

# *OpenBoot™ 2.x Quick Reference*



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## Syntax

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Commands are entered at the `ok` prompt and are executed left-to-right after a carriage-return. All commands must be separated by one or more spaces.

## Help Commands

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<code>help</code>	List main help categories.
<code>help <i>category</i></code>	Show help for all commands in the category. Use only the first word of the category description.
<code>help <i>command</i></code>	Show help for individual command (where available).

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## Restricted Monitor Commands

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<code>b [<i>specifier</i>]</code>	Boot the operating system (same as <code>boot</code> at <code>ok</code> prompt).
<code>c</code>	Resume the execution of a halted program (same as <code>go</code> at <code>ok</code> prompt).
<code>n</code>	Enter the Forth Monitor.

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## Examining and Creating Device Aliases

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<code>devalias</code>	Display all current device aliases.
<code>devalias <i>alias</i></code>	Display the device path name corresponding to <i>alias</i> .
<code>devalias <i>alias device-path</i></code>	Define an alias representing the device path. If an alias with the same name already exists, the new value supersedes the old.

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## Device Tree Browsing Commands

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<code>.attributes</code>	Display the names and values of the current node's properties.
<code>cd <i>device-path</i></code>	Select the indicated device node, making it the current node.
<code>cd <i>node-name</i></code>	Search for a node with the given name in the subtree below the current node, and select the first such node found.
<code>cd ..</code>	Select the device node that is the parent of the current node.
<code>cd /</code>	Select the root machine node.
<code>device-end</code>	De-select the current device node, leaving no node selected.
<code>ls</code>	Display the names of the current node's children.
<code>pwd</code>	Display the device path name that names the current node.
<code>show-devs [<i>device-path</i>]</code>	Display all the devices known to the system directly beneath a given level in the device hierarchy. (Used by itself, it shows the entire device tree.)
<code>words</code>	Display the names of the current node's methods.

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## Common Options for the boot Command

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boot [ <i>device-specifier</i> ][ <i>filename</i> ] [ <i>option</i> ]	
[ <i>device-specifier</i> ]	The name (full path name or alias) of a device. Examples: cdrom (CD-ROM drive) disk (hard disk) floppy (3-1/2" diskette drive) net (Ethernet) tape (SCSI tape)
[ <i>filename</i> ]	The name of the program to be booted (for example, <code>stand/diag</code> ). If specified, <i>filename</i> is relative to the root of the selected device and partition. If not, the boot program uses the value of the <code>boot-file</code> parameter.
[ <i>option</i> ]	-a - Prompt interactively for the device and name of the boot file. -h - Halt after loading the program. <b>(OS-specific options may differ from system to system)</b>

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## Diagnostic Test Commands

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probe-scsi	Identify devices attached to the built-in SCSI bus.
probe-scsi-all [ <i>device-path</i> ]	Perform <code>probe-scsi</code> on all SCSI buses installed in the system below the specified node. (If <i>device-path</i> is absent, the root node is used.)
test <i>device-specifier</i>	Execute the specified device's self-test method. For example: test floppy - test the floppy drive, if installed test /memory - test number of megabytes specified in <code>selftest-#megs</code> ; or test all of memory if <code>diag-switch?</code> is true test net - test the network connection
test-all [ <i>device-specifier</i> ]	Test all devices (that have a built-in self-test method) below the specified node. (If <i>device-specifier</i> is absent, the root node is used.)
watch-clock	Test the clock function.
watch-net	Monitor the network connection.

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## System Information Display Commands

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banner	Display the power-on banner.
.version	Display the version and date of the boot PROM.

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## Emergency Keyboard Commands

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Hold down keys during power-on sequence.	
Stop	Bypass POST. This command does not depend on security-mode. (Note: some systems bypass POST as a default; in such cases, use <code>stop-D</code> to start POST.)
Stop-A	Abort.
Stop-D	Enter diagnostic mode (set <code>diag-switch?</code> to true).
Stop-F	Enter Forth on TTYA instead of probing. Use <code>fexit</code> to continue with the initialization sequence. (Useful if hardware is broken.)
Stop-N	Reset NVRAM contents to default values.

