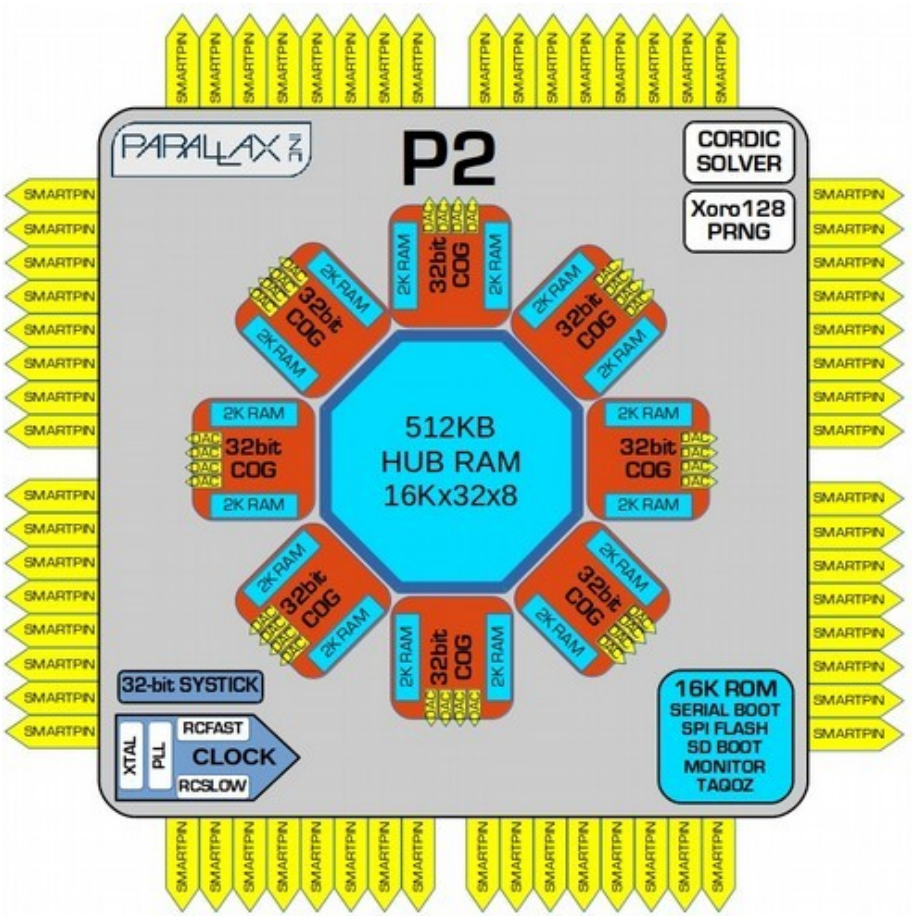
# TAQOZ Reloaded V2.8 GLOSSARY of WORDS

The Propeller P2




TAQOZ Reloaded is a really powerful extended version of TAQOZ ROM created by Peter Jakacki for the Propeller P2. The P2 is a feature packed 8 core 32 bit microcontroller from Parallax Inc. TAQOZ is a **Forth programmers' tool set** for the Parallax Propeller P2. This article explains how it came to be. Whereas TAQOZ ROM is permanently available in every P2, TAQOZ Reloaded resides on Flash memory or SD card.

This glossary is intended to be kept by you when programming. The headings and words are in alphabetic order to speed up searches. Acrobat Reader from Adobe will show a bookmark strip you can click on to jump to a particular section. Use **<ctrl> F** to search for a specific word. Please note that there are differences between this glossary for TAQOZ Reloaded and TAQOZ ROM glossary although many words work identically.

The experienced Forth programmer will notice many words that are unique to TAQOZ. TAQOZ is not intended to meet any international standard; and for a good reason. The non-standard word set is a very close fit around the unique P2 processor and its special circuits, as explained here. This results in a smaller, more useful and efficient tool with which to program P2. TAQOZ is also close enough to many Forth dialects to be quickly assimilated.

**About the format of the word tables**

- The **WORDS** column shows TAQOZ words
- The **STACK EFFECT** column shows the effect each word has on the data stack - in effect the required input parameters and results for each word
- The **PRE?** column (if yes is present) shows the word is preemptive, that is, will execute immediately, even if within a code definition. Preemptive words can be overidden with the word [C] to compile within a definition
- The **DESCRIPTION** column briefly describes what the word does or provides a working example
- The **TIME** column shows the number of clock cycles the instruction takes

**Entering data**

Data is referred to as bytes (ch, 8 bits), words (w, 16 bits), longs (n, 32 bits) and doubles (d, 64 bits). If the default number base is not the one required then the number base is best denoted by a prefix $<number> = hexadecimal, #<number> = decimal and %<number> = binary.
e.g. $AF #1234 %1011101

If a double (64 bits) is required, this is indicated by a . suffix e.g. 1234. or $4D2. puts 0 top of stack, with 1234 decimal next below.

Boolean values of FALSE and TRUE are simply 0 or -1 ($FFFF_FFFF) although in fact any non-zero value can be accepted as a boolean true but not necessarily suitable for bitwise operations such as AND. For instance 4 IF and 8 IF would both resolve as true however 4 8 AND IF fails. Use 0<> to promote any non-zero to a full TRUE in such cases.

If it is required to place a single printable character on the data stack, then enclose the char in single quotes e.g. 'A' places 41 hex on the stack

# LIST OF DEBUGGING CONTROL KEY SHORTCUTS

| | |
|---|---|
| ESC ESC ESC ESC | Reset - preserving the unsaved new words in RAM * - very handy to get out of an endless loop |
| ^Z ^Z ^Z ^Z | Reboot like switch on - losing the unsaved new words in RAM * |
| ^T^T^T^T | Start word TRACE - each word executed is displayed with a snapshot of the data stack, execution is slowed * |
| ^U^U^U^U | Stop TRACE, execution runs full speed * |
| ESC | Discard the current console line input |
| ^C | Reset |
| ^W | List 6 lines of most recently defined words in the dictionary (type WORDS to display all, or LWORDS <chars> to list selected) |
| ^D or ^? | Runs word DEBUG which displays data stack, COG ram, tthe registers, CODE space, Dictionary space and I/O status |
| ^Q | Print data stack |
| ^S | Clear data stack, then places a single value $DEADBEEF on the stack, to check stack balance when debugging new words |
| ^B | Runs the command BU to back up the system to SD card |
| ^F | Save the current TAQOZ image to flash memory |
| ^X | Re-eXecute last line (very useful) |

* works even if TAQOZ is not checking the console. If TAQOZ is at the user prompt, then only one control character is required, not four.

# ANSI TERMINAL

TAQOZ, by default, expects a computer terminal connected to smartpin P62 for data transmitted by the P2 and smartpin P63 for data received by the P2.

| NAME | STACK EFFECT | PRE? | DESCRIPTION | TIME (CYCLES) | SOURCE |
|---|---|---|---|---|---|
| *ANSI* | ( -- ) | no | Module header marker – use with FORGET | | extend.fth |
| %black | ( – 0 ) | no | constant colour | | extend.fth |
| %BLINK | ( -- ) | no | Set blinking - sets character red in tera term and no blinking | | extend.fth |
| %blue | ( – 4 ) | no | constant colour | | extend.fth |
| %BOLD | ( -- ) | no | Character set to bold yellow | | extend.fth |
| %CLS | ( -- ) | no | Clear screen – doesn't appear to work on Tera Term in Windows. I use %ERSCN %HOME instead | | extend.fth |
| %CURSOR | ( on/off – ) | no | Show the cursor – ON %CURSOR<br>Hide the cursor – OFF %CURSOR | | extend.fth |
| %cyan | ( – 6 ) | no | constant colour | | extend.fth |
| %ERLINE | ( -- ) | no | Erase the current line | | extend.fth |
| %ERSCN | ( -- ) | no | Erase the screen from the current location | | extend.fth |
| %green | ( – 2 ) | no | constant colour | | extend.fth |
| %HOME | ( -- ) | no | Home the cursor top left of the window | | extend.fth |
| %magenta | ( – 5 ) | no | constant colour | | extend.fth |
| %PAPER | ( col – ) | no | e.g. %green %PAPER | | extend.fth |
| %PEN | ( col – ) | no | e.g. %red %PEN | | extend.fth |
| %PLAIN | ( -- ) | no | White characters on a black background | | extend.fth |
| %red | ( – 1 ) | no | constant colour | | extend.fth |
| %REVERSE | ( -- ) | no | Swap character and background colour | | extend.fth |
| %UL | ( -- ) | no | Set underline | | extend.fth |
| %white | ( – 7 ) | no | constant colour | | extend.fth |
| %WRAP | ( on/off – ) | no | Word wrap at end of line | | extend.fth |
| %XY | ( x y – ) | no | Move cursor to x column, y row. 0 0 is top left | | extend.fth |
| %yellow | ( – 3 ) | no | constant colour | | extend.fth |
| ESC | ( ch -- ) | no | Send an ESC – ch sequence | | extend.fth |
| ESCB | ( ch -- ) | no | Send an ESC - [ - ch sequence | | extend.fth |

# ASSEMBLY LANGUAGE

| NAME | STACK EFFECT | PRE? | DESCRIPTION | TIME (CYCLES) | SOURCE |
|---|---|---|---|---|---|
| (ASM) | ( -- ) | no | Inline assembly language within a forth word e.g.<br><forth words> .. (ASM) <assembly code> (CODE) .. <more forth words | | kernel |
| (CODE) | ( -- ) | no | Terminates in-line assembly code, see (ASM) | | kernel |

Note: This basic assembly language facility for entering machine code instructions in hexadecimal has been superceded by P2ASM, the Taqoz Interactive Assembler, described elsewhere

# BENCHMARK

| NAME | STACK EFFECT | PRE? | DESCRIPTION | TIME (CYCLES) | SOURCE |
|---|---|---|---|---|---|
| fibo | ( n – f ) | no | Find the nth fibonacci element | | extend.fth |
| fibos | ( -- ) | no | Print a number of fibo runs | | extend.fth |

# BRANCHING

| NAME | STACK EFFECT | PRE? | DESCRIPTION | TIME (CYCLES) | SOURCE |
|---|---|---|---|---|---|
| ?EXIT | ( flg -- ) | no | Exit word if flg is true | | kernel |
| <CASE> | | yes | See SWITCH example below | | kernel |
| 0EXIT | ( flg -- ) | no | Exit word if flg is false (or zero) Used in place of IF.....THEN EXIT as false would just end up exiting | | kernel |
| BREAK | | yes | See SWITCH example below | | kernel |
| CALL | ( adr -- ) | no | Call the code field address on the top of stack | | kernel |
| CASE | ( compare – ) | yes | See SWITCH example below | | kernel |
| CASE@ | ( – value ) | no | Returns the value stored by the last SWITCH word | | kernel |
| ELSE | | yes | part of IF .. ELSE .. THEN structure | | kernel |
| EXECUTE | ( addr -- ) | no | Enter code or threaded code at address | | kernel |
| EXIT | ( – ) | no | Exit word now - pops return stack into IP | | kernel |
| GOTO | | yes | Used internally by IF and ELSE - compile a dummy NOP/GO to be replaced later with a goto (addr+ex) | internal use only | kernel |
| IF | ( n1 – ) | yes | If n1 true, do the words within IF … THEN, or IF .. ELSE .. THEN | | kernel |

| | | | | | |
|---|---|---|---|---|---|
| JUMP | ( adr -- ) | no | Jump to forth word code at adr | | kernel |
| NOP | ( – ) | no | do nothing | 72 | kernel |
| REVECTOR | ( <target> <new> -- ) | yes | Revector any calls to <target> to jump to <new> by rewriting first wordcode. <target> and <new> are both words taken from the input stream e.g. REVECTOR mytargetname mynewname | | |
| SWITCH | ( val – ) | no | See SWITCH example below | | kernel |
| THEN | | yes | part of IF .. ELSE .. THEN structure | | kernel |
| VECTOR: | | no | Create a vector table of fast jump addresses - see example below | | extend.fth |

**SWITCH example:-**

```
pub CASETEST ( val -- )
SWITCH
        1 CASE ." one" BREAK
        2 CASE ." two" BREAK
        3 CASE ." three" BREAK
        4 10 <CASE> ." between four and ten" BREAK
        ." default"
;
```

**VECTOR:  example:-**

```
:  BABA ." BABA" ;
: GAGA ." GAGA" ;
: DADA ." DADA" ;
: MYCHOICE VECTOR: BABA GAGA DADA NOP ;
```

Usage:
1 MYCHOICE prints GAGA on the terminal
0 MYCHOICE prints BABA on the terminal etc
It's down to you to guard against out of range values

# CHARACTER I/O

| NAME | STACK EFFECT | PRE? | DESCRIPTION | TIME (CYCLES) | SOURCE |
|---|---|---|---|---|---|
| @WORD | ( – n ) | no | Returns address of buffer where words from the input stream are assembled | | kernel |
| ?ERROR | ( cond n -- ) | no | Display error message and EXIT | | kernel |
| .” | ( -- ) | yes | Used to define a string for immediate print **  e.g. .” This prints immediately” | | kernel |
| .CLK | ( -- ) | no | Prints the processor clock frequency e.g. 200MHz | | kernel |
| .EMIT | ( ch – ) | no | Emit an alphanumeric character, else emit a dot for nonprintable | 1248 | kernel |
| .OK | ( -- ) | no | print OK! | | extend.fth |
| .SUCCESS | ( flag – ) | no | if true, print SUCCESS!, else print ERROR! | | extend.fth |
| .VER | ( -- ) | no | Prints ‘Parallax P2 *TAQOZ RELOADED sIDE* V2.8 'CHIP' Prop_Ver G C8MHz 210401-1230’ or similar on the output stream | | kernel |
| +BUF | ( -- ) | no | this is code pointed to by uemit to send an output chr to the buffer set up by =BUF. The buffer wraps on overflow | | extend.fth |
| +INFO | ( -- ) | no | Change prompt to include current code pointer | | extend.fth |
| =BUF | ( address size -- ) | no | initialise a new chr o/p buffer at addr and set EMIT to jump to the +BUF code - all subsequent calls to EMIT will then fill this buffer instead of going to the terminal | | extend.fth |
| BARE | ( -- ) | no | Plain non-interactive responses for remote operation - Remove prompt and accept strings | | extend.fth |
| BUFFERS | ( – n ) | no | returns the address of a 2k buffer used when reading files from SD card | 104 | kernel |
| CLS | ( – ) | no | clear the screen using $0C EMIT (doesn’t work with tera term under Windows, but %ERSCN %HOME works well) | 616 | kernel |
| COM | ( pin -- ) | no | direct output to a smartpin (after init) | | kernel |
| CON | ( – ) | no | select console output | 248 | kernel |
| CON? | ( – flag ) | no | Is console active? | | extend.fth |
| CONEMIT | ( chr – ) | no | output chr to the console, regardless of any redirection | 48 | kernel |
| CONKEY | ( – chr ) | no | Read ch from the console, if zero then no key was read, regardless of any redirection | 376 | kernel |
| CONOUT | ( -- ) | no | Redirect the output stream via MBXEMIT, mailbox emit | | extend.fth |
| CONSOLE | | no | Main console line loop – get a new line (word by word) | | kernel |
| CR | ( – ) | no | Emit carriage return | 608 | kernel |
| CRLF | ( – ) | no | Emit a carriage return line feed | 6640 | kernel |
| CTRL! | ( fnc key -- ) | no | Set a user function to be triggered by a control key press e.g. ' myfunction 'A' CTRL! will cause myfunction to run when CTRL-A is pressed | | kernel |
| CTYPE | ( str cnt -- ) | no | Display cnt chars, starting at address str | | kernel |
| DISCARD | | no | Discard the current line | 4002296 | kernel |
| EMIT | ( ch – ) | no | Emit a char to the current output stream | 520 | kernel |
| EMIT; | | no | Restore the setting previously save by EMIT: | | extend.fth |
| EMIT: | | no | save the current setting, and redirect (using uemit) all character output to the code that follows | | extend.fth |
| EMIT! | ( cfa -- ) | no | Set the emit vector or 0 to fall through to CONEMIT | 192 | kernel |
| EMIT@ | ( – cfa ) | no | Read the current emit vector | 168 | kernel |

| | | | | | |
|---|---|---|---|---|---|
| EMITS | ( ch n – ) | no | Emit n copies of chr to the current output stream | Around 257 per chr | kernel |
| EOL | ( -- adr) | no | Called at end of line - default action is do nothing – deferred word executed as part of the TAQOZ input stream interpreter. | | kernel |
| GET$ | ( -- str ) | no | Build a delimited word in wordbuf for wordcnt and return immediately upon a valid delimiter, like space, tab etc | | kernel |
| KEY | ( -- ch ) | no | Read ch from the current input stream, if zero then no key was read | 1280 if char found else 1032 if no char | kernel |
| KEY: | | no | redirect (using ukey) all character input to the code that follows | | extend.fth |
| KEY! | ( ch -- ) | no | Force a character as the next KEY read | 224 | kernel |
| KEY@ | ( – n ) | no | read last 4 keys | 152 | kernel |
| LOCAL | ( -- ) | no | Reset prompt to local interactive | | extend.fth |
| MBO | | no | Disable serial in / out on smartpins 62 / 63 | | kernel |
| MBX | | no | Use 'mailbox' as console for both transmit and receive | | kernel |
| MBXEMIT | ( chr -- ) | no | Waits until the mailbox buffer has been read, then sends chr to to that mailbox buffer as the console output stream | | extend.fth |
| MOUT | ( addr -- ) | no | Save output to hub memory address | 176 | kernel |
| NONE | | no | discard all console output | | kernel |
| NULL | | no | discard all console output - later word has same effect as NONE? | | extend.fth |
| PRINT” | ( -- ) | yes | Used to define a string for immediate print ** e.g.<br>PRINT” This prints immediately” | | kernel |
| PRINT$ | ( str – ) | no | Display string at address str ** e.g.<br>16 bytes mystring<br>“ FRED” mystring $!<br>mystring PRINT$ | | kernel |
| PROMPT | ( -- ) | no | execute user prompt code | 14464 with default | kernel |
| PROMPT! | ( cfa -- ) | no | Set the prompt or use 0 to reset to default | | extend.fth |
| SPACE | ( -- ) | no | emit a space char | 584 | kernel |
| SPACES | ( n – ) | no | emit n spaces | Around 566 per space | kernel |
| SPIN | ( -- ) | no | Emit the next character in a spinner sequence ( one of \| / - \ ) using backspace to reposition | | kernel |
| SPINNER | ( -- ) | no | Emit the next character in a spinner sequence ( one of \| / - \ ) using backspace to reposition | | extend.fth |
| TAB | ( -- ) | no | print the tab character | | extend.fth |
| TABS | ( n -- ) | no | print n tab chars | | extend.fth |
| WKEY | ( -- ch ) | no | wait for a key and return with character | | kernel |

** To print a non-visual character, include the chars \$nn in the string e.g. PRINT" \$07" sounds the bell on the terminal.

**GET$ example**

Quite often a PC <-> TAQOZ interface is possible using the TAQOZ console interpreter alone. The PC simply writes commands that you would write at the terminal. Where this won't do, the GET$ word becomes useful for loading numbers (it has other applications of course) e.g.

```
--- read 'count' number of longs directly off the console input stream into an array starting at 'adr'
pub GETLONGS   ( adr cnt -- )
FOR
        DUP                     --- backup of the array address
        GET$ $># DROP           --- read and convert the next word in the console input stream to a long
        SWAP !                  --- save the number in the array
        4+                      --- bump the address to the next array element
NEXT                            --- and repeat for all 'cnt' elements
DROP                            --- drop the address
;
```

How to add a PS-2 keyboard to the P2 is explained in this article.

