

v-FORTH 1.5

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Technical Info

Introduction

This document presents vForth 1.5 – ZX Spectrum Next version.

It contains some technical details on how this version is built and a list of all available words in the core.

Subsequent issues of this document will include some of optional parts.

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Technical specifications

This is a straight FIG-Forth implementation that uses Z80 register in the following way.

AF – Used as usual.

BC – **Instruction Pointer**: should be preserved on enter-exit a definition and during ROM/OS calls.

DE – Free (Low part when used for 32-bit manipulations)

HL – **Work Register** (High part when used for 32-bit manipulations)

AF' – Not used, somewhere used for backup purpose

BC' – Not used: available in fast Interrupt via EXX

DE' – Not used: available in fast Interrupt via EXX

HL' – Not used: available in fast Interrupt via EXX (saved at startup from Basic)

SP – Calculator Stack Pointer

IX – Not used: somewhere used for backup purpose

IY – Used by ZX System

Care has been taken to avoid any use of alternate registers (at least when interrupts are enabled). This should allow the user to create their own fast-response interrupt routine and use EXX instead of pushing all registers.

16 bits Number Encoding

A 16 bits *integer* represents an integer number between -32768 e +32767 inclusive. The sign is kept in the most significant bit. Alternatively, the it represents an *unsigned integer* between 0 and +65535.

		H		L
16 bit:	HL:	sbbb bbbb	bbbb bbbb	

In the CPU registers, an *integer* is kept in H e L where H is the most significant part.

In memory, an *integer* is stored in two contiguous bytes in “little-endian” way, that is, the lower address has the least significant part, the in L register. The byte at higher address has the most significant part, the one in H register, as usual for Zilog Z80.

32 bits Number Encoding

The second integer format requires two *integers* that form a 32 bits number said *double* or *long* that allows an integer between $-2.147.483.648$ and $+2.147.483.647$, and the sign is kept on the most significant bit of the first *integer*.

Imagine a *double integer* kept in CPU register in the in this way:

32 bits: **H** **L** **D** **E**
| **s**bbb bbbb | bbbb bbbb | bbbb bbbb | bbbb bbbb |

using register H, L, D and E, with the most significant part in H, and the least in E.

Then, on Calculator Stack the *double integer* requires four contiguous bytes split in the two *integers* that forms it with the most significant integer (HL) on top of Calculator Stack (i.e. in the lower addresses), and the least significant integer (DE) the second element from top is in the higher address, that is the second element from top. so it appears as L H E D,

CPU	Calculator Stack
D	SP + 3
E	SP + 2
H	SP + 1
L	SP + 0 (TOS)

More confusingly, in RAM it is kept as E D L H. see how 2VARIABLE is defined to understand this fact.

CPU	2VARIABLE
H	Address + 3
L	Address + 2
D	Address + 1
E	Address + 0

Floating-Point Number Encoding

There is a third optional format that use 32 bits as a *double integer*, but all bits are used in a different way to allows to represent a *floating point number* approximately between $-1.7 * 10^{38}$ e $+1.7 * 10^{38}$ with 6-7 precision digits.

The sign is kept in the most significant bit, the same way as a *double integer*; then eight bits follow as the exponential part, then 23 bits of mantissa. The sign in this position allows (IMO) using most of the same semantics of *double integers* as per the sign of the number.

32 bits f.p.: **H** **L** **D** **E**
| **sxxx xxxx** | **x**bbb bbbb | bbbb bbbb | bbbb bbbb |

Core dictionary

Legenda

In this list:

a	address: memory address	16 bits
b	byte: unsigned integer	8 bits
c	character	8 bits but often only lower 7 are significant.
d	signed double integer	32 bits
fp	floating point number.	32 bits
n	signed integer	16 bits
u	unsigned integer	16 bits
ud	unsigned double integer	32 bits
f	flag: a number evaluated as a boolean	16 bits
ff	false flag: zero	16 bits
tf	true flag: non-zero	16 bits
nfa	name field address	16 bits
lfa	link field address	16 bits
cfa	code field address	16 bits
pfa	parameters field address	16 bits
xt	execution token – same as cfa	16 bits
cccc	character string or word name available in the vocabulary	
...	a word list	
TOS	top of calculator stack	

'null' **---** **(immediate)**

This is a “ghost” word executed by `INTERPRET` to go back to the caller once the text to be interpreted ends. This word allows you to use a `0x00` (NULL ASCII) as the end-of-text indicator in the input text stream.

! **n a** **---**

It stores the integer `n` in the memory cell at address `a` and `a + 1`. Pronounced “store”
Zilog Z80 is a little-endian CPU that holds the high byte in the high address.

!CSP **---**

It saves the value of SP register in `CSP` user variable. It is used by `:` and `;` for syntax checking.

**d1** **---** **d2**

From a double number `d1` it produces the next ASCII character to be put in an output string using `HOLD`. The number `d2` is `d1 / BASE` and is kept for subsequent elaborations. It is used between `<# e #>`. See also `#S`.

#> **d** **---** **a b**

It terminates a numeric conversion started by `<#`. It removes `d` and leaves the values suitable for `TYPE`.

#BUFF --- n

This is a constant that gives the number of available buffers. This build has 3 buffers located at address between `FIRST @` and `LIMIT @`.

#S d1 --- d2 **CORE**

This word is equivalent of a series of `#` that is repeated until `d2` becomes zero. It is used between `<# e #>`.

#SEC --- n

This is a constant that gives the number of available screens/blocks.

' --- cfa

Pronounced "tick". Used in the form

`' cccc`

it leaves the cfa of word `cccc`, that is its xt or value to be compiled of passed to `EXECUTE`. If the word `cccc` is not found after the `CURRENT` and `CONTEXT` search phases, then an error is raised.

In a previous version of this Forth, this word returned pfa: we changed this previous standard to return cfa.

(--- **(immediate)**

Used in the form

`(cccc)`

it ignores what is between brackets. The space after `(` is not considered in `cccc`. The comment must be delimited in the same row with a closing `)` followed by a space or an end-of-line.

(+LOOP) n ---

This is the primitive compiled by `+LOOP`.

(. ") ---

This is the primitive compiled by `. "` and `. (`. It executes `TYPE`.

(;CODE) ---

This is the primitive compiled by `;CODE`. It rewrites the cfa of `LATEST` word so that it points to the machine code starting from the following cell.

(?DO) ---

This is the primitive compiled by `?DO`.