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## File Loading Commands

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boot [ <i>specifier</i> ]-h	( -- )	Load file from specified source.
byte-load	( adr span -- )	Interpret a loaded FCode binary file. <i>span</i> is usually 1.
dl	( -- )	Load a Forth file over a serial line with TIP and interpret. Type: ~C cat <b>filename</b> ^~D
dlbin	( -- )	Load a binary file over a serial line with TIP. Type: ~C cat <b>filename</b>
dload <b>filename</b>	( adr -- )	Load specified file over Ethernet at given address.
go	( -- )	Begin executing a previously-loaded binary program, or resume executing an interrupted program.
init-program	( -- )	Initialize to execute a binary file.
load [ <i>specifier</i> ]	( -- )	Load data from specified device into memory at the address given by <i>load-base</i> . (See <i>boot</i> format.)
load-base	( -- adr )	Address at which <i>load</i> places the data it reads from a device.

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## SPARC Register Commands

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%f0 through %f31	( -- value )	Return the value in the given floating point register.
%fsr	( -- value )	Return the value in the given floating point register.
%g0 through %g7	( -- value )	Return the value in the given register.
%i0 through %i7	( -- value )	Return the value in the given register.
%L0 through %L7	( -- value )	Return the value in the given register.
%o0 through %o7	( -- value )	Return the value in the given register.
%pc %npc %psr	( -- value )	Return the value in the given register.
%y %wim %tbr	( -- value )	Return the value in the given register.
.registers	( -- )	Display values in %f0 through %f31.
.locals	( -- )	Display the values in the i, L and o registers.
.psr	( -- )	Formatted display of the %psr data.
.registers	( -- )	Display values in %g0 through %g7, plus %pc, %npc, %psr, %y, %wim, %tbr.
.window	( window# -- )	Display the desired window.
ctrace	( -- )	Display the return stack showing C subroutines.
set-pc	( value -- )	Set %pc to the given value, and set %npc to (value+4).
to <b>regname</b>	( value -- )	Change the value stored in any of the above registers. Use in the form: <b>value</b> tO <b>regname</b>
w	( window# -- )	Set the current window for displaying %ix %Lx or %ox.

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## Breakpoint Commands

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+bp	( adr -- )	Add a breakpoint at the given address.
-bp	( adr -- )	Remove the breakpoint at the given address.
--bp	( -- )	Remove the most-recently-set breakpoint.
.bp	( -- )	Display all currently set breakpoints.
.breakpoint	( -- )	Perform a specified action when a breakpoint occurs (Example, ['] .registers is .breakpoint).
.instruction	( -- )	Display the address, opcode for the last-encountered breakpoint.
.step	( -- )	Perform a specified action when a single step occurs (see .breakpoint).
bpoff	( -- )	Remove all breakpoints.
finish-loop	( -- )	Execute until the end of this loop.
go	( -- )	Continue from a breakpoint. This can be used to go to an arbitrary address by setting up the processor's program counter before issuing go.
gos	( n -- )	Execute go n times.
hop	( -- )	(Like the step command.) Treats a subroutine call as a single instruction.
hops	( n -- )	Execute hop n times.
return	( -- )	Execute until the end of this subroutine.
returnL	( -- )	Execute until the end of this leaf subroutine.
skip	( -- )	Skip (do not execute) the current instruction.
step	( -- )	Single-step one instruction.
steps	( n -- )	Execute step n times.
till	( adr -- )	Execute until the given address is encountered. Equivalent to +bp go.

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## Disassembler Commands

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+dis	( -- )	Continue disassembling where the last disassembly left off.
dis	( adr -- )	Begin disassembling at the given address.

