



rt.buffer Reference Manual

Scannex Electronics Limited

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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.YYYYYMMDDHHMMSS.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 rt.buffer product.

Modifications to Lua 5.1

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\xff'` 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 $y=mx+c$



hardware iss2/iss3 ADC is LTC2485, 24-bit delta-sigma, that has V-REF = 3.0V.



hardware iss4 is TI ADS122C04/ADS112C04, 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.

```
adco = adc.obj(n, [adct]) v4.00
```

Get ADC object

- Parameters**
- **n**: Slot number (0-7)
 - **adct**: (optional) [configuration table](#)

- Returns**
- **adco**: ADC object

Description Provides access to an ADC object for measurement and control.

```
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.

Library `adc` | `adco` : ADC Objects

These functions work on the object returned from `adc.obj()`.

For the sake of documentation, these are shown to refer to 'adco'

```
fa = adco:array([fa]) v4.20
```

Get/set ADC Object float array

Parameters

- `fa`: float array (from `float.array`) to assign

Returns

- `fa`: the float array for the ADC objec

Description Returns, or sets the float array that will hold the discrete samples from the ADC object.

```
adct,ave,std,ts,working,ndone = adco:get() v4.00
```

Get ADC Object settings

Parameters None

Returns

- `adct`: ADC [table](#) of settings
- `ave`: mean value
- `std`: standard deviation
- `ts`: timestamp of first sample
- `working`: whether still sampling
- `ndone`: number of samples completed

Description Returns the readings and values.

adco:go() v4.00

Start ADC Object conversion

Parameters None**Returns** None**Description** Starts the sampling process.**prevstate = adco:pwr([docontrol])** v4.00

Get/set ADC Object power control

Parameters

- **docontrol**: whether to control the reference power

Returns

- **prevstate**: the setting before updating the setting

Description Returns (or modifies) whether to control the reference power during this ADC measurement.**t = adco:range()** v4.20

Get ADC Object ranges

Parameters None**Returns**

- **t**: mean value
 - '**.min**' = minimum
 - '**.max**' = maximum
 - '**.n**' = count

Description Returns the maximum, minimum, and count.

adco:set(adct) v4.00

Set ADC Object settings

- Parameters**
- **adct**: ADC [table](#) of settings
- Returns** None
- Description** Update or change the settings for the ADC object.

ave,var,std,skew,kurt,num = adco:stat() v4.00

Get ADC Object Statistics

- Parameters** None
- Returns**
- **ave**: mean value
 - **var**: variance
 - **std**: standard deviation
 - **skew**: skewness
 - **kurt**: kurtosis
 - **num**: number of data points
- Description** Returns the detailed statistics.

ADC Object Table 'adct'

adct ^{v4.00}

ADC Table Settings

Parameters

- `adct.vp`: Positive channel (0-3)
- `adct.vn`: Negative channel (0-3). If not provided then uses single-ended measurement on `.vp`
- `adct.g`: Gain (1,2,4,8,16,32,64,128). Default=2
- `adct.n`: Number of samples to take
- `adct.t`: Interval (milliseconds) between samples
- `adct.m`: Slope for conversion
- `adct.c`: Offset for conversion
- `adct.raw`: (boolean) = whether to read the ADC raw value
- `adct.pwr`: (integer) = whether to measure with power applied. 0=Off, 1=On, 2=On-always
- `adct.bcs`: (boolean) = whether to use Burnout Current Sources. NOTE: This affects measurement accuracy, but if the sensor is not connected or shorted it will go to full-scale.

Description As used by `adc.set` and returned by `adc.get`

ADC Callback

```
function onAdc() v3.00  
function onAdc(slot) v4.00  
ADC completion callback
```

Parameters • `slot`: The ADC slot that completed

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)
alm.set( {bitfield}, limiton, limitoff)
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 hysteresis zone
- Description** Returns state details about the specified alarm.

Alarm Table 'at'

at

Alarm Table

- Parameters**
- `at.co`: Counts on
 - `at.cf`: Counts off
 - `at.lo`: Limit on
 - `at.lf`: Limit off
 - `at.alm`: true if in the alarmed state
 - `at.vo`: Value on ^{v3.42}
 - `at.vf`: Value off ^{v3.42}

Description As returned by `alm.get(...)`

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. <code>ao.co=0</code> & <code>ao.cf=0</code>

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)
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.

alm.hys = ao:val()

Alarm Object value

Parameters None

Returns

- `alm`: true if active/alerted; false if inactive
- `hys`: true if `ao.co`>0; false if `ao.cf`>0; nil if in hysteresis 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.al(a,b) v3.44
v = bit.alshift(a, b) v3.44
Bit arithmetic shift right
```

Parameters

- `a`: Value to shift (signed 32-bit)
- `b`: Number of bits to shift

Returns

- `v`: Result

Description Returns `a` left shifted arithmetically `b` places.

```
v = bit.ar(a,b)
v = bit.arshift(a, b)
Bit arithmetic shift right
```

Parameters

- `a`: Value to shift (signed 32-bit)
- `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.lshift(a, b)  
v = bit.lshift(a, b)
```

Bitwise left shift

Parameters

- `a`: Value to shift (unsigned 32-bit)
- `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 (unsigned 32-bit)
- **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. `smg`, 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.



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



`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.

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

Coro wait until

Parameters • `ti`: Millisecond interval to wait
 • `ft`: Future time (as returned by `rt.msft`)
 • `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  
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	<ul style="list-style-type: none"> • <code>timeout</code>: Number of milliseconds to wait. If NIL, then waits forever. • <code>ok</code>: 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 two or three parameters:

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

Event callback function

- Parameters**
- **name**: Event name, e.g. "onSec"
 - **idx**: Event index number, 1-32
 - **value**: Optional value relating to the callback

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).