At compile-time compiles the cfa of `(?DO)` followed by an offset like `BRANCH` does that is used to jump after the whole `?DO ... LOOP` structure if the limit equals the initial index, otherwise it is equivalent to `(DO)`.

(?EMIT) c1 --- c2

It decodes the character `c1` using the following table. It is used internally by `EMIT`.

HEX 06 → print-comma

HEX 07 → bell rings

HEX 08 → back-space
HEX 09 → tabulator
HEX 0D → carriage return

For not listed character, c2 is equal to c1.

(ABORT)

Word executed in case of error issued by `ERROR` when `WARNING` contains a negative number. This word usually executes `ABORT` but can be patched with a user defined word at the pfa of `(ABORT)`.

(DO)

This is the primitive compiled by `DO`.

(FIND)

a1 a2 --- cfa b tf
--- ff

It searches in the dictionary starting from address a2 a word which text name is kept at address a1; it returns a cfa, the first byte b of nfa and a tf on a successful search; elsewhere a ff only.

Address a2 must be the nfa of the first word involved in the search in the vocabulary.

In previous version of this Forth, it returned a pfa, we change our mind.

Byte b keeps the length of the found word in the least significant 5 bits, bit 6 is the `IMMEDIATE` flag. Bit 5 is the `SMUDGE` bit. Bit 7 is always set to mark the beginning or end of the nfa.

(LINE)

n1 n2 --- a b

It retrieves line n1 of block n2 and send it to buffer. It returns the address a within the buffer and a counter b that is C/L (=32) to mean a whole line.

(LOOP)

This is the primitive compiled by `LOOP`. See also `DO` and `+LOOP`.

(NUMBER)

d a --- d2 a2

It converts the ASCII text at address a + 1 in a double integer using the current `BASE`. Number d2 is left for the subsequent elaborations, a2 is the address of the first non-converted character. A double integer is kept in CPU registers as HLDE. On the stack is treated as two distinct integers where HL is on TOS and DE is the second from top, so that in memory it appears as LHED. Instead, in a variable declared with `2VARIABLE` is stored as EDHL.

Used by `NUMBER`.

(SGN)

a --- a2 f

It determines if the character at address a is a sign (+ o -) and if found increments a. The flag f indicates the sign: ff when it founds a positive sign + or no sign at all, tf for a negative sign -. If a is incremented then variable `DPL` is incremented aswell. Used by `da NUMBER` and `(EXP)` in the floatin-point option.

*

n1 n2 --- n3

It leaves the product of two integers.

***/** **n1 n2 n3 --- n4**

It executes $(n1 \cdot n2) / n3$ using an intermediate double integer to avoid precision loss.

***/MOD** **n1 n2 n3 --- n4 n5**

It leaves the quotient $n5$ and the reminder $n4$ of the operation $(n1 \cdot n2) / n3$ using an intermediate double integer to avoid precision loss.

+ **n1 n2 --- n3**

It leaves the sum of two integer.

+! **n a ---**

It adds to the cell at address a the number n . It is the same as the sequence $a @ n + a !$

+ - **n1 n2 --- n3**

It leaves $n3$ as $n1$ with the sign of $n2$. If $n2$ is zero, it means positive.

+

BUF **a1 --- a2 f**

It advances the address of the buffer from $a1$ to $a2$, that is the next buffer. The flag f is false if $a2$ is the buffer pointed by $PREV$.

+LOOP **n1 --- (run time)**
 a n2 --- (compile time)

Used in colon definition in the form

DO ... $n1$ +LOOP

At run-time +LOOP checks the return to the corresponding DO, $n1$ is added to the index and the total compared with the limit. The jump back happens :

a) while index < limit if $n1 > 0$;

b) while index > limit if $n1 < 0$.

Otherwise the execution leaves the loop. On leaving the loop, the parameters are discarded and the execution continues with the following word.

At compile-time +LOOP compiles $(+LOOP)$ and a jump is calculated from HERE to a which is the address left on the stack by DO. The value $n2$ is used internally for syntax checking.

+ORIGIN **n --- a**

It gives the address n bytes after the "origin". In this build the origin is 6400h. Used rarely to modify the boot-up parameters in the origin area.

, **n ---**

It puts n in the following cell of the dictionary and increments DP (dictionary pointer) of two locations.

- n1 n2 --- n3

It leaves $n3 = n1 - n2$ as the difference from the penultimate and the last number on the stack.

--> ---

It continues the interpretation in the next Screen during a `LOAD`.

-1 --- n

This is the constant value `-1` that in this implementation is `OFFFh`. Compiling a constant result in a faster execution than a literal.

-ACCEPT a n1 --- n2

As for `ACCEPT`, but it reads at most `n1` characters text from current channel/stream via `INKEY` one character at a time, It stores the text at address `a`. Not so efficient, but it allows to compile an external source-file attached to the stream. It does not modify `SPAN`.

-DUP n --- n n (non zero)
n --- n (zero)

It duplicates `n` if it is non zero.

-FIND --- cfa b tf (ok)
--- ff (ko)

Used in the form `-FIND cccc`.

It accepts a word (delimited by spaces) from the current input stream, storing it at address `HERE`. Then, it run a search in the `CONTEXT` vocabulary first, then in the `CURRENT` vocabulary. If the word is found, it leaves the `cfa` of the word, its length-byte `b` and a `tf`. Otherwise only a `ff`.

-TRAILING a1 n1 --- a2 n2

It assumes that a string `n1` characters long is already stored at address `a1` that contains a word right-delimited with spaces. It determines `n2` as the position of the first delimiter after the word.

. n ---

It prints the integer `n` followed by a space.

. " --- (immediate)

Used in the form

`. " cccc "`

At compile-time, within a colon-definition, compiles the primitive to output the text followed by the string `cccc` (delimited by `"`). The text `cccc` is prepended by a length-counter that `TYPE` will use at run-time.

When interpreted, i.e. outside a colon-definition, immediately sends the text to output.

. (--- (immediate)

Used in the form

. (cccc)

it acts as **. " cccc "** but the string is delimited in a different way

.C c --- (immediate)

Used in the form

c .C xxxx C

Acts as **. " xxxx "** but the string is delimited by character **c**. It is a more generic form of **. (** and **. "** that, in fact, use this word as their primitive.

.LINE n1 n2 ---

It sends line **n1** of block **n2** to the current peripheral ignoring the trailing spaces.

