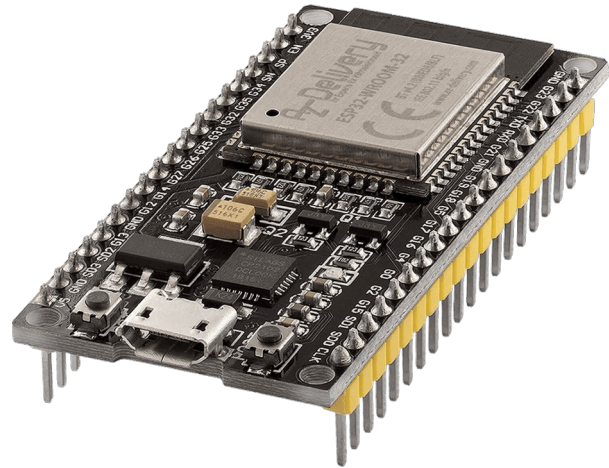


Word Glossary for ESP32forth v7.0.7.3

ESP32forth is a powerful forth tool set created by **Bradley D Nelson** and the late **Dr. Hanson Ting** for the low cost ESP32 module. This document is a word glossary for reference whilst programming. There are also some useful links to reference material at the back.

The headings and words in the following tables are in alphabetic order to speed up searches. Most document readers will show a bookmark strip you can click on to jump to a particular section. Use ctrl F to search for a specific word. Immediate words (that run at compile time) are shown in **red**. The right-hand column indicates the ESP32forth vocabulary in which the word is located.

There are plenty of gaps and probably a few errors. Any contributions welcome via the [Forth2020 forum](#) on Facebook



ESP32 is a series of low-cost, low-power system on a chip microcontrollers with integrated Wi-Fi and dual-mode Bluetooth. The ESP32 series employs either a Tensilica Xtensa LX6 microprocessor in both dual-core and single-core variations, Xtensa LX7 dual-core microprocessor or a single-core RISC-V microprocessor and includes built-in antenna switches, RF balun, power amplifier, low-noise receive amplifier, filters, and power-management modules.

ANSI terminal control

| | | | |
|---------------------|-----------|---|-------|
| at-xy | (x y -) | | forth |
| bel | (-) | Sound the terminal bell | ansi |
| bg | (n -) | | forth |
| clear-to-eol | (-) | Clear the line from the cursor position to the right margin | ansi |
| esc | (-) | sends the esc char to the terminal - many ANSI terminal commands start with the esc character | ansi |
| fg | (n -) | | forth |
| hide | (-) | Hide the cursor | ansi |
| normal | (-) | | forth |
| page | (-) | | forth |
| scroll-down | (-) | Scroll the cursor down one line | ansi |

| | | | |
|-------------------------|-----------|--|-------|
| scroll-up | (-) | Scroll the cursor up one line | ansi |
| set-title | (a n -) | | forth |
| show | (-) | Make the cursor visible | ansi |
| terminal-restore | (-) | Scroll the terminal back down, restoring the terminal to the state when terminal-save was executed | ansi |
| terminal-save | (-) | Scroll the present terminal up off the screen, leaving a blank screen | ansi |

Block File System

| | | | |
|----------------------|----------------|---|-------|
| block | (n -- a) | Get a 1024 character block | forth |
| block-fid | (- n) | value, default = -1 | forth |
| block-id | (-- n) | value, default = -1 | forth |
| buffer | (n -- a) | Get a 1024 byte block without regard to old contents | forth |
| copy | (from to --) | Copy contents of block 'from' to block 'to' | forth |
| default-use | | deferred word, defaults to common-default-use | forth |
| empty-buffers | (--) | Empty all buffers | forth |
| flush | (--) | Save and empty all buffers | forth |
| list | (n --) | List block n of 1024 characters to the display | forth |
| load | (n --) | Evaluate block n of 1024 characters as the input stream | forth |
| open-blocks | (a n --) | Open a file as the block file | forth |
| save-buffers | (--) | Save all buffers | forth |
| scr | (-- adr) | Pointer to last listed block | forth |
| thru | (a b --) | Load blocks a thru b | forth |
| update | (--) | Mark the last block modified | forth |
| use | ("name" --) | Use "name" as the blockfile, e.g. USE /spiffs/foo | forth |

Block File Editor

| | | | |
|----------|-----------------|---|--------|
| a | (n "text" --) | Add (insert) a line in the current block with the words that follow in the input stream, terminated with <cr> | editor |
| d | (n --) | Delete a line in the current block | editor |
| e | (n --) | Clear a line in the current block | editor |
| l | (-) | List the current 1024 character block | editor |
| n | (-) | Move to the next 1024 character block | editor |

| | | | |
|---------------|-----------------|--|--------|
| p | (–) | Move to the previous 1024 character block | editor |
| r | (n "text" --) | Replace a line in the current block with the words that follow in the input stream, terminated with <cr> | editor |
| wipe | (--) | Erase the 1024 character block | editor |
| editor | (--) | vocabulary name of the block file editor | forth |

Branching

| | | | |
|-----------------|-------------------------|---|-------|
| [ELSE] | (–) | Interpret time ELSE * | forth |
| [IF] | (f –) | Interpret time IF (conditional interpretation of words that follow, dependent on flag f) * | forth |
| [THEN] | (–) | Interpret time THEN * | forth |
| aft | (--) | : aft-example (n --) for <words that run only 1st iteration> aft <words that run for all but the 1st iteration> then <words that run on all iterations> next ; | forth |
| ahead | (--) | continue execution after then e.g. : myword333 ahead 222 444 then ; running myword would leave 333 on the stack | forth |
| DEFINED? | ("name" -- xt 0) | If the name that follows in the input stream is found in the dictionary, the execution address of the word is placed on the stack, else 0 if not found e.g. DEFINED? CREATE returns 1073637288. DEFINED? BABA returns 0 | forth |
| else | (–) | part of a conditional structure e.g. if <forth words> else <more forth words> then e.g. if <forth words> then | forth |
| if | (flag –) | Conditional structure, which executes depends on flag e.g. if <forth words> else <more forth words> then e.g. if <forth words> then | forth |
| then | (--) | part of a conditional structure e.g. if <forth words> else <more forth words> then e.g. if <forth words> then | forth |

* [IF] [ELSE] [THEN] are limited to appearing on the same line only – not multiline

CASE code

The CASE structure is missing in ESP32forth, but is easily added if required

```
internals
: case 0 ; immediate
```

```

: of [ ] over , [ ] = , [ ] 0branch , here 0 , [ ] drop , ; immediate
: endof [ ] branch , here 0 , swap here swap ! ; immediate
: endcase [ ] drop , begin ?dup while here swap ! repeat ; immediate

```

example:

```

: test      ( n -- )
  case
    0 of ." zero" endof
    1 of ." one" endof
    2 of ." two" endof
    ." many"
  endcase ;

```

\ this code runs if none of the cases are met

[IF] [THEN] example (n1 n2 --) Demonstrates creating words with no names, which can nevertheless be executed by execution token - saves space in the dictionary if the word is never used by name

\ Place this at the top of a forth source file

```

DEFINED? *codename* [IF] forget *codename* [THEN]
: *codename* ;

```

\ the string *codename* can be anything unique to suit the code file being loaded
 \ if that word is already defined, then the compiled words are forgotten from the
 \ dictionary before being recompiled

Camera

| | | | |
|---------------------------------|--|--|--------|
| camera-server | (--) | | forth |
| s->set_xclk | (s time xclk) | | camera |
| s->set_pll | (s bypass mul sys root pre seld5 pclk pclk) | | camera |
| s->set_res_raw | (s startX startY endX endY offsetX offsetY totalX totalY outputX outputY scale binning) | | camera |
| s->set_reg | (s reg mask value) | | camera |
| s->get_reg | (s reg mask) | | camera |
| s->set_lenc | (s enable) | | camera |
| s->set_raw_gma | (s enable) | | camera |
| s->set_ae_level | (s level) | | camera |
| s->set_wb_mode | (s mode) | | camera |
| s->set_special_effect | (s effect) | | camera |
| s->set_aec_value | (s gain) | | camera |

| | | | |
|--------------------------------|-----------------|----------|--------|
| s->set_agc_gain | (s gain) | | camera |
| s->set_awb_gain | (s enable) | | camera |
| s->set_aec2 | (s enable) | | camera |
| s->set_vflip | (s enable) | | camera |
| s->set_hmirror | (s enable) | | camera |
| s->set_exposure_ctrl | (s enable) | | camera |
| s->set_gain_ctrl | (s enable) | | camera |
| s->set_whitebal | (s enable) | | camera |
| s->set_colorbar | (s enable) | | camera |
| s->set_quality | (s quality) | | camera |
| s->set_gainceiling | (s gainceil) | | camera |
| s->set_denoise | (s level) | | camera |
| s->set_sharpness | (s level) | | camera |
| s->set_saturation | (s level) | | camera |
| s->set_brightness | (s level) | | camera |
| s->set_contrast | (s level) | | camera |
| s->set_framesize | (s framesize) | | camera |
| s->set_pixformat | (s pixformat) | | camera |
| s->reset | (s) | | camera |
| s->init_status | (s) | | camera |
| s->xclk_freq_hz | (a) | | camera |
| fb->usec | | | camera |
| fb->sec | | | camera |
| fb->format | | | camera |
| fb->height | | | camera |
| fb->width | | | camera |
| fb->len | | | camera |
| fb->buf | | | camera |
| field@ | (n -- n) | | camera |
| camera-format | | constant | camera |
| camera-frame-size | | constant | camera |
| camera-jpeg-quality | | constant | camera |
| camera-fb-count | | constant | camera |
| camera-config | | | camera |
| FRAMESIZE_UXGA | (– 13) | constant | camera |

| | | | |
|----------------------------|----------|----------|--------|
| | | | |
| FRAMESIZE_SXGA | (– 12) | constant | camera |
| FRAMESIZE_HD | (– 11) | constant | camera |
| FRAMESIZE_XGA | (– 10) | constant | camera |
| FRAMESIZE_SVGA | (– 9) | constant | camera |
| FRAMESIZE_VGA | (– 8) | constant | camera |
| FRAMESIZE_HVGA | (– 7) | constant | camera |
| FRAMESIZE_CIF | (– 6) | constant | camera |
| FRAMESIZE_QVGA | (– 5) | constant | camera |
| FRAMESIZE_240x240 | (– 4) | constant | camera |
| FRAMESIZE_HQVGA | (– 3) | constant | camera |
| FRAMESIZE_QCIF | (– 2) | constant | camera |
| FRAMESIZE_QQVGA | (– 1) | constant | camera |
| FRAMESIZE_96x96 | (– 0) | constant | camera |
| PIXFORMAT_RGB555 | (– 7) | constant | camera |
| PIXFORMAT_RGB444 | (– 6) | constant | camera |
| PIXFORMAT_RAW | (– 5) | constant | camera |
| PIXFORMAT_RGB888 | (– 4) | constant | camera |
| PIXFORMAT_JPEG | (– 3) | constant | camera |
| PIXFORMAT_GRAYSCALE | (– 2) | constant | camera |
| PIXFORMAT_YUV422 | (– 1) | constant | camera |
| PIXFORMAT_RGB565 | (– 0) | constant | camera |

Character I/O

| | | | |
|---------------|----------------|--|-------|
| #tib | (-- addr) | variable, Contains the size of the terminal input buffer (TIB) | forth |
| >in | (-- addr) | variable, contains address of a cell containing the offset in characters from the start of the input buffer to the start of the parse area | forth |
| ." | ("string" –) | display the string that follows in the input stream until a terminating " | forth |
| accept | (b u1 -- u2) | accepts u1 characters to buffer b. u2 returned is the actual count of characters received. Terminates when cr entered or u1 chars received. Supports delete for input correction | forth |
| bl | (-- 32) | returns the value of the SPACE char | forth |

| | | | |
|---------------|---------------------------------|---|---------------|
| char | ("character" -- c) | Convert the non-space char that follows in the input stream and place it's value tos e.g. char 0 places 48 on top of the stack | forth |
| cr | (--) | send carriage return, line feed to the display | forth |
| emit | (c –) | display the ascii character c | forth |
| key | (– chr) | deferred word - reads the next character in the input stream - defaults to word serial-key | forth |
| key? | (-- cnt) | deferred word - returns cnt, the number of characters waiting to be read. cnt=0 if no characters waiting - defaults to word serial-key? | forth |
| nl | (-- 10) | the value of the NEWLINE character | forth |
| ok | (--) | display the string ok | forth |
| page | (--) | Emit 30 CR characters to the display | forth |
| PARSE | (c "wordtoparse" -- addr cnt) | Parse the next word in the input stream, terminating on character c. Leave the address and character count cnt of word.If the parse area was empty then cnt=0 | forth |
| prompt | | send ok and <cr> to the display | forth |
| space | (--) | Emit a space character to the display | forth |
| tib | (-- addr) | returns the address of the the terminal input buffer where input text string is held. | forth |
| type | (addr n --) | deferred word - display an n long character string, located at addr, on the display - as a default executes serial-type | forth |
| ip. | (n --) | print n in IP address format e.g. 192.168.1.2 | web-interface |
| ip# | (n1 -- n2) | print one section of an ip address | web-interface |

Comment

| | | | |
|----------|----------------|--|-------|
| (| ("string"--) | Start of a 1 line comment, terminated with). Most often used to document the stack effect of word | forth |
| \ | | Start of a 1 line comment, no termination needed | forth |

Comparison

| | | | |
|--------------|----------------|--|-------|
| < | (n1 n2 -- f) | f=true of n1 less than n2, else f=false | forth |
| <= | (n1 n2 -- f) | f=true if n1 less than or equal n2, else f=false | forth |

| | | | |
|-----|----------------|---|-------|
| <> | (n1 n2 -- f) | f=true if n1 not equal n2, else f=false | forth |
| = | (n1 n2 -- f) | f=true if n1 equals n2, else f=false | forth |
| > | (n1 n2 -- f) | f=true if n1 greater than n2, else f=false | forth |
| >= | (n1 n2 -- f) | f=true if n1 greater than or equal n2, else f=false | forth |
| 0< | (n -- f) | f=true if n less than zero, else f=false | forth |
| 0<> | (n -- f) | f=true if n not equal zero, else f=false | forth |
| 0= | (n -- f) | f=true if n equals zero, else f=false | forth |

Debug

| | | | |
|--------------|---------------|---|-------|
| .s | (–) | display the data stack depth and data stack on one line of the display | forth |
| dump | (addr n –) | display memory starting at addr, for n longs | forth |
| see | ("text" --) | Attempt to decompile the word which follows in the input stream | forth |
| vlist | (--) | List the words in the context vocabulary (not chains) e.g. vlist WiFi only lists words in the Wifi vocabulary | forth |
| words | (--) | List the words in the context vocabulary (including chains) | forth |

See – example

Define a word:- `: demo 1 2 3 + . cr cr ;`

'see demo' will show a decompiled view of the word to check for errors `: demo
1 2 3 + . cr cr ;`

Dictionary

| | | | |
|-----------------------|-----------------|--|-------|
| >body | (xt -- addr) | addr is the data-field address corresponding to execution token xt | forth |
| >flags | (xt -- flags) | returns the flags of the word corresponding to execution token xt:- 1 if an immediate word 0 if a normal high level word 8 if a normal assembly language word | forth |
| >flags& | | | |
| >link | (xt -- addr) | addr is the link-field address corresponding to execution token xt | forth |
| >link& | (xt -- addr) | used internally by >link | forth |

| | | | |
|-------------------|----------------------|--|-------|
| >name | (xt -- addr n 0) | convert execution token xt to a name located at addr with n characters, else return 0 if not possible | forth |
| >params | | | |
| >size | | | |
| FIND | (addr n -- xt 0) | using the counted string at addr with n characters, look a word up in the current dictionary stack, returning the execution token xt if found, else 0 | forth |
| forget | ("name" --) | find the word that follows in the input stream; if it exists in the current dictionary, remove it and all words that followed it from the dictionary and the corresponding compiled code | forth |
| here | (-- addr) | returns the address of the first free location above the code dictionary, where new words are compiled | forth |
| transfer | ("name" --) | Move a word from its current dictionary to the current vocabulary. Useful for "hiding" helper words that aren't useful in normal programming | forth |
| transfer{ | (--) | Move all the words that follow in the input stream up until a terminating } to the current vocabulary. All the words must have been defined beforehand | forth |

Exceptions

| | | | |
|----------------|--------------------|--|-------|
| assert | (f --) | if flag f=true, execute throw | forth |
| catch | (xt -- err# 0) | CATCH is very similar to EXECUTE except that it saves the stack pointers before EXECUTEing the guarded word at xt, removes the saved pointers afterwards, and returns a flag indicating whether or not the guarded word completed normally. 0=normal | forth |
| handler | (-- addr) | holds the return stack pointer for error handling - zero if no error occurred. | forth |
| throw | (err# --) | For any non-zero err#, throws the system back to CATCH so that the error condition can be processed. CATCH is backtracked by restoring the return stack from the pointer stored in 'handler' and popping the old handler and SP off the error frame on the return stack. So - 0 THROW does nothing | forth |

See [Appendix 3](#) for an explanation of catch and throw.

