## `c.toa_pass = NIL` v1.10

**Description** The password override for the TOA terminal.

If this field is not present the c.term_pass password is used. This setting allows you to keep the passwords separate.

### `c.toa_try = 300` v1.10

**Description** The number of seconds to keep trying to make a TCP socket connection to the server. There is a 15 second pause between successive attempts.)

### `c.toa_url = ''` v1.10

**Description** The URL details for the TOA link.

TCP and TCPS (SSL) links are currently handled.

```
c.toa_url='tcp://matt@terminal.scannex.com:12345/Path/To/Resource'
```

This example will use a plain-text TCP client connection to `terminal.scannex.com` on TCP port 12345.

Once connected, a CONNECT header will be sent to the server with the `/Path/To/Resource` and `user:matt` fields.

# Config `c.user` : User IoT settings

The user process is typically triggered by the magnet.

### `c.user_ins = 15`

**Description** The interval, in seconds, for the default User mode (by default: how many seconds to wait after sending the diagnostics data before sending again).

### `c.user_onm = 2`

**Description** The online time, in minutes, for the default User mode (by default: how many minutes to keep pushing the diagnostics data).

# Information Variables

Like the Configuration table, the global table i provides a window into some internal C++ values (without consuming Lua memory).

However, there are two 'real' Lua tables available too - that can be used for passing back application-specific information.

# Info `i.app.XXXXX` : Application

For developers.

This is also a real Lua table that can be used by the application to hand back information through the USB console, or through the diagnostic dumps, etc.

The `i.app` table can contain additional tables within it, and these will be handled correctly.

```
-- within App
i.app.mine = \{} -- blank table

-- later in the App
i.app.mine.v = 123
i.app.mine.too = 'Hello'
```

```
-- Within the USB terminal or via Update.txt:
lv i.app.mine
```

# Info `i.cell` : Cellular Information

## Modem activity

### `i.cell_pha` v1.10 removed

**Description** The current, or last, phase of the cellular activity. (If i.cell_sta is 'off' then this is the last phase).

- _ / NIL = idle
- 'update' = update process
- 'ntp' = time sync
- 'pass' = pass thru
- 'toa' = Terminal Over Air
- 'user' = User Process
- 'data' = Data Upload
- 'loop' = Loopback control
- 'hold' = Hold-off

### `i.cell_pwr`

**Description** Total number of seconds the modem has been powered.

### `i.cell_sta`

**Description** String containing the state of the modem:

- `'off'` = powered off
- `'pwr'` = powering on
- `'reg'` = registered
- `'online'` = PDP context
- `'fail'` = serious error
- `'?'` = unknown error

# Modem timings

Cellular timings are split into the "Current" details, and the "Last" details - so you can see what the last transfer status was.

`i.cell_c_XXXX` has the current timings; `i.cell_l_XXXX` has the last timings.

### `i.cell_X_csq` v1.03

**Description** The signal quality indicator.

- 0-1 = nothing
- 2-9 = marginal
- 10-14 = ok
- 15-19 = good
- 20-31 = excellent
- 99 = unknown

## i.cell_X_log v1.10

**Description** Brief textual log of the modem activity and errors.

When the modem is powered up, the string starts with a colon ":".

Each job is listed. Any errors are listed with an exclamation mark "!" followed by the error.

Additional jobs are delimited by a comma "," and when the job list is complete the string is terminated with a full-stop "."

```
i.cell_c_log = ':ntp,update,test!FTP(625/530)!Connect.'
```

Shows that NTP time sync worked; the update process worked; but the test phase failed with an FTP 530 error (not logged in) - which failed the connection phase.

## i.cell_X_od v1.03

**Description** Online Duration. How many seconds the rt.buffer was online for.

> Being online only implies an IP address anddoes not guarantee access to the wide Internet.

## i.cell_X_pd v1.03

**Description** Power Duration, in seconds. i.e. how many seconds the modem was powered up.

## i.cell_X_pu v1.03

**Description** Power UTC. The UTC time the modem was successfully powered up. (Power was applied about 5 seconds earlier.)