# COG / HUB

From switch on, TAQOZ runs in COG 0 with COG7 running a vga display on smartpins P0 to P4. COGS 1 to 6 are idle. All COGS are potentially available for the user's application.

| NAME | STACK EFFECT | PRE? | DESCRIPTION | TIME (CYCLES) | SOURCE |
|---|---|---|---|---|---|
| AUTO | ( -- ) | yes | e.g. AUTO MAIN followed by a backup, would make MAIN the autostart routine | | kernel |
| COGATN | (mask -- ) | no | Strobe the “attention” event flag for all cogs whose corresponding bits are high in mask ( bit 0 - 8 for P2 ) | 56 | kernel |
| COGID | ( – n ) | no | Return current cog# | 64 | kernel |
| COGINIT | ( adr cog – ) | no | Start cog no. ‘cog’ with start up address ‘adr’ | | kernel |
| COGMOD | ( -- ) | no | Run the code  previously loaded to COG Ram by LOADMOD - see example below | | kernel |
| COGSTOP | ( cog -- ) | no | Stop a cog that is running a TAQOZ word | 56 | kernel |
| COLD | (– ) | no | Cold start TAQOZ - Taqoz will restart, but only with the kernel and SPIFLASH module loaded. The user can then select which other modules are loaded for the job in hand | | extend.fth |
| FILTER! | ( tap0..31 len0..3 filter0..3 -- ) | no | %0100_xxxx_xxxx_xxxx_xxxx_xxxR_RLLT_TTTT Set filter R to length L and tap T | | extend.fth |
| HUBSET | ( D -- ) | no | Set hub configuration - see note below | | kernel |
| LOADMOD | ( src len -- ) | no | Load COG memory from hub. With this version of TAQOZ, the COG memory starts at $1CB. 40 instructions (longs) appears to be the maximum permitted size.  * see comment below | | kernel |
| NEWCOG | ( n -- ) | no | An idling instance of TAQOZ is loaded and run in cog#n | 64 | kernel |
| P2? | ( – n ) | no | Return the P2 revision number | 72 | kernel |
| POLLATN | ( – flag ) | no | The ATN flag is a means of one cog shouting oi! to another<br>flag = FALSE  the ATN flag was received, ATN event flag then cleared.<br>flag = TRUE, no ATN flag received | 72 | kernel |
| REBOOT | ( – ) | no | | | kernel |
| REG | ( index -- addr ) | no | Find the address of the HUB REGISTER pointer specific to each COG. e.g. 38 REG C@  returns the current number base (variable pbase in the TAQOZ source code)  From switch on, 0 REG returns $200 for COG 0 | | kernel |
| RESET | ( – ) | no | | | kernel |
| RUN | ( task cog -- ) | no | e.g. ‘ MYWORD 6 RUN<br>Run word MYWORD in COG 6 | 5584 | extend.fth |
| RUN: | ( cog -- ) | no | Run the code that follows this word as a cog task | | extend.fth |
| TASK | ( cog -- addr ) | no | Return with address of task control register in "tasks" | | kernel |
| TERM | ( -- ) | no | Start main terminal console | | kernel |

***** N.B. Christof  Eb warns that in some versions of TAQOZ e.g V2.8 'CHIP' Prop_Ver G 200MHz 210401-1230. , word LOADMOD does not drop src and len from the stack like it should. If you find this too, use LOADMOD 2DROP as a bug fix.

## COG REGISTER LAYOUT

The cog's 512 x 32 dual-port COG RAM registers, are partially mapped as follows:-

| NAME | STACK EFFECT | PRE? | DESCRIPTION | TIME (CYCLES) | SOURCE |
|---|---|---|---|---|---|
| IJMP3 | ( -- $1F0 ) | no | Constant, interrupt call  address for INT3 | | extend.fth |
| IRET3 | ( -- $1F1 ) | no | Constant, interrupt return address for INT3 | | extend.fth |
| IJMP2 | ( -- $1F2 ) | no | Constant, interrupt call  address for INT2 | | extend.fth |
| IRET2 | ( -- $1F3 ) | no | Constant, interrupt return address for INT2 | | extend.fth |
| IJMP1 | ( -- $1F4 ) | no | Constant, interrupt call  address for INT1 | | extend.fth |
| IRET1 | ( -- $1F5 ) | no | Constant, interrupt return address for INT1 | | extend.fth |
| PA | ( -- $1F6 ) | no | Constant, CALLD-imm return, CALLPA parameter, or LOC address | | extend.fth |
| PB | ( -- $1F7 ) | no | Constant, CALLD-imm return, CALLPB parameter, or LOC address | | extend.fth |
| PTRA | ( -- $1F8 ) | no | Constant, pointer A to hub RAM | | extend.fth |
| PTRB | ( -- $1F9 ) | no | Constant, pointer B to hub RAM | | extend.fth |
| DIRA | ( -- $1FA ) | no | Constant, output enables for P31..P0 | | extend.fth |
| DIRB | ( -- $1FB ) | no | Constant, output enables for P63..P32 | | extend.fth |
| OUTA | ( -- $1FC ) | no | Constant, output states for P31..P0 | | extend.fth |
| OUTB | ( -- $1FD ) | no | Constant, output states for P63..P32 | | extend.fth |
| INA | ( -- $1FE ) | no | Constant, input states for P31..P0 also debug interrupt call address | | extend.fth |
| INB | ( -- $1FF ) | no | Constant, input states for P63..P32 also debug interrupt return address | | extend.fth |

Access to the above cog ram registers is by using words COG@ and COG!

**HUBSET** - The hub contains several global circuits which are configured using the HUBSET instruction. HUBSET uses a single D operand to both select the circuit to be configured and to provide the configuration data:-
D format:-

```
%0000_xxxE_DDDD_DDMM_MMMM_MMMM_PPPP_CCSS     Set clock generator mode
%0001_xxxx_xxxx_xxxx_xxxx_xxxx_xxxx_xxxx     Hard reset, reboots chip
%0010_xxxx_xxxx_xxLW_DDDD_DDDD_DDDD_DDDD     Set write-protect and debug enables
%0100_xxxx_xxxx_xxxx_xxxx_xxxR_RLLT_TTTT     Set filter R to length L and tap T
%1DDD_DDDD_DDDD_DDDD_DDDD_DDDD_DDDD_DDDD     Seed Xoroshiro128** PRNG with D
```

**ATN examples**
A cog may alert another cog by means of the ATN, the attention flag. Here's a demo - the SLAVE is mute until it receives an ATN from the MASTER:-

```
--- Just loop silently until an ATN flag is received
pub SLAVE               ( -- )
  BEGIN
        POLLATN
          IF
                ." Slave received ATN, thanks!" CRLF
          ELSE
                30 ms
                THEN
  AGAIN
;
```

```
--- Output a message to show the MASTER looping. Set cog 5's ATN flag on each pass
: MASTER                ( -- )
        BEGIN
                200 ms
                ." Hello from the Master, wake up cog# 5" CRLF
                %100000 COGATN                  --- Send ATN to cog 5
                KEY
        UNTIL
        ;
--- set them both going - press any key to stop MASTER and note SLAVE falls silent
' SLAVE 5 RUN
MASTER
```

**COGMOD example**

```
--- create a test word - up to 40 instructions
code test ( value n -- value+3*n 0 )
         add b,#3
         sub a,#1 wz
        if_nz jmp #\@COGMOD
        ret
end
```

```
--- copy the word to COG ram, starting at $1CB

AT test 2+ 4 LOADMOD
```

```
--- execute the word from COG Ram and print
--- results

10 5 COGMOD . .
```

# COMMENTS

| NAME | STACK EFFECT | PRE? | DESCRIPTION | TIME (CYCLES) | SOURCE |
|---|---|---|---|---|---|
| --- | ( -- ) | yes | Ignores the rest of the line | | kernel |
| ( | ( -- ) | yes | Ignores characters until closing brace ) - use on one line only | | kernel |
| { | ( -- ) | yes | Ignores characters until closing brace } - use across multiple lines | | kernel |
| } | ( -- ) | yes | Close a multi line comment | | kernel |
| \ | ( -- ) | yes | Ignores the rest of the line, does not echo | | kernel |

This article 'Comment all you like' is worth checking.

# COMPARISON

| NAME | STACK EFFECT | PRE? | DESCRIPTION | TIME (CYCLES) | SOURCE |
|---|---|---|---|---|---|
| < | ( n1 n2 -- flg ) | no | true if n1 less than n2 | 80 | kernel |
| <= | ( n1 n2 -- flg ) | no | true if n1 less than or equal n2 | 200 | kernel |
| <> | ( n1 n2 -- flg ) | no | true if n1 is not equal to n2 | 56 | kernel |
| = | ( n1 n2 -- flg ) | no | true if n1 is equal to n2 | 56 | kernel |
| => | ( n1 n2 -- flg ) | no | true if n1 greater than or equal n2 | 168 | kernel |
| > | ( n1 n2 -- flg ) | no | true if n1 greater than n2 | 80 | kernel |
| 0< | ( n1 n2 -- flg ) | no | true if n less than 0 | 24 | kernel |
| 0<> | ( n1 n2 -- flg ) | no | true if n1 not equal 0 | 32 | kernel |
| 0= | ( n1 n2 -- flg ) | no | true if n1 equals 0 | 32 | kernel |
| CLIP | ( n limit -- res \| 0 ) | no | If n>limit, returns 0, else returns n | 328 max | extend.fth |
| U< | ( u1 u2 -- flg ) | no | true if u1 less than u2 | 72 | kernel |
| U> | ( u1 u2 -- flg ) | no | true if u1 greater than u2 | 160 | kernel |
| WITHIN | ( n lo hi -- flg ) | no | true if n is within range of low and high inclusive | 416 | kernel |

# CONSTANTS

| NAME | STACK EFFECT | PRE? | DESCRIPTION | TIME (CYCLES) | SOURCE |
|---|---|---|---|---|---|
| -1 | ( – n1 ) | no | n1 = -1 | 56 | kernel |
| 1M | ( – n ) | no | Constant 1000000 | 112 | extend.fth |
| 64KB | ( – n ) | no | Constant 64 KB | 112 | extend.fth |
| BMP | ( – adr ) | no | Returns constant adr BMPORG | 112 | kernel |
| CLKMHZ | ( -- n ) | no | Returns default P2 clock frequency in MHz | 112 | kernel |
| CELLS | ( -- n ) | no | Returns 4, the number of addressable bytes in a long | | extend.fth |
| delim | ( – n ) | no | this stores the delimiter used in text input and a save location | | kernel |
| FALSE | ( – n1 ) | no | n1 = 0 | 56 | kernel |
| inbox | ( – n ) | no | pointer to the input stream buffer | | kernel |
| names | ( – n ) | no | this stores address of the latest word defined in the dictionary (builds down) | | kernel |
| OFF | ( – n1 ) | no | n1 = 0 | 56 | kernel |
| ON | ( – n1 ) | no | n1 = -1 | 56 | kernel |
| outbox | ( – n ) | no | pointer to the output stream buffer | | kernel |
| TRUE | ( – n1 ) | no | n1 = -1 | 56 | kernel |
| uaccept | ( – n ) | no | constant,this address stores addr of code to execute when Forth accepts a line to interpret (0=ok) | | kernel |
| uemit | ( – n ) | no | constant, this address stores the address of the emit code | | kernel |
| ufind | ( -- n ) | no | constant, returns relative address of extended dictionary flag | | kernel |
| ukey | ( – n ) | no | constant, stores the address of the key code | | kernel |
| unum | ( – n ) | no | constant, stores address of user number processing routine - executed if number conversion and word search in dictionary failed. unum routine should return true if successful, else false | | kernel |
| uprompt | ( – n ) | no | constant, stores address of code to execute when Forth prompts for a new line | | kernel |

# CONVERSION

| NAME | STACK EFFECT | PRE? | DESCRIPTION | TIME (CYCLES) | SOURCE |
|---|---|---|---|---|---|
| B>L | ( b1 b2 b3 b4 – n1 ) | no | n1 = b4.b3.b2.b1 four bytes to long conversion | 624 | kernel |
| B>W | (b1 b2 – w1 ) | no | w1 = b2*256 + b1 | 176 | kernel |
| L>S | ( n -- lsb9 h ) | no | specialized operation for filesystem addresses ( splits off 9 lsbs ) | 280 | kernel |
| L>W | ( n1 – w1 w2 ) | no | splits long n1 into to words | 200 | kernel |
| W>B | ( w1 – b1 b2 ) | no | splits word w1 into bytes | 216 | kernel |
| W>L | ( w1 w2 – n1 ) | no | n1 = w2*65536 + w1 | 200 | kernel |

# DEBUG

| NAME | STACK EFFECT | PRE? | DESCRIPTION | TIME (CYCLES) | SOURCE |
|---|---|---|---|---|---|
| ?PIN | ( pin -- ) | no | Print report of measuring pin capacitance as a float to high time | | extend.fth |
| .CONS | ( -- ) | no | Print all constants | | extend.fth |
| .CONVARS | ( -- ) | no | Print all constants and variables | | extend.fth |
| .CTRLS | ( -- ) | no | Print all keyboard shortcuts | | extend.fth |
| .DEVICES | ( – ) | no | Print report of loaded modules: on the P2-EVAL that is the SD card, I2C devices and clock frequency details | | extend.fth |
| .io | ( -- ) | no | Print the state of all 64 i/o pins on two lines | | extend.fth |
| .LAP | ( -- ) | no | print the time taken between LAP words - see below for a non-printing alternative | | kernel |
| .LAPS | ( n -- ) | no | e.g. LAP 100 0 DO I DROP LOOP LAP 100 .LAPS<br>Prints the time per pass through the loop | | kernel |
| .MODULES | ( – ) | no | Print a list of loaded modules | | extend.fth |
| .ms | ( -- ) | no | Another name for .LAP | | kernel |
| .PCB | ( – ) | no | If this is executed on a P2D2 card, then this prints P2D2 else P2 for all others | | extend.fth |
| .PU | ( -- ) | no | 57 lines of some kind of speed test | | extend.fth |
| .S | ( -- ) | no | Print out the data stack | | kernel |
| .USAGE | ( – ) | no | Prints a memory use report e.g.<br>CODE: 079BC 31,164 bytes<br>WORDS: 1DA82 9,493 bytes<br>DATA: 01B3D 419 bytes | | extend.fth |

| | | | | | |
|---|---|---|---|---|---|
| | | | ROOM: 90,310 bytes ok | | |
| .VARS | ( -- ) | no | Print all variables | | extend.fth |
| COG | ( -- ) | no | prefix for DUMP to show cog ram | | kernel |
| DEBUG | ( -- ) | no | Print the stack(s) and dump the registers - also called by hitting <ctrl>D during text input | 7396208 | kernel |
| DEVICES | ( – ) | no | Reports the devices connected to the P2. On the P2-EVAL that is: SD CARD 31 GB SANDISK SD SD32G REV$85 #3200344782 DATE:2021/1 | | extend.fth |
| DUMP | ( startadr cnt – ) | no | e.g. $0 $100 DUMP, or a modifier can be used:<br>$0 $100 RAM DUMP<br>Data is shown in bytes | | kernel |
| DUMP! | ( 'C@ 'W@ '@ -- ) | no | Creating a new DUMP device:<br>If at least one method is coded equivalent to C@ which takes an address and returns a byte, then it is possible to create a modifier for DUMP. In this example we will create one for the ROM which can normally be accessed at $FC000 but we will make it appear as its own memory addressed from 0.<br>pri ROMC@ ( addr -- byte ) $FC000 + C@ ;<br>pri ROMW@ ( addr -- byte ) $FC000 + W@ ;<br>pri ROM@ ( addr -- byte ) $FC000 + @ ;<br>pub ROM AT ROMC@ AT ROMW@ AT ROM@ DUMP! ;<br>Use: $1000 $40 ROM DUMP | | kernel |
| DUMPA | ( startadr cnt – ) | no | Like DUMP but data is shown as .ascii | | kernel |
| DUMPAW | ( startadr cnt – ) | no | Like DUMP but data is shown wide format as .ascii | | kernel |
| DUMPL | ( startadr cnt – ) | no | Like DUMP but data is shown as longs | | kernel |
| DUMPW | ( startadr cnt – ) | no | Like DUMP but data is shown as words | | kernel |
| DUMPZ | ( src cnt -- ) | no | dump memory as bytes but skip any 128 byte page that is all 0's or FF's | | extend.fth |
| FL | ( -- ) | no | prefix for DUMP to show flash ram e.g. 0 $20 FL DUMP | | kernel |
| I2C | ( -- ) | no | prefix for DUMP to read bytes from i2c device | | extend.fth |
| LAP | ( -- ) | no | Used to time words e.g.<br>LAP <forth words> LAP .LAP will display how long the code took to execute | | kernel |
| LAP@ | | no | used internally by .LAP | | kernel |
| lsi2c | ( – ) | no | Print list i2c devices | | extend.fth |
| lsio | ( -- ) | no | display all 64 pins states, high low etc | 220808 | kernel |
| LUT | ( -- ) | no | prefix with DUMP to show look up table (lut) ram | | kernel |
| LWORDS | ( -- ) | yes | detailed dictionary word list with optional match characters defined by next word in input stream | | extend.fth |
| MWORDS | ( width – ) | no | print dictionary in field ‘width’ | | extend.fth |
| QD | ( startadr – ) | no | quick dump of 32 bytes from addr | | kernel |
| QW | ( startadr – ) | no | Displays two lines of DUMP as words | | kernel |
| REDUMP | | no | Redump a byte dump listing back into memory - exit on empty line | | extend.fth |
| RTC | ( -- ) | no | prefix with DUMP for listing real time clock registers | | extend.fth |
| SD | ( – ) | no | select SD for DUMP method : use: 0 $200 SD DUMP | | file.fth |
| SYSINFO | ( – ) | no | Prints a report of: Loaded Modules, Memory usage, PCB type, P2 external clock frequency, SD card details, I2C device connected and P2 internal clock frequency | | extend.fth |
| TRACE | ( -- ) | no | Activate TRACE module displaying instruction pointer, code and name of word about to be executed, and the state of the data stack. Use: TRACE <words> UNTRACE | | kernel |
| TRACE! | ( floor -- ) | no | Set the TRACE module to only trace from this address or higher and activate TRACE - see example below | | extend.fth |
| UNTRACE | ( -- ) | no | Turns off the TRACE module | | kernel |
| W | ( -- ) | no | Print the 6 most recent lines of words | | kernel |
| WORDS | ( -- ) | yes | Print dictionary full width. If -L next word in input stream, then the next words after that is a search string e.g.<br>WORDS -L BL prints all words starting with BL | | extend.fth |

**New DUMP device example** - If at least one method is coded equivalent to C@ which takes an address and returns a byte, then it is possible to create a modifier for DUMP.

In this example we will create one for the ROM which can normally be accessed at $FC000 but we will make it appear as its own memory addressed from 0.

```
pri ROMC@ ( addr -- byte )      $FC000 + C@ ;
pri ROMW@ ( addr -- byte )      $FC000 + W@ ;
pri ROM@ ( addr -- byte )       $FC000 + @ ;
pub ROM                         AT ROMC@   AT ROMW@   AT ROM@  DUMP! ;
```

**TRACE! example** - most of the time we want to trace a recently defined word. Tracing through the rest of TAQOZ isn't useful. TRACE! allows us to filter the trace by address, so we trace only a few most recently defined words. Define a few test words ...

```
: wordA 1 - ;
: wordB wordA ;
: wordC
        2
        begin wordB dup 0 <= until
        drop
;
```

set detail level and switch trace on ...

```
' wordB TRACE!
wordC UNTRACE
```

set deeper trace level and switch trace on ...
Thanks for this example Christof Eb

```
' wordA trace!
wordC UNTRACE
```

This article 'Dumping permitted' explains how to use DUMP and friends effectively. Some of the other powerful tools are explained here.