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## Miscellaneous Operations

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eject-floppy	( -- )	Eject the diskette from the drive.
firmware-version	(-- n)	Return major/minor CPU firmware version (that is, 0x00020001 = firmware version 2.1).
ftrace	( -- )	Show calling sequence when exception occurred.
get-msecs	( -- ms )	Return the approximate current time in milliseconds.
ms	( n -- )	Delay for n milliseconds. Resolution is 1 millisecond.
reset	( -- )	Reset the entire system (similar to a power cycle).
sync	( -- )	Call the operating system to write any pending information to the hard disk. Also boot after sync-ing file systems.

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## NVRAM Configuration Parameters

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auto-boot?	true	If true, boot automatically after power-on or reset.
boot-device	disk	Device from which to boot.
boot-file	empty string	File to boot (an empty string lets secondary booter choose default).
boot-from	vmunix	Boot device and file (1.x only).
boot-from-diag	le()vmunix	Diagnostic boot device and file (1.x only).
diag-device	net	Diagnostic boot source device.
diag-file	empty string	File from which to boot in diagnostic mode.
diag-switch?	false	If true, run in diagnostic mode.
fcode-debug?	false	If true, include name fields for plug-in device FCodes.
hardware-revision	no default	System version information.
input-device	keyboard	Power-on input device (usually keyboard, ttya, or ttyb).
keyboard-click?	false	If true, enable keyboard click.
keymap	no default	Keymap for custom keyboard.
last-hardware-update	no default	System update information.
local-mac-address?	false	If true, network drivers use their own MAC address, not system's.
mfg-switch?	false	If true, repeat system self-tests until interrupted with <code>Stop-A</code> .
nvrामrc	empty	Contents of NVRAMRC.
oem-banner	empty string	Custom OEM banner (enabled by <code>oem-banner? true</code> ).
oem-banner?	false	If true, use custom OEM banner.
oem-logo	no default	Byte array custom OEM logo (enabled by <code>oem-logo? true</code> ). Displayed in hex.
oem-logo?	false	If true, use custom OEM logo (else, use Sun logo).
output-device	screen	Power-on output device (usually screen, ttya, or ttyb).
sbus-probe-list	0123	Which SBus slots are probed and in what order.
screen-#columns	80	Number of on-screen columns (characters/line).
screen-#rows	34	Number of on-screen rows (lines).
scsi-initiator-id	7	SCSI bus address of host adapter, range 0-7.
sd-targets	31204567	Map SCSI disk units (1.x only).
security-#badlogins	no default	Number of incorrect security password attempts.
security-mode	none	Firmware security level ( <code>none</code> , <code>command</code> , or <code>full</code> ).
security-password	no default	Firmware security password (never displayed). <b>Do not set this directly</b>

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selftest-#megs	1	Megabytes of RAM to test. Ignored if <code>diag-switch?</code> is true.
skip-vme-loopback?	false	If true, POST does not do VMEbus loopback tests.
st-targets	45670123	Map SCSI tape units (1.x only).
sunmon-compat?	false	If true, display Restricted Monitor prompt (>).
testarea	0	One-byte scratch field for NVRAM testing.
tpe-link-test?	true	Enable link test for built-in 10baseT Ethernet.
ttya-mode	9600,8,n,1,-	TTYA (baud, #bits, parity, #stop, handshake).
ttyb-mode	9600,8,n,1,-	TTYB (baud, #bits, parity, #stop, handshake).
ttya-ignore-cd	true	If true, OS ignores TTYA carrier-detect.
ttyb-ignore-cd	true	If true, OS ignores TTYB carrier-detect.
ttya-rts-dtr-off	false	If true, OS does not assert DTR and RTS on TTYA.
ttyb-rts-dtr-off	false	If true, OS does not assert DTR and RTS on TTYB.
use-nvramrc?	false	If true, execute commands in NVRAMRC during system start-up.
version2?	true	If true, hybrid (1.x/2.x) PROM comes up in version 2.x.
watchdog-reboot?	false	If true, reboot after watchdog reset.

### Viewing and Changing Configuration Parameters

<code>printenv</code>	Display all current parameters and current default values (numbers are usually shown as decimal values). <code>printenv <b>parameter</b></code> shows the current value of the named parameter.
<code>setenv <b>parameter value</b></code>	Set the parameter to the given decimal or text value. (Changes are permanent, but usually only take effect after a reset).
<code>set-default <b>parameter</b></code>	Reset the value of the named parameter to the factory default.
<code>set-defaults</code>	Reset parameter values to the factory defaults.