## i.cell_X_rs v1.03

**Description** Registration Seconds. How many seconds it took to get registered on the cellular network.

## i.cell_X_sc v1.03

**Description** Server Connected. Whether the IoT server was connected.

- 0=no server(s) connection
- 1=at least one server connection made

# Info `i.fw` : Firmware Information

## i.fw_blv

**Description** BootLoader version

## i.fw_date

**Description** Firmware date

## i.fw_desc

**Description** Firmware name

## i.fw_ver

**Description** Firmware version

# Info `i.iot` : IoT Information

## `i.iot_var`

| | |
|---|---|
| **Description** | The actual number of seconds this rt.buffer will have variance-enabled schedules delayed. |

# Info `i.lua` : Lua Information

## `i.lua_run`

| | |
|---|---|
| **Description** | The seconds-alive value when the Lua App was started. |

Zero means there is no Lua loop running - either onLoop has quit, or has not been defined.

# Info `i.rt` : rt.buffer Information

## `i.rt_cbf`

**Description** Number of configuration store bytes free.

## `i.rt_sn`

**Description** Serial number string

## `i.rt_utc`

**Description** The current time.

# Info `i.smp.XXXX` : Samples

This is a real Lua table that is used for the activities of the Lua App's Sample (smp) library. By default, any record that is saved by the Lua App will update these info entries.

These parameters are only updated when the default smp table (ft) is used. When other tables are used - e.g. when handling multiple sample files - these info variables are not updated.

## `i.smp.cnt`

| | |
|---|---|
| **Description** | The number of times that smp.save has been called. |

This counter is reset if the rt.buffer is cold-booted, watchdog restarted, or Lua reboots.

## `i.smp.txt`

| | |
|---|---|
| **Description** | The last text that was written with smp.save |

## `i.smp.utc`

| | |
|---|---|
| **Description** | The UTC time that smp.save was last called |

# Info `i.pwr` : Power Information

## `i.pwr_alv`

**Description** Seconds alive.

## `i.pwr_ccb`

**Description** Battery capacity, in C.

## `i.pwr_ccu`

**Description** Estimated charge used

## `i.pwr_full` v3.00

**Description** Set to `1` if running at full power.

`0` = running on backup mode.

## `i.pwr_pct` v1.00

**Description** Estimated percentage power remaining (0-99%)

## `i.pwr_slp`

**Description** Number of seconds spent asleep (in ultra-low power mode).

## i.pwr_tob

**Description** Number of seconds running on battery.

# Terminal Commands

These commands apply to the `rt.buffer>` prompt that is available through rtbTool via USB, serial, or TCP Terminal-Over-the-Air.

# Terminal: Internal Debug Commands

These commands are not guaranteed to remain, and the format may change. They are primarily for Scannex development and testing.

## `led`

**Description** Show LED status.

## `mv`

**Description** Show the millivolt readings for power, etc.

## `ninv`

**Description** Show the sense inputs on the COM ports.

## `pmm`

**Description** Show power manager modes.

## `wde`<br>`wde0`

**Description** Show watchdog entries.

`wde0` will reset the maximum counters.

## `work-`<br>`work+`

| | |
|---|---|
| **Description** | Decrement or increment the counter for hard-work. |

If the counter is >0 then the CPU runs at 96MHz and will not enter low power mode.

# Terminal: External Devices

## `adc`

**Description** Show the ADC readings.

## `pcr`

**Description** Pulse Counter Reset.

## `pcv`

**Description** Show Pulse Counter Values.

## `pt[@]d [STOP]`
## `pt[@]d[s] [STOP]` v3.31

**Parameters**

- `@`: Include the '@' symbol to pass the characters directly to the terminal. Without the '@' then control characters are escaped in Javascript/Lua/C style.
- `d`: Use the 'Device' COM port
- `s`: Optionally show the [LINK]/[link] states and [CTS]/[cts] line
- `STOP`: Optional Lua expression to alter the stop sequence. Normally the [ESC] key quits the pass through mode.

**Description** Enter pass-through mode for the Device COM port.

Use the `pt@d` format when using software to communicate directly through rtbAPI.dll or USB-HID control.

Without the `@` symbol e.g. a NULL will be escaped in ASCII as '\x00', an ACK character as '\x06' etc. See https://en.wikipedia.org/wiki/Escape_sequences_in_C - but `\r`, `\n`, and `\t` are sent as real characters CR, LF, TAB.