```
attr = fc.attr(fname) v4.00
attr,was = fc.attr(fname, change) v4.00
```

File attributes

- Parameters**
- `fname`: Filename
 - `change`: Change attribute string
 - `attr`: Attribute string
 - `was`: Previous attribute string

Description Query or change file attributes.

- `A` = archive
- `a` = not archive
- `H` = hidden
- `h` = not hidden

```
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 ≤ filemtime < 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.


```
-- 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 file sizes into table
```

```
sc,so = fc.gz(fname, [tname], [del]) v3.43
so,sc = fc.gz(fname, [tname], [del], [decomp]) v4.00
File gzip
```

- Parameters**
- **fname**: Source file name
 - **tname**: Target file name (optional)
 - **del**: Delete source (optional, default=false)
 - **dcomp**: Decompress file. If **fname** ends with **.gz** then this is implied. ^{v4.00}

- 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.

```
fao = float.array(size) v4.00
```

Create new float array object

Parameters

- `size`: Number of elements in the array

Returns

- `fao`: Float Array Object

Description Create a fix-size float array for statistics and FFT/DWT style operations.

```
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 multipliers

- Returns**
- **polyo**: [Polynomial 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)
```

Hex 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

Library float | fao : Float Array Object

```
sv = fao:add(fav) v4.00
sv = fao:sub(fav) v4.00
sv = fao:mul(fav) v4.00
sv = fao:div(fav) v4.00
```

add/sub/mul/div values

Parameters • fav: Float Array or Value

Returns • sv: Sum of all entries in fao

Description Modified the fao entries with add/sub/mul/div, by either referencing another float-array object, or a single value.

e.g.

```
local sv = fa1:sub(fa2) -- fa1[idx] = fa1[idx] - fa2[idx]
local sv = fa1:sub(4.56) -- fa1[idx] = fa1[idx] - 4.56
```



Modifies the values in the array

```
fao:clr() v4.00
```

Clear

Parameters None

Returns None

Description Clears all entries.

```
sv = fao:copy(fav) v4.00
```

Copy values

Parameters

- **fav**: Float Array or Value

Returns

- **sv**: Sum of all entries in **fao**

Description Copies the entries from the float array **fav**, or set to the value **fav**.

```
v = fao:each(func) v4.20
```

Find range

Parameters

- **func**: function to call for each element. **func(i,v)**

Returns

- **v**: return value from the **func**, or nil

Description Iterates through every value in the float array. Calls **func(i,v)** where **i** is the index, and **v** is the value.

If the function returns a non-nil value, the loop is aborted and the value returned. (like Lua 5.0's **table.foreachi** function)

```
sv = fao:ft(wa, [wo], [wi]) v4.00
svt = fao:ft(wa, [wo], [wit]) v4.00
```

Fourier Transform (FFT/DFT)

Parameters

- **wa**: Fourier wave array object
- **wo**: (optional) offset into the wave array (default=0). **true** = 1/4 wave (for cosine)
- **wi**: (optional) increment through wave array (default=1.0)
- **wit**: (optional) table of increments. Negative values will use cosine, positive will use sine.

Returns

- **sv**: Sum value
- **svt**: Table of results

Description Calculate a Fourier style multiply-and-sum with the wave array being repeated as the values of **fao** are iterated.



This is a building block of FFT, not the whole process. It allows calculation of certain harmonics, or of compound wave arrays (where the harmonics have been pre-summed).

Using the **wit** table of increments allows DFT calculations in one call.

e.g.

```
local wa = float.array(256)
wa:sin()
local svt = fao:ft(wa, nil, {1,-1,2,-2,4,-4,8,-8})
```

Calculates $\sin(x)$, $\cos(x)$, $\sin(2x)$, $\cos(2x)$, etc

```
v = fao:get(idx) v4.00
```

Get an array entry

Parameters

- `idx`: Index of the entry to get (1..count)

Returns

- `v`: Value

Description Retrieve a value from the float array.

Returns an out of bounds error if `idx` is not within 1..count.



`idx=1` is the oldest entry



Using `v = fao[n]` will wrap `n` to the number of entries. (i.e. a modulus index access)

```
n = fao:push(v) v4.00
n = fao:push(fao2) v4.20
```

Push value

Parameters

- `v`: Value to push
- `fao2`: Array of values to push

Returns

- `n`: Number of entries in `fao`

Description Push a value into the float array.

If the array is already full, the oldest value is shuffled off to make space.

`t = fao:range()` v4.20

Find range

Parameters None

Returns

- `t`: table of values
 - '`.min`' = Minimum value
 - '`.max`' = Maximum value
 - '`.sum`' = Sum of all values
 - '`.n`' = Number of entries

Description Finds the min, max, sum, and count of the float array object.

`v = fao:set(idx, v)` v4.00

Update an array entry

Parameters

- `idx`: Index of the entry to set (1..count)
- `v`: Value to set

Returns

- `v`: Original value

Description Update a value in the float array.

Returns an out of bounds error if `idx` is not within 1..count.



`idx=1` is the oldest entry

fao:sin() v4.00

Fill with sin values

Parameters None**Returns** None**Description** Fill the array with sin values (a single cycle).

(Cosine can be achieved by a 1/4 offset into the sin array.)

n = fao:size() v4.00

Get array size

Parameters None**Returns**

- **n**: Size of the float array

Description Returns the total size of the float-array.To find the current count, use `n = #fao`**sv = fao:sqrt()** v4.00

Square root entries

Parameters None**Returns**

- **sv**: Sum of all the updated entries in the float array

Description Update each of the entries so that $v = \text{sqrt}(v)$.

Modifies the values in the array

```
rso = fao:stat([idx],[n],[rso]) v4.00
rso,min,max,sum,count = float.stat() v4.20
```

Calculate stats

- Parameters**
- `idx`: (optional) index to start (default=1, modulus)
 - `n`: (optional) count of values (default #fao)
 - `rso`: (optional) Running Stats Object to feed values into

- Returns**
- `rso`: The results

Description Push the values from `fao` into either an existing, or a new, running stats object.