Files

| | | | |
|----------------------|--------------------------------|---|-------|
| BIN | (fam1 -- fam2) | Modify the implementation-defined file access method fam1 to additionally select a "binary", i.e., not line oriented, file access method, giving access method fam2. | forth |
| CLOSE-FILE | (fh -- ior) | Close the file identified by fileid. ior is the implementation-defined I/O result code. | forth |
| CREATE-FILE | (c-addr u fam -- fileid ior) | Create the file named in the character string specified by c-addr and u, and open it with file access method fam. The meaning of values of fam is implementation defined. If a file with the same name already exists, recreate it as an empty file. | forth |
| DELETE-FILE | (c-addr u -- ior) | Delete the file named in the character string specified by c-addr u. ior is the implementation-defined I/O result code. | forth |
| dump-file | (a1 n1 a2 n2 --) | a1,n1 text string to be saved in file: a2,n2 text string containing filename. Dump-file saves text to the spiffs using filename | forth |
| FILE-POSITION | (fileid -- ud ior) | ud is the current file position for the file identified by fileid. ior is the implementation-defined I/O result code. ud is undefined if ior is non-zero. | forth |
| FILE-SIZE | (fileid -- ud ior) | ud is the size, in characters, of the file identified by fileid. ior is the implementation-defined I/O result code. This operation does not affect the value returned by FILE- POSITION. ud is undefined if ior is non-zero. | forth |
| FLUSH-FILE | (fileid -- ior) | Attempt to force any buffered information written to the file referred to by fileid to be written to mass storage, and the size information for the file to be recorded in the storage directory if changed. If the operation is successful, ior is zero. Otherwise, it is an implementation-defined I/O result code. | forth |
| include | ("name" --) | Using the next word in the input stream, name ... | forth |
| included | (c-addr u --) | Remove c-addr u from the stack. Save the current input source specification, including the current value of SOURCE-ID. Open the file specified by c-addr u, store the resulting fileid in SOURCE-ID, and make it the input source. Store zero in BLK. Other stack effects are due to the words included. Typical use: ... S" filename" INCLUDED | forth |
| needs | ("name" --) | | forth |
| OPEN-FILE | (a n fam -- fh) | Open the file named in the character string | forth |

| | | | |
|------------------------|---|--|-------|
| | ior) | specified by c-addr u, with file access method indicated by fam. The meaning of values of fam is implementation defined. If the file is successfully opened, ior is zero, fileid is its identifier, and the file has been positioned to the start of the file. Otherwise, ior is the implementation-defined I/O result code and fileid is undefined. Typical use: : X ... S" TEST.FTH" R/W OPEN-FILE ABORT" OPEN-FILE FAILED" ... ; | |
| R/O | (-- fam) | read only mode - used with OPEN-FILE, CREATE-FILE | forth |
| R/W | (-- fam) | read write mode - used with OPEN-FILE, CREATE-FILE | forth |
| READ-FILE | (c-addr u1 fileid -- u2 ior) | Read u1 consecutive characters to c-addr from the current position of the file identified by fileid. If u1 characters are read without an exception, ior is zero and u2 is equal to u1. If the end of the file is reached before u1 characters are read, ior is zero and u2 is the number of characters actually read. If the operation is initiated when the value returned by FILE-POSITION is equal to the value returned by FILE-SIZE for the file identified by fileid, ior is zero and u2 is zero. If an exception occurs, ior is the implementation-defined I/O result code, and u2 is the number of characters transferred to c-addr without an exception. | forth |
| remember | (--) | Save a snapshot to the default file (./myforth or /spiffs/myforth on ESP32) | forth |
| RENAME-FILE | | | forth |
| REPOSITION-FILE | (n fh -- ior) (ud fileid -- ior) | Reposition the file identified by fileid to ud. ior is the implementation-defined I/O result code. An ambiguous condition exists if the file is positioned outside the file boundaries. At the conclusion of the operation, FILE-POSITION returns the value ud. | forth |
| required | (a n –) | | forth |
| RESET | (--) | Delete the default filename. | forth |
| RESIZE-FILE | (ud fileid -- ior) | Set the size of the file identified by fileid to ud. ior is the implementation-defined I/O result code. If the resultant file is larger than the file before the operation, the portion of the file added as a result | forth |

| | | | |
|-------------------|----------------------------|---|-------|
| | | of the operation might not have been written. At the conclusion of the operation, FILE-SIZE returns the value ud and FILE- POSITION returns an unspecified value. | |
| restore | ("name" --) | Restore a snapshot from a file | forth |
| revive | (--) | Restore the default filename | forth |
| save | ("name" --) | Saves a snapshot of the current dictionary to a file | forth |
| startup: | ("name" --) | Save a snapshot to the default file arranging for "name" to be run on startup | forth |
| W/O | (-- fam) | write only mode - used with OPEN-FILE, CREATE-FILE | forth |
| WRITE-FILE | (c-addr u fileid -- ior) | Write u characters from c-addr to the file identified by fileid starting at its current position. ior is the implementation-defined I/O result code. At the conclusion of the operation, FILE- POSITION returns the next file position after the last character written to the file, and FILE-SIZE returns a value greater than or equal to the value returned by FILE-POSITION. | forth |

Autoexec.fs example (--) Demonstrates how to load source code automatically on switch on and run the program

```
r| z" NETWORK-NAME" z" PASSWORD" webui | \ create a string to start the web server
s" /spiiffs/autoexec.fs" dump-file \ save it to file autoexec.fs
```

startup: example (--) snapshotting the dictionary and restoring it at startup, with a start word which exits to forth (alternatively it could be a complete application which never exits)

```
: welcome ." Hello!" cr 100 0 do i . loop cr ;
startup: welcome
bye ( Next boot will run a custom startup message )
reset ( Reset removes the custom message )
```

Floating Point Maths

Single precision floating-point support is available as a work in progress.

While initially left out in the name of minimalism, hardware support for floating-point argues some advantages to limited support.

Floating point numbers, denoted r below, are kept on a separate floating point stack.

NOTE: Tasks currently don't support floating point. A single floating point stack is shared by all tasks.

| | | | |
|------------------|-------------------|--|-------|
| 1/F | (r1 -- r2) | $r2 = 1/r1$ | forth |
| AFLITERAL | (r --) | Compile r inline | forth |
| DOFLIT | (--) | Puts a float from the next cell onto float stack | forth |
| F- | (r1 r2 -- r3) | $r3 = r1 - r2$ | forth |
| F. | (n--) | Display, with a trailing space, the top number on the floating-point stack using fixed-point notation: | forth |
| F.S | (--) | Print float stack | forth |
| F* | (r1 r2 -- r3) | $r3 = r1 * r2$ | forth |
| F** | (r1 r2 -- r3) | $r3 = r1$ to the power $r2$ | |
| F/ | (r1 r2 -- r3) | $r3 = r1 / r2$ | forth |
| F+ | (r1 r2 -- r3) | $r3 = r1 + r2$ | forth |
| F< | (r1 r2 -- flag) | flag = true if $r1 < r2$ | forth |
| F<= | (r1 r2 -- r3) | flag = true if $r1 \leq r2$ | forth |
| F<> | (r1 r2 -- r3) | flag = true if $r1 \neq r2$ | forth |
| F= | (r1 r2 -- r3) | flag = true if $r1 == r2$ | forth |
| F> | (r1 r2 -- r3) | flag = true if $r1 > r2$ | forth |
| F>= | (r1 r2 -- r3) | flag = true if $r1 \geq r2$ | forth |
| F>S | (r -- n) | $n =$ integer part of r (no rounding) | forth |
| F0< | (r -- f) | flag=true if r less than 0 | forth |
| F0= | (r -- f) | flag-true if $r == 0$ | forth |
| FABS | (r1 – r2) | $r2 =$ absolute value of $r1$ | forth |
| FATAN2 | (r1 – r2) | $r2 = \text{atan}(r1)$ | forth |
| FCONSTANT | (r "name") | creates a floating point constant | forth |
| FCOS | (r1 – r2) | $r2 = \cos(r1)$ | forth |
| FDROP | (r --) | drop $r1$ from the floating point stack | forth |

| | | | |
|----------------------|--------------------------|--|-------|
| FDUP | (r -- r r) | duplicate the top of floating point stack | forth |
| FEXP | (r1 – r2) | $r2 = \exp(r1)$ | forth |
| FLITERAL | (r --) | Compile r inline | forth |
| FLN | (r1 – r2) | $r2 = \ln(r1)$ | forth |
| FLOOR | (r1 – r2) | $r2 = \text{floor}(r1)$ | forth |
| FMAX | (r1 r2 – r3) | R3 = the larger of r1 or r2 | forth |
| FMIN | (r1 r2 – r3) | R3 = the smaller of r1 or r2 | forth |
| FNEGATE | (r1 – -r1) | Negate r1 | forth |
| FNIP | (ra rb -- rb) | Remove the 2 nd item on the floating stack | forth |
| FOVER | (ra rb -- ra rb ra) | Copy the 2 nd item on the floating stack to the top | forth |
| FP! | (a --) | | forth |
| FP@ | (-- a) | | forth |
| FROT | | | forth |
| FSIN | (r1 – r2) | $r2 = \sin(r1)$ | forth |
| FSINCOS | (r1 – r2 r3) | $r2 = \sin(r1)$, $r3 = \cos(r1)$ | forth |
| FSQRT | (r r -- r) | | forth |
| FSWAP | (ra rb -- rb ra) | | forth |
| FVARIABLE | ("name") | <i>create a floating point variable</i> | forth |
| PI | (-- r) | | forth |
| precision | (– 6) | value – default = 6 | forth |
| set-precision | (n –) | set the value of precision to n | forth |
| S>F | (n -- r) | | forth |
| SF, | (r --) | | forth |
| SF! | (r a --) | single precision store | forth |
| SF@ | (a -- r) | single precision load | forth |
| SFLOAT | (-- 4) | | forth |
| SFLOAT+ | (a -- a+4) | | forth |
| SFLOATS | (n -- n*4) | | forth |

HTTPD

| | | | |
|--------------------------|-------------------------------------|----------|-------|
| notfound-response | (--) | | httpd |
| bad-response | (--) | | httpd |
| ok-response | (mime\$ --) | | httpd |
| response | (mime\$ result\$ status --) | | httpd |
| send | (a n --) | | httpd |
| path | (-- a n) | | httpd |
| method | (-- a n) | | httpd |
| hasHeader | (a n -- f) | | httpd |
| handleClient | | | httpd |
| read-headers | | | httpd |
| completed? | (-- f) | | httpd |
| body | (-- a n) | | httpd |
| content-length | (-- n) | | httpd |
| header | (a n -- a n) | | httpd |
| crnl= | (n -- f) | | httpd |
| eat | (n ch -- n a n) | | httpd |
| skipover | (n ch -- n) | | httpd |
| skipto | (n ch -- n) | | httpd |
| in@<> | (n ch -- f) | | httpd |
| end< | (n -- f) | | httpd |
| goal# | (– a) | variable | httpd |
| goal | (– a) | variable | httpd |
| strcase= | (a n a n -- f) | | httpd |
| upper | (ch -- ch) | | httpd |
| server | (port --) | | httpd |
| client-cr | (–) | | httpd |
| client-emit | (ch --) | | httpd |
| client-read | (-- n) | | httpd |

| | | | |
|------------------------|------------|--|-------|
| client-type | (a n --) | | httpd |
| client-len | (– a) | variable | httpd |
| client | (– a) | sockaddr | httpd |
| httpd-port | (– a) | sockaddr | httpd |
| clientfd | (– n) | value, default = -1 | httpd |
| sockfd | (– n) | value, default = -1 | httpd |
| body-read | (– n) | value, default = 0 | httpd |
| body-1st-read | (– n) | value, default = 0 | httpd |
| body-chunk | (– a) | block of allotted data, body-chunk-size bytes long | httpd |
| body-chunk-size | (– 256) | constant | httpd |
| chunk-filled | (– n) | value, default = 0 | httpd |
| chunk | (– a) | block of allotted data, chunk-size bytes long | httpd |
| chunk-size | (– 2048) | constant | httpd |
| max-connections | (– 1) | constant | httpd |

Input / Output

| | | | |
|---------------------|---------------------------------|--|-------|
| adc | (pin# -- n) | alias for analogRead | forth |
| analogRead | (pin -- n) | Analog read from 0-4095 | forth |
| dacWrite | (pin 0-255 --) | Write to DAC (pin 25, 26) | forth |
| digitalRead | (pin -- value) | Read GPIO state | forth |
| digitalWrite | (pin value --) | Set GPIO pin state | forth |
| pin | (value pin# --) | Set GPIO pin value e.g. HIGH 3 pin LOW 3 pin | forth |
| pinMode | (pin mode --) | Set GPIO pin mode e.g. 14 input pinMode \ set pin 14 as input | forth |
| pulseIn | (pin value usec -- usec/0) | Wait for a pulse | forth |
| tone | (channel freq) | Write tone frequency | Forth |

PIN example (--) Demonstrates toggling GPIO23 at max rate using the PIN word

```
: maxtoggle
  23 output pinMode
  begin
    HIGH 23 pin
    LOW 23 pin
  key? Until ;
```

A scope showed that the pin remained high for 625nS or so. It was low for around 2.6uS because of the key? function slowing things up. So a reasonable speed, all considered

Read digital input example (gpiono --) Continuously display the state of a digital input until a key is pressed

```
: test ( gpiono -- )
  DUP INPUT pinMode \ set 'gpiono' as an input
  begin
    DUP digitalRead . cr \ display the state of 'gpiono'
  key? until \ until a key is pressed
  DROP ; \ stack tidy
```