## NVRAMRC Editor Commands

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<code>nvalias <i>alias device-path</i></code>	Store the command " <code>devalias <i>alias device-path</i></code> " in NVRAMRC. (The alias persists until the <code>nvunalias</code> or <code>set-defaults</code> commands are executed.)
<code>nvedit</code>	Enter the NVRAMRC editor. If data remains in the temporary buffer from a previous <code>nvedit</code> session, resume editing those previous contents. If not, read the contents of NVRAMRC into the temporary buffer and begin editing it.
<code>nvquit</code>	Discard the contents of the temporary buffer, without writing it to NVRAMRC. Prompt for confirmation.
<code>nvrecover</code>	Recover the contents of NVRAMRC if they have been lost as a result of the execution of <code>set-defaults</code> ; then enter the editor as with <code>nvedit</code> . <code>nvrecover</code> fails if <code>nvedit</code> is executed between the time that the NVRAMRC contents were lost and the time that <code>nvrecover</code> is executed.
<code>nvrun</code>	Execute the contents of the temporary buffer.
<code>nvstore</code>	Copy the contents of the temporary buffer to NVRAMRC; discard the contents of the temporary buffer.
<code>nvunalias <i>alias</i></code>	Delete the corresponding alias from NVRAMRC.

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## Editor Commands (for Command Lines and NVRAMRC)

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	Prev. Line	Beg. Line	Prev. Word	Prev. Char	Next Char	Next Word	End Line	Next Line
Move	<code>^P</code>	<code>^A</code>	<code>!B</code>	<code>^B</code>	<code>^F</code>	<code>!F</code>	<code>^E</code>	<code>^N</code>
Delete		<code>^U</code>	<code>^W</code>	<code>Del</code>	<code>^D</code>	<code>!D</code>	<code>^K</code>	
		Re-type line		<code>^R</code>				
		Show all lines		<code>^L</code>				
		Paste after	<code>^K</code>	<code>^Y</code>				
		Complete command		<code>^space</code>				
		Show all matches		<code>^/</code> or <code>^?</code> or <code>^}</code>				

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! = Press and release Escape key first; ^ = Press and hold Control key