The WORDS command has been made more useful by colour coding the lists it produces. Here's the key:-

Highlighting scheme used in dictionary listing

| | |
|---|---|
| pub | Public threaded words (normal : definitions) |
| pri | Private words - can be safely stripped & reclaimed from memory |
| pre | Preemptive immediate words (executes when typed - before enter) |
| DATA | DATA variable - points to variable in DATA memory |
| CON | Constant |
| COG | Cog kernel assembly code |
| HUB | Hubexec kernel assembly code |

| | |
|---|---|
| **Alternative to .LAP**<br>If code timing needs to be part of a process, then displaying the result isn't so useful. Instead we can use code to leave the number of cyles taken on the data stack. Here's a word TEST to time:-<br><br>Here we time TEST and the number of cycles it took is placed on the data stack. | pub TEST 10 FOR I . NEXT ;<br><br>LAP TEST LAP LAP@ LAP LAP LAP@ - .<br>--- 0 1 2 3 4 5 6 7 8 9 70208 ok |

# DECOMPILER

| NAME | STACK EFFECT | PRE? | DESCRIPTION | TIME (CYCLES) | SOURCE |
|---|---|---|---|---|---|
| *DECOMPILER* | ( -- ) | no | Module header marker – use with FORGET | | extend.fth |
| DECOMP | ( -- ) | yes | Prints a ‘source code’ decompilation of the words whose name is next in the input stream e.g. DECOMP WORDS | | extend.fth |
| SEE | ( -- ) | yes | Prints a detailed listing of the word whose name is next in the input stream e.g. SEE MYWORD | | extend.fth |
| SEECFA | ( cfaptr -- ) | no | | | extend.fth |

This article explains about this powerful inspection tool, the decompiler.

# DEFER

| NAME | STACK EFFECT | PRE? | DESCRIPTION | TIME (CYCLES) | SOURCE |
|---|---|---|---|---|---|
| -> | ( -- ) | no | Defers a word executing until the end of a line. e.g. in simulating prefix operation in an assembler, where OPCODE <params> is preferred | | extend.fth |
| CALL$ | ( string -- ) | no | Calls the word, if found in the dictionary, held in the string whose address is top of stack. Does not echo the word to the display e.g.<br>" WORDS" CALL$ will execute WORDS | | extend.fth |
| EVALUATE | ( string -- ) | no | Calls all the words held in the string whose address is top of stack. Note: echoes those words to the display. Won't evaluate word definitions | | extend.fth |

**-> example:-**

```
: test1 -> ." test1 executed " ;
: test2 ." test2 executed " ;
: test3  test1 test2 ; when run, displays 'test2 executed test1 executed'
```

This is handy when  sending a Taqoz based controller a command sentence like: 'CMDword1 parameter1 parameter2 parameter3'. If CMDword1, CMDword2 etc are made forth words, then the sentence can be parsed using the TAQOZ interpreter, rather than creating another special interpreter. But to do that cleanly, we would really want the command sentence to be translated to  'parameter1 parameter2 parameter3  CMDword1'. So the -> word defers the execution of CMDword1 to be last, so that all the parameters are on the stack ready for CMDword1 to process. The TAQOZ assembler makes use of -> so the user can write conventional assembly language rather than RPN style.

# DEFINING WORDS

Do not define words that start with $ # or % and also contain valid numbers e.g. a word defined as $GPRM**C** does not run properly, whereas a word defined as $GPRM**G** does. The interpreter compiles $GPRMC, but when run erroneously just puts $C on the stack.
Also do not define words that end in underscore _ , they will compile but will not be interpreted or execute.

Words in TAQOZ can be recursive, i.e. they can call themselves without any special words to do that. However, remember the depth of the return stack is a limiting factor.

| NAME | STACK EFFECT | PRE? | DESCRIPTION | TIME (CYCLES) | SOURCE |
|---|---|---|---|---|---|
| ' | ( -- cfa ) | yes | Using the next word in the input stream, look it up in the dictionary and return code field address | | kernel |
| , | ( n -- ) | yes | Compile long n into code memory | | kernel |
| ; | ( -- ) | yes | Compile an EXIT word and ends word definition | | kernel |
| : | ( -- ) | yes | an alias for pub | | kernel |
| [ | ( -- ) | yes | Flag that we have entered a definition - see below for an example | | kernel |
| ] | ( -- ) | yes | Used with [ - end definition and lock allocated bytes | | kernel |
| [C] | ( -- ) | yes | Force compilation of the next word in the input stream even if it was defined as preemptive | | kernel |
| [G] | ( -- ) | no | an alias for GRAB N.B. this alias is not preemptive, whereas as GRAB is preemptive, so they aren’t an exact match | | kernel |
| [W] | ( wordcode -- ) | yes | append this wordcode to next free code location + append EXIT (without counting) | | kernel |
| \| | ( ch -- ) | yes | Compile byte ch into code memory | | |
| \|\| | ( w – ) | yes | Compile word w into code memory | | kernel |
| +EXIT | | yes | end definition and lock allocated bytes | | kernel |
| ALIGN | ( adr1 n -- adr2 ) | no | adr2 = adr1 realigned on an n’th byte boundary | | kernel |
| @CODES | ( – adr ) | no | Point to code compilation memory | | kernel |
| @HERE | ( -- atradr ) | no | Variable which holds the code pointer HERE | | kernel |
| ALIAS | ( -- ) | yes | Create an alternative name for an existng word e.g. ALIAS <existingword> <newword>. **N.B. See the bug fix below** | | extend.fth |
| ALLOT | ( n -- ) | no | Allot n bytes of code memory - increments HERE by n. n must be an even number | | kernel |
| CREATE: | ( -- ) | yes | Create a name header in the dictionary using the next word in the input stream and compile a VARIABLE TYPE code entry | | kernel |
| CREATE$ | ( -- ) | yes | Create a name header in the dictionary using the string that follows in the input stream | | kernel |
| END | | no | Marks the end of source code to be 'block loaded' - see also TAQOZ word. N.B. The word must be on it's own on a line | | kernel |
| EXIT; | | yes | compile an EXIT | | kernel |
| GRAB | ( -- ) | yes | immediate word, executes preceding code to make it available for any immediate words following | | kernel |
| HERE | ( -- addr ) | no | Address of next compilation location | | kernel |
| IFDEF | ( -- ) | yes | If the next name in the input stream is already DEFINED then process all input stream that follows up to the terminating curly brace } | | kernel |
| IFNDEF | ( -- ) | yes | If next name in the input stream is NOT DEFINED then process all source between here and the curly brace } | | kernel |
| MKEY | ( -- chr \| false ) | no | Part of the TAQOZ word: return chr from hub memory buffer. If chr=0, return false and switch input stream back to the terminal | | kernel |
| MLOAD | ( adr -- ) | no | Part of the TAQOZ word: divert the input stream to a buffer in hub memory starting at address adr | | kernel |
| MSAVE | | no | Part of the TAQOZ word: save the input stream to a buffer in hub memory starting at address adr, until a line is detected which only contains END | | kernel |
| pre | ( -- ) | yes | Create a new preemptive word that has the "immediate" attribute set so that it executes immediately at compile time (words like IF ELSE THEN etc) | | kernel |
| pri | ( -- ) | yes | Create a new word using the next word in the input stream as the name; It is marked private so a RECLAIM can remove them from the dictionary | | kernel |

| | | | | | |
|---|---|---|---|---|---|
| | | | when required. The private words will still function, but can no longer be used to make new words. Keeps the dictionary free of unnecessary detail | | |
| private | ( -- ) | yes | All following variables and constants can be removed from the dictionary using RECLAIM. The private words will still function, but can no longer be used to make new words. Keeps the dictionary free of unnecessary detail | | kernel |
| pub | ( -- ) | yes | Create new word as public using the next word in the input stream as the name – the name will remain always in the dictionary | | kernel |
| public | ( -- ) | yes | All following variables and constants will remain always in the dictionary | | kernel |
| SETORG | ( adr -- ) | no | Code compilation is set to continue from adr | | kernel |
| TAQOZ | ( -- ) | no | TAQOZ marks the start of a block of source code to be input silently or 'block loaded', until the END word is encountered. All source between TAQOZ and END is transferred into a hub memory buffer (currently starting at hub address $60000)). The terminal input is switched temporarily to read all of that buffer, which speeds up loading source code | | kernel |
| uhere | ( -- ptr ) | no | pointer to compilation area (overwrites VM image) | | kernel |

**ALIAS bug fix**

| | |
|---|---|
| ALIAS and CPA! do not always work. This is a bug fix:- | pre ALIAS<br>[C] NFA' [G] ?DUP<br>IF ( nfa )<br>--- read cfa then create new header & store cfa in its cpa<br>DUP C@ $E0 AND SWAP CFA ( atrs cfa )<br>[C] CREATE$<br>--- blend old atrs in with new count (also patch 230309)<br>OVER @WORDS C@ OR @WORDS C!<br>--- then store the CFA into the new CPA as 2 or 3 bytes (atr.5)<br>@WORDS CPA ROT $20 AND IF M! ELSE W! THEN<br>ELSE ERROR<br>THEN<br>; |

**[ ] example**

| | |
|---|---|
| Some computation is needed during the compilation of a word. [ switches Taqoz to interpret the input stream. Notice the GRAB word to cause what's in the brackets to run before the ] bracket switches Taqoz back to compilation. Don't use the alias [G] as it isn't preemptive and doesn't work. | pub TEST<br>CRLF CRLF CRLF ." Executes when TEST is run "<br>[ CRLF CRLF CRLF ." Executes when TEST compiles " GRAB ]<br>; |

**[W] example**

| | |
|---|---|
| Put the code field address of a word on the data stack ...<br>Use [W] to compile that word into a new definition ...<br>Now check the result ...<br><br>.S has been successfully included in the new word. This is a trivial example, but could be more useful when the code field address has been the result of a calculation. | ' .S<br>pub Q [W] CRLF ;<br>SEE Q then returns on the terminal:-<br>1C6EF: pub Q<br>08F72: 2A74 .S<br>08F74: 20AF CRLF ;<br>( 4 bytes ) |

This article 'Code is contiguous' discusses how memory is saved in TAQOZ in much the same way as in assembly language.

This article 'Interactive compilation' explains why TAQOZ compiles words by word instead of the more usual line by line.

# DEFINING CONSTANTS

| NAME | STACK EFFECT | PRE? | DESCRIPTION | TIME (CYCLES) | SOURCE |
|---|---|---|---|---|---|
| := | (n – ) | yes | Create a long constant using the name next in the input stream | | kernel |
| :=! | ( n cfa – ) | no | Change the value of a long constant created with :=<br>e.g. 45 := myconstant<br>34 ‘ myconstant :=! | | kernel |
| DATCON | (n – ) | yes | Same as := to compile a constant but is recognized by FORGET | | kernel |

# DEFINING VARIABLES

| NAME | STACK EFFECT | PRE? | DESCRIPTION | TIME (CYCLES) | SOURCE |
|---|---|---|---|---|---|
| !org | ( -- ) | no | If 'org' has been used to relocate the start address for data storage, !org restores that start address to the saved value | | kernel |
| byte | ( -- ) | yes | Define new byte variable, using next word in input stream as the name<br>e.g. byte mybyte | | kernel |

| | | | | | |
|---|---|---|---|---|---|
| bytes | ( n -- ) | yes | Define new byte array variable , using next word in input stream as the name e.g. 4 bytes buffer | | kernel |
| long | ( -- ) | yes | Define new long variable, using next word in input stream as the name e.g. long mylong | | kernel |
| longs | ( n -- ) | yes | Define new long array variable, using next word in input stream as the name e.g. 4 longs mylongbuffer | | kernel |
| org | ( adr -- ) | no | save current org value and sets the start address for data storage to adr | | kernel |
| org@ | ( -- adr ) | no | read the current data storage address | | kernel |
| orglen | ( – n ) | no | n is the total number of bytes of data storage used | | kernel |
| res | ( n -- ) | yes | reserves n bytes of data memory | | kernel |
| VAR | ( -- ) | yes | Create a long variable in code space using the next word in the input stream. Variables made in this way are saved with their current values when a system backup is performed | | kernel |
| word | ( -- ) | yes | Define new word variable, using next word in input stream as the name e.g. word myword | | kernel |
| words | ( n -- ) | yes | Define new word array variable , using next word in input stream as the name e.g. 4 words mywordbuffer | | kernel |

**Variable Space** The amount of room available for variables is shown at switch-on in the 'ROOM' section of the 'MEMORY MAP' report. My system just happens to report 79,801 bytes free, but your system may be different. When that runs low, more space is available above the 'TAQOZ system space' starting at $20000. Before defining (maybe larger) variables from that address and upwards, use 'org' e.g.-->

```
$20000 := userdata
userdata org
4096 longs myvector1
4096 longs myvector2 ...
```

**Defining a new type of variable** TAQOZ's word-by-word compilation takes a little getting used to. Here's a definition of a new variable type. Notice the use of [G] to make sure results are on the stack when needed by later preemptive words. [C] is used so that [G] is compiled into the 'double' word, not immediately executed - a bit confusing at first. Also notice the 'double' word is made preemptive so that it executes at compile time as do long, word, byte etc.

```
 --- create a double variable (64 bits )
pre double  ( -- )
8 [C] [G] [C] bytes [C] [G] ;
double MYDOUBLE
0. MYDOUBLE D!
```

# DICTIONARY

| NAME | STACK EFFECT | PRE? | DESCRIPTION | TIME (CYCLES) | SOURCE |
|---|---|---|---|---|---|
| .NFA | ( nfa -- ) | no | Display the name of the word whose NFA is on the stack | | extend.fth |
| @WORDS | ( -- addr ) | no | Point to start of the dictionary (grows down) | | kernel |
| +DEVICE | ( cfa -- ) | no | | | extend.fth |
| AT | ( -- cfa ) | yes | More easily seen alias for ' | | kernel |
| CFA | ( nfa -- cfa ) | no | Convert name field address to code field address for a word in the dictionary | | kernel |
| CFA>NFA | ( cfa -- nfa ) | no | returns the name field address of the word whose code field address is top of stack | | extend.fth |
| CPA | ( nfa -- cpa ) | no | given the name field address (nfa) of a word, return it's cpa. The code pointer address (cpa) is used to store the cfa of the word (the cfa is where the word definition starts) | | kernel |
| FIND$ | ( str dict -- nfaptr \| false ) | no | Find str word in dictionary, returning name field address, else if not found return false | | kernel |
| flags | ( -- ptr ) | no | Pointer to long that stores flags:<br>echo,linenums,ipmode,leadspaces,prset,striplf,sign,comp,<br>Defining | | kernel |
| FORGET | ( -- ) | yes | Takes the next word in the input stream, and forgets all names in the current dictionary from this name onwards - from the most recent instance of the name. Also resets code pointers to the code pointer of the word. | | kernel |
| NFA’ | ( – nfaptr ) | yes | Takes next word in input stream as a name and returns the name field address | | kernel |
| NFA+ | ( nfa -- nfa2 ) | no | Traverse from NFA to next NFA but allow for extended CPA | | kernel |
| RECLAIM | | yes | Words that are only useful internally to a module clutter up the dictionary needlessly. It’s useful to hide these. All words entries marked private in the dictionary are stripped out. The words can no longer be part of future word definitions, although they continue to function for past definitions | | extend.fth |
| SEARCH | ( str -- nfaptr ) | no | Search dictionary for string str, returning name field address | | kernel |
| STRIP | ( – ) | yes | Strip a single header from the dictionary, whose name is next in the input stream e.g. STRIP MYPRIVATEWORD. Used internally by RECLAIM | | extend.fth |
| STRIPIT | ( nameptr -- nameptr+ ) | no | Strip a single header from the dictionary, whose name pointer is on the stack. Exits pointing to the next word in the dictionary. Used internally by RECLAIM | | extend.fth |
| uwords | ( -- ptr ) | no | pointer to start of dictionary (builds down) | | kernel |

This article is a very useful description of the structure of the TAQOZ Dictionary and the way code is laid down. A dictionary listing is show here.

# ERRORS

| NAME | STACK EFFECT | PRE? | DESCRIPTION | TIME (CYCLES) | SOURCE |
|---|---|---|---|---|---|
| ERROR | | no | count errors and force a new line to display error | | kernel |

# FLASH MEMORY

| NAME | STACK EFFECT | PRE? | DESCRIPTION | TIME (CYCLES) | SOURCE |
|---|---|---|---|---|---|
| .SF | ( -- ) | no | Displays flash memory manufacturers' I.D. serial number etc. Useful for checking flash memory communication is working | | kernel |
| *SPIFLASH* | ( -- ) | no | Serial Flash header - marker for use with FORGET | | kernel |
| SF | ( -- ) | no | Select SPI Flash as the source for DUMP | | kernel |
| SF? | ( – n ) | no | Read flash status | | kernel |
| SF@ | ( adr – n ) | no | Returns long from flash address adr | | kernel |
| SFBU | ( -- ) | no | BACKUP the first 128K of memory into flash | | kernel |
| SFBYTES | | no | Reads top bit of flash Jedec ID | | extend.fth |
| SFC@ | ( adr -- c ) | no | Returns byte from flash address adr | | kernel |
| SFCMD | | no | Send flash command | | kernel |
| SFER | ( adr -- ) | no | | | kernel |
| SFER32 | ( adr -- ) | no | | | kernel |
| SFER4 | ( adr -- ) | no | | | kernel |
| SFER64 | ( adr -- ) | no | | | kernel |
| SFERP | ( src dst -- ) | no | | | kernel |
| SFJID | ( – n ) | no | Read serial Flash Jedec ID | | kernel |
| SFPINS | ( &cs.so.si.ck -- ) | no | Set which pins are used by Serial Flash | | kernel |
| SFRDS | ( sfadr dst cnt -- ) | no | read block from SF to RAM | | kernel |
| SFRE | | no | RESTORE TAQOZ from FLASH by copying to $2.0000 first | | kernel |
| SFSID | ( -- n ) | no | Read serial Flash serial number | | kernel |
| SFW@ | ( adr – w ) | no | Returns word from flash address adr | | kernel |
| SFWD | | no | | | kernel |
| SFWE | | no | Write enable flash | | kernel |
| SFWRP | ( src dst -- ) | no | | | kernel |
| SFWRS | ( hubsrc sfdst cnt -- ) | no | write block from RAM to SF | | kernel |

# INPUT / OUTPUT & SMARTPIN BASICS

Smartpins can be read and written using the words below, or by directly reading and writing the 'cog ram' registers using words COG@ and COG! .

| NAME | STACK EFFECT | PRE? | DESCRIPTION | TIME (CYCLES) | SOURCE |
|---|---|---|---|---|---|
| keypoll | ( – n ) | no | Relative address to the keypoll register | 72 | kernel |
| @PIN | ( -- pin ) | no | Read the current selected smart pin back | | kernel |
| AKPIN | ( -- ) | no | Acknowledge pin S/# | 24 | kernel |
| F | ( – ) | no | Float the current pin | 24 | kernel |
| FLOAT | ( pin – ) | no | Set 'pin' output floating | 48 | kernel |
| H | ( – ) | no | Set current pin high e.g. 57 PIN H | 24 | kernel |
| HIGH | ( pin – ) | no | Set 'pin' output high e.g. : PINTEST BEGIN 10 HIGH 10 LOW AGAIN ; At 200MHz cpu clock, pin 10 goes high for 485nS and low for 675nS | 48 | kernel |
| IO? | ( pin -- mode ) | no | Return the i/o mode the pin is currently set to | | extend.fth |
| L | ( – ) | no | Set current pin low e.g. 57 PIN H L H L | 24 | kernel |
| LOW | ( pin – ) | no | Set 'pin' output low | 48 | kernel |
| MUTE | ( pin -- ) | no | Mute smartpin functions on current pin (pins) | | extend.fth |
| PIN | ( pin – ) | no | Define the current I/O pin (0-63) | 296 | extend.fth |
| PIN! | ( flag pin -- ) | no | output flag at pin | 64 | kernel |
| PIN@ | ( pin – flag ) | no | read pin state | 32 | kernel |
| PINS | ( from for -- ) | no | Create a pin code range for Rev B pins instructions | | extend.fth |
| POLLEDG | ( -- flg ) | no | Get SE1 event flag to stack, then clear it. flag = TRUE (-1) if edge occurred, else FALSE (0). See also SETEDG | 72 | kernel |
| PU? | ( pin -- flg ) | no | flg = true if there's a pullup attached to pin | 5240 | extend.fth |
| R | ( – flag ) | no | Read the state of the current pin as an input | 56 | kernel |
| RDPIN | ( -- res ) | no | Get smart pin S/# result Z into D, ack | 48 | kernel |
| RDPINC | ( – res ) | no | Get smart pin S/# result Z into D, flag into C, ack | 56 | kernel |
| RQPIN | ( -- res ) | no | Get smart pin S/# result Z into D, flag into C, don't ack | 48 | kernel |
| SETEDG | ( edge pin -- ) | no | Set SE1 event configuration, edge: 1=+ve edge 2=-ve edge, 3=+ve or -ve edge on 'pin' (0-63). See also POLLEDG | 80 | kernel |
| SETCT1 | ( delta -- ) | no | Calculate and set the cnt delta and waitcnt | | kernel |
| SETDACS | ( n1 – ) | no | DAC3 = n1[31:24], DAC2 = n2[23:16], DAC1 = n3[15:8], DAC0 = n4[7:0]. | 56 | kernel |
| T | ( – ) | no | Toggle the current pin ( set to the opposite state ) | 24 | kernel |
| WAITCT1 | ( -- ) | no | Wait for CT1 event flag, then clear it. Prior SETQ sets optional CT timeout value. C/Z = timeout. | | kernel |
| WAITPIN | ( -- ) | no | wait for smartpin ack e.g.<br>48 PIN --- P48 is the target pin | | kernel |

| | | | | | |
|---|---|---|---|---|---|
| | | | 12000 6000 HILO --- define the high and low periods<br>50 LOW --- P50 is driven low to signal code start<br>16 PULSES --- generate 16 pulses of set timing<br>WAITPIN --- wait for smartpin acknowledement<br>3 PULSES --- 3 more pulses, without any changes<br>50 HIGH --- P50 set high to indicate code complete | | |
| WAITX | ( n -- ) | no | Wait for 2n processor cycles (as measured by LAP / .LAP) | | kernel |
| WRACK | ( data -- ) | no | Write current smartpin data and wait for empty then ack | | kernel |
| WRPIN | ( dst -- ) | no | Set current smart pin mode to D/#, acknowledge pin | 48 | kernel |
| WSTX | ( adr cnt -- ) | no | output the data buffer at adr for cnt bytes to a WS2812 based Neopixel display | | kernel |
| WXPIN | ( dst -- ) | no | Set current smart pin S/# parameter X to D/#, ack | 48 | kernel |
| WYPIN | ( dst -- ) | no | Set current smart pin S/# parameter Y to D/#, ack | 48 | kernel |