.R n1 n2 ---

It prints a number **n1** right aligned in a field **n2** character long, with no following spaces. If the number needs more than **n2** characters, the excess protrudes to the right.

/ n1 n2 --- n3

It leaves $n3 = n1 / n2$, the quotient of the integer division.

/MOD n1 n2 --- n3 n4

It leaves the quotient **n4** and the remainder **n3** of the integer division $n1 / n2$. The remainder has the sign of **n1**.

0 --- n

This is a constant value zero. Compiling a constant results in a faster execution than a literal.

OBRANCH f ---

Direct procedure that executes a conditional jump. If **f** is zero the offset in the cell following **OBRANCH** is added to the Instruction Pointer to jump forward or backward.

It is compiled by **IF**, **UNTIL** e **WHILE**.

0< n --- f

It leaves a **tf** if **n** is less than zero, **ff** otherwise.

0= n --- f

It leaves a **tf** if **n** is not zero, **ff** otherwise. It is like a **NOT n**.

0> n --- f

It leaves a **tf** if **n** is greater than zero, **ff** otherwise.

1 --- n

Constant value 1. Compiling a constant results in a faster execution than a literal.

1+ n1 --- n2

It increments by one the number on TOS.

1- n1 --- n2

It decrements by one the number on TOS.

2 --- n

Constant value 2. Compiling a constant results in a faster execution than a literal.

2! d a ---
n-lo n-hi a ---

It stores the double integer held on TOS to address a.

2* n1 --- n2

It doubles the number on TOS.

2+ n1 --- n2

It increments by two the number on TOS.

2/ n1 --- n2

It halves the number on TOS.

2@ a --- d
a --- n-lo n-hi

It fetches the double integer at address a. to TOS.

2DROP d ---
n1 n2 ---

It discards a double integer from the TOS, i.e. discards the top two integer.

2DUP d --- d d

It duplicates the double integer on TOS, i.e. duplicates in order the two top integer.

2OVER d1 d2 --- d1 d2 d1
n1 n2 n3 n4 --- n1 n2 n3 n4 n1 n2

It copies to TOS the second double integer from top.

It rotates the three top double integers, taking the third and putting it on top. The other two double integers are pushed down from top by one place.

It swaps the two double integers on TOS.

Constant value 3. Compiling a constant results in a faster execution than a literal.

This is a defining word that creates and begins a colon-definition. Used in the form

creates in the dictionary a new word `cccc` so that it executes the sequence of already existing words '`...`'.

It ends a colon definition and stops compilation.. It compiles ;S and execute SMUDGE to make the word findable.

Used in the form

it terminates a colon definition stoppin copilation of word `cccc` and compiling `(;CODE)`. Usually `;CODE` is followed by suitable machine code sequence..

This is usually the last word compiled in a colon definition by ; it does the action of returning to the calling word. It is used to force the immediate end of a loading session started by `LOAD`.

It leaves a `tf` if `n1` is less than `n2`, `ff` otherwise.

It sets `HLD` to the value of `PAD`. It is used to format numbers using `#`, `#S`, `SIGN` and `#>`. The conversion is performed using a double integer, and the formatted text is kept in `PAD`.

Used in a colon definition in the form

Subsequent execution of `cccc` in the form
`cccc nnnn`

<BUILD and DOES> allow writing high-level procedures instead of using machine code as ;CODE would require.

It converts a cfa in its nfa. It is the same as the sequence >BODY NFA.
See also: CFA, LFA, NFA, PFA, >BODY.

It leaves a `tf` if `n1` equals to `n2`, `ff` otherwise.

It leaves a `tf` if `n1` is greater than `n2`, `ff` otherwise.

Converts a `cfa` in its `pfa`.
See also: `CFA`, `LFA`, `NFA`, `PFA`, `<NAME.`

It takes an integer from TOS and puts it on top of the Return Stack. It should be used only within a colon definition and the use of `>R` should be balanced with a corresponding `R>`.

It prints the content of cell at address `a`. It is the same as the sequence: `a @`.

It raises an error message #17 if the current STATE is not compile state.

It raises an error message #20 if the value of CSP is different from the current value of SP register. It is used to check the compilation in a colon definition.

Used in a colon definition in the form

It is used as `DO` to put in place a loop structure, but at run-time it first checks if `n1 = n2` and in that case the loop is skipped. At run-time `?DO` starts a sequence of words that will be repeated under control of an initial-index `n2` and a

At compile-time `?DO` compiles `(?DO)` followed by an offset like `BRANCH` and leaves the address of the following location and the number `n` to syntax-check

It clears the stack and pass to prompt command, prints the copyright message and returns the control to the human operator executing `QUIT`.

ABS n --- u

It leaves the absolute value of n .

ACCEPT a n1 --- n2

It transfers characters from the input terminal to the address `a` for `n1` location or until receiving a 0x13 "CR" character. A 0x00 "null" character is added. It leaves on TOS `n2` as the actual length of the received string. More, `n2` is also copied in `SPAN` user variable. See also `ACCEPT`.

```
AGAIN          --- (immediate) (run time)
               a n  --- (compile time)
```

Used in colon definition in the form

BEGIN . . . AGAIN

At run-time **AGAIN** forces the jump to the corresponding **BEGIN** and has no effect on the calculator stack. The execution cannot leave the loop (at least until a **R>** is executed at a lower level).

At compile-time `AGAIN` compiles `BRANCH` with an offset from `HERE` to `a`. The number `n` is used for syntax-check.

ALLOT n ---

It adds the signed integer `n` to `DP` (Dictionary Pointer). It is used to reserve some space in the dictionary or to free memory.

AND n1 n2 --- n3

It executes an AND binary operation between the two integers. The operation is performed bit by bit.

B/BUF --- n

Constant that is the number of bytes per buffer. In this implementation is 512.

B/SCR --- n

Constant that indicates the number of Blocks per Screen. In this implementation is 1.

BACK a ---

It calculates and compiles a relative offset from `a` to `HERE`. Used by `AGAIN`, `UNTIL`, `LOOP`, `+LOOP`.

BASE --- a

User variable that indicates the current numbering base used in input/output conversions. It is changed by `DECIMAL` that put ten, `HEX` that put sixteen, and with some extensions `BINARY` that put two and `OCTAL` that put eight.

BASIC u ---

It quits Forth and returns to Basic returning to the caller USR the unsigned integer on TOS.

```
BEGIN          ---      (immediate)      (run time)
               ---      a  n              (compile time)
```

Used in colon definition in the forms

```
BEGIN ... AGAIN or
BEGIN ... f UNTIL or
BEGIN ... f WHILE ... REPEAT or
BEGIN ... f END
```

At compile-time, it starts one of these structures.