Use `?fa:stat():get()` to return the values.

```
sv = fao:sum() v4.00
```

Sum all values

Parameters None

- Returns**
- `sv`: Sum of all entries in the float array

Description Add all entries in the array

```
t = fao:tab() v4.00
```

Convert to table

Parameters None

Returns None

Description Return the array as a table.

```
sv = fao:wt(wa, [dao], [wi]) v4.00
```

Wavelet Transform (DWT/CWT)

- Parameters**
- **wa**: Wavelet array object
 - **dao**: (optional) offset from the end of **fao** data. (default = `#fao/2`).
 - **wi**: (optional) wavelet increment (default=1.0)

- Returns**
- **sv**: Sum value

Description Calculate a wavelet style multiply-and-sum with a single run of the wave array. The optional **wi** parameter allows stretching or compressing of a single wavelet array object across the data values of **fao**.

The **wa** wave array should be a wavelet (e.g. Mexican hat, Haar, Daubechies, etc)

```
sv = fao:xs([dao],[dai],ra,[ro],[ri],n) v4.00
```

Multiply-and-sum two arrays

- Parameters**
- **dao**: (optional) Data array offset (default=0, modulus)
 - **dai**: (optional) Data array increment (default=1.0)
 - **ra**: Reference Array object
 - **ro**: (optional) offset into referebce (default=0)
 - **ri**: (optional) increment through reference data (default=1.0)
 - **n**: (optional) count of values to process (default `#fao`)

- Returns**
- **sv**: Sum value

Description Iterates through the **fao** object and multiplies by the values in **ra**.

This is the underlying calculation used for both **fao:ft** and **fao:wt**.

Library float | `mpco` : Multi-Point Conversion Object

`mpco:oob(uv,ov)` ^{v3.41}

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}

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.

mpco:set(idx, [x], [y]) ^{v4.20}

Update mpco value

- Parameters**
- **mpco**: Multi-Point-Conversion Object (returned from `[float.mpc]`)
 - **idx**: Index of values ("0"å1)
 - **x**: X-value to change
 - **y**: Y-value to change

Returns None

Description Modifies an mpco data point.



If you modify `x` so that the mpco object becomes unsorted, you **MUST** call `[mpco:sort]`

mpco:sort() ^{v4.20}

Resort mpco values

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

Returns None

Description Resorts the values.

The mpco object relies on binary search for the array - so the values **MUST** be in x-order.

x,y = mpco:xy(index) ^{v3.41}

Get x and 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 = mpc:xyt() v3.41
```

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 = mpc:y(xv) v2.00
```

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`.

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

i 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
```


Library float | polyo : Polynomial Object

`m = polyo:c(idx)` ^{v3.41}

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}

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}

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 conversion 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
```

Library float | `rro` : Running Regression Object

```
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.

```
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 • `rro`: Running Regression Object

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

Can include a mixture of tables and value as parameters.

Library float | `rso` : Running Statistics Object

```
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.

```
ave,var,std,skw,kur,count = rso: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.

```
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.

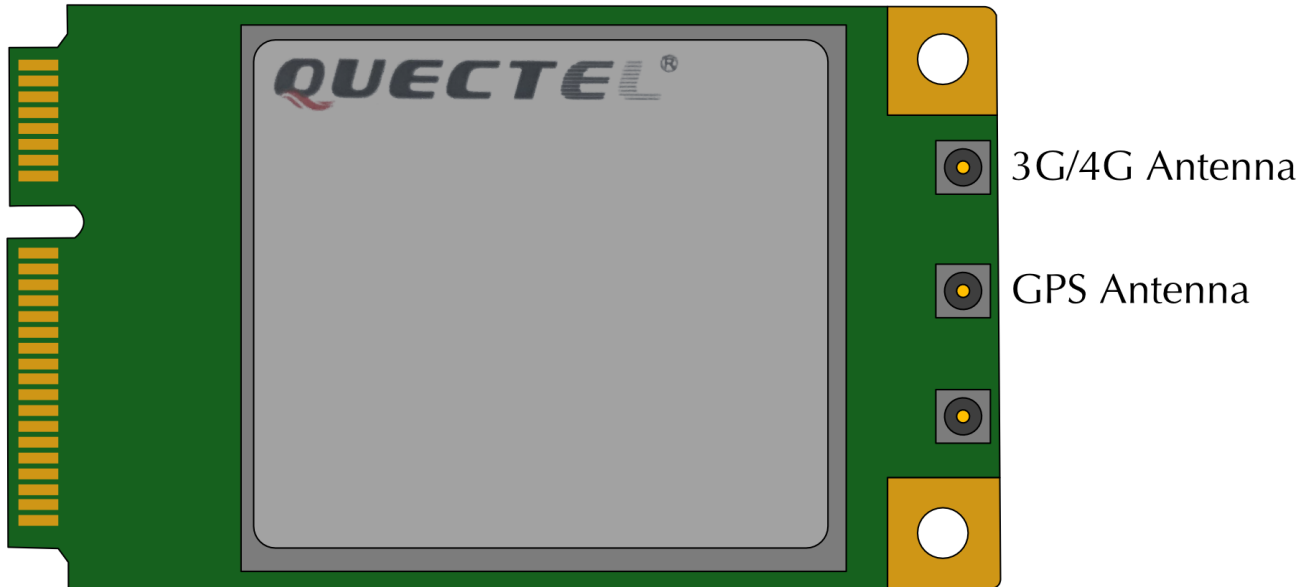
Can include a mixture of tables and value as parameters.

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

Hydrins Table `ht`

Parameters

- `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`: For each, there is a value and optional units. i.e. `ht.TOTm` is the value, and `ht.TOTmu` is the unit string.
- `ht.SPV .SPVu`: (ditto)
- `ht.VMAV .VAMVu`: (ditto)
- `ht.SMV .SMVu`: (ditto)
- `ht.FAV .FAVu`: (ditto)
- `ht.SVG .SVGv`: (ditto)
- `ht.TOTp .TOTpu`: (ditto)
- `ht.TOTm .TOTmu`: (ditto)
- `ht.TOTn .TOTnu`: (ditto)
- `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 .TEMPu`: temperature & units (for Hydrins 2.1 if enabled)
- `ht.NAMUR`: (for Hydrins 2.1 if enabled)

Description Table of values for Hydrins

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
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 \geq `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 than 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 `jq: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` | `jqr` : Job Queue Objects