Analogue input example (--) Demonstrates reading the voltage present on GPIO14 for 128 samples at 10 samples / s

```
100 value del \ this value determines the data sample rate
: delay del ms ; \ time delay used to pace reading samples
: read ( -- )
  128 0 do \ Read 128 the input 128 times
    14 ADC . CR \ Read the voltage on GPIO14
    DELAY \ And pause for 100 mS between each sample
  loop
;
```

Interrupts

| | | | |
|--|--|--|------------|
| timer_isr_register | (group timer xt arg ret -- 0/err) | | forth |
| esp_intr_alloc | (source flags xt args handle* -- 0/err) | | interrupts |
| ESP_INTR_FLAG_DEFAULT | (-- 0) | Default handler allows per pin routing | interrupts |
| ESP_INTR_FLAG_EDGE | (-- 512) | gpio_install_isr_service flag | interrupts |
| ESP_INTR_FLAG_INTRDISABLED | (-- 2048) | gpio_install_isr_service flag | interrupts |
| ESP_INTR_FLAG_IRAM | (-- 1024) | gpio_install_isr_service flag | interrupts |
| ESP_INTR_FLAG_LEVELn | (n1 -- n2) | n2 = 2 to the power n1, gpio_install_isr_service | interrupts |
| ESP_INTR_FLAG_NMI | (-- 128) | gpio_install_isr_service flag | interrupts |
| ESP_INTR_FLAG_SHARED | (-- 256) | gpio_install_isr_service flag | interrupts |
| esp_intr_alloc | | | interrupts |
| esp_intr_free | (handle -- 0/err) | | interrupts |
| gpio_config | (gpio_config _t* -- 0/err) | GPIO common configuration. Configure GPIO's Mode,pull-up,PullDown,IntrType from a GPIO configure structure gpio_config_t | interrupts |
| gpio_deep_sleep_hold_dis | (--) | Disable all digital gpio pad hold function during Deep-sleep | interrupts |
| gpio_deep_sleep_hold_en | (--) | Enable all digital gpio pad hold function during Deep-sleep. When the chip is in Deep-sleep mode, all digital gpio will hold the state before sleep, and when the chip is woken up, the status of digital gpio will not be held. Note that the pad hold feature only works when the chip is in Deep-sleep mode, when not in sleep mode, the digital gpio state can be changed even you have called this function. Power down or call gpio_hold_dis will disable this function, otherwise, the digital gpio hold feature works as long as the chip enter Deep-sleep | interrupts |

| | | | |
|----------------------------------|-----------------------|---|------------|
| gpio_get_drive_capability | (pin cap* -- 0/err) | | interrupts |
| gpio_get_level | (pin -- level) | GPIO get input level of 'pin' | interrupts |
| gpio_hold_dis | (pin -- 0/err) | | interrupts |
| gpio_hold_en | (pin -- 0/err) | | interrupts |
| gpio_install_isr_service | (a --) | a = combination of gpio_install_isr_service flags - Install the driver's GPIO ISR handler service, which allows per-pin GPIO interrupt handlers | interrupts |
| #GPIO_INTR_ANYEDGE | (-- 3) | constant - set interrupt for either +ve or -ve edge e.g. 2 #GPIO_INTR_ANYEDGE gpio_set_intr_type | interrupts |
| #GPIO_INTR_DISABLE | (-- 0) | constant - disable interrupt e.g. 2 #GPIO_INTR_DISABLE gpio_set_intr_type | interrupts |
| gpio_intr_disable | (pin -- 0/err) | Disable GPIO module interrupt signal for 'pin' | interrupts |
| gpio_intr_enable | (pin -- 0/err) | Enable GPIO module interrupt signal for 'pin' | interrupts |
| #GPIO_INTR_HIGH_LEVEL | (-- 5) | constant - e.g. 2 #GPIO_INTR_HIGH_LEVEL gpio_set_intr_type | interrupts |
| #GPIO_INTR_LOW_LEVEL | (-- 4) | constant - e.g. 2 #GPIO_INTR_LOW_LEVEL gpio_set_intr_type | interrupts |
| #GPIO_INTR_NEGEDGE | (-- 2) | constant - set interrupt on -ve edge e.g. 2 #GPIO_INTR_NEGEDGE gpio_set_intr_type | interrupts |
| #GPIO_INTR_POSEDGE | (-- 1) | constant - set interrupt on +ve edge e.g. 2 #GPIO_INTR_POSEDGE gpio_set_intr_type | interrupts |
| gpio_isr_handler_add | pin xt 0 -- 0/err) | Having already set up the interrupt type, attach a new entry to the interrupt list, so that when the entry fires, the execution token 'xt' is called. If adding this entry was successful return true, else return an error code e.g. 2 ' myinterrupthandlerword 0 gpio_isr_handler_add | interrupts |
| gpio_isr_handler_remove | (pin -- 0/err) | Remove ISR handler for the corresponding GPIO pin | interrupts |
| gpio_pulldown_dis | (pin -- 0/err) | Disable pull down load on 'pin' | interrupts |
| gpio_pulldown_en | (pin -- 0/err) | Enable pull down load on 'pin' | interrupts |
| gpio_pullup_dis | (pin -- 0/err) | Disable pull up load on 'pin' | interrupts |
| gpio_pullup_en | (pin -- 0/err) | Enable pull up load on 'pin' | interrupts |
| gpio_reset_pin | (pin -- 0/err) | Reset a gpio to default state (select gpio | interrupts |

| | | | |
|--|------------------------|---|------------|
| | | function, enable pullup and disable input and output) | |
| gpio_set_direction | (pin mode -- 0/err) | Set gpio signal direction of 'pin' | interrupts |
| gpio_set_drive_capability | (pin cap -- 0/err) | Set GPIO pad 'pin' drive capability or strength 'cap' | interrupts |
| gpio_set_intr_type | (pin type -- 0/err) | Set the required i/o pin to the interrupt type, returning true if successful, else an error code | interrupts |
| gpio_set_level | (pin level -- 0/err) | GPIO set the output level pf 'pin' =1 or 0 | interrupts |
| gpio_set_pull_mode | (pin mode -- 0/err) | Configure GPIO 'pin' pull-up/pull-down resistors by means of 'mode'. GPIO 34-39 don't have this facility | interrupts |
| gpio_uninstall_isr_service | (--) | Uninstall the driver's GPIO ISR service, freeing related resources | interrupts |
| gpio_wakeup_disable | (pin -- 0/err) | Disable GPIO wake-up function on 'pin' | interrupts |
| gpio_wakeup_enable | (pin type -- 0/err) | Enable GPIO wake-up function on 'pin' - only type #GPIO_INTR_LOW_LEVEL or #GPIO_INTR_HIGH_LEVEL can be used | interrupts |
| pinchange | (xt pin --) | Call xt when pin changes e.g. 17 input pinMode : test ." pinvalue: " 17 digitalRead . cr ; ' test 17 pinchange | interrupts |

Sense a digital input change using interrupt

(--)

When the 'boot' button is pressed or released, that change of state is reported on the display

interrupts

0 input pinmode

\ set GPIO0 as an input

: input. (--)

\ display the state of GPIO0

." GPIO0 input ="

0 digitalRead . cr

;

: pinanyedge (xt pin --)

\ add an ANYEDGE interrupt handler

dup GPIO_INTR_ANYEDGE gpio_set_intr_type throw

swap 0 gpio_isr_handler_add throw

;

' input. 0 pinanyedge (--)

\ If GPIO0 changes state, report it

: disableinterrupt (pin --)

GPIO_INTR_DISABLE gpio_set_intr_type throw

;

0 disableinterrupt

\ stop reporting GPIO0 changes

\ This is just a demo - generally you want an interrupt to be as brief as possible

\ so printing from an interrupt routine is not recommended for real programs

LED control – pulse width modulation

| | | | |
|----------------------|--|---|-------|
| duty | (channel duty --) | like ledcWrite, with bounds check and scaling i.e. : duty 255 min 8191 255 */ ledcWrite ; | forth |
| freq | (channel freq --) | like ledcSetup, with scaling i.e. : freq (n n --) 1000 * 13 ledcSetup drop ; | forth |
| ledcAttachPin | (pin channel --) | Assigns which 'channel' (0-15) of the PWM engine the 'pin' is connected to | ledc |
| ledcDetachPin | (pin --) | Detaches #pin' from the pwm engine | ledc |
| ledcRead | (channel -- n) | Read the current dutycycle setting for 'channel' | ledc |
| ledcReadFreq | (channel -- freq) | Get frequency (x 1,000,000) | ledc |
| ledcSetup | (channel freq resolution -- freq) | Setup one of the 16 pwm channels (0-15) at frequency=freq*1000 Hz with 'resolution' | ledc |
| ledcWrite | (channel duty --) | Set 'channel' (0-15) at 'duty' level (0-100) | ledc |
| ledcWriteNote | (channel note octave -- freq) | channel 0-12, octave 0-8, note 0-12 (note is as per the western musical scale) | ledc |
| ledcWriteTone | (channel freq -- n) | Write tone frequency (x 1000) e.g. 23 0 ledcAttachPin \ attach GPIO23 to channel 0 0 1000000 ledc WriteTone drop \ o/p 1kHz tine | ledc |

Logic

| | | | |
|----------------|-------------------|--|-------|
| AND | (n1 n2 – n3) | n3 = n1 AND n2 (bit wise) | forth |
| ARSHIFT | (n1 – n1/2) | Arithmetic right shift | |
| invert | | | forth |
| LSHIFT | (x1 u -- x2) | Perform a logical left shift of u bit-places on x1, giving x2. Put zeroes into the least significant bits vacated by the shift. An ambiguous | forth |

| | | | |
|---------------|-----------------|--|-------|
| | | condition exists if u is greater than or equal to the number of bits in a cell. | |
| OR | (n1 n2 -- n3) | n3 = n1 OR n2 (bit-wise) | forth |
| RSHIFT | (x1 u -- x2) | Perform a logical right shift of u bit-places on x1, giving x2. Put zeroes into the most significant bits vacated by the shift. An ambiguous condition exists if u is greater than or equal to the number of bits in a cell. | forth |
| XOR | (n1 n2 -- n3) | n3 = n1 XOR n2 (bit-wise) | forth |

Looping

| | | | |
|---------------|--------------|---|-------|
| ?do | (n1 n2 --) | e.g. : test ?do i . loop ; if n1 = n2, then inside ?do .. loop is NOT executed if n1 <> n2, it behaves like do .. loop | forth |
| +loop | (n --) | e.g. : +looptest 20 0 do i . 2 +loop ; results when run in 0 2 4 6 8 10 12 14 16 18 being displayed | forth |
| again | (--) | begin <forth words> again | forth |
| begin | (--) | begin <forth words> until | forth |
| do | (n1 n2 --) | : test 10 4 do i . loop ; produces 4 5 6 7 8 9 on the display | forth |
| EXIT | (--) | Return control to the calling definition. Before executing EXIT within a do-loop, a program shall discard the loop-control parameters by executing 'unloop' | forth |
| for | (n --) | : test 10 for i . next ; produces 10 9 8 7 6 5 4 3 2 1 0 on display n.b. n will make the for loop run n+1 times by design | forth |
| i | (-- n) | Place current loop index on top of stack | forth |
| j | (-- n) | Place index count for next outer loop top of stack | forth |
| leave | (--) | Force do loop termination | forth |
| loop | (--) | part of do <forth words> loop construct | forth |
| next | (--) | part of for <forth words> next construct | forth |
| repeat | (--) | part of begin <forth words that leave f on the stack> while < more forth words> repeat | forth |
| unloop | (--) | Discard the loop-control parameters for the | forth |

| | | | |
|--------------|----------|---|-------|
| | | current nesting level e.g. Typical use: : unlooptest <limit> <first> DO ... test IF ... UNLOOP EXIT THEN ... LOOP ... ; | |
| until | (f --) | begin <forth words that leave f on stack> until | forth |
| while | (f --) | part of begin <forth words that leave f on the stack> while < more forth words> repeat | forth |

unloop example

Demonstrates a loop being terminated before completion by UNLOOP

```
: test
1000 0 do
key? if
  key drop
  cr ." loop terminating "
  unloop
  exit
then
cr ." loopcount = " i .
500 ms
loop
;
```

```
\ start a 1000 long loop
\ if a key was pressed
\ read the key and drop it

\ get rid of the loop
\ return to the calling word

\ show us the loop count
\ loop every 1/2 s
```

Maths

| | | | |
|--------|--------------------------|--|-------|
| - | (n1 n2 -- n3) | $n3 = n1 - n2$ | forth |
| * | (n1 n2 -- n3) | $n3 = n1 * n2$ | forth |
| */ | (n1 n2 n3 -- n4) | Multiply n1 by n2 producing the intermediate double-cell result d. Divide d by n3 giving the single-cell quotient n4 | forth |
| */MOD | (n1 n2 n3 -- n4 n5) | Multiply n1 by n2 producing the intermediate double-cell result d. Divide d by n3 producing the single-cell remainder n4 and the single-cell quotient n5 | forth |
| / | (n1 n2 -- n3) | Divide n1 by n2, giving the single-cell quotient n3 | forth |
| /mod | (n1 n2 -- n3 n4) | Divide n1 by n2, giving the single-cell remainder n3 and the single-cell quotient n4 | forth |
| + | (n1 n2 -- n3) | $n3 = n1 + n1$ | forth |
| 2* | (n1 -- n2) | $n2 = n1 * 2$ | forth |
| 2/ | (n1 -- n2) | $n2 = n1 / 2$ | forth |
| 4* | (n1 -- n2) | $n2 = n1 * 4$ | forth |
| 4/ | (n1 -- n2) | $n2 = n1 / 4$ | forth |
| abs | (n1 -- n2) | n2 is the absolute value of n1 | forth |
| max | (n1 n2 -- n3) | $n3 = \text{the larger of } n1 \text{ or } n2$ | forth |
| min | (n1 n2 -- n3) | $n3 = \text{the smaller of } n1 \text{ or } n2$ | forth |
| mod | (n1 n2 -- n3) | Divide n1 by n2, giving the single-cell remainder n3 | forth |
| negate | (n -- -n) | Two's complement of top of stack | forth |
| U/MOD | (u1 u2 -- rem quot) | Unsigned division, leaving remainder and quotient | forth |
| 1+ | (n-- n+1) | increment value on the stack by 1 | forth |
| 1- | (n-- n1-) | decrement value on the stack by 1 | forth |