Although the STOP can be a string sequence, the terminal is not fully buffered. If you are using a keyboard, then just use a single character!

```
ptd
pt@d
ptd '!'
ptd '\x1b'
ptds
```

## pt[@]e [STOP]<br>pt[@]e[s] [STOP] v3.31

**Parameters** (as for ptd above)

**Description** Enter pass-through mode for the Engineer COM port.

# Terminal: General Functions

```
boot
reboot
```

**Description** Reboot the rt.buffer immediately. If USB is connected, the rt.buffer will remain in the Boot Loader for 5 seconds (unless you type a boot loader command).`

```
deepsleep
```

**Description** Turn 'off' the rt.buffer.

> You can only wake up by reconnecting the Engineer serial port or USB for more than 1 second.

```
info
```

**Description** Show information about the firmware.

```
temp
```

**Description** Show temperature.

```
time
time YYYY-MM-DD HH:MM:SS [TZ]
```

**Parameters**

- `YYYY`: Year
- `MM`: Month
- `DD`: Day
- `HH`: Hour
- `MM`: Minute
- `SS`: Second
- `TZ`: (Optional)timezone offset, in minutes

**Description** Show the current time information, or set and show the time.

# Terminal: Lua Core

## `lboot`

| | |
|---|---|
| **Description** | Reboot Lua. |

If the modem is active, the actual reboot will occur once Lua is unlocked. v3.00

The prompt will be shown when the reboot has happened. [ESC] will return to the prompt. v3.00

## `lgc`<br>`lgc0`

| | |
|---|---|
| **Description** | Garbage collect Lua memory and show stats. |

`lgc0` will show and reset the statistics.

## `lm`<br>`lm0`

| | |
|---|---|
| **Description** | Show Lua memory stats. |

`lm0` will show and reset the statistics.

## lv LIST<br>?LIST v1.00

**Parameters**
- `LIST`: comma separated list of values

**Description** Show Lua value tree(s), or specific values.

=CMD v1.00 NOTE: `=CMD` is effectively the short-cut for `lx return CMD`

```
lx iot.go()
lx return iot.flg()
/return rt.ms()
```

## c.KEY = VALUE

**Parameters**
- `KEY`: Configuration key name
- `VALUE`: Value in Lua format.

**Description** Set a configuration value.

```
c.iot_url='ftp://ftp.scannex.com/Path/To/Success'
```

Can also be used to wipe out a setting, or a tree of settings, using the Lua 'nil':

```
c.iot_url=nil
c.iot=nil
```

## `lf FILE`

**Parameters**
- `FILE`: Filename to run

**Description** Execute a Lua file.

> If FILE does not include a `/` character, then `/Lua/` is assumed.

> If FILE does not include a `.` character, then `.lua` is assumed.

# Terminal: NAND Flash

## `nfcheck`

**Description** Check the flash disk.

## `nfdel FILE`

**Parameters**

- `FILE`: Full path and filename

**Description** Delete a file from flash disk.

## `nfdir PATH`

**Parameters**

- `PATH`: Path of the folder to view.

**Description** Show the folder listing.

The path separator character is forward-slash `/` (Like UNIX/Linux, not Windows!)

## `nfformat`

**Description** Erase EVERYTHING.

There is no way to undo this command! You WILL lose everything in the rt.buffer

## `nfinfo`

**Description** Show information about the flash drive.

## `nfmkdir PATH`

**Parameters**

- `PATH`: Full path

**Description** Make a folder, and intermediaries.

```
nfmkdir /Temp/Dir/Here
```

## `nfmove SOURCE TARGET`

**Parameters**

- `SOURCE`: Source path + filename
- `TARGET`: Target path + filename

**Description** Moves a file or folder.

## `nfrename SOURCE TARGET`

**Parameters**

- `SOURCE`: Source path + filename
- `TARGET`: Target filename (no path!)

**Description** Rename a file.

## `nfrmdir PATH`

**Parameters**
- `PATH`: Full path

**Description** Remove a folder. Will fail if the folder is not empty

## `nftype FILE`

**Parameters**
- `FILE`: Full filename

**Description** Shows the contents of a file.

## `nfwipedir PATH`

**Parameters**
- `PATH`: Full path

**Description** Wipe a folder, including all its contents.

> There is no way to undo this! May take a long while to execute, especially if there are lots of files.

## `nfwrite FILE`

**Parameters**
- `FILE`: Path and filename

**Description** Write to a file. (Used internally by the rtbTool GUI app and rtbAPI tools)

# BootLoader Terminal Commands

These USB-HID terminal commands apply to the `bootloader>` prompt.

### `boot`<br>`reboot`

**Description** Reboot the rt.buffer.

### `deepsleep`

**Description** Turn 'off' the rt.buffer.

You can only wake up by reconnecting the Engineer serial port or USB for more than 1 second.