# I2C

I2C programming hints are given in this TAQOZ Bytes document
The default i2c bus appears on pin P56 providing clock and pin P57 for data. These pin assignments can be changed, using the I2CPINS word.

| NAME | STACK EFFECT | PRE? | DESCRIPTION | TIME (CYCLES) | SOURCE |
|---|---|---|---|---|---|
| !I2C | | no | Initialize the I2C bus pins with pullups and default to 400kHz | | extend.fth |
| <I2C> | ( -- ) | no | alias for I2C.RESTART | | extend.fth |
| I2C! | ( data -- ) | no | Write the data to the bus and count the ack in variable acks | | extend.fth |
| I2C? | ( -- flg ) | no | test for I2C bus by checking for pullups | | extend.fth |
| I2C.KHZ | ( khz -- ) | no | Set the bus frequency in kHz | | extend.fth |
| I2C.RD | ( ack -- data ) | no | Generate a start and send the address as a read | | kernel |
| I2C.RESTART | | no | Restart without checking busy | | kernel |
| I2C.START | | no | Generate a start condition (or a restart) | | kernel |
| I2C.START | | no | Generate a start condition (or a restart) redefined | | extend.fth |
| I2C.STOP | | no | Generate a stop condition | | kernel |
| I2C.WR | ( data -- ack ) | no | Generate a start and send the address as a write | | kernel |
| I2C@ | | no | Read and ack the data from the bus | | extend.fth |
| I2C> | ( -- ) | no | alias for I2C.STOP | | extend.fth |
| I2CC@ | | no | i2c DUMP support word | | extend.fth |
| i2cdev | ( – n ) | no | default i2c address - initialised with $A4, the RV-3028 real time clock address | | extend.fth |
| I2CPINS | ( scl sda -- ) | no | Select the I/O to be used as the I2C bus (and initialize to a stop) | | extend.fth |
| I2CRD | ( adr -- ) | no | Same as I2CRD?, ack is discarded | | extend.fth |
| I2CRD? | ( adr -- ack ) | no | Generate a start and send the address to prepare for a data read, return with ack | | extend.fth |
| I2CRDREG | ( dev reg -- ) | no | Select register 'reg' on i2c device 'dev' | | extend.fth |
| I2CWR | ( adr -- ) | no | Generate a start and send the address to prepare for data write | | extend.fth |
| nakI2C@ | | no | Read and nak the data from the bus (last byte) | | extend.fth |

# INITIALISATION

**Up to 8 user words** can be added to the tasks that TAQOZ performs on start-up.

| NAME | STACK EFFECT | PRE? | DESCRIPTION | TIME (CYCLES) | SOURCE |
|---|---|---|---|---|---|
| -CODE | | no | | | extend.fth |
| -INIT | ( 'code -- ) | no | Remove the word whose cpa  is top of stack to the user INIT list to execute when TAQOZ starts | | extend.fth |
| !INITS | ( -- ) | no | Init and clear all polling vectors | | extend.fth |
| +CODE | ( tbl entries -- ) | no | | | extend.fth |
| +INIT | ( 'code -- ) | no | Add the word whose cpa is top of stack to the user INIT list to execute when TAQOZ starts | | extend.fth |
| INITS | ( -- ) | no | A word initialized at startup with 8 NOPs terminated with EXIT. The NOPs can be overwritten by +INIT and -INIT | | extend.fth |

# LOGIC

| NAME | STACK EFFECT | PRE? | DESCRIPTION | TIME (CYCLES) | SOURCE |
|---|---|---|---|---|---|
| AND | ( n1 n2 – n3 ) | no | n3 = n1 and n2 | 48 | kernel |
| ANDN | ( n1 n2 – n3 ) | no | n3 = n1 nand n2 | 48 | kernel |
| NOT | ( n1 – n2 ) | no | n2 = inverse of n1 | 32 | kernel |
| OR | ( n1 n2 – n3 ) | no | n3 = n1 or n2 | 48 | kernel |
| XOR | ( n1 n2 – n3 ) | no | n3 = n1 xor n2 | 48 | kernel |

# LOOPING

N.B. All loops in TAQOZ are made with **relative jumps**. If code within a loop is too large then your new word may not work properly and Taqoz may even crash. If you suspect this, use SEE to decompile the new word and check the jump distances. All jumps have to be less than 127 words in scope. Thanks for this tip, Christof Eb.

| NAME | STACK EFFECT | PRE? | DESCRIPTION | TIME (CYCLES) | SOURCE |
|---|---|---|---|---|---|
| ?LEAVE | ( flag – ) | no | If flag is true, set the index to limit-1 so that it will LEAVE the loop at the next LOOP or +LOOP executed | | kernel |
| ?NEXT | ( flag – ) | no | Exit FOR NEXT loop early if flag is true (non-zero)<br>e.g. : TEST 1000000 FOR KEY ?NEXT ; | | kernel |
| +LOOP | ( incr – ) | no | e.g.0 8 ADO I . 2 +LOOP produces 0246 | | kernel |
| ADO | ( start count – ) | no | e.g. 0 8 ADO I . LOOP produces 01234567 | | kernel |
| AGAIN | | yes | part of BEGIN .. AGAIN structure | | kernel |
| BEGIN | | yes | part of BEGIN .. AGAIN, BEGIN .. <condition> UNTIL structures | | kernel |
| DO | ( limit start – ) | no | e.g. 8 0 DO I . LOOP produces 01234567 | | kernel |
| FOR | ( cnt -- ) | no | e.g. 3 FOR ." N" I . SPACE NEXT --- N3 N2 N1 | | kernel |
| I | ( – n1 ) | no | I returns the current loop index | | kernel |
| I+ | ( n -- n+I ) | no | fast index offset i.e. table I+ | | kernel |
| IC@ | ( – c ) | no | Fetch a byte using the current loop index I as the address | | kernel |
| J | ( – n1 ) | no | J returns the index for the next outer loop | | kernel |
| LEAVE | ( – ) | no | Set the index to limit-1 so that it will LEAVE the loop at the next LOOP or +LOOP executed | | kernel |
| LOOP | ( – ) | no | Increment the index and loop if not at limit yet, continue to following code | | kernel |
| NEXT | | no | e.g. 3 FOR ." N" I . SPACE NEXT --- N3 N2 N1 | | kernel |
| REPEAT | | yes | part of BEGIN .. <condition> WHILE .. REPEAT structure | | kernel |
| UNLOOP | | no | Discard current DO index and limit and branch address<br>e.g. : TEST 1000000 0 DO KEY IF UNLOOP EXIT<br>THEN LOOP ; | | kernel |
| UNTIL | | yes | part of BEGIN .. <condition> UNTIL structure | | kernel |
| WHILE | | yes | part of BEGIN .. <condition> WHILE .. REPEAT structure | | kernel |

Here's an article 'Loops never return' that discusses looping with TAQOZ.

# MASKING

| NAME | STACK EFFECT | PRE? | DESCRIPTION | TIME (CYCLES) | SOURCE |
|---|---|---|---|---|---|
| >! | | no | replace the inline 10-bit literal with a new value | | extend.fth |
| >\| | ( bitpos – bitmask ) | no | Encode - bitpos = the position of the msb set in bitmask<br>e.g. %0100 >\| . would print 2 | 24 | kernel |
| >9 | ( n – 9bits ) | no | mask n to 9 least significant bits | 32 | kernel |
| >B | ( n – byte ) | no | mask n to a byte | 32 | kernel |
| >N | ( n -- nibble ) | no | mask n to a nibble ( 4 bits ) | 32 | kernel |
| >W | ( n – word ) | no | mask n to 16 least significant bits | 32 | kernel |
| \|< | ( bitpos – bitmask ) | no | Decode - bitmask = long with one bit set at bitpos position<br>e.g. 3 \|< .BIN would print %1000 | 24 | kernel |
| 1& | ( n1 – n2 ) | no | n2 = n1 and 1 | 24 | kernel |
| BITS | ( n1 bits -- n2 ) | no | Masking off ‘bits’ number of least sig bits | 56 | kernel |
| BMASK | ( s -- mask ) | no | Get LSB-justified bit mask of size (S[4:0] + 1) into D. D = ($0000_0002 << S[4:0]) - 1. | 23 | kernel |
| MOVBYTS | ( D S – n2 ) | no | n2 = Move bytes within D, per S. D = {D.BYTE[S[7:6]], D.BYTE[S[5:4]], D.BYTE[S[3:2]], D.BYTE[S[1:0]]}. | 64 | kernel |
| SIGN | ( val bitpos -- sval ) | no | Extend sign from bitpos ($FC 7 sign .L --- $FFFF_FFFC) | 48 | kernel |

# MATHS

| NAME | STACK EFFECT | PRE? | DESCRIPTION | TIME (CYCLES) | SOURCE |
|---|---|---|---|---|---|
| - | ( n1 n2 – n3 ) | no | n3 = n1 - n2 | 56 | kernel |
| -NEGATE | ( n1 sn -- n1 \| -n1 ) | no | negate n1 if the sign of sn is negative (used in signed divide op) | 56 if negated, else 48 | kernel |
| ?NEGATE | ( n1 flg -- n2 ) | no | negate n1 if flg is true | 56 if negated, else 48 | kernel |
| * | ( n1 n2 – n3 ) | no | n3 = n1 * n2 | 128 | kernel |
| */ | ( n1 n2 n3 -- res ) | no | res = (n1 * n2 ) / n3  uses a 64 bit intermediate result for precision (cordic) | Around 216 data dependent | kernel |
| / | ( n1 n2 – n3 ) | no | n3 = n1 / n2 | Around 470 data dependent | kernel |
| // | ( n1 mod -- rem ) | no | n1 / mod, leaving just the remainder | Around 120 data dependent | kernel |
| + | ( n1 n2 – n3 ) | no | n3 = n1 + n2 | 48 | kernel |
| 1- | ( n1 – n2 ) | no | n2 = n1 - 1 | 24 | kernel |
| 1+ | ( n1 – n2 ) | no | n2 = n1 + 1 | 24 | kernel |
| 2- | ( n1 – n2 ) | no | n2 = n1 - 2 | 24 | kernel |
| 2+ | ( n1 – n2 ) | no | n2 = n1 + 2 | 24 | kernel |
| 4+ | ( n1 – n2 ) | no | n2 = n1 + 4 | 24 | kernel |
| ABS | ( n1 – n2 ) | no | n2 = absolute value of n1 | 24 | kernel |
| BIN | ( -- ) | no | Set the default number radix to binary | | kernel |
| DEC | ( -- ) | no | Set the default number radix to decimal | | kernel |
| DM* | ( d. u -- d. ) | no | Multiply signed double by unsigned long to give signed double result | Around 600 data dependent | kernel |
| EXP | ( e1 – n2 ) | no | n2 (long) = 2^^ e1 (5 bits whole exponent, 27 bits fractional) | 112 | kernel |
| GETQY | ( – n1 ) | no | retrieve cordic solver Y result | 64 | kernel |
| GETRND | ( – n1 ) | no | return a random number – method 2 | 64 | kernel |
| HEX | ( -- ) | no | Set the default number radix to hexadecimal | | kernel |
| KB | ( n1 – n2 ) | no | n2 = n1 * 1024 | 168 | kernel |
| LOG | ( n1 – e2 ) | no | e2 (5 bits whole exponent, 27 bits fractional) = binary log (n1) (cordic) | 96 | kernel |
| LW* | ( mclong mpword -- result. ) | no | Multiply a long by 16-bits and return 48-bits | Around 64 data dependent | kernel |
| M | ( n1 – n2 ) | no | n2 = n1 * 1000000 | 288 | kernel |
| MAX | ( u1 u2 – u3 ) | no | u3 = unsigned maximum of u1, u2 | 48 | kernel |
| MAXS | ( n1 n2 – n3 ) | no | n3 = signed maximum of n1, n2 | 48 | kernel |
| MB | ( n1 – n2 ) | no | n2 = n1 * 1048576 | 328 | kernel |
| MIN | ( u1 u2 – u3 ) | no | u3 = unsigned minimum of u1, u2 | 48 | kernel |
| MINS | ( n1 n2 – n3 ) | no | n3 = signed minimum of n1, n2 | 48 | kernel |
| n! | ( n -- fac. ) | no | Returns n factorial as a double | | extend.fth |
| NEGATE | ( n1 – n2 ) | no | n2 = -n1 | 24 | kernel |
| QFRAC | ( – n1 ) | no | retrieve cordic solver X result | 120 | kernel |
| QROTATE | ( x y z -- x y ) | no | rotate x and y by z (cordic) | 120 | kernel |
| QVECTOR | ( x y -- len th ) | no | convert x,y to amplitude len, angle th (cordic) | 104 | kernel |
| RND | ( – n1 ) | no | return a random number – method 1 | 72 | kernel |
| SQRT | ( d. -- sqrt ) | no | sqrt = the square root of double d | 120 | kernel |
| U*/ | ( u1 u2 div1 -- res ) | no | Multiply u1 by u2 and divide the double product by div1 | 200 | kernel |
| U/ | ( u1 u2 – u3 ) | no | u3 = u1 / u2 | 128 | kernel |
| U// | ( dvdn dvsr -- rem quot ) | no | quot = dvdn / dvsr, with rem remainder | 112 | kernel |
| UM* | ( u1 u2 -- ud. ) | no | unsigned 32bit * 32bit multiply -- 64bit result | Around 112 data dependent | kernel |
| UM/ | ( d. dvsr -- res ) | no | divide double d. by long dvsr. long res is the result | 136 | kernel |
| UM// | ( d. dvsr -- rem quot ) | no | divide double d. by long dvsr, double quot is result with long rem as remainder | Around 832 data dependent | kernel |
| W* | ( w1 w2 – n1 ) | no | n3 = w1 * w2 | 48 | kernel |

# MEMORY

| NAME | STACK EFFECT | PRE? | DESCRIPTION | TIME (CYCLES) | SOURCE |
|---|---|---|---|---|---|
| -- | ( adr – ) | no | long at hub address adr is decremented | 256 | kernel |
| ! | ( n addr -- ) | no | store n to long at hub memory addr | 64 | kernel |
| @ | ( addr -- long ) | no | Fetch a long from hub memory | 32 | kernel |
| +! | ( n addr -- ) | no | add n to long at hub memory addr | 80 | kernel |
| ++ | ( adr – ) | no | long at hub address adr is incremented | 224 | kernel |
| +-! | ( adr -- ) | no | negate long at adr | | |
| <CMOVE | ( src dst cnt -- ) | no | Same as CMOVE, in reverse address order<br>(Use one or the other when the two blocks overlap each other) | | kernel |
| ~ | ( adr – ) | no | long at hub address adr is zeroed | 72 | kernel |
| ~~ | ( adr – ) | no | long at hub address adr is set all 1’s | 72 | kernel |
| BIT! | ( mask addr flag -- ) | no | will take a flag and either SET or CLR bits in memory<br>e.g. $FF MYVAR 0 BIT! Would zero the bottom 8 bits of MYVAR<br>$FF MYVAR 1 BIT! Would set the bottom 8 bits of MYVAR | | kernel |
| C-- | ( cadr – ) | no | byte at hub address cadr is decremented | 256 | kernel |
| C! | ( n caddr -- ) | no | store n to byte at hub memory addr | 64 | kernel |
| C@ | ( caddr -- byte ) | no | Fetch a byte from hub memory | 32 | kernel |
| C@++ | ( caddr -- caddr+1 byte ) | no | fetch byte character from hub memory and increment address | 56 | kernel |
| C+! | ( n caddr -- ) | no | add n to byte at hub memory addr | 80 | kernel |
| C++ | ( cadr – ) | no | byte at hub address cadr is incremented | 216 | kernel |
| C~ | ( adr – ) | no | byte at hub address adr is zeroed | 72 | kernel |
| C~~ | ( adr – ) | no | byte at hub address adr is set all 1’s | 72 | kernel |
| CELL+ | ( n1 -- n2 ) | no | n2 = n1 +4 advance n1 by the 4 addressable bytes in a long | | extend.fth |
| CLR | ( mask addr -- ) | no | Clear bit(s) in hub memory long | 104 | kernel |
| CMOVE | ( src dst cnt -- ) | no | Move hub memory bytes starting from source to destination by cnt bytes | | kernel |
| COG! | (n adr – ) | no | Write long to COG memory adr | 64 | kernel |
| COG@ | ( adr – n ) | no | Read long at COG memory adr | 32 | kernel |
| D! | ( d. addr -- ) | no | store n to double at hub memory addr | 288 | kernel |
| D@ | ( addr -- d. ) | no | Fetch double from hub memory addr | 248 | kernel |
| DUPC@ | ( caddr – caddr data ) | no | Fetch a byte at addr in hub memory, leave addr on stack | 80 | kernel |
| ERASE | ( adr bytes -- ) | no | erase bytes starting at adr | | kernel |
| FILL | ( addr cnt fillch -- ) | no | fill cnt byteswith fillch starting from address addr | | kernel |
| GO: | ( index size -- ) | no | | | extend.fth |
| HERE: | | no | | | extend.fth |
| INDEX: | ( index -- ) | no | return with pointer to list of parameters etc following this word | | extend.fth |
| LERASE | ( src cnt -- ) | no | erase cnt longs starting at src | | kernel |
| LMOVE | ( src dst longs -- ) | no | Very fast block move uses SETQ2 and LUT to move chunks<br>64KB in 37,992 cycles= 151,968ns @250MHz | | kernel |
| LUT! | ( n adr – ) | no | Write long to LUT memory adr | 64 | kernel |
| LUT@ | ( adr – n ) | no | Read long at LUT memory adr | 24 | kernel |
| M! | | no | works just like ! does except it skips leading zero bytes. So:- $12345678 avar ! would store 4 bytes<br>but $C0 avar M! will only write to the first byte leaving $123456C0 | | kernel |
| RAM | ( -- ) | no | modifier to dump from RAM e.g. 0 100 RAM DUMP | | kernel |
| SET | ( mask addr -- ) | no | Set bit(s) in hub memory long | 104 | kernel |
| SET? | ( mask addr -- flg ) | no | Test single bit of a long in hub memory | 88 | kernel |
| TABLE | ( bytes -- ) ( -- addr ) | yes | create a table of preallocated bytes - must be an even number | | extend.fth |
| W-- | ( wadr – ) | no | word at hub address wadr is decremented | 256 | kernel |
| W! | ( n waddr -- ) | no | store n to word at hub memory addr | 64 | kernel |
| W@ | ( waddr -- word ) | no | Fetch a word from hub memory | 32 | kernel |
| W+! | ( n waddr -- ) | no | add n to word at hub memory addr | 80 | kernel |
| W++ | ( wadr – ) | no | word at hub address wadr is incremented | 224 | kernel |
| W~ | ( adr – ) | no | word at hub address adr is zeroed | 72 | kernel |
| W~~ | ( adr – ) | no | word at hub address adr is set all 1’s | 72 | kernel |