## Using the NVRAMRC Editor

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```
ok nvedit
:
(use editor commands)
:
^C                               (get back took prompt)
ok nvstore                        (save changes)
ok setenv use-nvramrc? true      (enable NVRAMRC)
```



## Numeric Usage and Stack Comments

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- Numeric I/O defaults to hexadecimal.
- Switch to decimal with `decimal`, switch to hexadecimal with `hex`.
- Use `10 .d` to see which base is currently active.

A numeric stack is used for all numeric parameters. Typing any integer puts that value on top of the stack. (Previous values are "pushed" down.) The right-hand item in a set always indicates the topmost stack item.

- The command `!` removes and displays the top stack value.
- The command `.s` non-destructively shows the entire stack contents.

A stack comment such as `(n1 n2 -- n3)` or `(adr len --)` or `(--)` listed after each command name shows the effect on the stack of executing that command. Items **before** the `--` are used by the command and removed from the stack. These items **must** be present on the stack **before** the command can properly execute. Items **after** the `--` are left on the stack after the command completes execution, and are available for use by subsequent commands.

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	Alternate stack results. Example: <code>( input -- adr len false   result true )</code> .
?	Unknown stack items (changed from ???).
???	Unknown stack items.
acf	Code field address.
adr	Memory address (generally a virtual address).
adr16	Memory address, must be 16-bit aligned.
adr32	Memory address, must be 32-bit aligned.
adr64	Memory address, must be 64-bit aligned.
byte <b>wxxx</b>	8-bit value (smallest byte in a 32-bit word).
char	7-bit value (smallest byte), high bit unspecified.
cnt/len/size	Count or length.
flag <b>xxx?</b>	0 = false; any other value = true (usually -1).
long <b>Lxxx</b>	32-bit value.
n n1 n2 n3	Normal signed values (32-bit).
+n u	Unsigned, positive values (32-bit).
n[64] or (n.low n.hi)	Extended-precision (64-bit) numbers (2 stack items).
phys	Physical address (actual hardware address).
pstr	Packed string ( <code>adr len</code> means unpacked string).
virt	Virtual address (address used by software).
word <b>wxxx</b>	16-bit value (smallest two bytes in a 32-bit word).

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## Changing the Number Base

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decimal	( -- )	Set the number base to 10.
d# <b>number</b>	( -- n )	Interpret the next number in decimal; base is unchanged.
hex	( -- )	Set the number base to 16.
h# <b>number</b>	( -- n )	Interpret the next number in hex; base is unchanged.
.d	( n -- )	Display n in decimal without changing base.
.h	( n -- )	Display n in hex without changing base.

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## Basic Number Display

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.	( n -- )	Display a number in the current base.
.s	( -- )	Display contents of data stack.
showstack	( -- )	Execute .s automatically before each ok prompt.

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## Stack Manipulation Commands

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-rot	( n1 n2 n3 -- n3 n1 n2 )	Inversely rotate three stack items.
>r	( n -- )	Move a stack item to the return stack. (Use with caution.)
?dup	( n -- n n   0 )	Duplicate the top stack item if non-zero.
2drop	( n1 n2 -- )	Remove two items from the stack.
2dup	( n1 n2 -- n1 n2 n1 n2 )	Duplicate two stack items.
2over	( n1 n2 n3 n4 -- n1 n2 n3 n4 n1 n2 )	Copy second two stack items.
2swap	( n1 n2 n3 n4 -- n3 n4 n1 n2 )	Exchange two pairs of stack items.
clear	( ??? -- )	Empty the stack.
depth	( ??? -- ??? +n )	Return the number of items on the stack.
drop	( n -- )	Remove the top item from the stack.
dup	( n -- n n )	Duplicate the top stack item.
nip	( n1 n2 -- n2 )	Discard the second stack item.
over	( n1 n2 -- n1 n2 n1 )	Copy the second stack item to the top of the stack.
pick	( ??? +n -- ??? n2 )	Copy +n-th stack item (1 pick = over).
r>	( -- n )	Move a return stack item to the stack. (Use with caution.)
r@	( -- n )	Copy the top of the return stack to the stack.
roll	( ??? +n -- ? )	Rotate +n stack items (2 roll = rot).
rot	( n1 n2 n3 -- n2 n3 n1 )	Rotate three stack items.
swap	( n1 n2 -- n2 n1 )	Exchange the top two stack items.
tuck	( n1 n2 -- n2 n1 n2 )	Copy the top stack item below the second item.

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## Arithmetic Functions

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*	( n1 n2 -- n3 )	Multiply n1 * n2.
+	( n1 n2 -- n3 )	Add n1 + n2.
-	( n1 n2 -- n3 )	Subtract n1 - n2
/	( n1 n2 -- quot )	Divide n1 / n2; remainder is discarded.
<<	( n1 +n -- n2 )	Left-shift n1 by +n bits.
>>	( n1 +n -- n2 )	Right-shift n1 by +n bits.