Memory

ESP32forth stores numbers in little-endian format (the LS byte of the number is place at the lowest address in memory) unless noted otherwise (e.g. in ‘sockets’)

| | | | |
|------------------|----------------------|--|-------|
| ! | (n addr -->) | store x at addr | forth |
| @ | (addr --n) | Retrieves the integer value n stored at address addr | forth |
| + | (n addr --) | Increments the content of a variable by the value n | forth |
| +to | (n "valuenam" --) | Adds n to the value whose name follows in the input stream e.g. 2 value myvalue \ define a value called myvalue = 2 3 +to myvalue \ myvalue now equals 5 | forth |
| to | (n --) | Change a value e.g. 10 value myvalue \ set up myvalue = 10 5 to myvalue \ myvalue now returns 5 | forth |
| 2! | (n1 n2 addr -->) | store n1, n2 as a 64 bit value at addr | forth |
| 2@ | (addr --n1 n2) | read n1, n2 as a 64 bit value from addr | forth |
| C! | (c addr -->) | store byte c at addr | forth |
| C@ | (addr --c) | read byte c from addr | forth |
| allocate | (n -- a ior) | reserve a memory chunk of n bytes, returns the start address, ior=true if successful, else false - see also free and resize | forth |
| blank | (addr n –) | Fill block starting at addr for n bytes with \$20 | |
| cell/ | (n1 -- n2) | $n2 = n1 / 4$ | forth |
| cell+ | (n1 -- n2) | $n2 = n1 + 4$ | forth |
| cells | (n – n*4) | Conversion, cells to bytes | forth |
| cmove | (addr1 addr2 n --) | move n bytes from addr1 to addr2, starting at addr1 and proceeding toward high memory | forth |
| cmove> | (addr1 addr2 n --) | copy n bytes from memory starting at addr1 to that starting at addr2, proceeding from higher addresses to lower addresses | forth |
| erase | (addr n –) | Fill block starting at addr for n bytes with \$00 | forth |
| fill | (addr n c) | fill memory from addr for n bytes with byte c | forth |
| free | (a --) | free memory previously reserved allocate - see also resize | forth |
| L! | (n addr --) | write n to addr in real ESP32 memory space | forth |

| | | | |
|---------------|------------------|---|-------|
| resize | (a n -- a ior) | ior=true if a memory chunk reserved with MALLOC resized to n bytes correctly, else ior=false - see also allocate and free. The high-address end is adjusted. When increasing the size, all data is preserved. High end-data is not initialised. When decreasing the size, high-end address data may be lost | forth |
| SL@ | (addr --n) | read signed long n from real ESP32 memory space | forth |
| SW@ | (addr -- sw) | Read signed word from real ESP32 memory space | forth |
| UL@ | (addr --u) | read unsigned long u from real ESP32 memory space | forth |
| UW@ | (addr -- uw) | Read unsigned word uw from real ESP32 memory space | forth |
| W! | (w addr --) | Store word w at address addr | forth |

Number I/O

| | | | |
|----------------|-------------------|---|-------|
| ? | (addr --) | display value at addr | forth |
| . | (n --) | display top of stack | forth |
| # | (u1 -- u2) | Convert next digit of u1 and HOLD it | forth |
| #> | (u -- addr n) | Drop u and prepare string for TYPE | forth |
| #s | (u -- 0) | Convert and HOLD all remaining significant digits | forth |
| <# | (--) | Begin a formatted number conversion | forth |
| base | (-- addr) | Stores the current number display base - defaults to 10 decimal | forth |
| binary | (--) | Set current number base to 2 decimal | forth |
| decimal | (--) | Set current number base to 10 decimal | forth |
| extract | (n base -- n c) | extracts the least significant digit from a number n. n is divided by the radix in BASE and returned on the stack | forth |
| hex | (--) | Set current number base to 16 decimal | forth |
| hold | (c --) | Insert character into formatted string | forth |
| n. | (n --) | display n in decimal, regardless of current number base | forth |
| octal | (--) | Set current number base to 8 decimal | forth |
| pad | (-- addr) | returns the address of the text buffer where | forth |

| | | | |
|-------------|----------|---|-------|
| | | numbers are constructed and text strings are stored temporarily | |
| sign | (n --) | HOLD minus sign only if n is negative | forth |
| u. | (u --) | Display u unsigned in the current number base | forth |
| f. | (r --) | | forth |

Formatted Number Conversion example

(n --)

Demonstrates printing numbers in special formats

```

: dollars.
dup abs          \ duplicate and take absolute value
<# # #          \ start the formatted number conversion and convert the cents
46 hold         \ insert a decimal point character
#s             \ convert the dollars
36 hold         \ add a $ character
swap sign       \ if the number is negative, add a - character
#> type ;      \ complete the formatted number conversion

--> 123456 dollars.
$1234.56 ok
--> -123456 dollars.
-$1234.56 ok

```

OLED display

To include the following words requires a change to the source code:-

```

#define          #define ENABLE_OLED_SUPPORT to activate
ENABLE_OLED_SUPPORT the lib.

# include <Adafruit_GFX.h>    install in your system the Adafruit libraries
# include <Adafruit_SSD1306.h> install in your system the Adafruit libraries

```

| | | | |
|--------------------|------------|---|------|
| OledInit | (--) | initialize the display to accept commands | oled |
| OledDelete | (n -- a) | | oled |
| OledBegin | (n -- a) | initialization | oled |
| OledHOME | (n -- a) | send cursor to upper left home position | oled |
| OledCLS | (n -- a) | clears the display | oled |
| OledTextc | (n -- a) | | oled |
| OledPrintln | (n -- a) | print a zero= null terminated string from the stack | oled |
| OledNumln | (n -- a) | print + CR a number on the stack (int) | oled |
| OledNum | (n --) | print a number on the stack (int) | oled |
| OledDisplay | (--) | show the buffer on the OLED display | oled |

| | | | |
|----------------------|--------------------|---|------|
| OO | (n -- a) | is an abbreviation of Oledisplay | oled |
| OledPrint | (z" " addr --) | print a zero= null terminated string from the stack | oled |
| OledInvert | (--) | invert the background & foreground colors | oled |
| OledTextsize | (n --) | | oled |
| OledSetCursor | (n --) | | oled |
| OledPixel | (x y C --) | draw a pixel x y coordinates C= Color , f.e.use 1 | oled |
| OledDrawL | (x y x2 y2 1 --) | draw a line x y x2 y2 coordinates C= Color , f.e. 1 | oled |
| OledCirc | (x y r 1 --) | draw a circle | oled |
| OledCircF | (x y r 1 --) | draw a circle filled | oled |
| OledRect | (x y x2 y2 1 --) | draw a rectangle | oled |
| OledRectF | (x y x2 y2 1 --) | draw a rectangle filled | oled |
| OledRectR | (x y x2 y2 1 --) | draw a rectangle rounded edges | oled |
| OledRectRF | (n -- a) | draw a rectangle rounded edges filled | oled |
| OledAddr | (n -- a) | address of I2C device | oled |
| OledNew | (n -- a) | | oled |

OLED example (–) *Demonstrates how to talk to the OLED 128x64 pixels*

```
Oled
OLEDINIT          \ initialise display / greeting message
123 Olednum Oleddisplay \ print the number top of stack
Oledhome oledcls OO \ home the cursor, clear the screen
1 1 35 35 1 Oledrect OO \ draw rectangle
Oledinvert OO      \ invert the display
```

Registers

| | | | |
|-----------|--|--|-----------|
| m! | | | registers |
| m@ | | | registers |

RMT Remote Control Transceiver

| | | | |
|------------------------|--------------------------|--|-----|
| rmt_set_clk_div | (channel div8 -- err) | | RMT |
| rmt_get_clk_div | (channel @div8 -- err) | | RMT |

| | | | |
|--|---|--|-----|
| rmt_set_rx_idle_thresh | (channel thresh16 -- err) | | RMT |
| rmt_get_rx_idle_thresh | (channel @thresh16 -- err) | | RMT |
| rmt_set_mem_block_num | (channel memnum8 -- err) | | RMT |
| rmt_get_mem_block_num | (channel @memnum8 -- err) | | RMT |
| rmt_set_tx_carrier | (channel enable highlev lowlev carrierlev -- err) | | RMT |
| rmt_set_mem_pd | (channel f -- err) | | RMT |
| rmt_get_mem_pd | (channel @f -- err) | | RMT |
| rmt_tx_start | (channel f -- err) | | RMT |
| rmt_tx_stop | (channel -- err) | | RMT |
| rmt_rx_start | (channel f -- err) | | RMT |
| rmt_rx_stop | (channel -- err) | | RMT |
| rmt_tx_memory_reset | (channel -- err) | | RMT |
| rmt_rx_memory_reset | (channel -- err) | | RMT |
| rmt_set_memory_owner | (channel owner -- err) | | RMT |
| rmt_get_memory_owner | (channel @owner -- err) | | RMT |
| rmt_set_tx_loop_mode | (channel f -- err) | | RMT |

| | | | |
|-------------------------------|---|--|-----|
| rmt_get_tx_loop_mode | (channel @f -- err) | | RMT |
| rmt_set_rx_filter | (channel enable thresh8 -- err) | | RMT |
| rmt_set_source_clk | (channel baseclk -- err) | | RMT |
| rmt_get_source_clk | (channel @baseclk -- err) | | RMT |
| rmt_set_idle_level | (channel enable level -- err) | | RMT |
| rmt_get_idle_level | (channel @enable @level -- err) | | RMT |
| rmt_get_status | (channel @status -- err) | | RMT |
| rmt_set_rx_intr_en | (channel enable -- err) | | RMT |
| rmt_set_err_intr_en | (channel enable -- err) | | RMT |
| rmt_set_tx_intr_en | (channel enable -- err) | | RMT |
| rmt_set_tx_thr_intr_en | (channel enable thresh -- err) | | RMT |
| rmt_set_gpio | (channel mode gpio# invertsigs -- err) | | RMT |
| rmt_config | (rmt_config_ t*) | | RMT |
| rmt_isr_register | (fn arg allocflags handle -- | | RMT |

| | | | |
|-------------------------------------|--|---------------------------------------|-----|
| | err) | | |
| rmt_isr_deregister | (handle -- err) | | RMT |
| rmt_fill_tx_items | (channel @items items# offset -- err) | | RMT |
| rmt_driver_install | (channel rxbufsize allocflags -- err) | | RMT |
| rmt_driver_uninstall | (channel -- err) | | RMT |
| rmt_get_channel_status | (channel @status -- err) | | RMT |
| rmt_get_counter_clock | (channel @clockhz -- err) | | RMT |
| rmt_write_items | (channel @items items# wait -- err) | | RMT |
| rmt_wait_tx_done | (channel time -- err) | | RMT |
| rmt_get_ringbuf_handle | (channel @handle -- err) | | RMT |
| rmt_translator_init | (channel fn -- err) | | RMT |
| rmt_translator_set_context | (channel @context -- err) | | RMT |
| rmt_translator_get_context | (channel @@context -- err) | | RMT |
| rmt_write_sample | (channel src src# wait -- err) | | RMT |
| rmt_register_tx_end_callback | | NOT SUPPORTED | RMT |
| rmt_memory_rw_rst | | DEPRECATED USE rmt_tx_memory_reset or | RMT |

| | | | |
|--|--|--|-----|
| | | rmt_rx_memory_reset | |
| rmt_set_intr_enable_mask | | DEPRECATED interrupt handled by driver | RMT |
| rmt_clr_intr_enable_mask | | DEPRECATED interrupt handled by driver | RMT |
| rmt_set_pin | | DEPRECATED use rmt_set_gpio instead | RMT |

RTOS support

| | | | |
|---|--|--|------|
| rtos-builtins | | | RTOS |
| vTaskDelete | | | RTOS |
| xPortGetCoreID | | | RTOS |
| xTaskCreatePinnedToCore | | | RTOS |

SD Card

| | | | |
|----------------------------------|---|----------------------------------|----|
| SD.begin | (--) | uses all the defaults "/sd" etc. | SD |
| SD.beginDefaults | (-- sspin SPIClass frequency mountpoint maxfiles format_if_empty) | (SS SPI 4000000 "/sd" 5 false) | SD |
| SD.beginFull | (sspin SPIClass frequency mountpoint maxfiles format_if_empty --) | | SD |
| SD.end | (--) | | SD |
| SD.cardType | (-- n) | | SD |
| SD.totalBytes | (-- n) | | SD |
| SD.usedBytes | (-- n) | | SD |

SD_MMC Card

| | | | |
|--------------------------------------|--------------------|------------------------|--------|
| SD_MMC.begin | (mount mode1bit) | default mode1bit=false | SD_MMC |
| SD_MMC.beginDefaults | | | SD_MMC |
| SD_MMC.beginFull | | | SD_MMC |
| SD_MMC.cardType | (-- n) | | SD_MMC |
| SD_MMC.end | (--) | | SD_MMC |

| | | | |
|--------------------------|----------|--|--------|
| SD_MMC.totalBytes | (-- n) | | SD_MMC |
| SD_MMC.usedBytes | (-- n) | | SD_MMC |

Serial communication

‘Serial’ is the default forth terminal, pin GPIO1 is data out from the ESP32, GPIO3 is data in.

‘Serial2’ is unused by default. Pin GPIO17 is data transmit from the ESP32, GPIO16 is data in.

| | | | |
|---|-------------------|---|--------|
| Serial.available Serial2.available | (-- f) | Get the number of bytes (characters) available for reading from the serial port. This is data that's already arrived and stored in the serial receive buffer (which holds 64 bytes) | serial |
| Serial.begin Serial2.begin | (baud --) | Start serial port. Sets the data rate in bits per second (baud) for serial data transmission | serial |
| Serial.end Serial2.end | (--) | Disables serial communication, allowing the RX and TX pins to be used for general input and output. To re-enable serial communication, call Serial.begin | serial |
| Serial.flush Serial2.flush | (--) | Waits for the transmission of outgoing serial data to complete | serial |
| Serial.readBytes Serial2.readBytes | (a length -- n) | Serial.readBytes reads characters from the serial port into a buffer, address a. The function terminates if the determined length has been read. The number of bytes, n is returned | serial |
| Serial.write Serial2.write | (a n -- n) | Writes n bytes of data to the serial port from buffer at address a | serial |

Serial Bluetooth

| | | | |
|-------------------------------|----------|-----------------------------------|------------------|
| esp_bt_dev_get_address | (-- a) | <i>addr of 6 byte mac address</i> | <i>bluetooth</i> |
|-------------------------------|----------|-----------------------------------|------------------|

Serial Bluetooth:-

| | | | |
|------------------------------|--------------------------------------|------------------------|-----------|
| SerialBT.new | (-- bt) | Allocate new BT object | bluetooth |
| SerialBT.delete | (bt --) | Free BT object | bluetooth |
| SerialBT.begin | (localname ismaster bt -- f) | | bluetooth |
| SerialBT.end | (bt --) | | bluetooth |
| SerialBT.available | (bt -- f) | | bluetooth |
| SerialBT.readBytes | (a n bt -- n) | | bluetooth |
| SerialBT.write | (a n bt -- n) | | bluetooth |
| SerialBT.flush | (bt --) | | bluetooth |
| SerialBT.hasClient | (bt -- f) | | bluetooth |
| SerialBT.enableSSP | (bt --) | | bluetooth |
| SerialBT.setPin | (z bt -- f) | | bluetooth |
| SerialBT.unpairDevice | (addr bt -- f) | | bluetooth |
| SerialBT.connect | (remotename bt -- f) | | bluetooth |
| SerialBT.connectAddr | (addr bt -- f) | | bluetooth |
| SerialBT.disconnect | (bt -- f) | | bluetooth |
| SerialBT.connected | (timeout bt -- f) | | bluetooth |
| SerialBT.isReady | (checkMaster timeout -- f) | | bluetooth |