# NUMBER I/O

| NAME | STACK EFFECT | PRE? | DESCRIPTION | TIME (CYCLES) | SOURCE |
|---|---|---|---|---|---|
| . | ( n -- ) | no | print n on the current output stream | up to 7528 | kernel |
| .ADDR | ( n -- ) | no | Display n as an address e.g. 00017: | | kernel |
| .ADRX | (n – ) | no | Display n as an address e.g. 00017 | | kernel |
| .AS | ( str -- ) | no | Like AS" but expects a string ptr on the stack e.g.<br>" #.###ms" .AS | | kernel |
| .AS” | ( n -- ) | yes | Display n with format as per string spec:<br># Convert one digit (default is decimal)<br>~ Toggle leading zero suppression<br>\ pad leading zeros with spaces<br>$\| Hexadecimal<br>*\| Convert all remaining digits<br>4\| Convert 4 digits<br>Terminated with “<br>e.g. .AS" #.###ms" | | kernel |
| .ASBYTES | ( n -- ) | no | Print n as Display n as decimal<br>"##,###,###,#### bytes” | | extend.fth |
| .B | (n – ) | no | Display n as two digit hex byte 00-FF | | kernel |
| .BIN | (n – ) | no | Display n in binary with leading % | | kernel |
| .BITS | ( n bits -- ) | no | e.g. $EC04 11 .BITS prints 0 0 1 0 0 0 0 0 0 0 1 | | extend.fth |
| .BYTE | (n – ) | no | Display n as two digit hex byte 00-FF | | kernel |
| .BYTES | ( adr bytes -- ) | no | e.g. 0 6 .BYTES prints 90 14 80 FD 50 32 | | extend.fth |
| .DEC | ( n -- ) | no | Display n in decimal with at least a single digit | | kernel |
| .DEC2 | ( val – ) | no | print unsigned val as two digits | | extend.fth |
| .DECL | ( n -- ) | no | Display n as decimal<br>"##,###,###,####" | up to 108424 | kernel |
| .DECS | ( val digits -- ) | no | print val right justified in a field of digits chars, leading spaces | | extend.fth |
| .DP | ( num left-digits -- ) | no | | | extend.fth |
| .H | ( n -- ) | no | Display n as hex nibble 0-F | | kernel |
| .HERE | ( -- ) | no | Print code pointer prompt | | extend.fth |
| .L | ( n -- ) | no | Display n in hex as long with leading $ and _ in the middle | | kernel |
| .LONG | (n – ) | no | Display n in hex as long with _ in the middle | | kernel |
| .M | ( n -- ) | no | print n as 5 hex digits | | extend.fth |
| .MEM | ( bytes -- ) | no | print bytes followed by B, KB, MB or GB | | extend.fth |
| .UBYTES | ( n1 n2 – ) | no | Prints n1 in hex n2 in decimal followed by ‘bytes’ | | extend.fth |
| .W | ( n -- ) | no | Display n in hex as a word with leading $ | | kernel |
| .WORD | (n – ) | no | Display n in hex as a word | | kernel |
| # | | no | Insert the next digit of the number being displayed into the formatted number string | | kernel |
| #> | ( -- str ) | no | Terminate the formatted number leaving the address of the formatted number string at tos, ready for display | | kernel |
| #S | ( -- ) | no | Insert all remaining significant digits of the number | | kernel |
| <# | ( -- ) | no | Start a new formatted number string | | kernel |
| <D> | ( d1 -- n1 ) | no | Store high long of double for formatting | | kernel |
| D. | ( d. – ) | no | print double number | | extend.fth |
| D.DECS | ( dval. digits -- ) | no | print a double number right justified | | extend.fth |
| D.R | ( dval. digits -- ) | no | print double dval in digits field, right justifed, leading spaces | | extend.fth |
| HOLD | ( c -- ) | no | Insert the character on the stack into the formatted string | | kernel |
| PRINT | ( n -- ) | no | more easily seen alias for . | up to 7528 | kernel |
| U. | ( u1 – ) | no | Print an unsigned number | | kernel |
| U.N | ( val digits -- ) | no | print unsigned val in digits field, right justifed, leading zeros | | extend.fth |
| U.R | ( val digits – ) | no | print unsigned val in digits field, right justifed, leading spaces | | extend.fth |

# P2 CLOCK

| NAME | STACK EFFECT | PRE? | DESCRIPTION | TIME (CYCLES) | SOURCE |
|---|---|---|---|---|---|
| !clkfreq | ( -- ) | no | Up to 8 words may be stored here to be performed as part of RCSLOW or RCFAST | | extend.fth |
| .CLK | ( -- ) | no | An alias for .clkfreq | | extend.fth |
| +PPPP | ( 2..30 -- ) | no | PPPP: Divide the PLL by 2 4 6 ... 30 for the system clock when SS = %11 --- 1 = 31 = no divide | | extend.fth |
| +SS | | no | clock source | | extend.fth |
| clkfreq! | ( Hz – ) | no | Set the P2 clock to Hz, adjusting other P2 parameters to maintain the system e.g. maintaining the required terminal baud rate. Can be | | extend.fth |

| | | | | | |
|---|---|---|---|---|---|
| | | | overclocked to around 300MHz it seems | | |
| CLKSET | | no | PLL should run between 100 – 200MHz | | extend.fth |
| CLKSRC | | no | An alias for +SS | | extend.fth |
| PLLDIV | ( 2..30 -- ) | no | An alias for +PPPP | | extend.fth |
| PLLEN | ( -- ) | no | Enable PLL | | extend.fth |
| PLLOFF | ( -- ) | no | Disable PLL | | extend.fth |
| RCFAST | ( -- ) | no | Set the P2 clock to around 25.1MHz 961600 terminal baud rate continues to work | | extend.fth |
| RCSLOW | ( -- ) | no | Set the P2 clock to around about 20kHz – fast terminal baud rates are not maintained | | extend.fth |
| USEPLL | | no | | | extend.fth |
| USEXTAL | | no | | | extend.fth |
| VCOMUL | ( 1..1024 -- ) | no | | | extend.fth |
| XIDIV | ( 1..64 -- ) | no | | | extend.fth |

This article 'Set TAQOZ clock frequency' is useful.

# POLLING

Background polling of user tasks can be initiated when a cog is waiting for KEY input. In the main console task this allows a user routine to add POLLS that check for low priority tasks that are more able to be handled by the main console cog such as detecting for SD card inserted etc. The user may add **up to 8 polls** and this needs to be done in the user start-up routine as all polls are cleared on boot. To keep TAQOZ responsive, make all user POLLS as short as possible.

| NAME | STACK EFFECT | PRE? | DESCRIPTION | TIME (CYCLES) | SOURCE |
|---|---|---|---|---|---|
| -POLL | ( 'code -- ) | no | Remove a task cpa from the polled list | 968 | extend.fth |
| !POLLS | ( -- ) | no | Init and clear all 8 polling vectors | 680 | extend.fth |
| +POLL | ( 'code -- ) | no | Add a task cpa to the polled list | 1424 | extend.fth |
| POLL: | | no | Background Polling<br>low priority background functions are checked when console input is idle<br>Up to 8 vectors are polled as part of POLLS | | extend.fth |

# REAL TIME CLOCK

These words are used to communicate with an RV-3028 real time clock via i2c if one is connected to the P2.

| NAME | STACK EFFECT | PRE? | DESCRIPTION | TIME (CYCLES) | SOURCE |
|---|---|---|---|---|---|
| _RTC! | ( byte reg -- ) | no | | | extend.fth |
| !PW | ( -- ) | no | rtc password init | | extend.fth |
| !RTC | | no | Initialise real time clock | | extend.fth |
| !TIME | | no | boot time inits | | extend.fth |
| .DATE | | no | | | extend.fth |
| .DAY | | no | | | extend.fth |
| .DT | | no | | | extend.fth |
| .FDT | | no | | | extend.fth |
| .TIME | | no | | | extend.fth |
| @date | | no | byte variable, rtc buffer | | extend.fth |
| @day | | no | byte variable, rtc buffer | | extend.fth |
| @hour | | no | byte variable, rtc buffer | | extend.fth |
| @min | | no | byte variable, rtc buffer | | extend.fth |
| @month | | no | byte variable, rtc buffer | | extend.fth |
| @sec | | no | byte variable, rtc buffer | | extend.fth |
| @year | | no | byte variable, rtc buffer | | extend.fth |
| >HMS | ( s m h -- hhmmss ) | no | | | extend.fth |
| BCD>DEC | ( bcds -- val ) | no | | | extend.fth |
| BCDS | ( bcds -- dec rem ) | no | | | extend.fth |
| bdate | | no | long variable, date at reset | | extend.fth |
| bms | | no | long variable, ms time at reset | | extend.fth |
| btime | | no | long variable, time at reset | | extend.fth |
| DATE! | ( yymmdd -- ) | no | | | extend.fth |
| DATE@ | | no | | | extend.fth |
| DAY! | | no | | | extend.fth |
| DAY@ | | no | | | extend.fth |
| HMS | ( #xxyyzz -- zz yy xx ) | no | split 6 digit decimal number into 3 two digit groups | | extend.fth |
| I2CREG! | ( dat reg dev -- ) | no | store 8-bit to i2c device register | | extend.fth |
| I2CREG@ | ( reg dev -- dat ) | no | fetch reg from 8-bit reg | | extend.fth |
| PW | ( flag – ) | no | turn pw protect on or off | | extend.fth |

| | | | | | |
|---|---|---|---|---|---|
| QDATE$ | ( --- yymmdd ) | no | use bdate but check if qtime has gone into the next day (if so then refesh bdate ) | | extend.fth |
| QTIME@ | ( --- hhmmss ) | no | Quick TIME@ (10us) using the boot time plus the curent GETMS | | extend.fth |
| RDRTC | | no | RV-3028 @$A4 can latch 7 bytes for I2C read | | extend.fth |
| RTC! | | no | | | extend.fth |
| RTC? | ( – flag ) | no | returns whether a real time clock is present on address $A4 | | extend.fth |
| RTC@ | ( reg -- byte ) | no | | | extend.fth |
| RTCB! | ( byte reg -- ) | no | store byte as BCD in RTC register | | extend.fth |
| SECS@ | ( -- seconds ) | no | return with seconds of the day | | extend.fth |
| TIME! | ( hhmmss -- ) | no | | | extend.fth |
| TIME@ | | no | | | extend.fth |
| UTIME! | ( secs -- ) | no | | | extend.fth |
| UTIME@ | ( -- secs ) | no | | | extend.fth |

# REVERSAL of BITS

| NAME | STACK EFFECT | PRE? | DESCRIPTION | TIME (CYCLES) | SOURCE |
|---|---|---|---|---|---|
| CREV | ( b1 -- b2 ) | no | Reverse byte 0..7 → 7..0 | 32 | kernel |
| REV | ( n1 -- n2 ) | no | Reverse bits 0..31 → 31..0 | 32 | kernel |

Why these obscure instructions? Bit reversal of data buffer addresses is an essential element of the fast fourier transform - a fundamental function of digital signal processing. The assembly instruction these TAQOZ words are based on saves a great deal of time over other means.

# SD CARD

An SD card, if fitted to the P2, offers huge, removable data storage as compared to relatively small, fixed-in-place Flash memory. Note that the SD card driver:-

- assumes that all files stored on SD card are unfragmented, which (from experimentation with Windows and Linux) seems always to be the case
- File delete is currently not supported
- Files are created with a fixed size
- Only one file is opened at a time

With those limitations in mind, the driver benefits from being simple to use, small, fast and P.C. compatible.

The SD card default connections are:-
Pin P58 SI
Pin P59 SO
Pin P60 CK
Pin P61 CS
These may be changed using the SDPINS word.

The following sections list the Basic through to High-level SD card words:-

# SD card - Data Buffers

| NAME | STACK EFFECT | PRE? | DESCRIPTION | TIME (CYCLES) | SOURCE |
|---|---|---|---|---|---|
| DIRBUF | ( – n ) | no | const, dir sector buffer | | file.fth |
| SDBUF | ( – n ) | no | const, file sector buffers initial value | | file.fth |

## SD card - Pin-out

These words relate to the Smart Pins used to interface to the SD card:-

| NAME | STACK EFFECT | PRE? | DESCRIPTION | TIME (CYCLES) | SOURCE |
|---|---|---|---|---|---|
| SDCK | ( – ck ) | no | pin number (0-63) assigned for CK signal, default is pin 60 | | file.fth |
| SDCS | ( – cs ) | no | pin number (0-63) assigned for CS signal, default is pin 61 | | file.fth |
| SDDI | ( – di ) | no | pin number (0-63) assigned for DI signal, default is pin 59 | | file.fth |
| SDDO | ( – do ) | no | pin number (0-63) assigned for DO signal, default is pin 58 | | file.fth |
| SDPINS | ( n – ) | no | set the four pins used for sd card interface e.g. &60.58.59.61 SDPINS | | file.fth |

## SD card - SPI commands

| NAME | STACK EFFECT | PRE? | DESCRIPTION | TIME (CYCLES) | SOURCE |
|---|---|---|---|---|---|
| !SD | ( --- ocr \| false ) | no | Initialise the SD card in SPI mode and return with the OCR | | file.fth |
| !SDIO | | no | release SPI I/O to SD | | file.fth |
| ACMD | ( data acmd -- res ) | no | send SD command | | file.fth |
| CMD | ( data cmd -- res ) | no | send SD command | 2777 | file.fth |
| SD? | ( – flg ) | no | flg=TRUE if SD card present, else flg=FALSE | | file.fth |

## SD card - Register status report

| NAME | STACK EFFECT | PRE? | DESCRIPTION | TIME (CYCLES) | SOURCE |
|---|---|---|---|---|---|
| .CID | ( – ) | no | Print the CID information in verbose report format e.g.<br>CARD: SANDISK SD SD32G REV$85 #BEC162CE DATE:7E5/1 | | file.fth |
| .CSD | ( – ) | no | Print the Card Specific Data information in verbose report format | | file.fth |
| .OCR | ( – ) | no | Print card Operating Conditions Register in verbose report format | | file.fth |

## SD card - File permissions

| NAME | STACK EFFECT | PRE? | DESCRIPTION | TIME (CYCLES) | SOURCE |
|---|---|---|---|---|---|
| RO | ( – ) | no | Read Only – files permission | | file.fth |
| RW | ( – ) | no | Read / Write – files permission | | file.fth |
| RWC | ( – ) | no | Read / Write and Create – files permission | | file.fth |
| RWS | ( – ) | no | Read / Write / System – files permission | | file.fth |

## SD card - Sector

| NAME | STACK EFFECT | PRE? | DESCRIPTION | TIME (CYCLES) | SOURCE |
|---|---|---|---|---|---|
| ?FLUSH | ( – ) | no | only flush sector if it has been written to | | file.fth |
| @FILE | ( -- sector ) | no | return starting sector at current FILE | | file.fth |
| @OPEN | ( -- sector ) | no | | | file.fth |
| FLUSH | ( – ) | no | flush sector | | file.fth |
| OPEN-SECTOR | ( sector -- ) | no | Set the starting sector for file access | | file.fth |
| SDRD | ( sector dst -- ) | no | read sector into memory and update sector number | | file.fth |
| SDRDS | ( sector dst bytes -- ) | no | read multiple sectors in continuous multiblock mode -- update @sdrd pointer | | file.fth |
| SDRDX | ( sector dst -- ) | no | read sector into memory silently | | file.fth |
| SDWR | ( src sect -- ) | no | Write a sector | | file.fth |
| SDWRS | ( ram sectr bytes -- ) | no | Write multiple sectors | | file.fth |
| SECTOR | ( sect -- sdbuf ) | no | sector to hub ram | | file.fth |
| SECTORF | ( sect -- sdbuf ) | no | Always read in a sector but flush first | | file.fth |

## SD card - Virtual Memory operations

| NAME | STACK EFFECT | PRE? | DESCRIPTION | TIME (CYCLES) | SOURCE |
|---|---|---|---|---|---|
| SD! | ( long xaddr -- ) | no | store long to SD virtual memory in current file | | file.fth |
| SD@ | ( xaddr -- long ) | no | fetch long from SD virtual memory in current file | | file.fth |
| SDADR | ( sdadr -- ramadr ) | no | Convert SD file address to hub ram address where file is buffered | 897 | file.fth |
| SDC! | ( byte xaddr -- ) | no | store byte to SD virtual memory in current file | | file.fth |
| SDC@ | ( xaddr – byte ) | no | fetch byte from SD virtual memory in current file | | file.fth |
| SDW@ | ( xaddr – word ) | no | fetch word from SD virtual memory in current file | | file.fth |

## SD card - FAT32

| NAME | STACK EFFECT | PRE? | DESCRIPTION | TIME (CYCLES) | SOURCE |
|---|---|---|---|---|---|
| @BOOT | ( -- sector ) | no | | | file.fth |
| @CWD | ( – n ) | no | | | file.fth |
| @ROOT | ( -- sector ) | no | | | file.fth |
| CD# | ( sect -- ) | no | change current working directory | | file.fth |
| CWD | | no | open the current working dir as if it were a file | | file.fth |
| CWD! | ( n – ) | no | | | file.fth |
| FAT1 | | no | Access FAT1 as a file | | file.fth |
| FAT2 | | no | Access FAT2 as a file | | file.fth |
| MBR | | no | Use the MBR as a file | | file.fth |
| ROOT | | no | Open the root folder as a file | | file.fth |

## SD card - Directory Record

| NAME | STACK EFFECT | PRE? | DESCRIPTION | TIME (CYCLES) | SOURCE |
|---|---|---|---|---|---|
| dirrcd | ( – adr ) | no | points to the start of the 32 byte directory record as follows:- | | file.fth |
| fname | ( – adr ) | no | 8 byte file name in the directory record | | file.fth |
| fname | ( – adr ) | no | 3 byte file extension in the directory record | | file.fth |
| fatr | ( – adr ) | no | 1 byte file attribute 0:read-only, 1:hidden, 2:system, 3:volume label, 4:directory, 5:archive, 6-7: undefined | | file.fth |
| res | ( – adr ) | no | reserved – set 0 | | file.fth |
| fcms | ( – adr ) | no | 1 byte file creation time - milliseconds | | file.fth |
| fctime | ( – adr ) | no | 2 byte file creation time | | file.fth |
| fcdate | ( – adr ) | no | 2 byte file creation date | | file.fth |
| fclsth | ( – adr ) | no | 2 bytes | | file.fth |
| ftime | ( – adr ) | no | 2 bytes file modification time | | file.fth |
| fdate | ( – adr ) | no | 2 bytes file modification date | | file.fth |
| fclstl | ( – adr ) | no | 2 bytes | | file.fth |
| fsize | ( – adr ) | no | 4 bytes file size | | file.fth |
| diridx | ( – adr ) | no | 2 bytes | | file.fth |
| file$ | ( – str ) | no | 16 bytes filename | | file.fth |
| FSIZE@ | ( – n ) | no | fsize @ | | file.fth |