>>a	( n1 +n -- n2 )	Arithmetic right-shift n1 by +n bits.
abs	( n -- u )	Absolute value.
and	( n1 n2 -- n3 )	Bitwise logical AND.
bounds	( startadr len -- endadr startadr )	Convert startadr len to endadr startadr for do loop.
bljoin	( b.low b2 b3 b.hi -- long )	Join four bytes to form a 32-bit longword.
bwjoin	( b.low b.hi -- word )	Join two bytes to form a 16-bit word.
lbsplit	( long -- b.low b2 b3 b.hi )	Split a 32-bit longword into four bytes.
lwsplit	( long -- w.low w.hi )	Split a 32-bit longword into two 16-bit words.
max	( n1 n2 -- n3 )	n3 is maximum of n1 and n2.
min	( n1 n2 -- n3 )	n3 is minimum of n1 and n2.
mod	( n1 n2 -- rem )	Remainder of n1 / n2.
negate	( n1 -- n2 )	Change the sign of n1.
not	( n1 -- n2 )	Bitwise ones complement.
or	( n1 n2 -- n3 )	Bitwise logical OR.
wbsplit	( word -- b.low b.hi )	Split 16-bit word into two bytes.
wljoin	( w.low w.hi -- long )	Join two words to form a longword.
xor	( n1 n2 -- n3 )	Bitwise exclusive OR.

## Memory Access Commands

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!	( n adr16 -- )	Store a 32-bit number at adr16, must be 16-bit aligned.
+!	( n adr16 -- )	Add n to the 32-bit number stored at adr16, must be 16-bit aligned.
@	( adr16 -- n )	Fetch a 32-bit number from adr16, must be 16-bit aligned.
c!	( n adr -- )	Store low byte of n at adr.
c@	( adr -- byte )	Fetch a byte from adr.
cpeek	( adr -- false   byte true )	Fetch the byte at adr. Return the data and true if the access was successful. Return false if a read access error occurred. (Also lpeek, wpeek.)

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<code>cpoke</code>	( byte adr -- okay? )	Store the byte to adr. Return true if the access was successful. Return false if a write access error occurred. (Also <code>lpoke</code> , <code>wpoke</code> .)
<code>comp</code>	( adr1 adr2 len -- n )	Compare two byte arrays, n = 0 if arrays are identical, n = 1 if first byte that is different is greater in array#1, n = -1 otherwise.
<code>dump</code>	( adr len -- )	Display len bytes of memory starting at adr.
<code>fill</code>	( adr size byte -- )	Set size bytes of memory to byte.
<code>L!</code>	( n adr32 -- )	Store a 32-bit number at adr32.
<code>L@</code>	( adr32 -- long )	Fetch a 32-bit number from adr32.
<code>move</code>	( adr1 adr2 u -- )	Copy u bytes from adr1 to adr2, handle overlap properly.
<code>w!</code>	( n adr16 -- )	Store a 16-bit number at adr16, must be 16-bit aligned.
<code>w@</code>	( adr16 -- word )	Fetch a 16-bit number from adr16, must be 16-bit aligned.

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### Memory Mapping Commands

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<code>alloc-mem</code>	( size -- virt )	Allocate and map size bytes of available memory; return the virtual address. Unmap with <code>free-mem</code> .
<code>cacheable</code>	( space -- cache-space )	Modify the address space so that the subsequent address mapping is made cacheable.
<code>free-mem</code>	( virt size -- )	Free memory allocated by <code>alloc-mem</code> .
<code>free-virtual</code>	( virt size -- )	Undo mappings created with <code>memmap</code> .
<code>map?</code>	( virt -- )	Display memory map information for the virtual address.
<code>memmap</code>	( phys space size -- virt )	Map a region of physical addresses; return the allocated virtual address. Unmap with <code>free-virtual</code> .
<code>obio</code>	( -- space )	Specify the device address space for mapping.
<code>obmem</code>	( -- space )	Specify the onboard memory address space for mapping.
<code>pgmap!</code>	( pentry virt -- )	Store a new page map entry for the virtual address.
<code>pgmap?</code>	( virt -- )	Display the page map entry (decoded and in English) corresponding to the virtual address.
<code>pgmap@</code>	( virt -- pentry )	Return the page map entry for the virtual address.
<code>pagesize</code>	( -- size )	Return the size of a page (often 4K).
<code>sbus</code>	( -- space )	Specify the SBus address space for mapping.

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## Defining Words

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:	<b>name</b>	( -- ) Usage: ( ??? -- ? )	Start creating a new colon definition.
;		( -- )	Finish creating a new colon definition.
buffer:	<b>name</b>	( size -- ) Usage: ( -- adr64 )	Create a named array in temporary storage.
constant	<b>name</b>	( n -- ) Usage: ( -- n )	Define a constant (for example, 3 constant bar).
create	<b>name</b>	( -- ) Usage: ( -- adr16 )	Generic defining word.
defer	<b>name</b>	( -- ) Usage: ( ??? -- ? )	Define forward reference or execution vector.
does>		( -- adr16 )	Start the run-time clause for defining words.
value	<b>name</b>	( n -- ) Usage: ( -- n )	Create a changeable, named 32-bit quantity.
variable	<b>name</b>	( -- ) Usage: ( -- adr16 )	Define a variable.

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## Dictionary Searching Commands