SPI FLASH memory

| | | | |
|---|--|--|-----------|
| esp_partition_check_id entity | | | spi_flash |
| esp_partition_erase_range | | | spi_flash |
| esp_partition_find | | | spi_flash |
| esp_partition_find_first | | | spi_flash |
| esp_partition_get | | | spi_flash |
| esp_partition_get_sha256 | | | spi_flash |
| esp_partition_iterator_release | | | spi_flash |
| esp_partition_mmap | | | spi_flash |
| esp_partition_next | | | spi_flash |
| esp_partition_read | | | spi_flash |
| esp_partition_t | | | spi_flash |
| esp_partition_t_size | | | spi_flash |
| esp_partition_verify | | | spi_flash |
| esp_partition_write | | | spi_flash |
| list-partition-type | | | spi_flash |
| list-partitions | | | spi_flash |
| p. | | | spi_flash |
| p>address | | | spi_flash |
| p>gap | | | spi_flash |
| p>label | | | spi_flash |
| p>size | | | spi_flash |
| p>subtype | | | spi_flash |

| | | | |
|-------------------------------|--|--|-----------|
| p>type | | | spi_flash |
| spi_flash_cache_enabled | | | spi_flash |
| spi_flash_cache2phys | | | spi_flash |
| spi_flash_erase_range | | | spi_flash |
| spi_flash_erase_sector | | | spi_flash |
| spi_flash_get_chip_size | | | spi_flash |
| spi_flash_init | | | spi_flash |
| spi_flash_mmap | | | spi_flash |
| spi_flash_mmap_dump | | | spi_flash |
| spi_flash_mmap_get_free_pages | | | spi_flash |
| spi_flash_munmap | | | spi_flash |
| spi_flash_phys2cache | | | spi_flash |
| spi_flash_read | | | spi_flash |
| spi_flash_read_encrypted | | | spi_flash |
| spi_flash_write | | | spi_flash |
| spi_flash_write_encrypted | | | spi_flash |
| spi_flash-builtins | | | spi_flash |
| SPI_PARTITION_SUBTYPE_ANY | | | spi_flash |
| SPI_PARTITION_TYPE_APP | | | spi_flash |
| SPI_PARTITION_TYPE_DATA | | | spi_flash |

Serial Peripheral Interface Flash File System (SPIFFS)

| | | | |
|--------------------------|--|---|----------------|
| SPIFFS.begin | (format-on-fail path-z max-files -- f) | Mounts file system. It must be called before any other SPIFFS words are used. Returns true if file system was mounted successfully, false otherwise. If format-on-fail is true the 'disk' will be formatted | SPI filesystem |
| SPIFFS.end | (--) | Unmounts the flash memory file system | SPI filesystem |
| SPIFFS.format | (-- f) | Format the flash memory 'disk'. returns true if successful | SPI filesystem |
| SPIFFS.totalBytes | (-- n) | Returns the total capacity of the flash memory 'disk' | SPI filesystem |
| SPIFFS.usedBytes | (-- n) | Returns the total space occupied by flash memory files | SPI filesystem |

Sockets

Addrln is a parameter in quite a few Sockets words. Unless otherwise noted, addrln is just the number 16 defining the length in bytes of a sockaddr structure for IPv4. When calling words **sockaccept** and **recvfrom**, addrln must be the address of a variable, so that these two functions can update the value.

| | | | |
|--------------------|-------------------------------|---|---------|
| ->addr! | (n a --) | set big-endian address in sockaddr | sockets |
| ->addr@ | (a -- n) | get big-endian address from sockaddr | sockets |
| ->h_addr | (hostent – a) | Get host address from a hostent structure (returned by gethostbyname) | sockets |
| ->port! | (n a --) | set port in sockaddr | sockets |
| ->port@ | (a -- n) | get port from sockaddr | sockets |
| ip. | (n --) | Print address as x.y.z.w IP address. | sockets |
| ip# | | Part of ip. | sockets |
| AF_INET | (-- 2) | constant | sockets |
| bind | (sock addr addrln -- 0/err) | The bind function assigns an address to an unnamed socket. Sockets created with socket() function are initially unnamed; they are identified only by their address family | sockets |
| bs, | (n –) | Compile 16 bit number (as 2 bytes) into a | sockets |

| | | | |
|----------------------|---|---|---------|
| | | definition, big-endian (ms byte in lowest address) | |
| connect | (sock addr addrlen -- 0/err) | The connect function requests a connection to be made on a socket. N.B. A socket is closed again with <sock> CLOSE-FILE | sockets |
| errno | (-- err) | f = the error number of the last sockets action | sockets |
| gethostbyname | (hostnamez -- hostent/0) | | sockets |
| l, | (n –) | Compile 32 bit number n (as 4 bytes) into a definition | sockets |
| listen | (sock backlog -- 0/err) | Listen for socket connections and limit the queue of incoming connections - 'backlog' is the max no. of connections that can be put on hold | sockets |
| NON-BLOCK | (sock – 0/err) | Certain words in the socket, file or serial port vocabs normally block until complete. NON-BLOCK converts these to non-blocking. If a function would have normally blocked, it now returns -1 and errno is set to ESP_ERR_WIFI_WOULD_BLOCK = \$300E | forth |
| poll | (pollfds n timeout -- fd/err) | A file descriptor for a socket that is listening for connections will indicate that it is ready for reading, once connections are available. A file descriptor for a socket that is connecting asynchronously will indicate that it is ready for writing, once a connection has been established. | sockets |
| recv | (sock a n1 flags -- n2/err) | receive data to buffer at address a, required size n1. returns number of bytes actually read n2. It's up to you to call recv again until all the data is read. Will block if the receive buffer is empty. Use NON-BLOCK to alter that | sockets |
| recvfrom | (sock a n1 flags addr addrlen -- n2/err) | Works like recv, albeit addr , addrlen is a sockaddr showing who sent the message. N.B. make sure here that addrlen is an address of a variable, not a number ! Will block if the receive buffer is empty. Use NON-BLOCK to alter that | sockets |
| recvmsg | (sock msg flags -- n/err) | Will block if the receive buffer is empty. Use NON-BLOCK to alter that | sockets |
| s, | | Compile 16 bit number (as 2 bytes) into a definition | sockets |
| select | (numfds | A file descriptor for a socket that is listening for | sockets |

| | | | |
|----------------------------|---|---|---------|
| | readfds writefds errfds timeout -- fd/err) | connections will indicate that it is ready for reading, when connections are available. A file descriptor for a socket that is connecting asynchronously will indicate that it is ready for writing, when a connection has been established | |
| send | (sock a n1 flags -- n/err) | send data at address a, n1 bytes long. Return n2 the actual number of bytes received or -1 as an error flag. Will block if the transmit buffer is full. Use NON-BLOCK to alter that | sockets |
| sendmsg | (sock msg flags -- n/err) | Returns the actual number of bytes received or -1 as an error flag. Will block if the transmit buffer is full. Use NON-BLOCK to alter that | sockets |
| sendto | (sock a n flags addr addrlen -- n/err) | Like send, but the recipient is specifically addressed with sockaddr addr, addrlen. Return the actual number of bytes received or -1 as an error flag | sockets |
| setsockopt | (sock level optname optval optlen -- 0/err) | The setsockopt() function sets the option specified by the option_name argument, at the protocol level specified by the level argument, to the value pointed to by the option_value argument for the socket associated with the file descriptor specified by the socket argument. | sockets |
| sizeof(sockaddr_in) | (-- 16) | Constant – the size of a standard IPv4 sockaddr is 16 bytes | sockets |
| SO_REUSEADDR | (– 2) | constant | sockets |
| SOCK_DGRAM | (– 2) | constant | |
| SOCK_RAW | (– 3) | constant | |
| SOCK_STREAM | (-- 1) | constant | sockets |
| socketaccept | (sock1 addr addrlen -- sock2/err) | The socketaccept function extracts the first connection on the queue of pending connections, creates a new socket sock2 with the same socket type protocol and address family as the specified socket, and returns a new file descriptor for sock2 in sockaddr addr, addrlen. N.B. make sure here that addrlen is an address of variable, not a number! It must be set to 16 (sockaddr size in bytes) before calling socketaccept. Normally blocks until a remote client connects. Use NON-BLOCK to alter that | sockets |
| sockaddr | ("name" --) | creates a sockaddr structure | sockets |
| socket | (domain | domain is usually AF_INET for tcpip using a 4 | sockets |

| | | | |
|-------------------------|-------------------------------|---|---------|
| | type protocol – sock/err) | byte internet address. type is SOCK_STREAM for tcp or SOCK_DGRAM for udp; protocol is 0 for internet: returns a reference sock | |
| sockets-builtins | | | sockets |
| SOL_SOCKET | (– 1) | constant | sockets |

Stack functions

| | | | |
|--------------|-------------------------|---|-------|
| -rot | (a b c – c a b) | rotate top cell to 3rd | forth |
| ?DUP | (x -- 0 x x) | Duplicate x if it is non-zero. | |
| >R | (n –) | move n to the return stack | forth |
| 2drop | (n1 n2 –) | discard the top of stack | forth |
| 2dup | (n1 n2 – n1 n2 n1 n2) | duplicate the top two items on the data stack | forth |
| depth | (– n) | return the data stack depth on the top of stack e.g. 3 2 1 depth displays 3 2 1 3 | forth |
| DROP | (n –) | discard the top of stack | forth |
| DUP | (n – n n) | duplicate the top of stack | forth |
| f.s | (–) | displays the floating point number stack | forth |
| nip | (n1 n2 -- n2) | remove the 2nd item on the data stack | forth |
| OVER | (n1 n2 -- n1 n2 n1) | duplicate 2nd item on the data stack | forth |
| R@ | (-- n) | copy the top of the return stack to the top of data stack | forth |
| R> | (– n) | Move top of return stack to data stack | forth |
| rdrop | (--) | drop the top of the return stack | forth |
| rot | (a b c -- b c a) | rotate 3rd cell to top | forth |
| RP! | (addr --) | set the return stack pointer | forth |
| RP@ | (-- addr) | read the return stack pointer | forth |
| rp0 | (-- addr) | constant - the initial value of the return stack pointer at switch-on | forth |
| SP! | (addr --) | set the data stack pointer | forth |
| SP@ | (-- addr) | read the data stack pointer | forth |

| | | | |
|-------------|--------------------|---|-------|
| sp0 | (-- n) | constant - the initial value of the data stack pointer at switch-on | forth |
| SWAP | (n1 n2 -- n2 n1) | swap the top two data stack entries | forth |

Streams

These words enable the creation of first-in first-out buffers or queues of chrs or bytes, useful where a stream of data is to be handled. The words are multitask compatible.

| | | | |
|---------------------|-----------------|--|---------|
| >offset | (n st -- a) | internal word | streams |
| >read | (st -- rd) | internal word | streams |
| >stream | (a n st --) | read string, a n , from stream. Terminate when n chrs received or stream empty | streams |
| >write | (st -- wr) | internal word | streams |
| ch>stream | (ch st --) | wait until there is space, then write one char | streams |
| empty? | (st -- f) | returns true if stream empty | streams |
| full? | (st -- f) | returns true if stream full | streams |
| stream | (n "name" --) | define a stream, size n, using the next word in the input stream as the name e.g. 200 stream myinputstream 20000 stream myoutputstream | streams |
| stream# | (st -- n) | returns the number of chrs waiting to be read in stream st | streams |
| stream> | (a n st --) | send string, a n , to stream st | streams |
| stream>ch | (st -- ch) | wait until data is available then read one char | streams |
| wait-read | (st --) | wait until there is data ready to read from st | streams |
| wait-write | (st --) | wait until there is space to write to stream st | streams |

String functions

ESP32forth supports both null terminated strings used in calling the various C based vocabularies and counted strings as used by many forth systems.

| | | | |
|---------------|---------------------|--|-------|
| [char] | (--) | compile the first letter of the following word in the definition e.g. : my-char [char] ALPHABET emit char emit ; executing my-char fred will display:- Af | forth |
| r" | ("string" -- a n) | Creates a temporary counted string | forth |
| r | (string -- a n) | Creates a temporary counted string ending with | forth |

| | | | |
|--------------------|----------------------------------|--|-------|
| s" | (-- addr cnt) | Creates a zero terminated string. Leaves the string address addr and the character count cnt on the stack e.g. s" Hello Bob" | forth |
| s>z | (a n -- z) | Convert a counted string string to null terminated string | forth |
| startswith? | (addr1 n1 addr2 n2 -- f) | f=true if string at addr1 starts with string at addr2, else f=false | forth |
| str | (n -- addr cnt) | convert n to a counted string | forth |
| str= | (addr1 n1 addr2 n2 -- f) | f=true if the two counted strings are equal, else f=false | forth |
| z" | ("string" -- addr) | Creates a null terminated string on the heap at addr | forth |
| z>s | (addr -- addr n) | Convert a null terminated string at addr to a counted string | forth |

r| example (--) Demonstrates making a standalone application with the aid of of a temporary string made with r|

```
r| z" NETWORK-NAME" z" PASSWORD" webui | \ create a string to start the web server
s" /spiffs/autoexec.fs" dump-file       \ save it to file autoexec.fs
```

Structures

| | | | |
|---------------------|---------------------------|---|------------|
| align-by | (a1 n -- a2) | Adjust address a up to an n byte boundary | structures |
| field | (n "name") | Define a field in the structure | structures |
| i16 | (– 2) | Used to define a 16 bit field | structures |
| i32 | (– 4) | Used to define a 32 bit field | structures |
| i64 | (– 8) | Used to define a 64 bit field | structures |
| i8 | (– 1) | Used to define a 8 bit field | structures |
| last-align | (– a) | variable | structures |
| last-struct | (– a) | variable | structures |
| long | (– 4) | Used to define a 32 bit field for a long | structures |
| ptr | (– 4) | Used to define a pointer field of one cell | structures |
| struct | ("name") (– total) | Start a structure definition. When "name" is execute it returns the total byte count of the structure | structures |
| struct-align | (n --) | Set the last structure defined to be on an n byte boundary | structures |

| | | | |
|--------------|------------------------|--|------------|
| typer | (align sz "name") | define a field type with alignment 'align' and 'sz' bytes in size | structures |
|--------------|------------------------|--|------------|

STRUCTURES example (--) Demonstrates definition and use of a structure

First a recipe for a structure is defined:-

```
struct timer
i32 field counter
i32 field limit
```

Now we create a variable based on that structure:-

```
create mytimer timer allot
```

Now we can access fields within that variable:-

```
mytimer limit @      20 mytimer counter !
```

System

| | | | |
|-----------------|-----------------|--|-------|
| bye | (--) | deferred word, defaults to esp32-bye | forth |
| CELL | (-- 4) | returns the number of bytes per standard forth number - 32 bits | forth |
| echo | (-- addr) | All input stream is echoed on output stream if echo = -1, else only partial echo (--> ok and errors) if set 0 | forth |
| evaluate | (addr cnt --) | evaluate the counted string at addr, as if typed in at the command line | forth |
| EXECUTE | (xt --) | Execute the word whose execution token is top of stack | forth |
| HIGH | (-- 1) | Logic high is represented by 1 e.g. HIGH 1 pin | forth |
| hld | (-- adr) | holds a pointer in building a numeric output string | forth |
| INPUT | (-- 1) | constant used to set a pin as an input e.g. 2 INPUT pinMode | forth |
| LED | (-- 2) | Some ESP32 modules have an LED fitted on GPIO pin 2 | forth |
| LOW | (-- 0) | Logic low is represented by 0 e.g. LOW 4 pin | forth |
| OUTPUT | (-- 2) | constant used to set a pin as an output e.g. 4 OUTPUT pinMode | forth |

| | | | |
|------------------|-------------|---|-------|
| quit | (--) | Leave stack intact, but return control to input stream | forth |
| state | (-- addr) | system variable, state=true system is interpreting, state=false system is compiling | forth |
| TERMINATE | (n --) | Call system exit | forth |

Tasks – multitasking

| | | | |
|-------------------|--------------------------|---|-------|
| .tasks | (--) | List running tasks | tasks |
| pause | (--) | yield to other tasks | forth |
| start-task | (task --) | Activate a task | forth |
| task | (xt dsz rsz "name" --) | Create a new task, named using the next word in the input stream, with 'dsz' size data stack, and 'rsz' size return stack, execution to start at 'xt' execution token | forth |
| main-task | | | tasks |
| task-list | (– addr) | Return the start address of the task list | tasks |