## SD card - Clusters

| NAME | STACK EFFECT | PRE? | DESCRIPTION | TIME (CYCLES) | SOURCE |
|---|---|---|---|---|---|
| !MOUNT | ( – ) | no | mount the sd card | | file.fth |
| ?MOUNT | ( – ) | no | mount the sd card  if not already mounted | | file.fth |
| C>S | ( clust# -- sector ) | no | Convert Cluster to sector | | file.fth |
| CLUSTERS? | ( cluster# -- clusters ) | no | count number of clusters allocated from start cluster | | file.fth |
| FCLUSTER | ( -- cluster#0 ) | no | convert Directory address to first cluster | | file.fth |
| FMAX | ( -- bytes ) | no | find total allocated cluster bytes for this byte | | file.fth |
| FSECTOR | ( -- sector ) | no | read Directory cluster and convert to starting sector | | file.fth |
| GETFAT | | no | read fat32 as a byte array | | file.fth |
| MOUNT | ( – ) | no | mount the sd card and display card identity | | file.fth |
| MOUNTED? | ( – flg ) | no | mount the sd card  if not already mounted, flg<>0 if successful | | file.fth |
| SECT>CLST | ( sector -- cluster ) | no | convert a sector to a cluster ( result 0 = out of range  ; 2 = 1st ) | | file.fth |

## SD card - Directory

| NAME | STACK EFFECT | PRE? | DESCRIPTION | TIME (CYCLES) | SOURCE |
|---|---|---|---|---|---|
| .FDATE | | no | print the file date | | file.fth |
| AS8.3 | ( str -- ) | no | save file name in file$ but convert to 8.3 format in dir | | file.fth |
| CREATED | ( -- ) | no | Update the ‘created’ time and date of the current file | | file.fth |
| f$ | ( – adr ) | no | pointer to 16 bytes, copy of 8.3 name in normal short format | | file.fth |
| FDATE! | ( #yymmdd field -- ) | no | update file modification/create date in dir buf, Date (7/4/5 bits, for year-since-1980/month/day) | | file.fth |
| FTIME! | ( #hhmmss field -- ) | no | update file modification/create time in dir buf, Time (5/6/5 bits, for hour/minutes/doubleseconds) | | file.fth |
| GETDIR | ( index -- ) | no | read the nth directory entry into the dir buffer (index saved in diridx) | | file.fth |
| IDX>DIR | ( dirIndex -- diradr ) | no | reads relevant dir sector in using index, returns with the address in the buffer | | file.fth |
| MODIFIED | ( -- ) | no | Update the ‘modified’ time and date of the current file | | file.fth |
| OPENDIR | ( – ) | no | | | file.fth |
| SAVEDIR | ( – ) | no | update directory on SD | | file.fth |

## SD card - Directory Structure

| NAME | STACK EFFECT | PRE? | DESCRIPTION | TIME (CYCLES) | SOURCE |
|---|---|---|---|---|---|
| .LIST | ( – ) | no | Display files in current directory one per line, with attributes | | file.fth |
| COPY | ( -- ) | yes | Using the next word in the input stream as filename, if this is found on disk, copy the file details to the ‘clipboard’ copybuf | | file.fth |
| copybuf | ( – adr ) | no | 32 byte ‘clipboard’ memory | | file.fth |
| DIR | ( – ) | no | Display files in current directory one per line | | file.fth |
| DIR+ | ( -- ) | no | Display files in current directory one per line with more detail | | |

| | | | | | |
|---|---|---|---|---|---|
| DIR++ | ( – ) | no | Display files in current directory one per line with yet more detail | | file.fth |
| DIRW | ( – ) | no | Display files in current directory in 6 columns | | file.fth |
| DIRX | ( n -- ) | no | Display files in current directory in ‘n’ columns | | file.fth |
| FREEDIR | ( – ) | no | Find the next free directory entry (just looks for a null but could do more) no range checking just to keep it simple for now | | file.fth |
| ls | ( – ) | yes | list the directory in simple format i.e. ls <enter> or in wide format e.g. ls -l <enter> | | file.fth |
| mk | ( size -- ) | yes | Create a new file by name ( using next word in input stream ) but if it already exists then delete the old one and reuse the dir entry, if size = 0 then max = 4GB | | file.fth |
| mk$ | ( size namestr -- ) | no | Create a new file, named ‘namestr’ allocating ‘size’ bytes | | file.fth |
| PASTE | ( -- ) | no | Make a duplicate entry in the Directory usIng the details saved in the COPY command (N.B. doesn’t copy the file contents) | | file.fth |

## SD card - File Operations

**N.B. All file operations are subject to 'File permissions' see the section above, so before attempting to write to a file, set RW, then afterwards optionally set RO to protect the contents from change. You won't get far otherwise!**

| NAME | STACK EFFECT | PRE? | DESCRIPTION | TIME (CYCLES) | SOURCE |
|---|---|---|---|---|---|
| (cat) | ( sector -- ) | no | Display the contents of the file, whose sector is top of stack | | file.fth |
| cat | ( <src> – ) | yes | Display the contents of the file, whose name follows in the input stream | | file.fth |
| CD | | yes | Alias for cwd | | file.fth |
| CD$ | ( str -- ) | no | change directory to ‘str’ | | file.fth |
| CLOSE-FILE | | no | Close file by flushing, switching to read-only and setting 'readsect' to -1 | | file.fth |
| cwd | ( <dir> -- ) | yes | change directory, using next word in input stream as name | | file.fth |
| DEL-FILE | ( -- ) | yes | currently does nothing | | file.fth |
| FCLOSE | | no | Alias for CLOSE-FILE | | file.fth |
| FCOPY | ( <src> <dst> -- ) | yes | old file name and new file name both follow in the input stream | | file.fth |
| FCOPY# | ( srcsect dstsec bytes -- ) | no | copy by by referring to the files’ index | | file.fth |
| FGET | ( -- ch ) | no | Read the next byte from the file | | file.fth |
| FLOAD | ( <name> -- ) | yes | load file as console input, filename as next word in input stream, then restore on null to console input | | file.fth |
| FLOADS | ( sector -- ) | no | load file as console input then restore on null to console input | | file.fth |
| FOPEN | ( <name> -- ) | yes | grab parameters and permissions then open-file | | file.fth |
| FOPEN$ | ( str -- sector \| 0 ) | no | Alias for OPEN-FILE$, returns sector else 0 if it fails | | file.fth |
| FOPEN# | ( index -- ) | no | open a file using the directory name index | | file.fth |
| FREAD | ( sdsrc hubdst bytes -- ) | no | Read file offset to memory | | file.fth |
| FSEND | ( -- ) | no | Send all output to the file if open - wraps using the variable fsize ( see section SD card - Directory Record) | | file.fth |
| FWRITE | ( hubsrc sddst bytes -- ) | no | Write memory to file offset | | file.fth |
| MAKE | ( size -- ) | no | force file open - create to size if it's not found | | file.fth |
| OPEN-FILE | ( <name> -- filesect ) | no | Get the file name as the next word in the input stream and try to open it, return with sector | | file.fth |
| OPEN-FILE$ | ( str -- sector \| 0 ) | no | check mount and find 8.3 file name, if found then convert directory entry to starting sector, else if create flag set then create a preallocated size file - else fail, open the sector although 0 = fail (mbr sector 0 is protected anyway) | | file.fth |
| opensect | ( -- adr ) | | long variable that stores starting sector of the open file | | file.fth |
| pwd | ( -- ) | no | display the current directory name | | file.fth |
| QV | ( <src> – ) | yes | Display the first 128 bytes as hex for the file whose name is next in the input stream | | file.fth |
| readsect | ( -- adr ) | no | long variable stores the current buffered sector | | file.fth |
| RENAME | ( <old> <new> -- ) | yes | old file name and new file name both follow in the input stream | | file.fth |
| RENAME# | ( dir# <new> -- ) | yes | rename by referring to the files’ index | | file.fth |
| REOPEN-FILE | ( – flg ) | no | Like OPEN-FILE$, but use filename stored in file$ | | file.fth |
| SAVETEXT | ( -- ) | yes | Save all text that follows in the input stream to the filename, until the ESC char, then close the file. The file size is always 1 Mbyte<br>e.g. RW SAVETEXT MYFILE.TXT Hello from myfile.txt <ESC><br>N.B If the file is more than one sector in size - the transfer speed of the terminal sending the file has to be limited -Christof Eb reports 1mS delay per character works OK. This delay is needed to give TAQOZ time to write to the SDcard. | | file.fth |

## SD card - Disk Reporting / Formatting

| NAME | STACK EFFECT | PRE? | DESCRIPTION | TIME (CYCLES) | SOURCE |
|---|---|---|---|---|---|
| *DISK* | ( -- ) | no | Module marker word – used by FORGET for module removal | | file.fth |
| !FATS | ( -- ) | no | | | file.fth |
| .DISK | ( -- ) | no | display OCR, CSD, Speeds, MBR and FAT32 information | | file.fth |
| .FAT | ( -- ) | no | display fat32 boot record | | file.fth |
| .FREE | ( -- ) | no | display SD card free and used space ( takes a few seconds ) | | file.fth |
| .MB | ( sectors -- ) | no | Fetch sectors, print, and display in MB as well ( 15,515,648 = 7,944MB ) | | file.fth |
| .MBR | ( -- ) | | Scan all 4 entries : check active partition type | | file.fth |
| .SD | ( -- ) | no | Display OCR, CSD and Speeds | | file.fth |
| .SPEEDS | ( -- ) | no | Display Latency, Sector and Blocks speeds | | file.fth |
| FORMAT | ( – ) | no | Use xx CLSZ beforehand to set non-default cluster size Use RWS to set system permissions etc<br>Usage: 32 KB CLSZ RWS FORMAT | | file.fth |
| FORMAT.FAT | ( -- ) | no | Format SD card (takes a while ) | | file.fth |
| FORMAT.MBR | | no | Format the Master Boot Record of the SD card | | file.fth |

## SD card - Block File display

Originally, Forth programs accessed disk as contiguous memory, splitting the disk up into consecutive 'blocks'. Each block was dimensioned to store just one screen full of text. TAQOZ Reloaded supports the block file system, based on the current file, rather than the whole disk. Of course, the file must exist and be of appropriate size beforehand.

| NAME | STACK EFFECT | PRE? | DESCRIPTION | TIME (CYCLES) | SOURCE |
|---|---|---|---|---|---|
| .BLOCK | ( blk# -- ) | no | List an old-school block within the current file | | file.fth |
| LISTBLOCKS | ( -- ) | no | List all old-school blocks with the current file | | file.fth |

## SD card - System

| NAME | STACK EFFECT | PRE? | DESCRIPTION | TIME (CYCLES) | SOURCE |
|---|---|---|---|---|---|
| ?SD | ( -- ) | no | Display SD card summary – e.g. SD CARD 31 GB SANDISK SD SD32G REV$85 #3200344782 DATE:2021/1 | | file.fth |
| BACKUP | ( <src> – ) | yes | Backup to filename ( following in input stream) or FLASH : options: DISABLE, FLASH, MBR, BIX<br>usage examples – see section on Backup at rear of the document | | file.fth |
| BACKUP$ | ( str -- ) | no | Backup to filename or FLASH : options: DISABLE, FLASH, MBR, BIX<br>usage example: “ MBR” BACKUP$ | | file.fth |
| BOOT | ( -- ) | no | Reboot Taqoz Reloaded, preserving all unsaved work | | file.fth |
| BU | ( -- ) | no | Backup to SD MBR shortcut | | file.fth |

# SERIAL RAM

These words enable communication with Serial RAM if one is connected to the P2

| NAME | STACK EFFECT | PRE? | DESCRIPTION | TIME (CYCLES) | SOURCE |
|---|---|---|---|---|---|
| !SR | ( init SPIRAM ) | no | | | extend.fth |
| .SR | ( – ) | no | Print the SPIRAM ID | | extend.fth |
| P2PAL | | no | Use PSRAM on P2PAL pins 53,49,48 and 52 | | extend.fth |
| SPIRW | ( -- word ) | no | | | extend.fth |
| SR | ( – ) | no | prefix for DUMP to show serial ram e.g. 0 $20 SR DUMP | | extend.fth |
| SR! | ( long adr -- ) | no | write long from adr | | extend.fth |
| SR@ | ( adr -- long ) | no | read long from adr | | extend.fth |
| SRC! | ( byte adr -- ) | no | write byte to adr | | extend.fth |
| SRC@ | ( adr -- byte ) | no | read byte from adr | | extend.fth |
| SRCMD | ( cmd -- ) | no | | | extend.fth |
| SRID | ( -- long long ) | no | | | extend.fth |
| SRRD | ( readadr -- ) | no | | | extend.fth |
| SRW! | ( word adr -- ) | no | write word to adr | | extend.fth |
| SRW@ | ( adr -- word ) | no | read word from adr | | extend.fth |
| SRWRP | ( src dst -- ) | no | | | extend.fth |
| SRWRS | ( hub srdst bytes -- ) | no | | | extend.fth |

# SHIFTING

| NAME | STACK EFFECT | PRE? | DESCRIPTION | TIME (CYCLES) | SOURCE |
|---|---|---|---|---|---|
| << | ( n1 bits -- n2 ) | no | Shift n1 left by count | 48 | kernel |
| >> | ( n1 cnt -- n2 ) | no | Shift n1 right by count | 48 | kernel |
| 16<< | ( n1 – n2 ) | no | n2 = n1 shifted left 16 places | 32 | kernel |
| 16>> | ( n1 – n2 ) | no | n2 = n1 shifted right 16 places | 32 | kernel |
| 2* | ( n1 -- n2 ) | no | shift n1 left one bit (equiv to multiply by 2) | 32 | kernel |
| 2/ | ( u1 -- u1/2 ) | no | Shift u1 right by 1 (equiv to divide by 2) – N.B. unsigned arithmetic | 32 | kernel |
| 4* | ( n1 – n2 ) | no | n2 = 4 x n1 | 32 | kernel |
| 4/ | ( n1 – n1/4 ) | no | Shift n1 right by 2 (equiv to divide by 4) | 32 | kernel |
| 8<< | ( n1 – n2 ) | no | n2 = n1 shifted left 8 places | 32 | kernel |
| 8>> | ( n1 – n2 ) | no | n2 = n1 shifted right 8 places | 32 | kernel |
| 9<< | ( n1 – n2 ) | no | n2 = n1 shifted left 9 places | 32 | kernel |
| 9>> | ( n1 – n2 ) | no | n2 = n1 shifted right 9 places | 32 | kernel |
| ROL | ( n1 bits -- n2 ) | no | rotate n1 by bits leftwise | 48 | kernel |
| ROR | ( n1 cnt -- n1>>cnt ) | no | rotate n1 by bits rightwise | 48 | kernel |
| ROR? | ( n1 cnt -- n1>>cnt carry ) | no | rotate n1 by bits rightwise, carry=0 if no carry, else non-zero | 32 | kernel |
| SAR | ( n1 cnt -- n1>>>cnt) | no | shift n1 right cnt arithmetic | 40 | kernel |

# SMARTPIN ANALOGUE

| NAME | STACK EFFECT | PRE? | DESCRIPTION | TIME (CYCLES) | SOURCE |
|---|---|---|---|---|---|
| ADC | ( cycles -- ) | no | Set the number of cycles for A/D conversion - see below | | extend.fth |
| DAC | ( bits -- ) | no | 16-bit dither DAC | | extend.fth |
| mV | ( millivolts --- ) | no | Output a scaled voltage onto the DAC pin | | extend.fth |
| SETADC | ( min ref -- ) | no | usage: 40 PIN 40000 ADC 7191 7675 SETADC - see below for further explanation | | extend.fth |
| VOLTS@ | ( -- volts*1000 ) | no | Read the DC input signal in millivolts from the current smartpin - N.B. this needs calibrating with SETADC prior to use | | extend.fth |

**mV example**

The TEST word produces a 47 Hz 3.2V peak sawtooth waveform out of smartpin 17, until a key is pressed (assuming the P2 is running at 200 MHz)

```
pub TEST
        17 PIN
        BEGIN
                3200 0 DO I mV LOOP
        KEY UNTIL
;
```

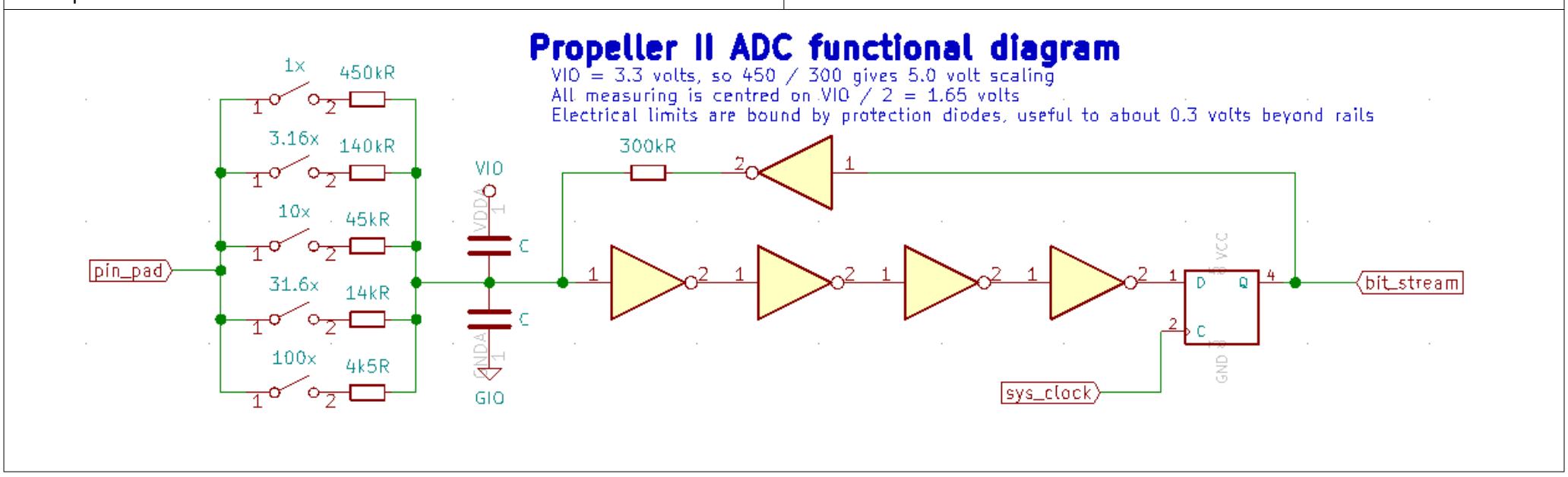
**SETADC - further explanation:-**

SETADC stores calibration values in an array for the active smartpin before its use as an analogue input with VOLTS@. This kind of calibration is useful, because the sigma delta adc of P2 has a range different from 0...3.3V. The centre of this range is near to 1.65 Volts. The feedback resistor in the P2 smartpin circuit is 300 kohm, so for gain=1 the measurement resistor connected between signal source and P2 pin would need to be the 450 kohm option, giving **in theory** a range of 0 ... 5.0V. However, be aware of input voltage limitations of the P2 for the true input range - see the data sheet for more details.

NB all parts in the circuit below are **internal** to the P2.

```
40 PIN                  --- Set the current pin to pin 40
40000 ADC               --- Set the full scale value for the converter
7191 7675 SETADC        --- Set offset and scaling for the current pin

--- 7191 sets the input for 0V offset, 20000*(1-1.65V/2.5V) = 6800
--- 7675 sets the input scaling, 20000/2.5 = 8000
```




This article 'Output 0 - 3.3V in millivolts on any pin' may also be useful for D/A conversion.

# SMARTPIN FREQUENCY COUNTER

| NAME | STACK EFFECT | PRE? | DESCRIPTION | TIME (CYCLES) | SOURCE |
|---|---|---|---|---|---|
| .FREQ | ( us -- ) | no | demo to print the frequency and duty cycle | | extend.fth |
| FREQCNT | ( clocks mode0..2 -- ) | no | Set up the pin in frequency counting mode | | extend.fth |
| RAWFREQ? | ( us -- clocks states periods ) | no | Return with raw frequency measurements from current pin | | extend.fth |

The article 'Measure Frequency and duty cycle with P2 Smartpins' is a useful tutorial on frequency counting.