```
ok = jqr: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 `jqr` 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 = jqr:del()  
count = jqr:del(func, all)  
count = jqr: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 (`jqr:del()`), or a specific set of jobs from the queue.

ok = jco: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 **jco** for a matching **func** + **argt** set. If **argt** is not provided, then checks if there is any **func** queued.

foo, argt = jco: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 $n \times$ 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) 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.

tm,tc = pwr.bpp([tm], [tc]) ^{v4.20}

Set Battery Profile Points

Parameters

- **tm**: Table of battery profile mapping points
- **tc**: Table of coefficient mappings
 - '**.scale**' = the multiplier for V_I-V_m and V_s-V_I
 - '**.mid**' = the mid point
 - '**.coeff**' = the ratio correction coefficient

Returns

- **tm**: Table of battery profile mapping points
- **tc**: Table of coefficient mappings

Description Up to seven points can be defined to override the Coulomb-estimation to provide a more accurate percentage-remaining value for the battery.

Either absolute milli-Volt values or milli-volt drops can be defined.

Negative mV readings are TMV measurements. Positive mV readings are level based measurements.



The percentage value is returned in `i.pwr_pct`.

Two different methods for defining 15%, 8%, 0%:

```
-- absolute mV points
pwr.bpp({ {6100,15}, {6000,8}, {3250,0} })

-- delta/drop values from start mV
pwr.bpp({ {-830,15}, {-920,8}, {-1850,0} })
```



The coulomb estimation will clamp at the first %-age value. So, if the estimation results in 10%, but the millivolt readings are not yet within the range of the `pwr.bpp` values, this will result in 15% (in the examples).

```
was = pwr.cas([v]) v4.20
```

Count Coulombs At Source

Parameters

- `v`: Boolean value, whether to reference Coulombs at source (default:false)

Returns

- `was`: The value prior to setting

Description The default is to measure milli-Amps at the device/sensor - which requires voltage conversion.

When `pwr.cas(true)` is called, all the Coulomb values are at source.

Since there are buck/boost convertors - especially in hardware issue 4 - it is no longer a simple voltage conversion. Physically measuring current/Coulomb use at the power source is much simpler.

```
pc = pwr.dpc([mA, [V]]) v1.00
```

```
pc = pwr.dpc([mC]) v4.20
```

Set the Coulomb consumption for device

Parameters

- `mA`: Current in milliamps
- `mC`: milli Coulombs
- `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.



If `pwr.cas(true)` has been set, the values are milli-Coulombs at source.

To get the current value, pass no parameters.

```
sec = pwr.dpt([true]) v4.20
```

Device Power Time

Parameters

- `true`: Pass `true` to reset the timer to zero

Returns

- `sec`: The number of seconds

Description Returns the duration the power has been on

```
pc = pwr.epc([mA, [V]]) v1.00
pc = pwr.epc([mC]) v4.20
```

Set the Coulomb consumption for engineer

Parameters

- `mA`: Current in milliamps
- `mC`: milli Coulombs
- `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.



If `pwr.cas(true)` has been set, the values are milli-Coulombs at source.

To get the current value, pass no parameters.

```
sec = pwr.ept([true]) v4.20
```

Engineer Power Time

Parameters

- `true`: Pass `true` to reset the timer to zero

Returns

- `sec`: The number of seconds

Description Returns the duration the power has been on

```
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 = $(sa - rt) / sa * 100$

```
cu = pwr.icu([mcu]) v4.20
```

Increment Coulombs Used

Parameters

- `mcu`: **Milli**-Coulombs to increment by

Returns

- `cu`: Total Coulombs used.

Description Manually add milli-Coulomb usage to the total coulombs estimated.



The parameter is mC, the return is C

```
pc = pwr.mpc([mC]) v4.20
```

Set the Coulomb consumption for the modem

- Parameters**
- `mC`: milli Coulombs
- Returns**
- `pc`: Power consumption in milli-Coulombs
- Description** Set or get the Modem power consumption.

To get the current value, pass no parameters.

```
sec = pwr.mpt() v4.20
```

Modem Power Time

- Parameters** None
- Returns**
- `sec`: The number of seconds
- Description** Returns the duration the power has been on.



Same as `i.cell_pwr`

```
tc = pwr.nct() v4.20
```

Get Nano-Coulombs Table

- Returns**
- `tc`: Table of Coulomb values
 - '`.nc.tot`' = total nano-Coulombs
 - '`.nc.dp`' = device nano-Coulombs per second
 - '`.nc.ep`' = engineer nano-Coulombs per second
 - '`.nc.mp`' = modem nano-Coulombs per second
 - '`.t.dp`' = seconds device has been on
 - '`.t.ep`' = seconds engineer has been on
 - '`.t.mp`' = seconds modem has been on

Description Get a table of internal information.



The values are always "Coulombs at Source" values, and not scaled.

`was = pwr.ocb([v])` v4.20

Only Count on Batteries

Parameters

- `v`: Boolean value, whether to Coulomb count while on batteries (default:true)

Returns

- `was`: The value prior to setting

Description By default the Coulomb estimation only happens when the internal batteries are being used.

Calling `pwr.ocb(false)` will set the Coulomb estimation for all power sources.

`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,'?'`