Tasks example (--) Demonstrates adding a 10 second timer task

```
: hi begin ." Time is: " ms-ticks . cr 10000 ms again ;      \ Print the tick every 10sec.
' hi 100 100 task my-counter                                \ define my-counter task
my-counter start-task                                       \ start the my-counter task
```

\ in between print outs, type tasks .tasks <cr> and observe the active tasks are
 \ main-task my-counter yield-task

Actually the word 'hi' above could have been written as:-

```
: hi ." Time is: " ms-ticks . cr 10000 ms ;                  \ Print the tick and pause 10s
```

The word 'task' compiles:-

```
again: xt of 'hi'
      pause
      branch to again
```

So any word written as a 'one-shot' will in fact repeat when assigned to a task and a 'pause' is already built in to ensure task switching

Telnet

| | | | |
|---------------|--------|---|---------|
| broker | (--) | Deferred word - executes broker-connection by default | telnetd |
|---------------|--------|---|---------|

| | | | |
|--------------------------|---------------|--|---------|
| broker-connection | (--) | Processing loop for the active TELNET link | telnetd |
| client | | | telnetd |
| client-len | (-- adr) | variable | telnetd |
| clientfd | (-- flag) | value, default to -1 | telnetd |
| connection | | | telnetd |
| server | (port --) | Start telnet server daemon on port | telnetd |
| sockfd | (-- flag) | value, default to -1 | telnetd |
| telnet-emit | (c --) | Emit c character on the active telnet port | telnetd |
| telnet-emit' | | | telnetd |
| telnet-key | (-- c) | Retrieve a character c from the active telnet port | telnetd |
| telnet-port | (a n --) | | telnetd |
| telnet-type | (adr len --) | Send a counted string on the active telnet port | telnetd |

Telnet example (--) Demonstrates starting the telnet server to enable terminal communication with ESP32forth over WiFi

z" yourrouterid" z" yourpassword" login cr \ Login to your Wifi router
telnetd \ vocabulary TELNET
552 server \ start the telnet server on port 552

Time / Timers

n = group (0/1) There are two groups of two timer channels
x = timer (0/1)
m = watchdog (0-5)

| | | | |
|----------------------|------------------|--|--------|
| ms | (n1 --) | pause for "n" milliseconds. | forth |
| MS-TICKS | (-- n1) | Time since start in milliseconds | forth |
| alarm | (t -- a) | | timers |
| alarm-enable! | (f t --) | Alarm enable | timers |
| alarm-enable@ | (t -- f) | Alarm enabled? | timers |
| autoreload! | (v t --) | | timers |
| divider! | (n t --) | Timer divider 2 - 65535 | timers |
| edgeint! | (f t --) | Edge trigger | timers |
| enable! | (v t --) | Timer enable/disable | timers |
| increase! | (v t --) | Timer increasing/decreasing | timers |
| int-enable! | (f t --) | | timers |
| interval | (xt usec t --) | Setup timer t to call execution token xt after | timers |

| | | | |
|---------------------------------|-------------------|--|--------|
| | | usec delay | |
| levelint! | (v t --) | Level trigger | timers |
| onalarm | (xt t --) | Set callback | timers |
| rerun | (t --) | Rerun timer t triggering | timers |
| t>nx | (t -- n x) | x=1 if bit0 of t=1, else x=0 n=1 if bit1 of t=1, else n=0 | timers |
| timer! | (lo hi t --) | | timers |
| timer@ | (t -- lo hi) | | timers |
| TIMG_BASE | (-- \$3ff5f000) | constant | timers |
| TIMGn | | | timers |
| TIMGn_RTCCALICFG_REG | (n -- a) | | timers |
| TIMGn_RTCCALICFG1_REG | (n -- a) | | timers |
| TIMGn_Tx | (n x -- a) | | timers |
| TIMGn_Tx_INT_CLR_REG | (n -- a) | | timers |
| TIMGn_Tx_INT_ENA_REG | (n -- a) | | timers |
| TIMGn_Tx_INT_RAW_REG | (n -- a) | | timers |
| TIMGn_Tx_INT_ST_REG | (n -- a) | | timers |
| TIMGn_Tx_WDTCONFIGm_REG | (n m -- a) | | timers |
| TIMGn_Tx_WDTFEE_D_REG | (n -- a) | | timers |
| TIMGn_Tx_WDTWPROTECT_REG | (n -- a) | | timers |
| TIMGn_TxALARMLOHI_REG | (n x -- a) | | timers |
| TIMGn_TxCONFIG_REG | (n x -- a) | | timers |
| TIMGn_TxLOAD_REG | (n x -- a) | | timers |
| TIMGn_TxLOADLOHI_REG | (n x -- a) | | timers |
| TIMGn_TxLOHI_REG | (n x -- a) | | timers |

| | | | |
|---------------------------|--------------|--|--------|
| TIMGn_TxUPDATE_REG | (n x -- a) | | timers |
|---------------------------|--------------|--|--------|

Interval example (--) Demonstrates starting a timed word with interval

timers

```
: hellobob ." hello bob" cr 0 rerun ;
' hellobob 10000000 0 interval
```

```
\ Print a message and restart timer 0
\ and run that every 10 seconds
```

\ note the input terminal remains reponsive whilst the timer is counting down

\ there are a total of only four timer channels - so turn to multitasking if more is needed

Two Wire Interface / I2C

| | | | |
|-------------------------------|---------------------|--|------|
| Wire.available | (-- f) | Returns the number of bytes available for retrieval with Wire.read. This should be called on a master device after a call to Wire.requestFrom | Wire |
| Wire.begin | (-- f) | Initiate the Wire library and join the I2C bus as a master. This should normally be called only once. | Wire |
| Wire.beginTransmission | (n --) | Begin a transmission to the slave device at address n. Subsequently, queue bytes for transmission with the Wire.write function and transmit them by calling Wire.endTransmission | Wire |
| Wire.busy | (-- f) | | Wire |
| Wire.endTransmission | (sendstop -- f) | Ends a transmission to a slave device that was begun by Wire.beginTransmission and transmits the bytes that were queued by Wire.write Sends a stop message if sendstop=true | Wire |
| Wire.flush | (--) | | Wire |
| Wire.getClock | (-- frequency) | Read the clock frequency set by Wire.setClock | Wire |
| Wire.getErrorText | (n -- z) | | Wire |
| Wire.getTimeout | (-- ms) | | Wire |
| Wire.lastError | (-- n) | | Wire |
| Wire.peek | (-- ch) | | Wire |
| Wire.read | (-- ch) | Reads a byte that was transmitted from a slave device to a master after a call to Wire.requestFrom or was transmitted from a master to a slave | Wire |
| Wire.readTransmission | (addr a n sendstop | | Wire |

| | | | |
|-------------------------------|---|---|------|
| | account -- err) | | |
| Wire.requestFrom | (address quantity sendstop -- n) | Used to request bytes from a slave device. The bytes may then be retrieved with the Wire.available and Wire.read functions. A stop message is sent after the request if sendstop is true | Wire |
| Wire.setClock | (frequency --) | Modifies the clock frequency for I2C communication. I2C slave devices have no minimum working clock frequency, however 100KHz is usually the baseline | Wire |
| Wire.setTimeout | (ms --) | Default is 50ms | Wire |
| Wire.write | (a n -- n) | Writes data from a slave device in response to a request from a master, or queues bytes for transmission from a master to slave device (in-between calls to Wire.beginTransaction and Wire.endTransmission) | Wire |
| Wire.writeTransmission | (addr a n sendstop -- err) | | Wire |

Vectored Execution

| | | | |
|--------------|-------------------------|---|-------|
| defer | ("vectornam e" --) | Define a deferred execution vector e.g. defer myemit | forth |
| is | (--) | Set the vector of a deferred word e.g. ' emit is myemit - sets the deferred word myemit to execute emit when called | forth |

Vocabulary (or Wordlist)

| | | | |
|--------------------|-------------|--|-------|
| }transfer | | transfer the words enclosed in curly brackets to the current library e.g. { word1 word2 word3 ... }transfer | forth |
| also | (--) | Duplicate the vocabulary at the top of the vocabulary stack | forth |
| context | (-- a) | an area to specify vocabulary search order - defaults to forth. context @ puts the current vocab id on the stack context @ @ puts the xt of the last word defined in the current vocab | forth |
| current | (-- addr) | points to a vocabulary thread to which new definitions are to be added | forth |
| definitions | (--) | Make the context vocabulary the current vocabulary | forth |
| forth | (--) | Make the forth vocabulary the current vocabulary | forth |
| internals | | Make the internals vocabulary the current vocabulary | forth |
| interrupts | | Make the interrupts vocabulary the current vocabulary | forth |
| ledc | | Make the ledc vocabulary the current vocabulary | forth |
| only | (--) | Reset context stack to one item, the FORTH dictionary | forth |
| order | (-) | Print the vocabulary search order | forth |
| registers | (--) | set the current vocabulary to registers | forth |
| rtos | | Make the rtos vocabulary the current vocabulary | forth |
| SD_MMC | | Make the SD_MMC vocabulary the current vocabulary | forth |
| sealed | (--) | Alter the last vocabulary defined so it doesn't chain | forth |
| Serial | | Make the Serial vocabulary the current vocabulary | forth |
| sockets | | Make the sockets vocabulary the current vocabulary | forth |
| SPIFFS | | Make the SPIFFS vocabulary the current vocabulary | forth |
| streams | (--) | set the current vocabulary to streams | forth |

| | | | |
|----------------------|---------------|---|-------|
| tasks | | make tasks vocabulary the current one | forth |
| telnetd | | Make the telnetd vocabulary the current vocabulary | forth |
| timers | (--) | Make the timers vocabulary the current vocabulary | forth |
| vocabulary | ("name" --) | Create a vocabulary with the current vocabulary as parent | forth |
| web-interface | | Make the web-interface vocabulary the current vocabulary | forth |
| WebServer | | Make the WebServer vocabulary the current vocabulary | forth |
| WiFi | | Make the WiFi vocabulary the current vocabulary | forth |
| Wire | (--) | Make the Wire vocabulary the current vocabulary | forth |
| previous | (--) | Drop the vocabulary at the top of the vocabulary stack | forth |

Visual

| | | | |
|-------------|-------------------|---|--------|
| edit | ("filename" --) | ANSI terminal file editor e.g. visual edit /spiffs/autoexec.fs | visual |
|-------------|-------------------|---|--------|

| | |
|-----------------|--------------------------------------|
| Key strokes: | Action: |
| Ctrl-S | Save now |
| Ctrl-X / Ctrl-Q | Quit, asking Y/N to save |
| Ctrl-L | Redraw the screen |
| Backspace | Delete a character backwards |
| Arrow keys | Move the cursor up, down, left right |
| PgUp /PgDown | Scroll up / down a page |

Web Interface

| | | | |
|-----------------------|-----------------------------------|---|----------------------|
| do-serve | | | <i>web-interface</i> |
| handle-index | | | <i>web-interface</i> |
| handle-input | | | <i>web-interface</i> |
| handle1 | | | <i>web-interface</i> |
| index-html | | | <i>web-interface</i> |
| index-html# | (– 2268) | constant | <i>web-interface</i> |
| input-stream | (– a) | stream of size 200 | <i>web-interface</i> |
| out-size | (– 2000) | constant | <i>web-interface</i> |
| out-string | | block of storage, size out-size+1 | <i>web-interface</i> |
| output-stream | (– a) | stream of size out-size | <i>web-interface</i> |
| serve-key | (-- n) | | <i>web-interface</i> |
| serve-type | (a n --) | | <i>web-interface</i> |
| server | (port --) | | <i>web-interface</i> |
| webserver | (– a) | variable | <i>web-interface</i> |
| webserver-task | | multitasker task | <i>web-interface</i> |
| webui | (network-z password-z --) | login and start webui e.g. z" NETWORK-NAME" z" PASSWORD" webui | forth |

WiFi

| | | | |
|--------------|---------------------------|--|-------|
| login | (network-z password-z | login to wifi only e.g. z" NETWORK-NAME" z" PASSWORD" login | forth |
|--------------|---------------------------|--|-------|

| | | | |
|-------------------------------|--|--|------|
| | --) | | |
| WIFI_MODE_AP | (-- 2) | access point mode: stations can connect to the ESP32 e.g. WIFI_MODE_AP WiFi.mode | WiFi |
| WIFI_MODE_APSTA | (-- 3) | access point and a station connected to another access point e.g. WIFI_MODE_APSTA WiFi.mode | WiFi |
| WIFI_MODE_NULL | (-- 0) | | WiFi |
| WIFI_MODE_STA | (-- 1) | station mode: the ESP32 connects to an access point e.g WIFI_MODE_STA WiFi.mode | WiFi |
| WiFi.begin | (ssid-z password-z --) | Initializes the WiFi library's network settings and provides the current status. e.g. z" mySSID" z" myPASSWORD" WiFi.begin | WiFi |
| WiFi.config | (ip dns gateway subnet --) | Allows you to configure a static IP address as well as change the DNS, gateway, and subnet addresses on the WiFi shield. Packaged a.b.c.d little-endian | WiFi |
| WiFi.disconnect | (--) | Disconnects the WiFi shield from the current network | WiFi |
| WiFi.getTxPower | (-- powerx4) | Get power x4 | WiFi |
| WiFi.localIP | (-- ip) | Get local IP | WiFi |
| WiFi.macAddress | (a --) | Gets the MAC Address of your ESP32 WiFi port | WiFi |
| WiFi.mode | (mode --) | Set WiFi mode example below | WiFi |
| WiFi.setTxPower | (powerx4 --) | Set power x4 | WiFi |
| WiFi.softAP | (ssid password/0 -- success) | Software enabled Access Point – essentially behaviour like a Router | WiFi |
| WiFi.softAPIP | (-- ip) | Return IP address of the soft access point's network interface. | WiFi |
| WiFi.softAPBroadcastIP | (-- ip) | Function to get the AP IPv4 broadcast address | WiFi |
| WiFi.softAPConfig | (localip gateway subnet -- success) | Configure the soft access point's network interface. | WiFi |
| WiFi.softAPdisconnect | (wifioff -- | Disconnect stations from the network | WiFi |

| | | | |
|---------------------------------|------------|--|------|
| | success) | established by the soft-AP. | |
| WiFi.softAPgetStationNum | (-- num) | Get the count of the stations that are connected to the soft-AP interface. | WiFi |
| WiFi.softAPNetworkID | (-- id) | Get the softAP network ID | WiFi |
| WiFi.status | (-- n) | Returns the connection status | WiFi |

WiFi.mode (mode –) Set Wifi mode

0 WIFI_MODE_NULL In this mode, the internal data struct is not allocated to the station and the AP, while both the station and AP interfaces are not initialized for RX/TX Wi-Fi data. Generally, this mode is used for Sniffer, or when you only want to stop both the STA and the AP to unload the whole Wi-Fi driver.

1 WIFI_MODE_STA Station mode: in this mode, will init the internal station data, while the station's interface is ready for the RX and TX Wi-Fi data.

2 WIFI_MODE_AP AP mode: in this mode, init the internal AP data, while the AP's interface is ready for RX/TX Wi-Fi data. Then, the Wi-Fi driver starts broadcasting beacons, and the AP is ready to get connected to other stations.