At run-time **BEGIN** marks the beginning of a words sequence to be repeatedly executed and indicates the jump point for the corresponding **AGAIN**, **REPEAT**, **UNTIL** or **END**.

With **UNTIL**, the jump to the corresponding **BEGIN** happens if on TOS there is a **f f**, otherwise it quits the loop.

With **AGAIN** and **REPEAT**, the jump to the corresponding **BEGIN** always happens.

The **WHILE** part is executed if and only if on TOS there is a **t f**, otherwise it quits the loop.

BL --- **c**

Constant for "Blank". This implementation uses ASCII and **BL** is 32.

BLANKS **a n** ---

It fills with "Blanks" **n** location starting from address **a**.

BLK --- **a**

User variable that indicates the current block to be interpreted. If zero then the input is taken from the terminal buffer **TIB**.

BLOCK **n** --- **a**

It leaves the address of the buffer that contains the block **n**. If the block isn't already there, it is fetched from disk. If in the buffer there was another buffer and it was modified, then it is re-written to disk before reading the block **n**.

See also **BUFFER**, **R/W**, **UPDATE**, **FLUSH**.

BRANCH ---

Direct procedure that executes an unconditional jump. The memory cell following **BRANCH** has the offset to be relatively added to the Instruction Pointer to jump forward or backward. It is compiled by **AGAIN**, **ELSE**, **REPEAT**.

B/SCR --- **n**

Constant that indicates the number of blocks per Screen. In this implementation it is 1.

BUFFER **n** --- **a**

It makes the next buffer available assigning it the block number **n**. If the buffer was marked as modified (by **UPDATE**), such buffer is re-written to disk. The block is not read from disk. The address point to the first character of the buffer.

BYE ---

It executes **FLUSH** and **EMPTY-BUFFERS**, then quits Forth and returns to Basic returning to the caller **USR** the value of **0 +ORIGIN**. See also **BASIC**.

C! **b** **a** ---

It stores a byte **b** to address **a**.

C, **b** ---

It puts a byte **b** in the next location available in the dictionary and increments **DP** (dictionary pointer) by 1.

C/L --- **c**

Constant that indicate the number of characters per screen line. In this implementation it is 32.

C@ **a** --- **b**

It puts on TOS the byte at address **a**.

CELLS **n1** --- **n2**

It doubles the number **n1** on TOS giving the number of bytes equivalent to **n1** "cells". In this implementation a cell is two bytes.

CELL+ **n1** --- **n2**

It increments **n1** by 1 "cell", that is two units. In this implementation a cell is two bytes.

CFA **pfa** --- **cfa**

It converts a **pfa** in its **cfa**. See also **LFA**, **NFA**, **PFA**, **>BODY**, **<NAME**.

CHAR --- **c**

Used in the form

CHAR **c**

determines the first character of the next word in the input stream.

CMOVE **a1** **a2** **n** ---

It copies the content of memory starting at address **a1** for **n** bytes, storing them from address **a2**. The content of address **a1** is moved first. See also **CMOVE>**.

CMOVE> **a1** **a2** **n** ---

The same as **CMOVE** but the copy process starts from location $a1 + n - 1$ proceeding backward to the location **a1**.

CLS ---

It clears the screen using the ZX Spectrum ROM routine **ODAFh**.

COLD ---

This word executes the Cold Start procedure that restore the system at its startup state.
It sets **DP** to the minimum standard and executes **ABORT**.

COMPILE ---

At compile-time, it determines the `cfa` of the word that follows `COMPILE` and compile it in the next dictionary cell.

CONSTANT n --- (immediate) (compile time) --- n (run time)

Defining word that creates a constant. Used in the form

`n CONSTANT cccc`

it creates the word `cccc` and `pfa` holds the number `n`. When `cccc` is later executed it put `n` on TOS.

CONTEXT --- a

User variable that points to the vocabulary address where a word search begins.

COUNT a1 --- a2 b

It leaves the address of text `a2` and a length `b`. It expects that the byte at address `a1` to be the length-counter and the text begins to the next location.

CR ---

It transmits a 0x0D to the current output peripheral.

CREATE --- a

Defining word used in the form

`CREATE cccc`

it creates a new dictionary entry for the definition `cccc`. The `cfa` of such a definition points to its `pfa` that is empty for the moment. `HERE` points this location.

The new word is created in the `CURRENT` vocabulary but won't be found by `(FIND)` because it has the `SMUDGE` bit set. Once the word construction is complete, it is a programmer responsibility to execute `SMUDGE`.

Used by `:` and `CONSTANT`.

CSP --- a

User variable that temporarily holds the value of `SP` register during a compilation syntax error check.

CURRENT --- a

User variable that points to the address in the Forth vocabulary where a search continues after a failing search executed in the `CONTEXT` vocabulary. See also `LATEST`.

D+ d1 d2 --- d3

It leaves `d3` as the sum of `d1` and `d2`. This is a 32 bits sum.

D+- ud n --- d

It leaves `d` that is `ud` with the sign of `n`.

It prints a double integer followed by a space. The double integer is kept on stack in the format n-lo n-hi and the integer on TOS is the most significant.

It prints a double integer right aligned in a field `n` character wide. No space follows. If the field is not large enough, then the excess protrudes to the right.

It leaves the absolute value of a double integer.

It sets `BASE` to 10, that is the decimal base.

Variable that holds the number of current channel: 2 for video, 3 for printer, 4 for the file open to “!Blocks.bin”, etc.

To be used in the form

CCCC DEFINITIONS

sets the `CURRENT` vocabulary to be the `CONTEXT` vocabulary and this allows adding new definitions to `cccc` vocabulary. For example: `FORTH DEFINITIONS` or `ASSEMBLER DEFINITIONS`.

In this implementation an `ASSEMBLER` vocabulary is available as an extra-option that can be `LOAD`ed from screens 100 - 160.

```
DIGIT      c  n      ---  u  tf      (ok)
           c  n      ---  ff      (ko)
```

It converts the ASCII character `c` in the equivalent number using the base `n`, followed by a `tf`. If the conversion fails it leaves a `ff` only.

User variable that keeps the data-stream number used in a `LOAD` from stream using a negative screen number.