### `eraseall`

**Description** Erase the whole NAND flash - erasing all Lua Apps, settings, and stored data.

The firmware and bootloader are not affected.

> ⚠ You will lose everything that was stored. Each block of NAND flash is physically erased. This is useful if the data was sensitive and the device needs to be shipped.

### `erasefw`

**Description** Erase the current application firmware. Only the bootloader will remain.

This will not affect any stored NAND flash data.

## `info`

**Description** Show information about the rt.buffer, bootloader, and application firmware.

## `run`

**Description** Leave the bootloader and run the install firmware.

# LED Sequences

The single, ultra-bright, amber LED gives an indication of the state of the rt.buffer. LED sequences consist of pairs of flashes.

Do not stare directly into the LED - it is *very* bright (especially if the top lid is off)!

In the list below, e.g. "12" = one flash + pause + two flashes

- Status
  - 11 = Alive (every 10 seconds)
    - If the rt.buffer is in ultra-low power mode the LED will be very dim, otherwise you'll see the '11' sequence but at normal brightness.
  - 11 = Alive (every 30 seconds) v3.00
    - The rt.buffer is in 'backup' battery mode (Lua not running)
  - 12 = Data has been stored
- Engineer Port
  - 22 = Engineer USB connected
  - 23 = Engineer USB in use
  - 25 = Magnet triggered
- Modem
  - 31 = Modem powering up
  - 32 = Modem registered
  - 33 = Modem online
- Boot Loader
  - 41 = Boot Loader active
  - 42 = USB running
  - 44 = Upgrading firmware
  - 45 = No Application BLF
- Faults
  - 54 = Debug
  - 55 = Fault

# Example Lua App

To illustrate how to start coding a Lua App, consider an app that logs digital pulse counts.

> This example uses the v2.00+ `coro` coroutine library.

# The Main Sample

```
function GetSample()
 local p1,p2 = dpc.rst()
 local t = {p1,p2}
 smp.save( smp.csv(t) )
end
```

At the moment, the function will not be called.

So, we need to glue in a job schedule, and define a job:

```
function onJob1()
 coro.add(GetSample)
end

job.set(1, '00:01')
```

# Keeping Tally

Let's now extend the app to keep a total, where: `total = total + p1 - p2`

```
pt = 0 -- the total ①

function GetSample()
 local p1,p2 = dpc.rst()
 pt = pt + p1 - p2 ②
 local t = {p1,p2,pt} ③
 smp.save( smp.csv(t) )
end
```

① `pt` has the running total

② The value is updated

③ We create a temporary table to convert to CSV

Now, you can see the temporary table `t` also has the value of `pt` logged.

# Linking the Schedule into the Configuration

Let’s make the job setting more flexible by linking into the config table.

You’ll see we’ll make use of Lua’s "or" - that takes the default if there is no config value defined (i.e. it’s NIL):

```
job.set(1, c.myapp_job or '00:01')
```

# Updating the Schedule Immediately

At the moment, the schedule is only assigned when Lua reboots (or the rt.buffer starts up). To apply the job settings whenever the configuration changes, we need to put the job.set function inside an onConfig handler function:

```
function onConfig()
 job.set(1, c.myapp_job or '00:01')
end
```

# Adding Diagnostic Information

To illustrate making life easier to debug, we can feed back some information back into the i.app table. Let's just add the `t` table by adding the highlighted line:

```
local t = {p1,p2,pct}
i.app.t = t ①
smp.save( smp.csv(t) )
```

① The whole table is saved for examination in `i.app.t`

# Adding Pressure Readings

It's not difficult to add the pressure reading as well:

```
function GetSample()
 local p1,p2 = dpc.rst()
 pt = pt + p1 - p2
 local pv = rt.adc() ①
 local t = {p1,p2,pt,pv} ②
 i.app.t = t
 smp.save( smp.csv(t) )
end
```

① Reads the ADC value into `pv`

② Adds it to the table for conversion to CSV

# Adding ADC Scaling

Now, let’s add `y=mx+c` scaling, by linking the `rt.adc` command into the values: `c.adc_m` and `c.adc_c`

```
local pv = rt.adc(c.adc_m or 1, c.adc_c or 0)
```

Again, you can see the default values being used.