# SMARTPIN ELECTRICAL CHARACTERISTICS

| NAME | STACK EFFECT | PRE? | DESCRIPTION | TIME (CYCLES) | SOURCE |
|---|---|---|---|---|---|
| !IN | | no | set for inverted input | | extend.fth |
| !OUT | | no | set for inverted output | | extend.fth |
| 100ua | ( – 5 ) | no | drive mode operand for source/sink | | extend.fth |
| 10ua | ( – 6 ) | no | drive mode operand for source/sink | | extend.fth |
| 150K | ( – 3 ) | no | drive mode operand for source/sink | | extend.fth |
| 15K | ( – 2 ) | no | drive mode operand for source/sink | | extend.fth |
| 1K5 | ( – 1 ) | no | drive mode operand for source/sink | | extend.fth |
| 1ma | ( – 4 ) | no | drive mode operand for source/sink | | extend.fth |
| CLOCKED | | no | | | extend.fth |
| CMOS | ( – 0 ) | no | drive mode operand for source/sink | | extend.fth |
| OPEN | ( – 7 ) | no | drive mode operand for source/sink | | extend.fth |
| OPEN-DRAIN | ( -- ) | no | open source cmos sink | | extend.fth |
| PD | ( -- ) | no | alias for PULLDOWN | | extend.fth |
| PU | ( -- ) | no | alias for PULLUP | | extend.fth |
| PULLDOWN | ( -- ) | no | alias for SINK | | extend.fth |
| PULLUP | ( -- ) | no | alias for SOURCE | | extend.fth |
| SETPIN | | no | executes 0 WRFNC | | extend.fth |
| SINK | ( val – ) | no | drive mode operand for source/sink | | extend.fth |
| SOURCE | ( val – ) | no | drive mode operand for source/sink | | extend.fth |
| WRFNC | ( MMMMM -- ) | no | WRPIN in combo with modes - float, shift, combine, wrpin, low (DIR=1) enables smartpin | | extend.fth |

**To set up a pins' electrical characteristics**, use the following syntax in descriptive combination e.g.

```
4 PIN          --- This defines pin 4 characteristics
1K5 SOURCE --- Pin 4 has a 1.5k ohm pullup to 3V3
CMOS SINK    --- Pin 4 has a CMOS output transistor down to 0V
```

```
6 PIN
OPEN SOURCE
10ua SINK          --- 10ua constant current sink - when pin 6 set low
```

# SMARTPIN NUMERICALLY CONTROLLED OSCILLATOR

| NAME | STACK EFFECT | PRE? | DESCRIPTION | TIME (CYCLES) | SOURCE |
|---|---|---|---|---|---|
| BLINK | ( pin -- ) | no | flash pin on and off at 2Hz | | extend.fth |
| DUTY | ( val -- ) | no | | | extend.fth |
| HZ | ( Hz -- ) | no | Set the current pin frequency in Hz | | extend.fth |
| KHZ | ( kHz -- ) | no | Set the current pin frequency in kHz | | extend.fth |
| MHZ | ( MHz -- ) | no | Set the current pin frequency in MHz | | extend.fth |
| NCO | ( count – ) | no | set the NCO output to counter clock / count e.g. $8000_0000 NCO would divide by 2 | | extend.fth |
| SETNCO | ( count mode --) | no | | | extend.fth |

Here's an article 'Make Notes' on producing a series of steady tones from a pin. Another article 'Smartpin NCO frequency' is useful.

# SMARTPIN PULSES

| NAME | STACK EFFECT | PRE? | DESCRIPTION | TIME (CYCLES) | SOURCE |
|---|---|---|---|---|---|
| HILO | ( high low -- ) | no | e.g. If the P2 is running at 300MHz, the command 12000 6000 HILO produces pulses 40uS high, 20uS low | | extend.fth |
| PULSE | ( -- ) | no | Output one pulse on the current pin | | extend.fth |
| PULSES | ( n -- ) | no | Output n pulses on the current pin | | |
| PW | ( width -- ) | no | | | extend.fth |

**Pulse stream example** (assuming the P2 is clocking at 300MHz):-

```
48 PIN              --- Select pin 48 as the target smartpin
12000 6000 HILO     --- HILO takes high and low count and sets up the Smartpin, so 40us high, 20us low
50 LOW              --- set pin 50 low
16 PULSES           --- writes wypin with that value (just an alias) to generate 16 pulses of set timing
WAITPIN             --- waits for smartpin ack (that the smartpin is ready for more)
3 PULSES            --- 3 more pulses without any other changes
50 HIGH             --- HIGH drives P50 high to indicate that the code has completed (although the smartpin is still busy)
```

This is explained further in the article 'Smartpin variable pulse stream'

# SMARTPIN PWM

| NAME | STACK EFFECT | PRE? | DESCRIPTION | TIME (CYCLES) | SOURCE |
|---|---|---|---|---|---|
| PWM | ( duty frame div -- ) | no | | | extend.fth |
| SMPS | ( duty fram div -- ) | no | | | extend.fth |
| TRI | ( duty frame div -- ) | no | | | extend.fth |

**PWM example:-**
Here we setup 4 pins P0..P3 to output 4 different rates from 20 to 80% duty cycle:-

```
4 FOR I PIN I 1+ 20 * 100 10 PWM NEXT
```

This article 'Smartpin PWM' is useful

# SMARTPIN UART

TAQOZ, by default, expects a computer terminal connected to smartpin P62 for data transmitted by the P2 and smartpin P63 for data received by the P2. These pin assignments can be changed permanently or temporarily - use SEE CONBAUD to see how that's done.

| NAME | STACK EFFECT | PRE? | DESCRIPTION | TIME (CYCLES) | SOURCE |
|---|---|---|---|---|---|
| -bit | | no | Set up the number of data bits | | extend.fth |
| COMPORT | ( pin -- ) | no | All further console output is diverted to this pin as a serial out port | | extend.fth |
| CONBAUD | ( baud -- ) | no | Set pin 62 for o/p, 63 for i/p as the console i/o, set at 'baud' rate | | extend.fth |
| RXD | ( baud -- ) | no | Set up the receiver baud rate | | extend.fth |
| SEROUT | ( data pin -- ) | no | Transmit a character through the smartpin that is normally configured for asynch | | extend.fth |
| TXD | ( baud -- ) | no | Set up transmitter baud rate | | extend.fth |
| TXDAT | ( buf cnt -- ) | no | write byte buffer direct to WYPIN | | kernel |

**Transmit examples:-**

```
48 PIN 1 M TXD                          --- Set up pin 48 for 1Mbaud rate serial output
48 COMPORT PRINT" Hello World! " CON    --- Output a serial string on pin 48, then revert to the default console pin

8 PIN 115200 RXD                        -- Set up PIN 8 as serial input at 115200 baud (default 8-bit)

9 -bit 1 M TXD                          --- Set up serial output for  9-bit 1 megabaud
```

This article 'Smartpin asynch serial transmit' gives some further insight into serial comms, with 'scope traces.

**Receive example  (thanks to Peter_F on the Parallax forum):-**

```
--- This example repeats the incoming 9600 baud NMEA sentences from a GY-GPS6MV2 module on smartpin 55 to the terminal screen
9600 := BRATE                           --- Smartpin async operation at this baudrate only works at 20 MHz clock rate e.g. P2-EVAL board
55   := RXPIN                           --- Smartpin P55 chosen for serial data input  - N.B. P2 IO input voltage must be no greater 3.3 volts

pub SERIN ( -- char )                   --- Wait until char received from smart pin serial input
   WAITPIN                              --- wait for smartpin acknowledement
   RDPIN                                --- receive smartpin char on RXPIN
   #24 >>                               --- shift data from bits 31-24 to 7-0
;

pub RXINIT ( -- )                       --- initialise smartpin for ASYNC serial RX at BRATE baud rate
  RXPIN PIN MUTE                        --- stop any previous smartpin activity on P55
  BRATE RXD H                           --- H - set pin high needed to enable smartpin operation?
;

pub GPS. ( -- )                         --- Repeat incoming serial stream to the terminal until key pressed
  RXINIT                                --- set up the serial input port
  CRLF
  BEGIN
  SERIN EMIT                            --- stream incoming chars to the terminal screen
  KEY UNTIL                             --- until the user presses a key
;
```

If two way communication is required, then the transmit function must be run in a separate cog from the receive, since both operate asynchronously from each other. For an example of this, see Peter-F's full article on the Parallax forum. It demonstrates a loopback test of the Serial Tx to the Rx.

# SPI

The default smartpins for the SPI bus are:-
pin P27 slave select
pin P26 master in slave out
pin P25 master out slave in
pin P24 serial clock
These pin assignments may be changed using the SPIPINS word

| NAME | STACK EFFECT | PRE? | DESCRIPTION | TIME (CYCLES) | SOURCE |
|---|---|---|---|---|---|
| *SPIRAM* | | PRE? | Module header marker – use with FORGET. This module supports LY68L6400 8MB SPI RAM | | |
| CLKS | ( cnt -- ) | no | idle is set low, mosi set high, then emit cnt clocks | | kernel |
| SPICE | | no | Set SPI slave select and clock high | | kernel |
| SPIPINS | ( &cs.mi.mo.ck -- ) | no | Setup I/O pins to be used for SPI instructions | | kernel |
| SPIRD | ( n1 -- n2 ) | no | Read 8-bits left into n1 so that n2 = n1<<8+new.<br>Four successive SPIRDs will receive 32-bits | | kernel |
| SPIRL | ( n1 -- n2 ) | no | Read 32-bits from SPI | | kernel |
| SPIRX | ( dst cnt -- ) | no | Read bytes in from SPI to memory | | kernel |
| SPITX | ( src cnt -- ) | no | Write bytes from memory to SPI | | kernel |
| SPITXE | ( src bytes -- ) | no | Write bytes from memory to SPI | | kernel |
| SPIWB | ( byte -- ) | no | Shift 8 bits from data[0..7] out and leave data on stack (restored with other bytes zeroed) | | kernel |
| SPIWC | ( com – ) | no | Write SD Command | | kernel |
| SPIWL | ( long -- ) | no | write 32 bits | | kernel |
| SPIWM | ( long -- ) | no | write 24 bits | | kernel |
| SPIWR | | no | | | kernel |
| SPIWW | ( word -- ) | no | write 16 bits | | kernel |

# STACK

Taqoz stacks are all located in LUT memory with a bit of COG memory too. All stacks extend upwards in address as data is stored in them. LUT memory for each COG is 32 bits wide, 512 long. It is only addressable as longs.

1. The data stack is 32 longs deep, starting at LUT address $0. The top four entries of this stack are stored in COG memory, however.
2. The loop stack used by DO, FOR etc. is 16 longs deep starting at LUT address $20. The top three entries in this stack are in COG memory. Each loop will consume 3 longs in the stack, so loops can be a maximum of 6 deep at any one place in an application.
3. The branch stack used by IF THEN etc. is 16 longs deep starting at LUT address $30
4. The return stack used for subroutining, R> , >R etc. is 64 longs deep starting at LUT address $40
5. The auxiliary stack used by >L and L> starts from LUT address $80 to the end of LUT at $1FF if the user so wishes. More likely the user will choose to limit the depth of the L stack in his application. The rest of LUT memory is then available for user application storage. User variables should be located near the $1FF end of LUT, to maximise the L stack size.

| NAME | STACK EFFECT | PRE? | DESCRIPTION | TIME (CYCLES) | SOURCE |
|---|---|---|---|---|---|
| -ROT | ( c b a -- a c b ) | no | rotate the top four data stack entries | 56 | kernel |
| -ROT4 | ( a b c d -- d a b c ) | no | reverse rotate the top four data stack entries | 56 | kernel |
| !SP | ( – ) | no | Empty the data stack | 40 | kernel |
| ?DUP | ( n1 -- n1 n1 \| 0 | no | DUP n1 if non-zero | 56 if non-zero, else 40 | kernel |
| >L | ( n – ) | no | Push n onto the general purpose L stack | 40 | kernel |
| >R | ( n -- ) | no | Push n onto the return stack from the data stack | 40 | kernel |
| 2DROP | ( n1 n2 -- ) | no | Drop the top two data stack entries | 56 | kernel |
| 2DUP | ( n1 n2 -- n1 n2 n1 n2 ) | no | Duplicate the top two data stack entries | 80 | kernel |
| 2SWAP | ( n1 n2 n3 n4 -- n3 n4 n1 n2 ) | no | Swap the top two data stack entries with entries 3 and 4 | 56 | kernel |
| 3DROP | ( n1 n2 n3 -- ) | no | Drop the top three data stack entries | 64 | kernel |
| 3RD | ( n1 n2 n3 -- n1 n2 n3 n1 ) | no | Copy the 3rd item on the stack | 48 | kernel |
| 4TH | ( n1 n2 n3 n4 -- n1 n2 n3 n4 n1 ) | no | Copy the 4th item on the stack | 48 | kernel |
| b++ | ( n1 n2 – n1+1 n2 ) | no | Increment 2nd on the stack | 56 | kernel |
| BOUNDS | ( n1 n2 – n3 n2 ) | no | n3 = n1 + n2 | | kernel |
| DEPTH | ( – n) | no | Return the number of entries on the data stack | 64 | kernel |
| DROP | ( n -- ) | no | Pop the data stack using fixed size register stack in COG memory (allows fast direct access for operations) | 48 | kernel |
| DUP | ( n1 - n1 n1 ) | no | Duplicate the top item on the stack | 48 | kernel |
| L> | ( – n ) | no | Pop n from the general purpose L stack | 56 | kernel |
| NIP | ( n1 n2 -- n2 ) | no | drop the 2nd stack entry only | 48 | kernel |
| OVER | ( n1 n2 -- n1 n2 n1 ) | no | read second data item and place copy top of data stack | 48 | kernel |

| | | | | | |
|---|---|---|---|---|---|
| OVER+ | ( n1 n2 -- n1 n2+n1 ) | no | read second data item, add to top of data stack | 32 | kernel |
| R> | ( -- n ) | no | Pop n from the return stack to the data stack | 56 | kernel |
| ROT | ( a b c -- b c a ) | no | rotate the top three data stack entries | 40 | kernel |
| ROT4 | ( a b c d -- b c d a ) | no | rotate the top four data stack entries | 64 | kernel |
| SWAP | ( n1 n2 -- n2 n1 ) | no | Swap the top two items | 40 | kernel |

# STRINGS

The end of TAQOZ strings are marked with byte 00 (zero delimited strings)
If it is required to place a single printable character on the data stack, then enclose the char in single quotes e.g. 'A' places  41 hex on the stack
To print a non-visual character, include the chars \$nn in the string e.g. " \$07" sounds the bell on the terminal, when printed.
Here's the ASCII character set.

| NAME | STACK EFFECT | | DESCRIPTION | TIME (CYCLES) | SOURCE |
|---|---|---|---|---|---|
| [“] | ( -- ) | yes | Compile string inline e.g. [“] my string” within a definition | | kernel |
| “ | ( --  str ) | yes | Interpret a string in the input stream up to the trailing " and leave the address of the null terminated string on the stack e.g. " Hi Bob" | | kernel |
| >STR | ( num -- str ) | no | convert num to string at addr str | | extend.fth |
| >UPPER | ( str1 -- ) | no | Convert string at address str to upper-case | | kernel |
| $! | ( str1 str2 -- ) | no | Store string at hub memory address str1, at address str2 e.g.<br>16 bytes  mystring<br>" Hello" mystring $! | | kernel |
| $+ | ( str1 str2 -- strx ) | no | strx = str1 + str2 ..... strx being a temporary 32 char store (returned by X$) | | extend.fth |
| $+! | ( str1 str2 -- ) | no | str2 = str1 + str2 | | extend.fth |
| $= | ( str1 str2 -- flag ) | no | flag = true if string at hub memory address str1 is identical tostring at str2, else flag = false | | kernel |
| $= | ( str1 str2 – flag ) | no | flag = true if string at hub memory address str1 is identical to string at str2, else flag = false | | extend.fth |
| $># | ( str -- value digits \| false ) | no | attempts to convert str to number | | kernel |
| a>A | ( ch1 – ch2 ) | no | Converts ch to uppercase if a-z, else ch2 = space | | kernel |
| LEN$ | ( str - n ) | no | n = length of string at addr str e.g. mystring LEN$ | | kernel |
| NULL$ | ( – str ) | no | An empty string at address str | | kernel |
| NUMBER | ( str -- value digits \| false ) | no | an alias for $># | | kernel |
| SPACE? | ( – flag ) | no | returns true if delimiter is the space char | | extend.fth |
| UPPER$ | ( str – ) | no | Convert lower-case letters to upper-case | | kernel |
| WORD$ | ( str1 -- str2 ) | no | terminate a string at the end of the first word | | extend.fth |
| X$ | ( -- n ) | no | Returns the address n of a 32 char temporary store for strings - used in $+ | | extend.fth |

# TIMING

| NAME | STACK EFFECT | PRE? | DESCRIPTION | TIME (CYCLES) | SOURCE |
|---|---|---|---|---|---|
| ?UNTIL | ( daddr -- ) | no | a double variable at daddr stores a TIMEOUT. ?UNTIL will wait until that timeout occurs - see below | | extend.fth |
| CLKDIV | | no | | | kernel |
| CLKHZ | ( – n ) | no | Returns the p2 clock frequency in Hz | | kernel |
| CNT@ | ( – n ) | no | read the 32 bit CNT register | | kernel |
| CYCLES | ( cycles -- ) | no | define a delay unit in processor cycles | | kernel |
| DELAY | ( -- ) | no | Wait for one delay | | kernel |
| DELAYS | ( n -- ) | no | Wait for n delays | | kernel |
| GETMS | ( – m ) | no | read the number of milliseconds since reset - rolls over in about 49 days | | kernel |
| INS | ( cnt -- ) | no | interruptable count loop used for timing instructions | | kernel |
| ms | ( n -- ) | no | wait n milliseconds | | kernel |
| s | ( n -- ) | no | wait n seconds | | kernel |
| TIMEOUT | ( ms daddr -- ) | no | a simple timer, value 'ms'  is stored at the double variable daddr, along with the current time. ms can be in the range 0 - 65535 - see below | | extend.fth |
| TIMEOUT? | ( daddr -- flg ) | no | flg = true indicates the TIMEOUT stored in double variable daddr has passed - see below | | extend.fth |
| us | ( n – ) | no | wait for n microseconds | | kernel |
| WAIT | ( n -- ) | no | Wait for n clock cycles to pass (uses P2 WAITX) | | kernel |

**TIMEOUT examples**

```
8 bytes TIME1                 --- storage for a timeout - (a 'double' variable)
1000 TIME1 TIMEOUT            --- start a timeout, stored at TIME1
TIME1 TIMEOUT? .              --- we check whether TIME1 has timed out yet - would return 0 (false)
2000 ms TIME1 TIMEOUT? .      --- we check again, after a delay of 2s - TIMEOUT? returns -1 (true)

3000 TIME1 TIMEOUT            --- somewhere in a program we start a timer and elsewhere we can program ...
```

TIME1 ?UNTIL --- ?UNTIL will only finish executing once timeout has occurred

# VIDEO

| NAME | STACK EFFECT | PRE? | DESCRIPTION | TIME (CYCLES) | SOURCE |
|---|---|---|---|---|---|
| @VGA | ( n -- addr ) | no | return with VGA parameter table address | | kernel |
| DWIDTH | ( src scr -- src+640 scr ) | no | 3ms per frame QVGA-->VGA FULL-SCREEN upscaler. Upscales 320x240 bmp frames to 640x480 | | kernel |

# VOCABULARY

| NAME | STACK EFFECT | PRE? | DESCRIPTION | TIME (CYCLES) | SOURCE |
|---|---|---|---|---|---|
| @VOCAB | ( index -- addr ) | no | | | extend.fth |
| +VOCAB | ( nfa --- ) | no | push this vocab to the top of the search list | | extend.fth |
| FORTH | ( -- ) | no | Make Forth the current vocabulary | | extend.fth |
| SEARCH-VOCABS | ( str -- nfa ) | no | | | extend.fth |
| VOCAB | ( <name> <including> -- ) | yes | First create a dummy link word with no skip (04)<br>Then create a definition that calls the vocab linking code<br>Then calculate the link displacement and update it<br>Use: VOCAB ASSEMBLER *TIA* | | extend.fth |

**Vocabulary example**

```
pub *MYVOCAB* ;                  --- mark the start of a new vocabulary
   pub TEST1 10 0 DO I . LOOP ;  --- the 1st word in the new vocabulary, display 0 to 9
   pub TEST2 20 10 DO I . LOOP ; --- another word in the new vocabulary
VOCAB MYVOCAB *MYVOCAB*          --- create the vocabulary, encompassing the words between here and the word *MYVOCAB*
FORTH
TEST1                            --- TAQOZ will respond with "???" as TEST1 will not be found in the FORTH vocabulary
MYVOCAB
TEST1                            --- TAQOZ reponds with "0 1 2 3 4 5 6 7 8 9  ok", because TEST1 is now in the search path
```

See PASM2.FTH, the TAQOZ Assembler source file, for another example of the use of VOCAB.