```
tm = pwr.tmvt() v4.20
tmf = pwr.tmvt(true) v4.20
```

Get the transient minimum voltage info as a table

Parameters • **true**: pass true to retrieve a full table

- Returns**
- **tm**: TMV table:
 - '`.tmv.ws`' = TMV which source ('E'=external, '1'=BATT1, '2'=BATT2)
 - '`.tmv.vs`' = Start voltage, mV
 - '`.tmv.vm`' = TMV voltage, mV
 - '`.tmv.vl`' = Minimum of secondary ('level') measurement
 - '`.tmv.sl`' = Start voltage of secondary ('level') measurement
 - '`.tmv.ta`' = Time alive (seconds)
 - '`.mv.b1`' = Battery 1 static reading (mV)
 - '`.mv.b2`' = Battery 2 static reading (mV)
 - '`.mv.ext`' = External static reading (mV)
 - **tmf**: TMV full table (same as **tm** plus):
 - '`.tmv.ext.vs`' = External Start voltage, mV
 - '`.tmv.ext.vm`' = External TMV voltage, mV
 - '`.tmv.ext.vl`' = External 'Level' voltage, mV
 - '`.tmv.b1.vs`' = BATT1 Start voltage, mV
 - '`.tmv.b1.vm`' = BATT1 TMV voltage, mV
 - '`.tmv.b1.vl`' = BATT1 'Level' voltage, mV
 - '`.tmv.b2.vs`' = BATT2 Start voltage, mV
 - '`.tmv.b2.vm`' = BATT2 TMV voltage, mV
 - '`.tmv.b2.vl`' = BATT2 'Level' voltage, mV
 - '`.tmv.sn`' = Number of samples taken

Description Returns the Transient Minimum Voltage information as a table.

`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.

Battery Callbacks

function onPwrPct(tm) ^{v4.20}

Battery Percentage Calculation callback

- Parameters**
- **tm**: Table of values for calculation:
 - '**.pct**' = Coulomb estimation percentage
 - '**.tmv.ws**' = TMV which source ('E'=external, '1'=BATT1, '2'=BATT2)
 - '**.tmv.sv**' = Start voltage, mV
 - '**.tmv.mv**' = TMV voltage, mV
 - '**.tmv.sl**' = Start voltage of secondary ('level') measurement
 - '**.tmv.ml**' = Minimum of secondary ('level') measurement
 - '**.tmv.ta**' = Time alive (seconds)
 - '**.batt.b1**' = Battery 1 static reading (mV)
 - '**.batt.b2**' = Battery 2 static reading (mV)
 - '**.batt.ext**' = External static reading (mV)

- Returns**
- **pct**: Optional percentage value to return

Description A hook for calculating the battery percentage remaining.



The value is used in [i.pwr_pct](#) and for the LCD display.



Values less than 0 and greater than 100 are ignored.

function onTmv(tm) ^{v4.20}

Battery TMV Calculation callback

- Parameters**
- **tm**: Table of values for calculation. The table is the same as for [onPwrPct](#)

- Returns**
- **pct**: Optional percentage value to return

Description Called when the modem handler completes the TMV measurement.

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.

```
pct = pwr._pc([start],[tmv],[level],[perc],[nb]) v4.20
```

Perform percentage calculation

Parameters

- **start**: Starting voltage (mV)
- **tmv**: TMV measurement (mV)
- **level**: Level voltage (mV)
- **perc**: Percentage to assume
- **nb**: Number of batteries

Description Processes the values to estimate a percentage remaining.

`pct = pwr._po([pct])` ^{v4.20}

Apply a percentage override

Parameters • `pct`: Percentage to override. -1 means "not assigned"

Description This applies a percentage override for verifying.

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`.



`rt.print` will output nothing if not in a terminal context, but `print` will output to USB if not in a terminal.

```
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 coroutines 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 representation.

```
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.

```
count,txt = rt.ccr([v]) v4.20
```

Crash Counter Reset

Parameters • `v`: Set to `true` to reset the values, otherwise just read.

Returns • `count`: Number of times crashed
 • `txt`: Last crash reason

Description Reset/read the crash count and text.

```
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. 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.

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.

```
ti = rt.info() v4.20
```

Get Information

Parameters None

- Returns**
- `ti`: Table of information
 - '`.dev.company`' = Device company
 - '`.dev.product`' = Product name
 - '`.dev.desc`' = Device description
 - '`.dev.build`' = Original Build serial number
 - '`.dev.serial`' = Serial number
 - '`.dev.id`' = Device ID
 - '`.dev.tag`' = Asset tag
 - '`.app.ver`' = Application Version (e.g. `4.20.0262`)
 - '`.app.date`' = Application date
 - '`.app.name`' = Application name (e.g. `rt.buffer.Lua`)
 - '`.loader.ver`' = Bootloader Version
 - '`.loader.date`' = Bootloader Date
 - '`.loader.name`' = Bootloader name (e.g. `rt.BootLoader`)
 - '`.boot.count`' = Number of times rebooted ("Start" count)
 - '`.boot.txt`' = Reason for boot
 - '`.crash.count`' = Number of times crashed ("Guardian" count)
 - '`.crash.txt`' = Reason for crash

Description Return details corresponding to the `info` terminal command.