# Adding file headers and footers

Here, we can add a header that consists of all c & i values, with a blank CR/LF. In addition, the `ft` assignment makes use of the built-in MD5 hash generator to add an ASCII hash at the end of the file:

```
function Hdr(tb,h,nm)
 fc.lv(h, 'c,i', '\r\n')
end
ft = {h=Hdr,f=smp.t_md5}
```

# Full Listing

```
--------------------------
-- Demo App
-- Logs: time,count1,count2,total,adc
--------------------------
pt = 0 -- the total

function Hdr(tb,h,nm)
 fc.lv(h, 'c,i', '\r\n')
end
ft = {h=Hdr,f=smp.t_md5}

function GetSample()
 local p1,p2 = dpc.rst()
 pt = pt + p1 - p2
 local pv = rt.adc(c.adc_m or 1, c.adc_c or 0)
 local t = {p1,p2,pt,pv}
 i.app.t = t
 smp.save( smp.csv(t) )
end

function onJob1()
 coro.add(GetSample)
end

function onConfig()
 job.set(1, c.myapp_job or '00:01')
end
```

Configuration settings can be controlled through:

```
c.adc_m = 1 -- Slope
c.adc_c = 0 -- Offset
c.myapp_job = '00:01' -- Job string for logging
```

# Terminal Over the Air (TOA) Details

The Terminal Over the Air (TOA) establishes a TCP client connection to an Internet server so that full terminal functions can be executed remotely.

The Internet-connected server can be a port-forwarding rule into a user's PC, or into a server (e.g. node.js) that can act as a broker for the rt.buffers and the user connections (which might be Telnet, Web-access, etc).

The config values `c.toa_XXX` set the URL, the timeouts, and the shared key. This section provides details on the TOA protocol, and authentication phase.

# Sequence of Connection

The sequence works as follows:

1. The TOA job gets requested, e.g. through `iot.go('toa')`
2. The rt.buffer will try for c.toa_try seconds:
3. Make TCP or TCP+SSL connection to c.toa_url
4. On connection, send the CONNECT TOA header
5. If c.toa_key is set, the rt.buffer will wait for a response of the correct SHA-256 key
6. The TCP connection then carries raw terminal commands (the PASSWORD prompt may be enabled if either c.toa_pass or c.term_pass is set)
7. (During connection you can issue commands - concurrently with the USB terminal, if connected)
8. If nothing is received by the rt.buffer in c.toa_ito seconds, the connection is dropped.

# CONNECT header

```
CONNECT /Tester TOA/1.0
serial: 99889988
site: Test
time: 2018-01-09 14:31:31 UTC
utc: 1515508291
device: rt.buffer;co=Scannex
version: 1.10;bu=0118;da=2018-01-09;na=rt.buffer.Lua;ca=.uft.dlo.
idle: 120
user: matt
sha: 88f62c194223beefcdbb43ef39181dcfb4bbef0801672fcfe5ace0c779badd4f


<<rt.buffer>>>
```

## `CONNECT /Tester TOA/1.0`

**Description**

- `CONNECT`: The verb
- `/Tester`: The path from the URL. Use this for any purpose, e.g. routing traffic.
- `TOA/1.0`: Terminal Over the Air protocol version 1.0

Very similar to an HTTP header, this is the first line that is sent - allowing a broker to route the incoming connection.

### `device: rt.buffer;co=Scannex`

**Description** The device type and company (co).

### `version: 1.10;bu=0118;da=2018-01-09;na=rt.buffer.Lua;ca=.uft.dlo.`

**Description** The firmware version.

- `bu` = Build number
- `da` = Build date
- `na` = Name of application firmware
- `ca` = Capabilities of firmware.

### `idle: 120`

**Description** Idle time, in seconds. See `c.toa_ito`.

### `user: matt`

**Description** If the URL contains a user, e.g. `tcp://matt@mylocation.com:1234/Tester` then the username is added to the set of headers. Use this for routing incoming connections.

### `utc: 1515508291`

**Description** The computer-readable UNIX-style UTC timecode.

## `site: Test`

**Description** The site name of the rt.buffer.

## `time: 2018-01-09 14:31:31 UTC`

**Description** The human-readable local time of the rt.buffer.

## `serial: 99889988`

**Description** The serial number of the rt.buffer.

## `sha: 093d300671ff1878fa4da0345f4d0a8ea365c1ab9b4bef7600b17d867a8edcce`

**Description** If the shared key is not blank (`c.toa_key`) then:

```
sha = HMACSHA256( '', c.toa_key | HEADER )
```

If the shared key is blank, then:

```
sha = HMACSHA256( SECRET, HEADER )
```

Only the header text is used, with CR/LFs.