# ORPHAN WORDS

| NAME | STACK EFFECT | PRE? | DESCRIPTION | TIME (CYCLES) | SOURCE |
|---|---|---|---|---|---|
| HUBEXEC | ( – ) | no | marker for end of HUBEXEC code itself (NOP) | Obsolete – do not use | kernel |
| RCLIO | | no | | | kernel |
| WE | | no | | | kernel |
| WP | | no | | | kernel |

# SYSTEM INSTALLATION and BOOTING UP

## Dip your toe in with no effort - try TAQOZ ROM

This article 'Getting Started' is useful advice for trying out TAQOZ ROM, built right into the P2. This is a useful first step in testing any new P2 board, as it doesn't depend on any external memory or SD card. Not much more than the serial terminal port has to work. The 'BitBashers Guide' is also a good intro. The glossary for TAQOZ ROM is a useful programmer's reference.

## Installing TAQOZ RELOADED - Method 1

The **simplest way** of installing TAQOZ Reloaded is by means of a .BIX file saved on an SD Card:-

1. Download the TAQOZ forth system
2. Unzip it to a folder on your Windows PC
3. Format a **Sandisk SD card** on Windows using SD Card Formatter with **Overwrite format** set. ( Other makes have been found to work, but *don't* expect much from unmarked SD cards you've found in your junk box )
4. Copy the latest _BOOT_P2.BIX file from drop box folder P2\TAQOZ\binaries
5. Rename this file if need be to exactly _BOOT_P2.BIX
6. Install the SD card in the P2 board and set your P2 to boot from SD card (This may be a dip switch or a link)
7. Start tera term and set **Serial port** to the port your P2 is connected to, 921600 baud, 8 bits, no parity, 1 stop bit, no flow control. Set **Terminal** to CR for New-line on Receive and Transmit, no local echo, terminal VT-100
8. Reset the P2 and a **TAQOZ Reloaded** start up message should appear in the tera term window.

**Some background information on what is going on:**

The root directory is searched for file "_BOOT_P2.BIX", and if not found then the root directory is searched for file "_BOOT_P2.BIY" (upper case is required). If the file is found, then all files' data is loaded into HUB $0. Maximum file size is 512KB-16KB = 496KB. Once loaded into HUB, the first 496 longs will be copied to COG $0 and then a JMP #$0 will be executed. Note: The files' data must be in contiguous sectors.

If the above doesn't work for you, then try Method 2 below.

## Installing TAQOZ RELOADED - Method 2

This method takes more steps, but allows the user to select which modules are installed. Method 1 installs the lot. Here is what worked for me on a Windows computer:-

1. Download the Taqoz forth system
2. Unzip it to a folder
3. Set the '**Flash**' dip switch on the P2-EVAL, reset **P59^** and **P59v**. **USB RES** stays set.
4. Download the flexprop tool and unzip it to a folder
5. Run flexprop and in **Ports** set 921600 baud and the com port your P2 is connected on
6. Using flexprop, send file **TAQOZ.bin** from folder **Tachyon dropbox April 2021\P2\TAQOZ** to the P2 with **Flash binary file** found in the **Commands** menu - it only takes a second or so as shown by just three lines on the **Propeller Output** window.
7. Shut down flexprop
8. Start tera term and set **Serial port** to the port your P2 is connected to, 921600 baud, 8 bits, no parity, 1 stop bit, no flow control. Set **Terminal** to CR for New-line on Receive and Transmit, no local echo, terminal VT-100
9. Press the reset on the P2-EVAL, you should get this start up message from TAQOZ v2.8:-

```
þxQOZ#
 *Cold start*
--------------------------------------------------------------------------------
 Parallax P2  *TAQOZ RELOADED sIDE*  V2.8 'CHIP' Prop_Ver G 200MHz 210401-1230
--------------------------------------------------------------------------------
TAQOZ#
```

10. Using tera term, upload to TAQOZ two TAQOZ modules **EXTEND.FTH** and then **FILE.FTH** from folder **Tachyon dropbox April 2021\P2\TAQOZ\Forth** Check they compile with no errors. You might decide to upload others. I loaded **P2ASM.FTH** to allow writing new TAQOZ words in assembly code as I am interested in DSP for software defined radio.
11. Format a **Sandisk SD card** on Windows using SD Card Formatter with **Overwrite format** set. (Other makes have been found to work, but don't expect much from unmarked cards found in the bottom of your junk box) Insert newly formatted SD card into the P2-EVAL
12. At the TAQOZ prompt, type **BU** *enter* to backup the tool set to the SD card - this takes around 2 s
13. Reset the **FLASH** dip switch, so that the P2 will boot from SD card next time

14. Reset the P2, the following start up message appeared (for my choice of extensions) in tera term. Notice the results of an improved I2C bus scanner at the bottom of the start-up message :-

```
BOOTING....  CARD: SANDISK   SD SD32G REV$85 #3200344782 DATE:2021/1
KERNEL          Parallax P2  *TAQOZ RELOADED sIDE*  V2.8 'CHIP' Prop_Ver G 200MHz 210401-1230
  MODULES:
  4890 *P2ASM*        TAQOZ INTERACTIVE ASSEMBLER for the PARALLAX P2 - 210124-1200
  2726 *DISK*         SD DISK REPORTING & FORMATTING TOOLS 190800-0000
  5042 *FILE*         TAQOZ FAT32 FILE SYSTEM for SD CARD plus VIRTUAL MEMORY  210128-0830
  1996 *SPIRAM*       LY68L6400 8MB SPI RAM ACCESS 191020-0000
  1760 *DECOMPILER*   A decompiler for TAQOZ 190825-0000
   822 *UBI2C*        EFM8UB3 I2C COMMANDS 210118-0000
   614 *RTC*          RV-3028 RTC DATE and TIME 190800-0000
   882 *SMARTPINS*    SMARTPIN FUNCTIONS and drive modes 190800-0000
   382 *P2CLOCK*      P2 CLOCK CONTROL 190800-0000
  2780 *ANSI*         ANSI TERMINAL SUPPORT 200410-0000
   494 *EXTEND*       Primary kernel extensions for TAQOZ 210421-2100
  5990 *SPIFLASH*
MEMORY MAP
  CODE:        08F3C  36,668 bytes
  WORDS:       1C6F5  14,498 bytes
  DATA:        01EF5  1,368 bytes
  ROOM:              79,801 bytes
HARDWARE
  PCB          P2
  CLOCK IN     20.000000MHZ
DEVICES
  SD CARD      31 GB  SANDISK   SD SD32G REV$85 #3200344782 DATE:2021/1

I2C DEVICES
Address Max clock      Identity
  $1A   2600kHz        QMC5883 Magnetic Field Sensor
  $C0   1700kHz        Si5351A Clock Generator
  $EC   2100kHz        BMP280 Pressure Sensor or MS5611 Pressure Sensor with pin CSB=1
  $EE   2600kHz        MS5611 Pressure Sensor with pin CSB=0

STATS          cpufreq: 200MHz  systicks: 1,497
--------------------------------------------------------------------------------
TAQOZ#
```

15. TAQOZ is now installed on SD card, although it won't appear in the directory as a filename
16. Other files can be loaded onto the SD card from Windows - and they *will* be listed with the TAQOZ **DIR** or **DIRW** command

**Some background information on what is going on:**

The SD boot will check for valid P2 Boot Data on the MBR sector (sector 0), and if not found it will try the VOL sector (provided the SD Card is in FAT32 format).

- Valid Boot Data is "Prop" at offset $17C on the MBR/VOL sector...The sector (512 bytes) will be read into Hub $0, followed by a JMP $080. Only code in sector byte offset $080-$17F is considered valid but this program may know that other areas are also valid.
- Valid Boot Data is "ProP" at offset $17C on the MBR/VOL sector...The long at offset $174 is used as the sector start address, and the long at $178 is used as the maximum filesize (in bytes) is 512B-16KB = 496KB for the data to be loaded into Hub, followed by a `JMP $000`.
- These two methods also cover the case where the SD Card is not formatted as FAT32 (eg exFAT). The boot sector(s) MBR and/or VOL must be specifically written with a program such as HxD on Windows 10.

## SD card formatting advice

Peter Jakacki advises "If you want to format your SD card then I'd recommend using the maximum cluster size that FAT32 supports of 64KB which is much better suited for embedded systems. Even if you had one thousand small files (really!?), that's still only 64MB which is barely noticed even in the smallest SD cards. I've made that the default now although you can specify the cluster size and also set permissions (for safety) before a FORMAT".

# SYSTEM BACKUP

The word **BACKUP**, defined in **FILE.FTH** from folder **Tachyon dropbox April 2021\P2\TAQOZ\Forth** is used to permanently store the current TAQOZ system to the Flash Memory or SD card. You can check FILE.FTH is compiled in with your TAQOZ system as part of the start-up message:-

```
5042 *FILE*         TAQOZ FAT32 FILE SYSTEM for SD CARD plus VIRTUAL MEMORY  210128-0830
```

**Saving to SD card**

The command options are:-

- **BACKUP <filename>** Remember this is limited to 8chrs with 3chr extension
- **BACKUP BIX**, save the system to file _BOOT_P2.BIX in the root folder
- **BACKUP MBR** backs the system up to sector 1 and sets the boot signature in the MBR. (Assumes you have a properly formatted SD card with unassigned storage before the first partition) As a shortcut, you can also just type **BU <enter>** or press **<ctrl>B**

**Saving to Flash memory**

The command is:-

- **BACKUP FLASH** will write the bootloaded to Flash page 0 and then writes the 128kbyte TAQOZ image.
  As a shortcut, you can also press **<ctrl>F**

**Backup disable**

- **BACKUP DISABLE** will disable Flash and MBR booting only - if you also want to disable the BIX file then use something like

```
RENAME _BOOT_P2.BIX _BOOT_P2.BIN
```

# AUTO-START A USER PROGRAM FROM SOURCE CODE

Thanks to Christof Eb on the Parallax forum for this one:-

You want an application, stored as source code on SD Card, to load when the P2 is switched on. The following code would load file 'auto.fth' from the SD card:-

```
: aload
        " auto.fth" FOPEN$              --- attempt to open auto.fs
        IF                              --- if it opens
                @FILE FLOADS            --- starting from the 1st sector, load file as console input
        THEN
        ;

!INITS                                  --- Initialise and clear all polling vectors
' aload +INIT                           --- add the word aload to the list that executes when TAQOZ starts

BACKUP BIX                              --- save the TAQOZ system to SD Card as _BOOT_P2.BIX
```

This approach maximises available memory: The user program can load and unload parts of itself to suit the task in hand, rather than it all be loaded at start up and taking up unnecessary space that would otherwise be useful.

# AUTO-START A COMPILED USER PROGRAM

You have your program compiled in hub memory as part of the Taqoz system: You want that program to run when the P2 is switched on. Here's a smalll example 'user program' - it counts until the user presses a key:-

```
pub TEST 0 BEGIN 1+ DUP . SPACE KEY UNTIL DROP ;
```

To get this to run on switch on:-

```
 ' TEST +INIT           --- Add TEST to the list of words that run at start-up
BU                      --- Save TAQOZ to SD card
```

When TAQOZ is reset, TEST will run and pressing a key will return you to the system prompt. The system can be returned to normal for more coding by:-

```
FORGET TEST             --- Forget the user application from the dictionary
!INITS                  --- Remove all user words form the list that runs at start up
BU                      --- Save TAQOZ to SD card
```

# TERMINAL BAUD RATE

TAQOZ v2.8 terminal runs at a default of 921600 baud. This baud rate can be inspected and changed:-

28 @ . will print the present baud rate of 921600

115200 28 ! changes the baud rate to that lower speed, which will take effect the next time the system is restarted if the system is backed up. Also don't forget to reset the terminal to the same rate, ready for TAQOZ restart.

By default,  the terminal serial input to the P2 is on smartpin P63, the serial output is smartpin P62.

# DICTIONARY LAYOUT

The dictionary is a contiguous block of word headers. New word headers extend downwards in memory, usually located within the lowest 64k of RAM, although the dictionary can be relocated. The address of the most recently defined word header in the dictionary is returned by @WORDS. This points to the char count byte in the word header. The same is true of word NFA' as can be seen when this Taqoz phrase is run to display the dictionary header of the word DUP:-

```
NFA' DUP 10 DUMP
```

Each word header within the Taqoz dictionary, **in increasing address order**, comprises:-

## The char count byte

| b7 | b6 | b5 | b4 | b3 | b2 | b1 | b0 |
|---|---|---|---|---|---|---|---|
| WORD ATTRIBUTES | | CPA TYPE | WORD NAME STRING COUNT N | | | | |

Word attributes can take the following values:-

00 = public or code word

01 = private word – header can be reclaimed

10 = pre-emptive word – executes immediately

11 = command line interactive but compiles in definition

CPA type:-

0 = Word has a 16-bit CPA

1 = Word has a 24-bit extended CPA

## Word name string

The word name occupies N bytes as defined by the string count in the char count byte:-

| b7 | b6 | b5 | b4 | b3 | b2 | b1 | b0 |
|---|---|---|---|---|---|---|---|
| char1 (first) | | | | | | | |
| char2 | | | | | | | |
| ... | | | | | | | |
| char N (last) | | | | | | | |

## The CPA

The CPA contains the address of the start of code to execute.
The CPA contains a 16 bit code field address if CPA TYPE = 0 in the char count byte
OR contains a 24 bit extended code field address if CPA TYPE = 1 in the char count byte

i.e. If CPA TYPE = 0

| b7 | b6 | b5 | b4 | b3 | b2 | b1 | b0 |
|---|---|---|---|---|---|---|---|
| ls byte | | | | | | | |
| msbyte | | | | | | | |

If CPA TYPE = 1

| b7 | b6 | b5 | b4 | b3 | b2 | b1 | b0 |
|---|---|---|---|---|---|---|---|
| ls byte | | | | | | | |
| middle byte | | | | | | | |
| msbyte | | | | | | | |

The next word in the dictionary follows immediately.

## Dictionary Bottom

The end of the dictionary is indicated by a dummy word header whose char count byte = 00

# USEFUL LINKS

**Documentation:-**

Parallax's Propeller 2 Documentation page
The Parallax Forum is a great resource for all things Propeller P2. Here's the TAQOZ thread.
The latest version of this document can be found here.
The TAQOZ P2 Boot Firmware web site is a useful intro to TAQOZ
This Tachyon Forth Model paper explains quite a lot of the differences form ANSI forth
These TAQOZ and Tachyon links are useful
The Propeller P2 Get Started Here page
A thread on the TAQOZ Interactive Assembler
Notes on getting started writing inline Assembly code
The P2 Assembly Language Instruction set table
The P2 Assembly Language Manual
120 back issues of the magazine Forth Dimensions - full of code snippets to adapt to Taqoz or Tachyon
An ASCII Table is always useful
Tera Term for Windows help index

**Code:-**

All source code and binaries for TAQOZ can be found here
Tera Term for Windows can be found here
CCS811 Air Quality sensor via i2c
SI5351 dual clock driver via i2c which can provide two clocks 8kHz to 120MHz with around 2Hz resolution
QMC5883 magnetic field sensor via i2c
MS5611 barometric pressure sensor via i2c
64 bit integer maths library - not often needed, but when you do - you do!
Mini-OOF - a tiny object oriented forth module originally written by Bernd Paysan and now adapted for TAQOZ
Timers - running multiple words periodically on one COG or more, each with it's own period - written in Mini-OOF
State Machines - running multiple state machines on one COG or more - written in Mini-OOF
Queues / Stacks - written in Mini-OOF, so as many of them as needed can be made
A few useful string words borrowed from Tachyon Forth
Running commands from SD card
Improved I2C bus scanner shows max clock speed and identifies a few extra devices
The P2 has 16 lock bits used to prevent race conditions in executing code or accessing data
Reading a quadrature encoder

**Hardware:-**

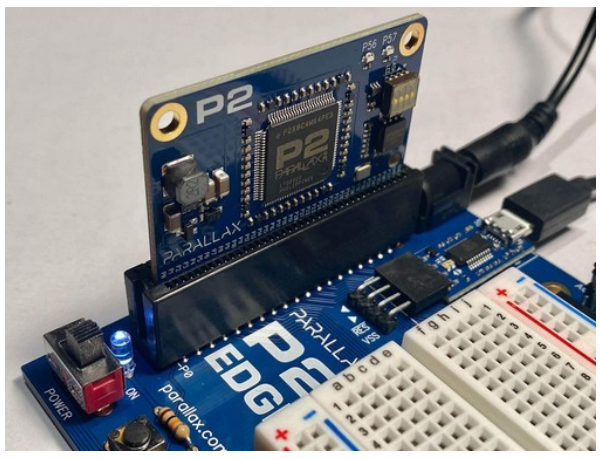
There are now quite a few modules available, for p2 evaluation and development or encorporation within your own product

A reference design, the P2D2 by Peter Jakacki

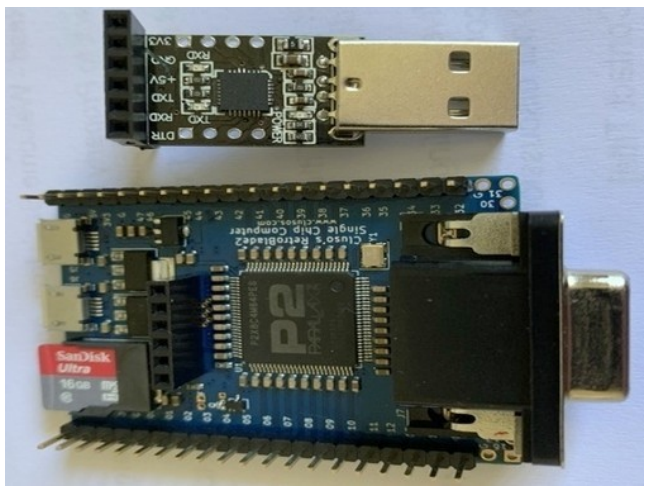

The P2-EVAL evaluation board


The P2 Edge module

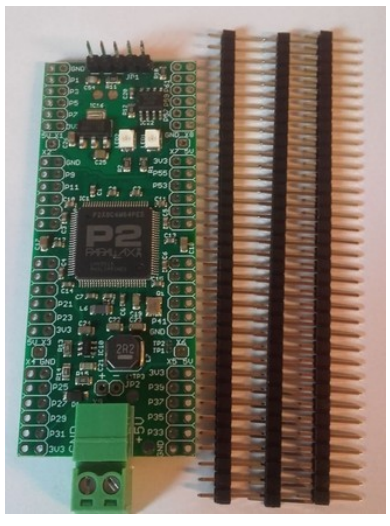

Here's the Edge module mounted in the P2 Edge Module breadboard




The RetroBlade2 board




The KISS Eval board




# CONCLUSION

If you'd like a change or make a contribution to this glossary, you're very welcome to get in touch via the Parallax Forum. It's likely the document still contains a few errors and omissions. The document is up-issued quite often, as and when I've discovered something new. Quite a few words are not fully described - there wasn't enough information in the source listings or forum. If you know how to use these words, then please tell.

This glossary was compiled by Bob Edwards, retired EMC engineer in SW U.K. Radio Amateur callsign G4BBY, 2021-2022. He uses it all the time whilst programming with TAQOZ Reloaded, and hopes you do too.