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)
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()
  local t = sdi12.go(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:

```
sdi12 = { {'1C5'}, {'2C1'}, {'2C2'}, {'3CC'} }
```

Once `sdi12.go` and `sdi12.done` have completed, there will be additional fields within the table:

- `sdi12.c` = Comport object
- `sdi12.[#].t` = Millisecond alive time when ready. False if the device did not respond
- `sdi12.[#].n` = Number of samples (if a measurement command)
- `sdi12.[#].v` = Table of results, or a string result

Library `ser` : Serial Ports

```
isen,wasen = ser.bias([enable]) v4.00
```

Set RS485 bias control

Parameters

- `enable`: true to enable bias pull-up

Returns

- `isen`: is bias now enabled
- `wasen`: was bias enabled before change

Description For hardware iss4 (only) this allows script control of the RS485+ pull-up resistor. This allows for better power management if the RS485 bus is live while idling.

```
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 engineer 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]) v1.00
nb,ti = cp:cap(fh, [ms])
nb,ti = cp:cap(file/fh, tab)
```

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 = $\text{size} / 2 \times \text{character-time}$. e.g. at 115200 baud, with `cp:fifo(4096)` will give a time of $4096/2 \times 87\mu\text{s} = 178\text{ms}$.

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:pwr(x(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 pwr(x 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
mode,main = cp:rs(485) v4.00
```

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) -- use add-on board in RS485 (fw v4.00+)
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:rx([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:rx(iison)

Set receive flow control

Parameters • **iison**: True if RTS should unassert when receive buffers are full.

Returns None

Description Set RX flow control (uses RTS line).



If `iison` is true, this also calls `:pwt(true)` and `:rts(true)` Therefore, power will be consumed all the time that `:rx(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:rxt(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 & transmitting
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, **rtx** = 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(smhc, pdu) v1.10
```

SMS callback function

Parameters

- **smhc**: 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 meaningful 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 string *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(addr,[addt])
```

Query TWI bus

Parameters

- `addr`: Device address to start
- `addt`: Device address to finish

Returns

- `a1`: Addresses
- `ok`: If found

Description Queries the TWI bus.

```
res = twi.rd(addr,[txt])
res = twi.rd(addr,num,[v])
```

Read TWI

Parameters

- `addr`: 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

utc = utc.now() ^{v4.00}

Return current UTC

Parameters None

Returns • `utc`: Current UTC time

Description Return the current UTC time.

utcoff, utcon = utc.offt() ^{v4.00}

Get power off time

Parameters None

Returns • `utcoff`: UTC time the power was cut
• `utcon`: UTC time the power was restored

Description Returns the off/on time from the RTC chip (if present).

If no RTC (hardware iss2/iss3) this returns `nil, 'No RTC'`

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,utcoff,batok = utc.rtc() v4.00
ok = utc.rtc(true) v4.00
```

Get/Set Real Time Clock

- Returns**
- `utc`: Current UTC
 - `utcoff`: UTC the power was last turned off
 - `batok`: true if the battery is good
 - `ok`: true if the sync from CPU to RTC was ok.

Description Returns the current settings from the RTC (Real Time Clock) chip that is on hardware iss4.

When used as `utc.rtc(true)` this syncs the current CPU time back to the RTC chip.

```
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.

```
t = util.bits(v) v3.44  
t = util.bits(v, F00) v3.44
```

Create bits table

- Parameters**
- **v**: Number (up to 32-bits wide)
 - **F00**: `function(bitno,mask,count)` to call

- Returns**
- **t**: Table of `t[] = bit`

Description Creates a table entry for each bit that is set in `n`.

Additionally, can call a function for each bit that's set in `n`.

Example:

```
X = util.bits(42)  
-- X[1] = 1  
-- X[2] = 3  
-- X[3] = 5
```

t = util.btab(v, tab, [nils]) ^{v3.44}

Create table from table with bits

- Parameters**
- **v**: Number (up to 32-bits wide)
 - **tab**: Table to extract from (1-based)
 - **nils**: Include nil values from **tab** (defaults to false)

- Returns**
- **t**: Table of t[] generated from **tab**

Description Creates a table from **tab** for each bit that is set in **n**.



Bit zero in **v** corresponds to **tab[1]**

Example:

```
Y = {'zero', 'one', 'two', 'three', 'four', 'five', 'six'}
X = util.btab(42, Y)
-- X[1] = 'one'
-- X[2] = 'three'
-- X[3] = 'five'
```

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(F00,start,[depth]) v2.00
```

Iterate table

- Parameters**
- **F00**: Function to call. `n = F00(o)` is the prototype.
 - **start**: Starting object or table
 - **depth**: (optional) table depth. Default = 3

- Returns**
- **n**: Count or total

Description The function **F00** 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)

```
txt = util.zdec(txt) v4.00
```

Z-base-32 decode

- Parameters**
- `txt`: z-base-32 encoded string
- Returns**
- `txt`: Decoded string
- Description** Convert a z-base-32 string to string/binary data.

```
txt = util.zenc(txt) v4.00
```

Z-base-32 encode

- Parameters**
- `txt`: Text string to convert
- Returns**
- `txt`: z-base-32 encoded string
- Description** Convert a string, or binary string, to z-base-32

See: <https://github.com/criptii/criptii/blob/main/src/Encoder/Base32.js>

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)
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

- 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

- 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

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 monochrome
- 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.size() v4.00
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.



DOGL128 should have KEY6+KEY7 linked. The dimensions of the LCD are detected in fw v4.00+

`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.



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 height
 - **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(uname, 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
:key: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

:skms: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,[tfn])`

Draw soft key

- Parameters**
- `kn`: Key number, 1 to 4
 - `txt`: String to display
 - `tfn`: 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.in`.

`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.

`ui.set.bklt(enable)` v4.00

Control LCD backlight

Parameters • `enable`: true to enable backlight

Returns None

Description Specify the backlight control.

KEY8 is controlled as an output to enable backlight. It is automatically turned on/off from the UI.

Calling `ui.set.bklt(false)` disables this control.