3 WIFI_MODE_APSTA Station-AP coexistence mode: in this mode, will simultaneously init both the station and the AP. This is done in station mode and AP mode. Please note that the channel of the external AP, which the ESP Station is connected to, has higher priority over the ESP AP channel.

WiFi.status (n –) Returns the connection status – n can take the following values:-

255 WL_NO_SHIELD - no WiFi shield is present

0 WL_IDLE_STATUS - WiFi.begin is called and remains active until the number of attempts expires (resulting in WL_CONNECT_FAILED) or a connection is established (resulting in WL_CONNECTED)

1 WL_NO_SSID_AVAIL - no SSID are available

2 WL_SCAN_COMPLETED - scan networks is completed

3 WL_CONNECTED - connected to a WiFi network

4 WL_CONNECT_FAILED - connection fails for all the attempts

5 WL_CONNECTION_LOST - connection is lost

6 WL_DISCONNECTED - disconnected from a network

WiFi connection example (--) Connect and disconnect from WiFi demo web-interface also WiFi

```
: status. ( -- ) \ print WiFi connection status
." Current WiFi status = " WiFi.status . cr
;
```

```

: test      ( -- )
WIFI_MODE_STA WiFi.mode          \ set to connect to an access point
z" yourroutername" z" yourpassword" WiFi.begin \ attempt to connect
3000 ms
status.                          \ report our Wifi link status
." Your assigned IP address = " WiFi.localIP
ip. cr                          \ report local IP address
WiFi.disconnect                  \ disconnect
." Now disconnecting" cr
3000 ms
status.                          \ report WiFi status again
;

```

\ N.B. edit the above with your router's name and password!!

Word definition

| | | | |
|---------|--------------------------|--|-------|
| , | (n --) | store a value into the dictionary space | forth |
| ; | (--) | stop compiler, and finish word definition e.g. : gday ." good day to you" ; | forth |
| : | ("wordname " --) | start compiler mode, creates a word definition e.g. : hi ." hello world" ; | forth |
| :noname | (-- xt) | Create a word with no name, leaving it's execution token on the stack. The xt would then usually be stored elsewhere from which the word can be executed | forth |
| ' | ("wordname " -- xt) | xt = execution token of the word that follows in the input stream e.g. ' words puts 1073654684 on the stack. Errors if word not found, stopping execution | forth |
| [| (--) | stop compiling the input stream and start executing - sets state=true | forth |
| [] | (-- xt) | xt = execution of the word that follows inside a : definition e.g. : COMING [] HELLO 'aloha ! ; | forth |
|] | (--) | Stop executing and start compiling the input stream, sets state=false | forth |
| { | (--) | Mark the start of a local variable block | forth |
| align | | | forth |
| aligned | (addr1 -- addr2) | converts an address on the stack to the next higher cell boundary, to help accessing memory by cells | forth |
| allot | (n --) | Allocate n bytes for storage and increment HERE by that space. See also the word | forth |

| | | | |
|------------------|--------------------|---|-------|
| | | ALLOCATE | |
| c, | (c --) | compile byte c at the next available location in the word definition | forth |
| constant | (n "name" --) | create a constant whose name follows in the input stream, value n. e.g. 12 constant dozen | forth |
| CREATE | (-- ; -- pfa) | create an empty dictionary entry <name>, returns the parameter field address when executed | forth |
| DOES> | (-- addr) | Used with create in defining new defining words e.g. : array (n -- ; i -- addr) \ new array type variable create cells allot does> swap cells + ; 10 array baba \ create a 10 cell array named baba 0 baba puts the 1st element address on the stack 1 baba puts the 2nd element address on the stack 10 0 baba ! stores 10 in the 1st element. | forth |
| IMMEDIATE | | Marks the last defined word as immediate - it will execute immediately if called whilst compiling a word | forth |
| literal | (n -- ; -- n) | add top of stack into the word being compiled at the next free memory location. When the word is run, place n top of stack | forth |
| postpone | ("text" --) | Skip leading space delimiters. Parse name delimited by a space. Find name. Append the compilation semantics of name to the current definition. Useful when an immediate word needs to be compiled in a word definition instead of immediately executing. Use instead of the obsolete COMPILE or [COMPILE] , you don't have to remember if word is immediate or normal | forth |
| recurse | (--) | Allows a word to call itself e.g. : FACTORIAL DUP 2 < IF DROP 1 EXIT THEN DUP 1- RECURSE * ; so 5 FACTORIAL leaves 120 on the stack | forth |
| SMUDGE | (--) | stops the current word being defined being found during a dictionary lookup | forth |
| to | (n "valuenam" -) | e.g. 24 to myvalue - sets myvalue = 24 | forth |

| | | | |
|-------------------|---------------------------------|--|-------|
| +to | (n "valuenname" –) | e.g. 4 +to myvalue – set myvalue = myvalue+4 | forth |
| value | (n "valname" -- ; -- n) | creates a value, named with the word that follows in the input stream, initialised n | forth |
| value-bind | (xt-val xt –) | | forth |
| variable | ("varname" -- ; -- addr) | variable takes the next word in the input stream as the name and reserves space for a variable | forth |

Local variables (n1 n2 --) Demonstrates defining a word where the input parameters on the stack are labelled for enhanced readability

```
: summ { foo bar }
    foo bar + .
;
```

\ so 2 3 summ results in 5 displayed

:NONAME example (-) Demonstrates creating words with no names, which can nevertheless be executed by execution token - saves space in the dictionary if the word is never used by name

```
:noname ." Saturday" ;
:noname ." Friday" ;
:noname ." Thursday" ;
:noname ." Wednesday" ;
:noname ." Tuesday" ;
:noname ." Monday" ;
:noname ." Sunday" ;
```

```
create (day) ( --- addr) \ an array of execution tokens for the 7 headerless words
, , , , , , ,
```

```
: day. ( n -- ) \ valid n=0-6
cells (day) + @ execute ;
```

\ executing 2 day. displays Tuesday etc.

Useful documentation

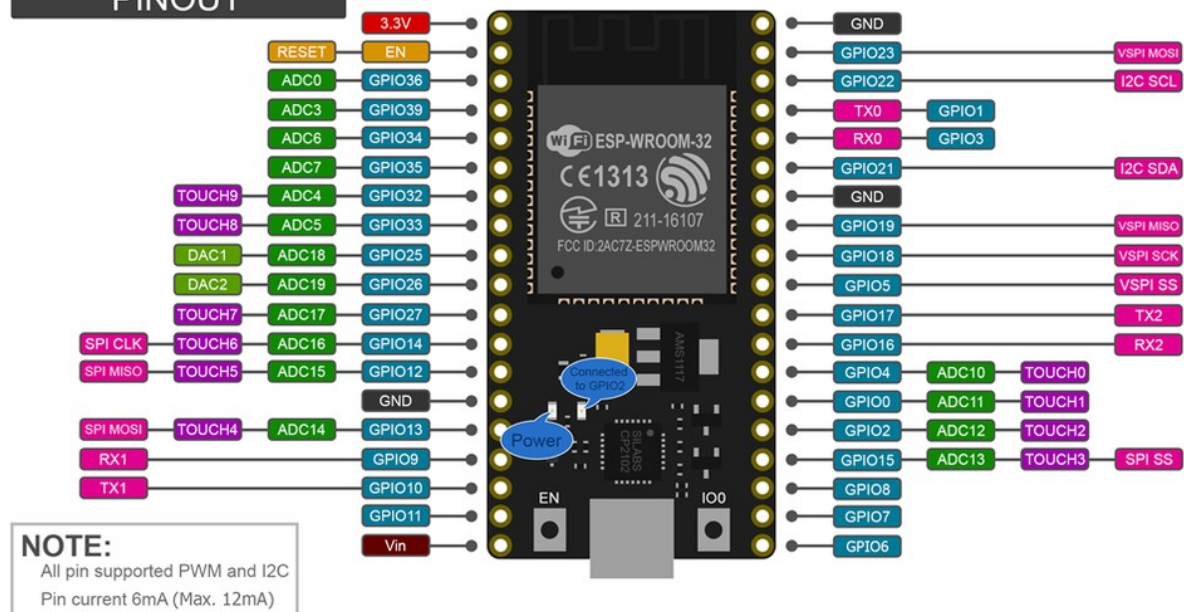
Bradley Nelsons's [ESP32forth home page](#), which includes downloads & **installation instructions**
 Marc PetreMann's excellent webpage on [ESP32forth programming](#)
[Forth2020](#) on facebook
 ESP32 module [buying guide](#)
 The [latest version of this document](#) is found here

Useful Code

The Forth2020 group's [archive of examples](#) is very useful
 Marc Petremann's [ESP32forth github](#) page
 The github [ESP32forth / forth2020group code page](#)
[My code](#) on github

NodeMCU-32 pin-out

NodeMCU-32 PINOUT



Conclusion

This glossary was compiled in Aug 2022 by Bob Edwards, retired EMC engineer in SW U.K. He always has it open, on screen, when he programs ESP32forth and hopes you will find it useful too.

Appendix 1 Internal Words

The following words are system internal 'worker words' and are liable to change from version to version of ESP32forth. For that reason they are non-preferred for User programs – caveat emptor. Nevertheless, when nothing else will do – here they are:-

Block File system

| | | | |
|----------------------------|-------------|---|-----------|
| arduino-default-use | (--) | attempt to open block file "/spiffs/blocks.fb" | internals |
| block-data | (-- addr) | A 1024 byte buffer for handling block file data | internals |
| block-dirty | (-- n) | value, default=0 | internals |
| clobber | (a --) | fill one block of 1024 characters with spaces | internals |
| clobber-line | (a -- a') | fill one block file line with spaces | internals |
| common-default-use | (--) | attempt to open block file "blocks.fb" | internals |
| grow-blocks | (n --) | Increase the size of the file by n blocks | internals |

Block File Editor

| | | | |
|-----------|----------|----------------------|-----------|
| e' | (n --) | used internally by e | internals |
|-----------|----------|----------------------|-----------|

Branching

| | | | |
|----------------|--|---|-----------|
| 0BRANCH | | | internals |
| BRANCH | | | internals |
| [SKIP] | | deferred word, defaults to [SKIP]', used internally in [ELSE] | internals |
| [SKIP]' | | used internally in [ELSE] | internals |

Character I/O

| | | | |
|------------------|----------|--|-----------|
| ?arrow. | (--) | If system variable arrow is true, the user prompt of an arrow followed by the data stack contents shows the system is ready for user input | internals |
| ?echo | (c --) | If system variable echo=true, then display the ascii character c, else if echo=false, c is dropped | internals |
| *emit | (n –) | | internals |
| *key | (– n) | | internals |
| dump-line | (a –) | print address line leaving room – part of the | internals |

| | | | |
|---------------------|-------------|---|-----------|
| | | dump word | |
| eat-till-cr | | | internals |
| input-buffer | (-- addr) | character buffer, size input-limit | internals |
| input-limit | (-- 200) | constant - the maximum permitted input char count before being terminated with <cr> | internals |
| line-pos | (– n) | value, | internals |
| line-width | (-- n) | value, defaults to 75 = the number of characters per line on the output stream | internals |

Debug

| | | | |
|--------------|--------|---|-----------|
| raw.s | (--) | display the data stack on one line of the display | internals |
|--------------|--------|---|-----------|

Files

| | | | |
|----------------------------------|----------------------|--|-----------|
| arduino-remember-filename | (-- addr cnt) | returns the filename "/spiffs/myforth" | internals |
| dirname | (a n --) | | internals |
| ends/ | (a n -- f) | | internals |
| include-file | (fh --) | | internals |
| include+ | | | internals |
| included-files | | value, default = 0 | internals |
| path-join | { a a# b b# -- a n } | | internals |
| raw-included | (a n --) | | internals |
| remember-filename | (-- a n) | Deferred word specifying the platform specific default snapshot filename - defaults to arduino-remember-filename = "/spiffs/myforth" | internals |
| restore-name | ("name" --) | Restore a snapshot from a file | internals |
| save-name | (a n --) | Save a snapshot of the current vocabulary to a file | internals |
| sourcedirname | (-- a n) | | internals |
| sourcefilename | (-- a n) | | internals |
| sourcefilename! | (a n --) | | internals |
| sourcefilename& | | value, default =0 | internals |
| sourcefilename# | | value, default =0 | internals |
| starts../ | (a n -- f) | | internals |
| starts./ | (a n -- f) | | internals |

Internal words

| | | | |
|----------------------------------|-------------------|---|-----------|
| 'cold | (– a) | | internals |
| (local) | (addr n --) | | internals |
|)leaving | | | internals |
| @line | (n --) | | internals |
| ALITERAL | | | internals |
| default | | | |
| default-remember-filename | (– string) | default value is “myforth” | |
| DOLIT | | | internals |
| evaluate-buffer | | | internals |
| EVALUATE1 | | | internals |
| exit= | (xt -- f) | f=true if the execution token at top of stack is that of 'exit', else f=false | internals |
| leaving | (-- addr) | variable | internals |
| leaving, | | | internals |
| leaving(| | | internals |
| notfound | (addr cnt n --) | | internals |
| onlines | (n xt -- n xt) | | internals |
| park-forth | (-- addr) | | internals |
| park-heap | (-- addr) | | internals |
| parse-quote | (-- addr cnt) | | internals |
| RAW-YIELD | (--) | | internals |
| restore-name | (“name” –) | | |
| save-name | | | |
| saving-base | | | internals |
| scope | (-- addr) | variable | internals |
| scope-clear | | reset the r stack and set scope=0 | internals |
| scope-create | (a n --) | | internals |
| scope-depth | (-- addr) | variable | internals |
| scope-doer | | creates a new word of type scope-doer | internals |
| scope-template | | is an instance of a scope-doer | internals |
| see-all | | | internals |
| see-loop | | | internals |

| | | | |
|--------------------------|----------------|--|-----------|
| see-one | (xt -- xt+1) | | internals |
| see-xt | (xt --) | | internals |
| see. | (xt --) | | internals |
| setup-saving-base | (--) | | |
| tib-setup | | | internals |
| use?! | | | internals |
| voc-stack-end | (-- addr) | | internals |
| voc. | (voc --) | | internals |
| xt-find& | (xt -- xt&) | | internals |
| xt-hide | (xt --) | | internals |
| xt-transfer | (xt --) | | internals |

Memory

| | | | |
|-----------------------------|-----------------|---|-----------|
| 'heap-size | | | internals |
| 'heap-start | | | internals |
| ca@ | (a -- n) | | internals |
| fill32 | | | internals |
| heap_caps_free | | | internals |
| heap_caps_malloc | | | internals |
| heap_caps_realloc | | | internals |
| LONG-SIZE | (-- 4) | Returns the size of a 32 bit long in bytes | internals |
| MALLOC | (n -- a 0) | System malloc - reserve n bytes of memory, returns start address a if successful, else returns 0 on failure | internals |
| MALLOC_CAP_32BIT | (-- 2) | constant | internals |
| MALLOC_CAP_8BIT | (-- 4) | constant | internals |
| MALLOC_CAP_DEFAULT | (-- 4096) | constant | internals |
| MALLOC_CAP_DMA | (-- 8) | constant | internals |
| MALLOC_CAP_EXEC | (-- 1) | constant | internals |
| MALLOC_CAP_INTERNAL | (-- 2048) | constant | internals |
| MALLOC_CAP_IRAM_8BIT | (-- 8192) | constant | internals |
| MALLOC_CAP_PID | (n1 -- n1 n2) | n1 range is 3-28, then n2 = 32*2 ⁿ¹⁻³ e.g. if n1=3, n2=32; if n1=4. n2=64 etc | internals |

| | | | |
|-----------------------------|------------------|--|-----------|
| MALLOC_CAP_RETENTION | (-- 8192) | constant | internals |
| MALLOC_CAP_SPIRAM | (-- 1024) | constant | internals |
| mem= | (a1 a2 n -- f) | f=true if the memory contents at a1 is equal to that at a2 for n bytes | internals |
| REALLOC | (a n -- a 0) | System realloc | internals |
| SYSFREE | (a --) | System free - release memory previously reserved with MALLOC? | internals |