DLITERAL	d	---	d	(immediate)	(run time)
	d	---			(compile time)

Same as `LITERAL` but a 32 bits number is compiled. `DLITERAL` is an immediate word that is executed and not compiled.

It leaves the opposite double number.

Used in colon definition in the form

It is used to put in place a loop structure: The execution of `DO` starts a sequence of words that will be repeated, under control of an initial-index `n2` and a limit `n1`. `DO` drops these two value from stack and the corresponding `LOOP` increments the index. If the index is less than the limit, the executions returns to the corresponding `DO`, otherwise the two parameters are discarded and the execution continues after the `LOOP`.

The limit `n1` and the initial value `n2` are determined during the execution and can be the result of other previous operations. Inside a loop the word `I` copies to TOS the current value of the index.

See also: `I`, `DO`, `LOOP`, `+LOOP`, `LEAVE`. In particular `LEAVE` allows leaving the loop at the first opportunity.

At compile-time DO compiles (DO) and leaves the address of the following location and the number `n` to syntax-check.

Word that defines the execution action of a high-level defining word. `DOES>` changes the pfa of the word being defined to point the words sequence compiled after `DOES>`. It is used in conjunction with `<BUILDS`. When the machine-code part of `DOES>` is executed, it leaves on TOS the pfa of the new word, this allows the interpreter to use this area. Obvious use are new vocabularies (Assembler), multidimensional array and other compiling operations.

User variable (Dictionary Pointer) that holds the address of next available memory location in the dictionary. It is read by `HERE` and modified by `ALLOC`.

User variable that holds the number of digits after the decimal point during the interpretation of double integer. It can be used to keep track of the column of the decimal point during a number format output. For 16 bit integer it defaults to -1. It takes into account the exponential part and its sign for floating point numbers.

It drops the value on TOS. See also **OVER**, **NIP**, **TUCK**, **SWAP**, **DUP**, **ROT**.

It duplicates the value on TOS. See also `OVER`, `DROP`, `NIP`, `TUCK`, `SWAP`, `ROT`.

Used in colon definition in the form

At run-time `ELSE` forces the execution of the false part of an IF-ELSE-ENDIF structure. It has no effects on the stack.

At compile-time `ELSE` compiles `BRANCH` and prepares the following cell for the relative offset, stores at `a1` the previous

offset from `HERE`; then it leaves `a2` and `n2` for syntax checking.

EMIT `c` `---`

It sends a printable ASCII character to the current output peripheral. `OUT` is incremented. 7 `EMIT` activates an acoustic signal. The 'null' 0x00 ASCII character is not transmitted.

EMITC `b` `---`

It sends a byte `b` character to the current output peripheral selected with `SELECT`. See also `DEVICE`.

EMPTY-BUFFERS `---`

It erases all buffers. Any data stored to buffers after the previous `FLUSH` is lost.

ENCLOSE `a c` `---` `a n1 n2 n3`

Starting from address `a`, and using a delimiter character `c`, it determines the offset `n1` of the first non-delimiter character, `n2` of the first delimiter after the text, `n3` of first character non enclosed.

This word doesn't go beyond a 'null' ASCII that represent a unconditional delimiter. For example:

1:	c	c	x	x	x	c	x	→	2	5	6
2:	c	c	x	x	x	'null'		→	2	5	5
3:	c	c	'null'					→	2	3	2

END `a n` `---` `(immediate)` `(compile time)`
`f` `---` `(run time)`

Synonym of `UNTIL`.

ENDIF `a n` `---` `(immediate)` `(compile time)`

At run-time, `ENDIF` indicates the destination of the forward jump from `IF` or `ELSE`. It marks the end of a conditional structure. `THEN` is a synonym of `ENDIF`.

At compile-time `ENDIF` calculates the forward jump offset from `a` to `HERE` and store it at `a`. The number `n` is used for syntax checking.

ERASE `a n` `---`

It erases `n` memory location starting from `a`, filling them with 0x00 'null' characters.

ERROR `b` `---` `n1 n2`
`---` `ff`

It notifies an error `b` and resets the system to command prompt. First of all, the user variable `WARNING` is examined.

If `WARNING` is 0 then the offending word is printed followed by a "?" character and a short message "MSG#n".

If `WARNING` is 1, instead of the short message, the text available on line `b` of block 4 (of drive 0) is displayed. Such a number can be positive or negative and lay beyond block 4.

If `WARNING` is -1 then `ABORT` is executed, which resets the system to command prompt. The user can (with care) modify this behavior of that by altering `(ABORT)`.

If `BLK` is non zero, then `ERROR` leaves on the stack `n1` that is the value of `IN` and `n2` that is the value of `BLK` at the error moment. These numbers can then be used by `WHERE` to determine and show the exact error position.

In any case, the final action is QUIT .
If BLK is zero, then only a ff is left on TOS.

EXECUTE cfa ---

It executes the word which cfa is held on TOS.

EXPECT a n ---

It transfers characters from the input terminal to the address a for n location or until receiving a 0x13 "CR" character. A 0x00 "null" character is added in the following location. The actual length of the received string is kept in SPAN user variable. See also ACCEPT.

FENCE --- a

User variable that holds the (minimum) address to where FORGET can act.

FILL a n b ---

It fills n memory location starting from address a with the value of b.

FIRST --- a

User variable that holds the address of the first buffer. See also LIMIT.

FLD --- a

User variable that holds the width of output field.

FLUSH ---

It executes SAVE-BUFFERS. It saves to disk the buffers marked "modified" by UPDATE.

FORGET ---

Used in the form

FORGET cccc

removes from the dictionary the word cccc and all the preceding definitions. Care must be put when more than one vocabulary is involved.

FORTH --- (immediate)

This is the name of the first vocabulary. Executing FORTH sets this to be the CONTEXT vocabulary. As soon as no new vocabulary is defined, all new colon definitions became part of FORTH vocabulary. FORTH is immediate, so it is executed during the creation of a colon definition to select the needed vocabulary. See also ASSEMBLER (optional vocabulary).

HERE --- a

It leaves the address of next location available on the dictionary.

HEX --- a

It changes the base to hexadecimal, setting `BASE` to 16.

HLD --- a

User variable that holds the address of last character used in a numeric conversion output.

HOLD c ---

Used between `<#` and `#>` to put a ASCII character during a numeric format.

I --- n

Used between `DO` and `LOOP` (or `DO` and `+LOOP`, `?DO` and `LOOP`, `?DO` and `+LOOP`) to put on TOS the current value of the loop index.