`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.**ui.set.onebtn(enable)** ^{v4.00}**Parameters** • **enable**: true to use single button UI**Returns** None**Description** When `ui.set.onebtn(true)` is called, only KEY3 is required. This is suitable for display-only UI (i.e. not for on-screen editing functions).

The DOGL128 defaults to requiring a single button interface.

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.showsk(enable) v4.00

Parameters • `enable`: true to enable soft-keys

Returns None

Description Control whether soft-keys appear on the LCD.



The DOGL128 defaults to having no soft-keys

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

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

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

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 = '' ...
```

Alarm text names

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
```

Archive number of files

Description Maximum number of files to keep in the `/Archive/` directory.

```
c.arc_gz = 0 v3.43
```

Archive use gzip

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
```

Archive maximum kbytes

Description Maximum number of kilo-bytes to keep in the `/Archive/` directory.

Config `c.cell` : Cellular

```
c.cell_apn = 'Internet'
```

Internet APN name

Description APN name for the Internet connection

```
c.cell_auth = -1
```

Override APN authentication method

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
```

Hold off failure time

Description (optional) hold off failure time, in minutes.

```
c.cell_hos = 2
```

Hold off success time

Description (optional) hold off success time, in minutes.

```
c.cell_init = '' v3.31
```

Modem init sequence

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
```

Maximum time online

Description (optional) Maximum time online, minutes.

```
c.cell_pass = ''
```

Internet password

Description (optional) Password for the Internet connection

```
c.cell_pin = ''
```

SIM PIN code

Description (optional) PIN number for the SIM card

```
c.cell_reg = 120
```

Cell registration time limit

Description (optional) Set the time limit for registration, in seconds.

```
c.cell_sms = ''
```

Default SMS number

Description (optional) Default SMS target number. Should be in international format (i.e. starting with "+" and the country code)

```
c.cell_user = ''
```

Internet username

Description (optional) Username for the Internet connection

Config `c.iot` : IoT Parameters

```
c.iot_data = ''
```

Data process URL or path

Description (optional) Data process URL or path.

Uses Lua expansions.

```
c.iot_gz = 1
```

Use gzip compression

Description (optional) Use GZIP compression and naming.

```
c.iot_job = '@23:00'
```

Job schedule

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'
```

NTP server

Description (optional) NTP server name.

```
c.iot_tfr = 1
```

Use Temp-File-and-Rename for FTP

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
```

Time-zone override

Description (optional) Timezone override, in minutes.



When set, there is no DST (Daylight Saving Time) applied.

```
c.iot_ujob = _
```

Update job schedule

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}'
```

Update URL or path

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 = ''
```

Base 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 = ''
```

User process URL or path

Description (optional) User process URL or path.

Uses Lua expansions.

```
c.iot_var = 3600
```

Push variance

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 = ''
```

Lua app name

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 = ''
```

Site location string

Description Optional Site location details. Can be used by the App.

```
c.site_name = ''
```

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  
Use password on engineer serial terminal
```

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 = ''  
Terminal password
```

Description (optional) Terminal password.



Do NOT forget this password - there is no backdoor.

Config `c.tls` : Security Settings

```
c.tls_csc = 0xffff v1.00
```

TLS cipher suite

Description (optional) The modem cipher suite code for IoT connections

Cipher suites in this list from `0x003D` to `0x000A` are supported by the Quectel `UC20` modem. The Quectel `EG21` modem supports all in the list.

- `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
- `0X003D` = TLS_RSA_WITH_AES_256_CBC_SHA256
- `0XC002` = TLS_ECDH_ECDSA_WITH_RC4_128_SHA
- `0XC003` = TLS_ECDH_ECDSA_WITH_3DES_EDE_CBC_SHA
- `0XC004` = TLS_ECDH_ECDSA_WITH_AES_128_CBC_SHA
- `0XC005` = TLS_ECDH_ECDSA_WITH_AES_256_CBC_SHA
- `0XC007` = TLS_ECDHE_ECDSA_WITH_RC4_128_SHA
- `0XC008` = TLS_ECDHE_ECDSA_WITH_3DES_EDE_CBC_SHA
- `0XC009` = TLS_ECDHE_ECDSA_WITH_AES_128_CBC_SHA
- `0XC00A` = TLS_ECDHE_ECDSA_WITH_AES_256_CBC_SHA
- `0XC011` = TLS_ECDHE_RSA_WITH_RC4_128_SHA
- `0XC012` = TLS_ECDHE_RSA_WITH_3DES_EDE_CBC_SHA
- `0XC013` = TLS_ECDHE_RSA_WITH_AES_128_CBC_SHA
- `0XC014` = TLS_ECDHE_RSA_WITH_AES_256_CBC_SHA
- `0xC00C` = TLS_ECDH_RSA_WITH_RC4_128_SHA
- `0XC00D` = TLS_ECDH_RSA_WITH_3DES_EDE_CBC_SHA
- `0XC00E` = TLS_ECDH_RSA_WITH_AES_128_CBC_SHA
- `0XC00F` = TLS_ECDH_RSA_WITH_AES_256_CBC_SHA
- `0XC023` = TLS_ECDHE_ECDSA_WITH_AES_128_CBC_SHA256

- `0xC024` = TLS_ECDHE_ECDSA_WITH_AES_256_CBC_SHA384
- `0xC025` = TLS_ECDH_ECDSA_WITH_AES_128_CBC_SHA256
- `0xC026` = TLS_ECDH_ECDSA_WITH_AES_256_CBC_SHA384
- `0XC027` = TLS_ECDHE_RSA_WITH_AES_128_CBC_SHA256
- `0XC028` = TLS_ECDHE_RSA_WITH_AES_256_CBC_SHA384
- `0xC029` = TLS_ECDH_RSA_WITH_AES_128_CBC_SHA256
- `0XC02A` = TLS_ECDH_RSA_WITH_AES_256_CBC_SHA384
- `0XC02F` = TLS_ECDHE_RSA_WITH_AES_128_GCM_SHA256`
- `0xFFFF` = Support all ciphersuites above (default)



For the UC20 fitted modem we recommend either `0x0035` or `0x002f` as a balance between security and server compatibility.

```
c.tls_ilt = 1 v1.00
```

TLS ignore local time

Description (optional) Ignore Local Time ^[1]

- 0 = Care about time checks for certificates
- 1 = Ignore time checks

```
c.tls_sni = 1 v3.44
```

TLS Server-Name-Indicator

Description (optiona) Present the Server-Name-Indicator when establishing TLS/SSL connection.