In the above example:

```
sha = HMACSHA256("secret", CONNECT /Tester TOA/1.0\r\nserial: 99889988\r\nsite:
Test\r\n
time: 2018-01-09 14:31:31 UTC\r\nutc: 1515508291\r\ndevice:
rt.buffer;co=Scannex\r\nversion:1.10;bu=0118;da=2018-01-
09;na=rt.buffer.Lua;ca=.uft.dlo.\r\nidle: 120\r\nuser: matt")
```

# CONNECT header with Authentication

```
CONNECT /Tester TOA/1.0
serial: 99889988
site: Test
time: 2018-01-09 14:47:12 UTC
utc: 1515509232
device: rt.buffer;co=Scannex
version: 1.10;bu=0118;da=2018-01-09;na=rt.buffer.Lua;ca=.uft.dlo.
idle: 120
user: matt
auth: hmac.sha256
sha: 093d300671ff1878fa4da0345f4d0a8ea365c1ab9b4bef7600b17d867a8edcce
sha:
```

The header is the same as the non-authenticated header, but the "auth" field is present, and the rt.buffer waits for the SHA-256 response.

## sha:[TAB]

**Description** The rt.buffer is waiting for a line of text that should be the ASCII-hex of the HMAC-SHA-256:

```
shar = HMACSHA256( secret, sha )
```

e.g. if c.toa_key = 'secret':

```
shar = HMACSHA256("secret",
"093d300671ff1878fa4da0345f4d0a8ea365c1ab9b4bef7600b17d867a8edcce")
```

If the SHA response is correct, the rt.buffer will then present the terminal (either the PASSWORD prompt, or the rt.buffer prompt). In this case, 'shar' calculates to `c7ef5df1bf21df68ebf302174c1c844f57cd37d47c9251fd07f880794d6d25b2`, and sending this will unlock the connection:

```
sha: 093d300671ff1878fa4da0345f4d0a8ea365c1ab9b4bef7600b17d867a8edcce
sha: c7ef5df1bf21df68ebf302174c1c844f57cd37d47c9251fd07f880794d6d25b2


<<rt.buffer>>>
```

## `auth: hmac.sha256`

**Description** Indicating that an HMAC-SHA-256 response will be expected before the link is established.

# HTTP POST Protocol

The HTTP protocol uses custom headers that begin with `rtbuffer-`, along with the HTTP `POST` verb.

The protocol also supports HMAC-SHA256 handshaking for a cryptographic 'lock' between the rt.buffer and the server.

A sample PHP server application is available from Scannex.

The protocol allows sending zlib compressed data; cellular info; diagnostics dumps; general files; and update events.

Files from the rt.buffer are sent as multipart/post.

Files from the server are sent as a binary response, with additional data in custom headers.

> The rt.buffer always uses 'Keep Alive' - so the server is forced to use Content-Length in the response. Otherwise, the server could use chunked, or no content-length (which is then unreliable).

# Custom Headers

All the custom headers begin with `rtbuffer-`.

## `rtbuffer-req`

**Description** The `req` header specifies what action the server should take.

- `'upd'` = Check for updates.
- `'put'` = rt.buffer is putting a file onto the server
- `'get'` = rt.buffer would like to request a file from the server
- `'ack'` = rt.buffer is acknowledging completed update
- `'nak'` = rt.buffer is telling the server there was an error with the update

## `rtbuffer-serial: SERIAL`

**Description** The serial number of the rt.buffer.

## `rtbuffer-name: NAME`

**Description** The name of the rt.buffer (from `c.site_name`).

## `rtbuffer-utc: UNIXTIME; tz=OFFSET`

**Description** The UNIX UTC time, and timezone (tz=) of the rt.buffer. `tz` is expressed in minutes.

### `rtbuffer-sha: HEXSTRING`

**Description** Authentication HMAC-SHA256 hex string.

### `rtbuffer-req: nak; msg=MESSAGE`

**Description** The rt.buffer failed to apply the update.

### `rtbuffer-req: upd`

**Description** The rt.buffer is requesting an update file.

The server should reply:

- Nothing to do:
  - `rtbuffer-ack: 0`
- Data to process:
  - `rtbuffer-ack: 1`
  - File contents of `update.txt` should be sent as `Content-Type: application/octect-stream`
  - The rt.buffer will then execute the lines (if `rtbuffer-sha` agrees)

### `rtbuffer-req: ack`

**Description** The rt.buffer completed the update.

## `rtbuffer-req: put; fn=FILENAME`

| | |
|---|---|
| **Description** | `fn` is the target source filename. Of course, the server script can override this. |