ID. nfa ---

It prints the definition name whose `nfa` is on TOS.

IF f --- (immediate) (run time)
--- a n (compile time)

Used in colon definition in the form

```
IF ... ENDIF
IF ... ELSE ... ENDIF
```

At run-time `IF` selects which words sequence to execute based on the flag on TOS:

If `f` is true, the execution continues with the instruction that follows `IF` ("true" part).

If `f` is false, the execution continues after the `ELSE` ("false" part).

At the end of the two parts, the executions always continues after `ENDIF`.

`ELSE` and its "false" part are optional and if omitted no "false part" will be executed and execution continues after `ENDIF`.

At compile time `IF` compiles `0BRANCH` reserving a cell for an offset to the point after the corresponding `ELSE` or `ENDIF`.

The integer `n` is used for syntax checking.

IMMEDIATE ---

It marks the latest defined word such that at compile-time it is always executed instead of being compiled. The bit 6 of the length byte of the definition is set. This allows such definitions to handle complex compilation situation instead of burdening the main compiler.

The user can force the compilation of an immediate definition prepending a `[COMPILE]` to it.

IN --- a

User variable that keeps track of text position within an input buffer. `WORD` uses and modifies the value of `IN` that is incremented when consuming input buffer.

INDEX n1 n2 ---

It prints the first line of screen between `n1` and `n2`. Handy to quick check the content of a series of screens.

INKEY --- b

It reads the next character available from current stream and previously selected with `SELECT` leaving it on TOS. It is the opposite of `EMITC`.

INTERPRET ---

This is the text interpreter. It executes or compiles, depending on the value of `STATE`, text from input buffer a word at a time. It first searches on `CONTEXT` and `CURRENT` vocabularies; if these fail, the text is interpreted as a numeric value, converted using the current `BASE`, and put on TOS. If that numeric conversion fails too, an error is notified with the symbol “?” followed by the word that caused the error. `INTERPRET` executes `NUMBER` and the presence of a decimal point “.” indicates that the number is assumed as double integer instead of a simple integer. After execution of the word found, the control is given back to the caller procedure.

KEY --- b

It shows a (flashing) cursor on current video position and waits for a keypress. It leaves the ASCII code `b` of the character read from keyboard without printing it to video. In this implementation some `SYMBOL-SHIFT` key combinations are decoded as follow:

E2	STOP	→	7E	~
C3	NOT	→	7C	
CD	STEP	→	5C	\
CC	TO	→	7B	{
CB	THEN	→	7D	}
C6	AND	→	5B	[
C5	OR	→	5D]
AC	AT	→	7F	@
C7	<=	→	20	space
C8	>=	→	20	space
C9	<>	→	06	as CAPS-SHIFT + 2 and toggles CAPS-SHIFT On and Off,

LATEST --- nfa

It leaves the `nfa` of the latest word defined in `CURRENT` vocabulary.

LEAVE ---

It forces the conclusion of a `DO . . . LOOP` setting the limit at the current index `I`, inducing an exit at the first occasion. The index remains unaltered and the execution continues normally up to the following `LOOP` or `+LOOP`.

LFA **pfa** --- lfa

It converts a `pfa` in its `lfa`. See also `CFA`, `NFA`, `PFA`, `>BODY`, `<NAME`.

LIMIT --- a

User variable that points to the first location above the last buffer. Normally it is the top of RAM, but not always. In this implementation, it can be set at `E000h` to allow MMU7 as a general purpose 8K RAM bank. See also: `FIRST`.

LIST **n** ---

It prints screen number `n`. Sets `SCR` to `n`.

LIT --- **n**

It puts on TOS the value hold in the following location. It is automatically compiled a before each literal number.

LITERAL **n** --- **n** (immediate) (run time)
n --- (compile time)

At compile-time, **LITERAL** compiles **LIT** followed by the value **n** in the following cell. This is an immediate word and, a colon definition, it will be executed.

It is used in the form

: cccc ... [*calculations*] **LITERAL** ... ;

the compilation is suspended during the calculations and, when compilation resumes, **LITERAL** compiles the value put on TOS during the previous calculations.

LOAD **n** ---

It starts interpretation of screen **n**. The loading phase ends at the end of the screen or at the first occurrence of ; S.

See also -->

LOOP **a** **n** --- (immediate) (run time)
n --- (compile time)

Used in colon defintion in the form

DO ... **LOOP**
?DO ... **LOOP**

At run-time **LOOP** checks the jump to the corresponding **DO**. The index is incremented and the total compared with the limit; the jump back happens while the index is less than the limit. Otherwise the execution leaves the loop. On loop leaving, the parameters are discarded and the execution continues with the following word.

At compile-time **LOOP** compiles (**LOOP**) and the jump is calculated from **HERE** to **a** which is the address left by **DO** on the stack. The value **n2** is used internally for syntax checking.

LP --- **a**

User variable for printer purposed. Not used.

LSHIFT **n1** **u** --- **n2**

Shifts left an integer **n1** by **u** bit.

M* **n1** **n2** --- **d**

Mixed operation. It leaves the product of **n1** and **n2** ad a double integer.

M/ **d** **n1** --- **n2** **n3**

Mixed operation. It leaves the remainder **n2** and the quotient **n3** of the integer division of a double integer **d** by the divisor **n1**. The sign of the reminder is the same as **d**.

M/MOD **ud1** **u1** --- **u2** **ud3**

Mixed operation. Leaves the remainder **u2** and the quotient **ud3** of the unsigned integer division of a double integer **d** by

the divisor `n1`.

MAX `n1` `n2` `---` `n3`

It leaves the maximum between `n1` e `n2`.

MESSAGE `n` `---`

It prints to the current device the error message identified by `n`. If `WARNING` is zero, a short `MSG#n` is printed. If `WARNING` is non zero 1, line `n` of screen 4 (of drive 0) is displayed. Such a number can be positive or negative and lay beyond block 4. See also `ERROR`.

MIN `n1` `n2` `---` `n3`

It leaves the minimum between `n1` e `n2`.

MINUS `n1` `---` `n2`

It changes the sing of `n1`

MOD `n1` `n2` `---` `n3`

It divides `n1` by `n2` and leaves the remainder `n3`. The sign is the same as `n1`.

NFA `pfa` `---` `nfa`

It converts a word's `pfa` into its `nfa`. See also `CFA`, `LFA`, `PFA`, `>BODY`, `<NAME`.