Number I/O

| | | | |
|--------------|------------|--|-----------|
| #f+s | (r -) | | internals |
| digit | (u -- c) | converts an integer to an ascii char e.g. 5 is converted to 53 | internals |

Serial Communication

| | | | |
|--------------------|------------------|--|-----------|
| serial-key | (-- c) | reads the next character from the serial port | internals |
| serial-key? | (-- f) | an alias for Serial.available | internals |
| serial-type | (addr count --) | send the counted string at addr to the serial port | internals |

Stack functions

| | | | |
|---------------------|-------|---|-----------|
| ?stack | (-) | throws an error if stack underflow or overflow has occurred | internals |
| 'stack-cells | | | internals |

String functions

| | | | |
|---------------------|------------------------------------|---|-----------|
| 'tib | | | internals |
| \$@ | | | internals |
| \$place | (addr cnt --) | | internals |
| S>NUMBER? | (addr cnt -- n f=true f=false) | converts the counted ascii string stored at addr to number n with f=true, else just returns f=0, no n | internals |

System

| | | | |
|-----------------|-------------|-----------------|-----------|
| 'context | (-- addr) | system variable | internals |
|-----------------|-------------|-----------------|-----------|

| | | | |
|---------------------------|-----------------|---|-----------|
| 'heap | (-- addr) | system variable | internals |
| 'notfound | (-- addr) | system variable | internals |
| 'SYS | (-- addr) | system variable - used as the base address for system variables e.g. : 'context 'SYS 7 cells + ; | internals |
| 'boot | | | internals |
| 'boot-size | | | internals |
| 'cold | (– addr) | Address of the word that will run on start-up | internals |
| arrow | (-- addr) | variable, default=true if so, the user will be prompted by --> to show the forth system is ready for user input | internals |
| autoexec | (--) | at system start, check for autoexec.fs on the flash drive and run if present | internals |
| default-remember-filename | (-- addr cnt) | returns the string myforth | internals |
| esp32-bye | (–) | Restarts ESP32forth as though from switch-on | internals |
| esp32-stats | (–) | Displays chip model, type, clock speed, number of cores, flash chip size, system heap stats | internals |
| free. | (nf nu --) | Part of the sign-on message printed by raw-ok | internals |
| growth-gap | (-- \$4000 | constant | internals |
| raw-ok | (–) | Sign-on message – displays version, clockrate, number of cores, space, dictionary status, stack info | internals |

Tasks – multitasking

| | | | |
|------------|--|------------------------|-----------|
| YIELD | | | internals |
| yield-step | | Assigned to yield-task | internals |
| yield-task | | | internals |

Vocabulary

| | | | |
|-----------------|--------------|--------------------------------|-----------|
| 'context | | | internals |
| 'latestxt | | | internals |
| 'notfound | | | internals |
| >vocnext | (xt -- xt) | | internals |
| forth-wordlist | (-- n) | constant, defined as current @ | internals |
| last-vocabulary | (– n) | | internals |
| latesttext | (– xt) | | internals |

| | | | |
|------------------------|------------|--------------------------|-----------|
| nonvoc? | (xt – f) | | internals |
| see-all | (–) | | internals |
| see-vocabulary | (voc) | | internals |
| size-all | (–) | | internals |
| size-vocabulary | (voc) | | internals |
| voc. | (voc –) | | internals |
| vocs. | (voc --) | | internals |
| voclist | (–) | Display all vocabularies | internals |
| voclist-from | (voc –) | | internals |

Word definition

| | | | |
|-----------------------|-----------------|---|-----------|
| -TAB | (– 64) | constant | internals |
| }? | (addr cnt --) | used internally by { in defining local variables | internals |
| +TAB | (– 32) | constant | internals |
| BUILTIN_FORK | (– 4) | constant | internals |
| DOCOL | | | internals |
| DOCON | | | internals |
| DOCREATE | | | internals |
| DODOES | | | internals |
| DOSET | | | internals |
| DOVAR | | | internals |
| IMMEDIATE_MARK | (– 1) | constant | internals |
| immediate? | (xt -- f) | f=true if the word whose execution token is on the stack is an immediate word e.g. ' if immediate? returns true ' load immediate? returns false | internals |
| MARK | (– 128) | constant | internals |
| NONAMED | (– 16) | constant | internals |
| SMUDGE | (– 2) | constant | internals |

Orphan Words

| | | | |
|----------------|--|--|-----------|
| 'argc | | | internals |
| 'argv | | | internals |
| 'runner | | | internals |

| | | | |
|-----------|--|--|-----------|
| RAW-YIELD | | | internals |
| | | | internals |
| | | | internals |
| | | | internals |
| | | | internals |
| | | | internals |
| | | | internals |
| | | | internals |

Appendix 2 Notes on using the Sockets Dictionary

A very useful guide to programming with Internet Sockets [is located here](#).

Addresses

IPv4 internet addresses are represented by a 'sockaddr' structure in memory:-

| | | | | |
|-----------------|---------|----------|--------|--|
| ← 32 bit cell → | | | | len = 16, the number of bytes in the structure family = 2, AF_INET for internet use |
| long1 | [len] | [family] | port] | |
| long2 | [| address |] | |
| long3 | [| unused | | |
|] | | | | |
| long4 | [| unused | | |
|] | | | | |

A sockaddr can be created like a variable with a user provided name e.g. sockaddr data_in

len and family fields are set automatically.

All 16 bit fields and upwards are 'big-endian' i.e. The ms byte of the number resides at the lowest memory address. Since ESP32forth is 'little-endian' a number of transfer words are available to read and write fields in sockaddr structures:-

| | | | |
|---------|------------|--------------------------------------|---------|
| ->addr! | (n a --) | set big-endian address in sockaddr | sockets |
| ->addr@ | (a -- n) | get big-endian address from sockaddr | sockets |
| ->port! | (n a --) | set big-endian port in sockaddr | sockets |
| ->port@ | (a -- n) | get big-endian port from sockaddr | sockets |

Making a Transmission Control Protocol (TCP) Connection

When making connections a 'server' is the name given to the semi-permanent entity which can be connected to by one or more less-permanent 'clients'. These clients can disconnect from the server when done. e.g. A thermometer server in your greenhouse may be connected to by a client running on your PC in the house. Before shutting down the PC, the client application disconnects from the thermometer. It's all a bit like making a telephone call: Dial, Accept Call, Chat, Hangup.

The tcp server has to execute the following steps in sequence:-

| | | |
|----------------------|----------------------------|---|
| gethostbyname | (hostnamez -- hostent/0) | Look up the host by name, using a zero terminated string. Returns a pointer to a hostent structure or 0 if failed |
| ->h_addr | (hostent – a) | Get host address from hostent |

| | | |
|-------------------|-------------------------------------|--|
| | | (returned by gethostbyname) |
| socket | (domain type protocol – sock/err) | Make a socket |
| bind | (sock addr addrlen -- 0/err) | A server will bind to an address |
| listen | (sock backlog -- 0/err) | Listen for socket connections and limit the queue of incoming connections - 'backlog' is the max no. of connections that can be put on hold. If you only want to ever allow one connection, set backlog = 0 |
| sockaccept | (sock1 addr addrlen -- sock2/err) | The sockaccept function extracts the first connection on the queue of pending connections, creates a new socket sock2 with the same socket type protocol and address family as the specified socket, and returns a new file descriptor for sock2 in sockaddr addr, addrlen. N.B. make sure here that addrlen is an address of variable, not a number! It must be set to 16 (sockaddr size in bytes) before calling sockaccept. |

Once the connection is established, the client and server can repeatedly exchange data with:-

| | | |
|-------------|-------------------------------|---|
| send | (sock a n flags -- n/err) | send data at address a, n bytes long |
| recv | (sock a n1 flags -- n2/err) | receive data to buffer at address a, required size n1. returns number of bytes actually read n2. It's up to you to call recv again until all the data is read |

After all communication is done, the connection is closed with:-

| | | |
|-------------------|-----------------|------------------|
| CLOSE-FILE | (sock -- ior) | close the socket |
|-------------------|-----------------|------------------|

Let's look at the forth programming needed for a tcp client:-

Get the host address

z" google.com" gethostbyname constant google.com \ look up the host details using the name

google.com → h_addr

\ from the details extract the host ip addr

.ip 142.251.46.238 ok

\ .ip converts and displays the address

Create a sockaddr and populate it with address + port

sockaddr googleaddr

\ create a sockaddr

80 googleaddr → port!

\ save the port address required

google.com → h_addr googleaddr ->addr!
googleaddr

\ get host address and save in

Create a Socket

AF_INET SOCK_STREAM 0 socket value sock

\ create 'sock' SOCK_STREAM = TCP

Connect to the server

sock googleaddr sizeof(sockaddr_in) connect throw

\ throw used because connect may fail

Send an HTTP request

S" GET / HTTP/1.0" sock write-file throw

\ send a string using write-file

: semit (chr sock -) swap >r rp@ swap 1 swap write-file throw rdrop ;

: semit (chr sock -) swap >r rp@ 1 0 send 0< throw rdrop;
character

\ either version will send a

: scr 13 sock semit 10 sock semit ;

\ send CR-LF

scr scr

Read part of the reply

here 100000 sock read-file throw constant len

\ read the response from google.com

here len type

\ using read-file

Close the connection

sock close-file throw

Another Example - Reading and Writing blocks of bytes

Another example which demonstrates sending data between two ESP32s is [shown here](#), including instructions on how to run the demo.

Communication by User Datagram Protocol (UDP)

If TCP communication was like making a connection with a telephone, UDP is a bit like radio broadcasting – there's no end-to-end formal connection to be made. Consequently data can be missed, out of sequence or damaged.

In pseudo-code, the client has to execute the following steps:-

- `gethostbyname (hostname)`
- `socket (domain,type,protocol)`
- `bind (sock,addr,addrlen)`
- `sendto (sock,data, datalen, flags, addr, addrlen)`
- `recvfrom (sock,data,datalen,flags,addr, *addrlen)`
- `close (sock)`

Some example forth:-

Create a 'listening' address

`sockaddr incoming`

`9999 incoming ->port!`

Create a socket and bind to the address

`AF_INET SOCK_DGRAM 0 socket value sockfd`

`sockfd non-block throw`

`sockfd incoming sizeof(sockaddr_in) bind throw`

Read an incoming packet

`sockaddr received`

`variable received-len`

`sizeof(sockaddr_in) received-len !`

`sockfd msg len 0 received`

`received-len recvfrom to len`

`received ->addr@ ip. .": received ->port@ .`

`space space msg swap type cr`

Appendix 3 Catch and Throw

Another useful article on CATCH and THROW [appears here](#). The words CATCH and THROW, discussed in this section, provide a method for propagating error handling to any desired level in an application program. THROW may be thought of as a multi-level EXIT from a definition, with CATCH marking the location to which the THROW returns. Suppose that, at some point, word A calls word B, whose execution may cause an error to occur. Instead of just executing word B's name, word A calls word B using the word CATCH. Somewhere in word B's definition (or in words that B's definition may call) there is at least one instance of the word THROW, which is executed if an error occurs, leaving a numerical throw code identifier on the stack. After word B has executed and program execution returns to word A just beyond the CATCH, the throw code is available on the stack to assist word A in resolving the error. If the THROW was not executed, the top stack item after the CATCH is zero.

THROW (errcode –)

When you detect an error in your program, you can use THROW to "throw an error". In practice, THROW is used with a number (on the stack) so that the type of error can be identified. Let's take an imaginary word, DIV which divides two numbers. You want to check for a division by zero, and if so, act upon it. First, the Forth 83 way:

```
: DIV ( quotient divisor -- result ) dup 0= abort" DIV: Divide by 0 error." / ;
```

That's about the best you can do in Forth 83 without having to resort to passing flags to indicate if the division succeeded or not. The problem is that in the event of 0 being passed, the running program will stop. That's what ABORT and ABORT" does. Even worse, DIV can't tell us which word passed 0 to DIV in the first place, so it's not particularly useful.

Let's look at how we would trap errors using THROW :-

```
: DIV ( quotient divisor -- result ) dup 0= if 99 throw else / then ;
```

Here, if the divisor is 0, we "throw" error code 99 (which, in our program, means "divide by zero" - I chose 99 at random - it could be any value you like). But to where do we "throw" this 99? Or put it another way, who, or what is going to catch this error?

Best to throw an error at the deepest convenient part of the program. Using THROW without CATCH is OK during development because the system has a CATCH which leads to the word Error being displayed. Just barely useful for debugging.

CATCH (xt – 0 | errorcode)

CATCH will catch an error thrown by THROW. The critical difference is, this allows your program to gracefully handle the error situation (prompt the user to change disks if the disk is full, rather than just abort, causing the user to lose his magnum opus in your word processor application). Let's have a look at how we would use CATCH with our DIV example above :-

```
: test-div ( quotient divisor -- result )  
  ['] div catch dup 0<> if  
    dup 99 = if  
      ." Divide by zero error"  
    else
```

```

        throw
    then
then ;

```

The stack signature for CATCH is as follows:

```
CATCH ( ... xt -- 0|error_code )
```

What this means is, CATCH expects the execution token (xt) of the word you want to execute, in our example, DIV, to be on the stack. CATCH itself will then execute that word on your behalf. After DIV executes, CATCH can determine if control came back to CATCH via THROW or by a normal termination of the word. If the word terminated normally, CATCH puts a 0 on the stack (meaning that CATCH did not catch anything). If control came back to CATCH via THROW, the THROW code will be on the stack.

Best to catch at the highest point convenient in the program, some say

Thusly, in our example test above we test the error code returned by CATCH. If it's 0 then DIV did not throw anything, everything worked. If the return code is not zero however, something went wrong in DIV. We then examine the code, and, if it's 99 we indicate a divide by zero error.

If the error code is not 99 (which is the only thing that test-div is interested in) then something else went wrong (maybe the word / threw a different error of its own). All we know is, we're interested in error codes 0 and 99, and if aint either of them then it's "sombodys problem". In this case, we can THROW the error again, which will cause it to be caught by the next higher CATCH in the chain (if there is one).

Another THROW – CATCH example:-

```
: could-fail ( -- char )
```

```
    KEY DUP [CHAR] Q = IF 1 THROW THEN ;
```

```
: do-it ( a b -- c ) 2DROP could-fail ;
```

```
: try-it ( --)
```

```
    1 2 ['] do-it CATCH IF
```

```
    ( x1 x2 ) 2DROP ." There was an exception" CR
```

```
    ELSE ." The character was " EMIT CR
```

```
    THEN ;
```

```
; retry-it ( -- )
```

```
    BEGIN 1 2 ['] do-it CATCH WHILE
```

```
    ( x1 x2 ) 2DROP ." Exception, keep trying" CR
```

```
    REPEAT ( char )
```

```
    ." The character was " EMIT CR ;
```