The multipart/post will also include:

- `name` = The type of file
  - `'diag'` = diagnostics dump
  - `'data'` = data file from the /Send/ folder
  - `'cellinfo'` = cellular survey information file
  - `'file'` = other file (e.g. pulled by the update process)
- `filename` = The target filename. '.zlib' will be appended if the file is zlib-compressed

## `rtbuffer-req: get; fn=FILENAME`

| | |
|---|---|
| **Description** | rt.buffer is requesting the file `FILENAME`. The filename will be as passed within the `update.txt` file. Consequently handling of relative and absolute paths can be handled within the server-side script. |

The sample PHP script adjusts relative paths based on the buffer's serial/name, and absolute paths based on the pseudo root path. The PHP script also checks for stupid values that break out of the pseudo root (e.g. '../../../../../../../sbin/somenastyfile')

The server should reply:

- File does exist:
  - `rtbuffer-ack: 0`
- File exists:
  - `rtbuffer-ack: 1`
  - File contents should be passed as application/octet-stream

### `rtbuffer-upd: now`

| | |
|---|---|
| **Description** | The server can add this header to tell the rt.buffer that it needs to perform an update request. |

# Example - Sending Diagnostics

## rt.buffer sends

```
POST /rtb/upload.php/Update/No99889988 HTTP/1.1
User-Agent: rt.buffer.Lua/3.00.0157 (2019-03-22)
Host: 217.37.194.108:80
Accept: */*
rtbuffer-req: put; fn=diag.99889988.txt
rtbuffer-serial: 99889988
rtbuffer-utc: 1553531822; tz=0
rtbuffer-sha: 610cd0e71a1487752c5cac64dd95249d4df21685d23a18c7baabeb5f5c7b236a
Connection: keep-alive
Content-Type: multipart/form-data; boundary=--------
aSiQmphJ5k4BnWJjwnAOXpPboH31W0iD--------
Content-Length: 1716

----------aSiQmphJ5k4BnWJjwnAOXpPboH31W0iD--------
Content-Disposition: form-data; name="diag"; filename="diag.txt.zlib"
Content-Type: binary/octet-stream;
```

## Server replies

```
HTTP/1.1 200 OK
Date: Mon, 25 Mar 2019 16:37:00 GMT
Server: Apache
X-Powered-By: PHP/5.4.16
rtbuffer-ack: 1
rtbuffer-sha: 6ecc930cac1b91c69c828265541696e6883589ac4cf0dfa829b0a6ff3d31f099
Content-Length: 0
Keep-Alive: timeout=5, max=100
Connection: Keep-Alive
Content-Type: text/html
```

# Example - Requesting Updates

## rt.buffer sends

```
POST /rtb/upload.php/Update/No99889988 HTTP/1.1
User-Agent: rt.buffer.Lua/3.00.0157 (2019-03-22)
Host: 217.37.194.108:80
Accept: */*
rtbuffer-req: upd
rtbuffer-serial: 99889988
rtbuffer-utc: 1553531819; tz=0
rtbuffer-sha: fe7d8abedcc514ab9e7c6d6db08ed6ef86cb8e1af9332c9cd9b8d70eb647fd05
Connection: keep-alive
Content-Length: 0
```

## Server replies

```
HTTP/1.1 200 OK
Date: Mon, 25 Mar 2019 16:36:57 GMT
Server: Apache
X-Powered-By: PHP/5.4.16
rtbuffer-ack: 0
rtbuffer-sha: 72f1beb92e3a7a9360e448d5f1622757bffe0d8cbb8c6d8d52f7d83d913f29c6
Content-Length: 0
Keep-Alive: timeout=5, max=100
Connection: Keep-Alive
Content-Type: text/html
```

# Crypographic Hash Calculations

## Initialisation

HMAC is HMAC-SHA-256

```
SECRET = 'RTB1:' + SHARED_SECRET
SERVER_SECRET = HMAC( '|' + HOST_ID + '|',  SECRET)
```

Having a separate SERVER_SECRET based on the HOST_ID means the specific hash can be safely stored in the PHP script. If the server is compromised then the SHARED_SECRET is not compromised.

## Verifying rt.buffer Request

```
DATA = 'POST' + '|' +
  [rtbuffer-req] + '|' +
  [rtbuffer-serial] + '|' +
  [rtbuffer-name] + '|' +
  [rtbuffer-utc]
```

e.g.

```
DATA = 'POST|upd||99889988|153531819; tz=0'
```

For each file:

```
FILE_SHA = FILE_SHA .. '|' + NAME + '|' + CONTENTS + '|'
```

So, use a single SHA256 context, and hash in the name and contents for each file in turn.