NIP `n1` `n2` `---` `n2`

It removes the second element from TOS. See also: `OVER`, `DROP`, `TUCK`, `SWAP`, `DUP`, `ROT`.

NMODE `---` `a`

User variable that indicates how double numbers are interpreted. During the input, numbers can be read as double integers or as floating-point numbers. This variable is modified by the optional words `INTEGER` that sets it to 0 and `FLOATING` that sets it to 1.

NOOP `---`

This token does nothing. Useful as a placeholder or to prevent crashes in `INTERPRET`.

NUMBER `a` `---` `d`
 `a` `---` `fp` (compile time)

It converts a counted string at address `a` with a `a` in a double number. If `NMODE` is 0, the string is converted to double integer. Position of the last decimal point encountered is kept in `DPL`.

If `NMODE` is 1, a floating-point number conversion is tried.

If no conversion can be done, and error #0 is raised.

OFFSET --- a

User variable that states the beginning of “blocks area”. The content of **OFFSET** is added by **BLOCK** to the number on TOS to determine the right offset to read from file open to “!Blocks.bin”. Messages issued by **MESSAGE** are independent from **OFFSET**.

OR n1 n2 --- n3

It executes an OR binary operation between the two integers. The operation is performed bit by bit.

OUT --- a

User variable incremented by **EMIT**. The user can examine and alter **OUT** to control the video formatting.

OVER n1 n2 --- n1 n2 n1

It copies the second number from TOS and put it on the top. See also **DROP**, **NIP**, **TUCK**, **SWAP**, **DUP**, **ROT**.

P! u b ---

It sends to port **u** a byte **b**. Note: **u** is a 16 bit port address and an **OUT (C)** op-code is internally executed.

P@ n --- b

It accepts the byte **b** from port **u**. Note: **u** is a 16 bit port address and an **IN(C)** op-code is internally executed.

PAD ---

It leaves on TOS the address of text output buffer. It is at a fixed distance of 68 byte over **HERE**.

PFA nfa --- pfa

It converts a word's **nfa** to its **pfa**. See also **CFA**, **LFA**, **NFA**, **>BODY**, **<NAME**.

PLACE --- a

User variable that holds the number of places after the decimal point to be shown during a numeric output conversion. See also **PLACES**.

PREV --- a

User variable that points to the last referred buffer. **UPDATE** marks that buffer so that it is later written to disk.

QUERY ---

It awaits from terminal up to 80 characters or until a **CR** is received. The text is stored in **TIB**. User variable **IN** is set to zero.

QUIT ---

It clears the Return-Stack, stops any compilations and return the control to the operator terminal. No message is issued.

$$\mathbb{R} \quad \text{---} \quad n$$

It copies to TOS the value on top of Return Stack without alter it.

R# --- a

User variable that holds the position of the editing cursor or other function relative to files.

R0 --- a

User variable that holds the initial value of the Return Stack Pointer. See also `RP!` and `RP@`.

R> --- n

It removes the top value from Return Stack and put it on TOS. See also `>R`, `R` and `RP !`.

R/W a n f ---

Standard FIG-FORTH read-write facility. Address *a* specifies the buffer used as source or destination; *n* is the sequential number of the block; *f* is a flag, 0 to Write, 1 to Read. *R/W* determines the location on mass storage, performs the transfer and error checking.

RENAME ---

Used in the form:

```
RENAME  CCCC  XXXX
```

Searches the word `cccc` in the `CONTEXT` vocabulary and changes its name to `xxxx`. The two word-names `cccc` e `xxxx` must have the same length.

```
REPEAT      a1 n1 a2 n2      --- (immediate)      (compile time)
                                     --- (run time)
```

Used in colon definition in the form:

BEGIN ... WHILE ... REPEAT

At run-time REPEAT does an unconditional jump to the corresponding BEGIN.

At compile-time `REPEAT` compiles `BRANCH` and the offset from `HERE` to `a1` and resolves the offset from `a1` to the location after the loop; `n1` and `n1` are used for syntax check.

```

ROT      n1  n2  n3      ---  n2  n3  n1

```

It rotates the three top integers, taking the third and putting it on top. The other two integers are pushed down from top by one place. See also **OVER**, **DROP**, **NIP**, **TUCK**, **SWAP**, **DUP**.

RP! a ---

System procedure to initialize the Return Stack Pointer to the value passed on TOS that should be the address held in `R0` user variable.

RP@ --- a

It leaves the current value of Return Stack Pointer.

RSHIFT n1 u --- n2

It shifts right an integer n1 by u bit.

S->D n --- d

It converts a 16 bit integer into a 32 bit double integer, sign is preserved.

S0 --- a

User variable that holds the initial value of the SP register. See also: SP! and SP@.

SCR --- a

User variable that holds the number of the last screen retrieved with LIST.

SELECT n ---

It selects the current channel. As usual for ZX Spectrum, n is 0 and 1 for lower part of screen, 2 for the upper part, 3 for printer, 4 for "!Blocks.bin" stream. Note: KEY always select channel 2 to display the (flashing) cursor.

SIGN n d --- n

If n is negative, it puts an ASCII "-" at the beginning of the numeric string converted in the text buffer. Then, n is discarded while d is kept. Used between <# and #>.

SMUDGE ---

Used by the creation word : during the definition of a new word; it toggles the smudge-bit of the first byte in the nfa of the LATEST defined word. When a word's smudge-bit is set, it prevents the compiler to find it. This is typical for incomplete or not correctly defined words.

It is also used to remove malformed incomplete words via

SMUDGE FORGET cccc

SP! a ---

System procedure to initialize the SP register to the address a that should be the address held in S0 user variable.

SP@ --- a

It returns the content of SP register before SP@ was executed.

SPACE ---

It sends a space to the current output peripheral, usually the video. See also SELECT.

U. **u** **---**

It prints an unsigned integer followed by a space.

U< **u1** **u2** **---** **f**

It leaves a **tf** if **u1** is less than **u2**, a **ff** otherwise.

UM* **u1** **u2** **---** **ud**

Unsigned product of the two integers **u1** and **u2**. The result is a double integer.

UM/MOD **ud** **u1** **---** **u2** **u3**

It leaves the quotient **u3** and the remainder **u2** of the integer division of **ud** / **u1**.

UNTIL **a** **n** **---** **(immediate)** **(compile time)**
f **---** **(run time)**

Used in colon definition in the forms

BEGIN ... UNTIL

At run-time **UNTIL** controls a conditional jump to the corresponding **BEGIN** when **f** is false; the exit from the loop happens if **f** is true.