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'	<b>name</b>	( -- acf )	Find the named word in the dictionary. (Returns the code field address. Use outside definitions.)
[]	<b>name</b>	( -- acf )	Similar to ' but is used either inside or outside definitions.
.calls		( acf -- )	Display a list of all words that call the word whose compilation address is acf.
\$find		( adr len -- adr len false   acf n )	Find a word. n = 0 if not found, n = 1 if immediate, n = -1 otherwise.
see	<b>thisword</b>	( -- )	Decompile the named command.
(see)		( acf -- )	Decompile the word indicated by the code field address.
sifting	<b>ccc</b>	( -- )	Display names of all dictionary entries containing the sequence of characters. <b>ccc</b> contains no spaces.
words		( -- )	Display all visible words in the dictionary.

---

## Dictionary Compilation Commands

---

,		( n -- )	Place a number in the dictionary.
c,		( byte -- )	Place a byte in the dictionary.
w,		( word -- )	Place a 16-bit number in the dictionary.
L,		( long -- )	Place a 32-bit number in the dictionary.

---

---

allot	( n -- )	Allocate n bytes in the dictionary.
forget <i>name</i>	( -- )	Remove word from dictionary and all subsequent words.
here	( -- adr )	Address of top of dictionary.
is name	( n -- )	Install a new action in a <i>defer</i> word or <i>value</i> .
patch <i>new-word</i> <i>old-word</i> <i>word-to-patch</i>	( -- )	Replace <i>old-word</i> with <i>new-word</i> in <i>word-to-patch</i> .
(patch	( new-n old-n acf -- )	Replace old-n with new-n in word indicated by acf.

---

### Controlling Text Input

---

( <i>ccc</i> )	( -- )	Begin a comment.
\ <i>rest-of-line</i>	( -- )	Skip the rest of the line.
ascii <i>ccc</i>	( -- char )	Get numerical value of first ASCII character of next word.
key	( -- char )	Read a character from the assigned input device's keyboard.
key?	( -- flag )	True if a key has been typed on the input device's keyboard.

---

### Displaying Text Output

---

cr	( -- )	Terminate a line on the display and go to the next line.
emit	( char -- )	Display the character.
type	( adr +n -- )	Display n characters.

---

### Manipulating Text Strings

---

" <i>ccc</i>	( -- adr len )	Collect an input stream string, either interpreted or compiled. Within the string, use "(00,ff...)" to include arbitrary byte values.
." <i>ccc</i>	( -- )	Compile a string for later display.
bl	( -- char )	ASCII code for the space character; decimal 32.
count	( pstr -- adr +n )	Unpack a packed string.
p" <i>ccc</i>	( -- pstr )	Collect a string from the input stream; store as a packed string.

---

### Redirecting I/O

---

input	( device -- )	Select device ( <i>ttya</i> , <i>ttyb</i> , <i>keyboard</i> , or " <i>devicespecifier</i> ") for subsequent input.
io	( device -- )	Select device for subsequent input and output.
output	( device -- )	Select device ( <i>ttya</i> , <i>ttyb</i> , <i>screen</i> , or " <i>devicespecifier</i> ") for subsequent output.

---

## Comparison Commands

---

<	( n1 n2 -- flag )	True if n1 < n2.
<=	( n1 n2 -- flag )	True if n1 <= n2.
<>	( n1 n2 -- flag )	True if n1 <> n2.
=	( n1 n2 -- flag )	True if n1 = n2.
>	( n1 n2 -- flag )	True if n1 > n2.
>=	( n1 n2 -- flag )	True if n1 >= n2.
between	( n min max -- flag )	True if min <= n <= max.
u<	( u1 u2 -- flag )	True if u1 < u2, unsigned.
u<=	( u1 u2 -- flag )	True if u1 <= u2, unsigned.
u>	( u1 u2 -- flag )	True if u1 > u2, unsigned.
u>=	( u1 u2 -- flag )	True if u1 >= u2, unsigned.
within	( n min max -- flag )	True if min <= n < max.

---

## if-then-else Commands

---

else	( -- )	Execute the following code if <i>if</i> failed.
if	( flag -- )	Execute the following code if <i>flag</i> is true.
then	( -- )	Terminate <i>if...then...else</i> .

---

## begin (Conditional) Loop Commands

---

again	( -- )	End a <i>begin...again</i> infinite loop.
begin	( -- )	Begin a <i>begin...while...repeat</i> , <i>begin...until</i> , or <i>begin...again</i> loop.
repeat	( -- )	End a <i>begin...while...repeat</i> loop.
until	( flag -- )	Continue executing a <i>begin...until</i> loop until <i>flag</i> is true.
while	( flag -- )	Continue executing a <i>begin...while...repeat</i> loop while <i>flag</i> is true.

---

## do (Counted) Loop Commands

---

+loop	( n -- )	End a <i>do...+loop</i> construct; add <i>n</i> to loop index and return to <i>do</i> (if <i>n</i> < 0, index goes from <i>start</i> to <i>end</i> inclusive).
?do	( end start -- )	Begin <i>?do...loop</i> to be executed 0 or more times. Index goes from <i>start</i> to <i>end</i> -1 inclusive. If <i>end</i> = <i>start</i> , loop is not executed.
do	( end start -- )	Begin a <i>do...loop</i> . Index goes from <i>start</i> to <i>end</i> -1 inclusive. Example: 10 0 do i . loop (prints 0 1 2...d e f).
i	( -- n )	Loop index.
j	( -- n )	Loop index for next enclosing loop.
leave	( -- )	Exit from <i>do...loop</i> .
loop	( -- )	End of <i>do...loop</i> .

---

## case Statement

---