SHA-256, not HMAC-SHA-256

```
CALC_SHA = HMAC( DATA + '|' + FILE_SHA, SERVER_SECRET )
```

Then `CALC_SHA` should match the contents of `rtbuffer-sha`

# Generating Response

```
HASH_DATA = [rtbuffer-sha] + '|' + HEADERVALUE + '|' + HEADERVALUE ''æ etc
```

`HEADERVALUE` is the value of each `rtbuffer-XXXX` header. e.g. "□0"□ or "□1"□ for `rtbuffer-ack`.

`HASH_OF_FILE` = either `SHA256( '' )` if there is no file, or `SHA256( CONTENTS )`

```
REPLY_SHA = HMAC( HASH_DATA + '|' + HASH_OF_FILE, SERVER_SECRET )
```

This REPLY_SHA should be sent back as `rtbuffer-sha: REPLY_SHA`

# Software Licenses

# Operating System

- Segger embOS
- Segger emFile
- Segger emUSBD

Portions:

```
(c) 2014 - 2019 SEGGER Microcontroller GmbH & Co. KG
www.segger.com Support: support@segger.com
```

# Cortex Support Libraries (CMSIS)

# Atmel Files

Portions of Atmel's ASF have been used:

# Lua License

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(end of COPYRIGHT)

# Libstruct Library

# eLua additions

Some portions of the eLua project have been used:

```
Copyright (c) 2007, 2008, 2009, 2010, 2011 Dado Sutter and Bogdan Marinescu

eLua is Open Source and is freely distributed under the MIT licence.

The Lua part of eLua is licensed under the Lua licensing terms, which
you can find at http://www.lua.org/license.html.

The "pack" module is adapted from the "lpack" module by Luiz Henrique de
Figueiredo and it's placed in the public domain.

The "bit" module is adapted from the "bitlib" library by Reuben Thomas,
distributed under a MIT license.

The multiple memory allocator (dlmalloc) is written by Doug Lea and is
placed on the public domain.

Manufacturer provided CPU support libraries are licensed under their own
terms, check src/platform/*platform-name* for details.
```

The rest of the eLua code is licensed under MIT, listed below: The MIT License

```
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DEALINGS IN THE SOFTWARE.
```

# zlib Compression Library

```
zlib.h -- interface of the 'zlib' general purpose compression library
 version 1.2.11, January 15th, 2017

Copyright (C) 1995-2017 Jean-loup Gailly and Mark Adler

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Jean-loup Gailly        Mark Adler
jloup@gzip.org          madler@alumni.caltech.edu

The data format used by the zlib library is described by RFCs (Request for
Comments) 1950 to 1952 in the files http://tools.ietf.org/html/rfc1950
(zlib format), rfc1951 (deflate format) and rfc1952 (gzip format).
```

# Cryptographic Functions

Portions of mbedTLS have been used:

# U8G2 LCD Library

https://github.com/olikraus/u8g2

```
The U8g2lib code (http://code.google.com/p/u8g2/) is licensed under the terms of
the new-bsd license (two-clause bsd license).
See also: http://www.opensource.org/licenses/bsd-license.php

The repository and optionally the releases contain icons, which are
derived from the WPZOOM Developer Icon Set:
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Fonts are licensed under different conditions.
See
  https://github.com/olikraus/u8g2/wiki/fntgrp
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============ X11 Fonts COUR, HELV, NCEN, TIM, SYMB ============

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HELVB18.BDF HELVB24.BDF HELVR08.BDF HELVR10.BDF HELVR12.BDF HELVR14.BDF
HELVR18.BDF HELVR24.BDF NCENB08.BDF NCENB10.BDF NCENB12.BDF
NCENB14.BDF NCENB18.BDF NCENB24.BDF NCENR08.BDF NCENR10.BDF
NCENR12.BDF NCENR14.BDF NCENR18.BDF NCENR24.BDF SYMB08.BDF SYMB10.BDF
SYMB12.BDF SYMB14.BDF SYMB18.BDF SYMB24.BDF TIMB08.BDF TIMB10.BDF
TIMB12.BDF TIMB14.BDF TIMB18.BDF TIMB24.BDF TIMR08.BDF TIMR10.BDF
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