At compile-time **UNTIL** compiles **0BRANCH** and an offset from **HERE** to **a**; **n** is used for syntax checking.

UPDATE **---**

It marks as modified the most recent used buffer, the one pointed by **PREV**. The block contained in the buffer will be transferred to disk when that buffer is requested for another block.

USE **---** **a**

User variable that holds the buffer address of the block to be read from disk or that has just been written to.

USER **n** **---**

Defining word used in the form

n USER cccc

creates an user variable '**cccc**'. The first byte of pfa of **cccc** is a fixed offset for the User Pointer, that is the pointer for the user area. In this implementation there is only one User Area and a fixed User Pointer.

When **cccc** is later executed, it put on TOS the sum of offset and User Pointer, sum to be used as the address for that specific user variable. The user variable are: **TIB**, **WIDTH**, **WARNING**, **FENCE**, **DP**, **VOC-LINK**, **FIRST**, **LIMIT**, **EXP**, **NMODE**, **BLK**, **IN**, **OUT**, **SCR**, **OFFSET**, **CONTEXT**, **CURRENT**, **STATE**, **BASE**, **DPL**, **FLD**, **CSP**, **R#**, **HLD**, **USE**, **PREV**, **LP**, **PLACE**, **DL**.

VALUE **n** **---**

Defining word used in the form:

n VALUE cccc

Creates the word **cccc** that acts as a variable. To store a value in such a variable you have to use **TO**.

When **cccc** is later executed it directly returns the value of the variable without the need to access its address using **@**.

VARIABLE **n** ---

Defining word used in the form:

`n VARIABLE cccc`

creates the word `cccc` with the pfa containing the initial value `n`. When `cccc` is executed, it puts on TOS the pfa of `cccc` that is the address that holds the value `n`.

When used in the form

`cccc @`

the content of the variable `cccc` is left on TOS.

When used in the form

`n cccc !`

the value on TOS is stored to the variable `cccc`.

VIDEO ---

It sets `DEV\ICE` to 2 select the video as current output peripheral.

VOC-LINK --- **a**

User variable that holds the address of a field in the definition of the last vocabulary. Each vocabulary is part of a linked-list that use that field as pointer-chain.

VOCABULARY ---

Defining word used in the form

`VOCABULARY cccc`

creates the word `cccc` that gives the name of a new vocabulary.

Later execution of

`cccc`

makes such vocabulary the `CONTEXT` vocabulary, so that it is possible to search for words defined in this vocabulary first and execute them.

Used in the form

`cccc DEFINITIONS`

makes such vocabulary the `CURRENT` vocabulary, so that it is possible to insert new definitions in it.

XOR **n1** **n2** --- **n3**

It executes a XOR binary operation between the two integers. The operation is performed bit by bit.

WARM ---

It executes a warm system restart. Executes `EMPTY-BUFFERS` and `ABORT`.

WARNING --- **a**

User variable that determines the way an error message is reported. If zero, only a short "MSG#n" is reported. If non zero, a long message is reported. See also `ERROR`.

WHILE **f** --- (immediate) (run time) **a** **n** --- **a1** **n1** **a2** **n2** (compile time)

Used in colon definition in the form:

BEGIN ... WHILE ... REPEAT

At run-time **WHILE** does a conditional execution based on *f*. If *f* is true, the execution continues to a **REPEAT** which will jump to the corresponding **BEGIN**. If *f* is false, the execution continues after the **REPEAT** quitting the loop.

At compile-time **WHILE** compiles **0BRANCH** leaving *a2* for the offset; *a2* will be consumed by a **REPEAT**. The address *a1* and the number *n1* was left by a **BEGIN**.

WIDTH

--- *a*

User variable that indicates the maximum number of significant characters of the words during compilation of a definition. It must be between 1 and 31.

WORD

c --- *a*

It reads characters from the current input stream up to a delimiter *c* and stores such string at **HERE** that is left on TOS.

WORD leaves, as the first byte, the length of the string and ends everything with at least two spaces. Further occurrences of *c* will be ignored.

If **BLK** is zero, the text is taken from the terminal input buffer **TIB**. Otherwise the text is taken from the disk block held in **BLK**. User variable **IN** is added with the number of character read, the number **ENCLOSE** return.

WORDS

It lists the words of **CONTEXT** vocabulary. Pressing Break stops.

X

It show the splash screen.

[

--- (immediate)

Used in colon definition in the form:

: cccc [...] ... ;

it suspends compilation. The words that follows **[** will be executed instead of being compiled. This allows to perform some calculations or start other compilers before resuming the original compilation with **]**. See also **LITERAL**.

[**CHAR**]

--- (immediate)

(compile time)

It is the same as the sequence **[CHAR c] LITERAL**.

It is used in colon definition in the form:

: cccc ... [**CHAR**] c ... ;

At compile time, [**CHAR**] compiles **LIT** and the numeric value of ASCII character *c* in the following cell.

[**COMPILE**]

--- (immediate)

Used in colon definition in the form:

: cccc ... [**COMPILE**] www ... ;

[**COMPILE**] forces the compilation of a definition *www* that is immediate. Normally immediate words aren't compiled but executed and to compile an immediate word it is not possible to use the sequence **COMPILE www** but it is necessary to use the sequence [**COMPILE**] *www*.

\

Used in the from:

\ . . .

Any character that follow \ until the end of line are treated as a comment.

]

It resumes the compilation suspended by [so it is possible to complete the definition.

Error messages.

Code	Message
#0	?
#1	Stack is empty.
#2	Dictionary full.
#3	No such line.
#4	has already been defined.
#5	Invalid stream.
#6	No such block.
#7	Stack is full!
#8	Old dictionary is full.
#9	Tape error.
#10	Wrong array index.
#11	Invalid floating point.
#17	Can't be executed.
#18	Can't be compiled.
#19	Syntax error.
#20	Bad definition end.
#21	is a protected word.
#22	Aren't loading now.
#23	Forget across vocabularies.
#24	RS loading error.
#25	Cannot open stream.
#26	Error at postit time.
#27	Inconsistent fixup.
#28	Unexpected fixup/commaer.
#29	Commaer data error.
#30	Commaer wrong order.
#31	Programming error.
#33	Programming error.
#45	NextZXOS pos error.
#46	NextZXOS read error.
#47	NextZXOS write error.