```
( value )
case
2 of ." it was two" endof
0 of ." it was zero" endof
." it was " dup . (optional default clause)
endcase
```

## Cache Manipulation Commands

---

clear-cache	( -- )	Invalidate all cache entries.
cache-off	( -- )	Disable the cache.
cache-on	( -- )	Enable the cache.
flush-cache	( -- )	Write back any pending data from the cache.

---

## Alternate Address Space Access Commands

---

spacec!	( byte adr asi -- )	Store the byte at asi and address.
spacec@	( adr asi -- byte )	Fetch the byte from asi and address.
spaced!	( n1 n2 adr asi -- )	Store the two 32-bit words at asi and address. Order is implementation-dependent.
spaced@	( adr asi -- n1 n2 )	Fetch the two 32-bit words from asi and address. Order is implementation-dependent.
spaceL!	( long adr asi -- )	Store the 32-bit word at asi and address.
spaceL@	( adr asi -- long )	Fetch the 32-bit word from asi and address.
spacew!	( word adr asi -- )	Store the 16-bit word at asi and address.
spacew@	( adr asi -- word )	Fetch the 16-bit word from asi and address.

---

## Multiprocessor Commands

---

module-info	( -- )	Display type and speed of all CPU modules.
switch-cpu	( cpu# -- )	Switch to indicated CPU.

---

## Program Execution Control Commands

---

abort	( -- )	Abort current execution and interpret keyboard commands.
abort" <b>ccc</b> "	( abort? -- )	If flag is true, abort and display message.
eval	( adr len -- )	Interpret Forth source from an array.
execute	( acf -- )	Execute the word whose code field address is on the stack.
exit	( -- )	Return from the current word. (Cannot be used in counted loops.)
quit	( -- )	Same as <code>abort</code> , but leave stack intact.

---

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