- 0 = Do not use TLS-SNI extension
- 1 = Use TLS-SNI extension



SNI is **required** when the target server is a virtually hosted server.


```
c.tls_ver = 3 v1.00
```

TLS version

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!

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
```

TOA idle timeout

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
```

TOA secret key

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
```

TOA password override

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
```

TOA retry time

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
```

TOA URL

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
```

Interval for user mode

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
```

User mode online time

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

Modem activity phase

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`

Modem power duration

Description Total number of seconds the modem has been powered.

i.cell_sta

Modem state

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}

Modem signal quality indicator

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}

Brief modem activity log

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}

Modem online duration

Description Online Duration. How many seconds the rt.buffer was online for.

Being online only implies an IP address and does not guarantee access to the wide Internet.

i.cell_X_pd ^{v1.03}

Modem power duration

Description Power Duration, in seconds. i.e. how many seconds the modem was powered up.

i.cell_X_pu v1.03

Modem power up time

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

Modem registration seconds

Description Registration Seconds. How many seconds it took to get registered on the cellular network.

i.cell_X_sc v1.03

Modem server connected

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`

Bootloader version

Description BootLoader version

`i.fw_date`

Firmware date

Description Firmware date

`i.fw_desc`

Firmware description

Description Firmware name

`i.fw_ver`

Firmware version

Description Firmware version

Info `i.iot` : IoT Information

`i.iot_var`

Variance time applied

Description The actual number of seconds this `rt.buffer` will have variance-enabled schedules delayed.

Info `i.lua` : Lua Information

`i.lua_run`

Lua app start point

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`

Configuration bytes free

Description Number of configuration store bytes free.

`i.rt_sn`

Serial number

Description Serial number string

`i.rt_so` ^{v4.00}

Original serial number

Description The original serial number.

This is z-base-32 encoded.

To decode:

```
original_serial = struct.unpack('L', util.zdec(i.rt_so))
```

`i.rt_tag` ^{v4.00}

Asset tag

Description The asset tag (if programmed)

`i.rt_utc`

Current time

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`

Number of samples

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`

Last sample text

Description The last text that was written with smp.save

`i.smp.utc`

Last sample time

Description The UTC time that smp.save was last called

Info `i.pwr` : Power Information

`i.pwr_alv`

Seconds alive

Description Seconds alive.

`i.pwr_ccb`

Battery capacity

Description Battery capacity, in C.

`i.pwr_ccu`

Estimated charge used

Description Estimated charge used

`i.pwr_full` ^{v3.00}

Seconds on full power

Description Set to 1 if running at full power.

0 = running on backup mode.

`i.pwr_pct` ^{v1.00}

Estimated percentage power remaining

Description Estimated percentage power remaining (0-99%)

i.pwr_slp

Seconds asleep

Description Number of seconds spent asleep (in ultra-low power mode).

i.pwr_tob

Seconds on battery

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`
`wde0`

Description Show watchdog entries.

`wde0` will reset the maximum counters.

work-
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
pt[@]d[s][f] [STOP] v4.00
```

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
- **f**: use hardware TX flow control
- **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]
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
lgc0

Description Garbage collect Lua memory and show stats.

lgc0 will show and reset the statistics.

lm
lm0

Description Show Lua memory stats.

lm0 will show and reset the statistics.

lv LIST
?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: Modem

cellinfo v1.10

Description Triggers the mechanism to obtain the cellular and modem information into [/Logs/cellinfo.txt](#)

cellwait v1.10

Description Provides feedback on the modem. If the modem is busy, this will loop - showing the modem power-on time, and modem status ([i.cell_c_log](#)) every second.

You can halt the feedback by hitting the [\[ESC\]](#) key.

e.g.

```
cellinfo
cellwait
```

cho

Description Clear modem holdoff. If the modem was pausing between attempts, this command will make it finish the pause immediately.

diag v4.00

Description Triggers a push of diagnostics and check for updates.

modem

Description Enter modem loop-back mode. Useful for diagnostics via USB.

toa v1.10

Description Trigger the Terminal-Over-Air immediately.



Will clear the modem hold off and attempt to connect to the `c.toa_url`

update

Description Triggers a check for updates, clearing the modem holdoff.

Terminal: NAND Flash

nfcheck

Description Check the flash disk.



Firmware v4.00+ shows the results in the rtbTool log window, since the check operates in the background.

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  
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 removed)!

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.buffer 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: 88f62c194223beefcddb43ef39181dcfb4bbef0801672fcfe5ace0c779badd4f
```

```
<<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/octet-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
```

Cryptographic 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 emUSB

Portions:

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Cortex Support Libraries (CMSIS)

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zlib Compression Library

zlib.h -- interface of the 'zlib' general purpose compression library
version 1.2.12, March 11th, 2022

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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](http://tools.ietf.org/html/rfc1951) (deflate format) and [rfc1952](http://tools.ietf.org/html/rfc1952) (gzip format).

Cryptographic Functions

Portions of mbedTLS have been used:

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This file is part of mbed TLS (<https://tls.mbed.org>)

U8G2 LCD Library

<https://github.com/olikraus/u8g2>

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Universal 8bit Graphics Library (<http://code.google.com/p/u8g2/>)

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