E8 Manual

E8 is an Emacs-like text editor for PDP-8 family computers. It runs under OS/8 and communicates with the user via character I/O on the console terminal. The console is expected to be, or behave like, a simple fixed-size character-oriented display terminal, able to process a few basic ANSI escape sequences. This document assumes some familiarity with the PDP-8, OS/8, and Emacs.

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Cautions

I've been using E8 to further its own development with no trouble, but it has not yet been tested extensively. Save often and make backups. Note that OS/8 provides almost no protection for its file system from errant application code. E8 has some fail-safes to prevent bugs from overwriting other files, and there are no known bugs, but still, this is software. Until community use is further along, I recommend editing files on some removable media that doesn't contain stuff you can't afford to lose.

"Hardware" Requirements

E8 runs on any PDP-8 family computer with at least three fields of memory (12K). The maximum file size (characters) that can be edited is simply the

number of words of memory minus fields 0 and 1. So if you have all eight fields, you get a max size of 24K characters. E8 can display, but not properly edit, larger files.

Terminal Requirements and Processing

Display

The terminal must be able to process the following ANSI escape sequences:

Sequence	Action	To change, search for
`ESC [` *row*`;`*col*`H`	set cursor position	`SETCUR,`
`ESC [ 2 J`	clear screen	`CLRSC,`
`ESC [ K`	clear to end of line	`CLREOL,`

E8 sends the BELL code (007_8) if you try to do something that can't be done, like entering an unimplemented command character, moving the cursor past the ends of the buffer, or entering a bad filename character. If your terminal doesn't beep or flash the screen, you'll miss these.

The Linux console (e.g. `CTRL-ALT-F1`) and MobaXterm are fine.

Keyboard

Many E8 commands are intended for use with the `ALT` key. E8 recognizes the sequence

```
ESC char
```

to mean `ALT-char`. Many terminals and terminal emulators that have an `ALT` key will send that sequence when the `ALT` key is pressed. If yours doesn't, just type the `ESC`.

Some control characters that Emacs has traditionally used may be captured by a screen manager (e.g. `^A` for GNU `screen` or `^B` for `tmux`) or SimH (`^E`) and

not sent along to the terminal. The serial flow control characters `^Q` and `^S` may also be captured, but if you are not using serial communication you can stop that with the command `stty -ixon` (SSH and VNC are not serial and don't need flow control). `ALT` alternatives are provided in each case, but it takes a little getting used to if you have Emacs muscle memory.

There is some ambiguity about whether the modern `Backspace` key should send the backspace code (^H, 010_8) or the delete code (177_8). E8 considers them the same and converts 177 to 010.

E8 responds to escape sequences that are sent by certain special keys on modern keyboards:

Sequence	Key	Action
`ESC [ A`	↑	beginning of previous line
`ESC [ B`	↓	beginning of next line
`ESC [ C`	→	forward one character
`ESC [ D`	←	back one character
`ESC [ 1 ~`	HOME	beginning of line
`ESC [ 3 ~`	DEL	delete forward one character
`ESC [ 4 ~`	END	end of line
`ESC [ 5 ~`	PAGE UP	back one screen
`ESC [ 6 ~`	PAGE DOWN	forward one screen

Installation

Source Files

There are three equivalent configurations of source files, depending on whether you use PIP, or something that can handle larger files, to transfer to OS/8, and depending on whether you want files smaller than 24K characters so E8 can edit them (assuming 8 fields of memory).

Use PIP	E8 can edit	Files
yes	yes	E8.PA, EA.PA, EB.PA, EC.PA, ED.PA, EE.PA, EF.PA, EG.PA
no	yes	E8BASE.PA, E8FILE.PA, E8SRCH.PA
no	no	E8ALL.PA

Setting Screen and Memory Size

The default screen size is 42 lines of 80 characters, and the default number of fields is 8. If your setup is different, make a Pal8 source file (e.g. E8DEFS.PA) to define your values. For example:

```
DECIMAL
SCRWD=120
SCRHT=24
MEMSIZ=6
OCTAL
```

The symbols SCRWD and SCRHT define your screen size. Make them whatever you like, as long as

```
SCRWD * (SCRHT + 1) <= 3968
```

The symbol `MEMSIZ` specifies the number of fields installed. 3 ≤ `MEMSIZ` ≤ 8

Lines Longer than the Screen Width

There is no limit on the size of lines that can be in files and edited, but you can only see the first SCRWD-1 characters of each line. What you can't see is there and not lost. If the length of any line is >= SCRWD, E8 will display a > in the last column to let you know that there are more characters that you can't see.

Likewise, you can place the edit cursor (where you insert and delete characters) anywhere in the file, even at invisible positions. If the edit cursor is at an invisible position the screen cursor is placed on the > to let you know.

If you want to see the invisible text, put the cursor just before the > and insert a newline (CR) to break the line in two. You can always delete the CR when you're done looking.

Getting the Code Onto OS/8

Choose an OS/8 device to hold the E8 source and the files you want to edit, and assign it to DSK:

```
.AS <physical device> DSK
```

My method is to copy/paste the source code into a MobaXterm session connected to OS/8, while PIP on the OS/8 receives it, like this:

```
.R PIP
*E8.PA<TTY:
```

After each file is copied this way, type ^Z to PIP to signify end of file, and then you're back at the PIP command prompt ready to do the next file. I have found that PIP can't handle files longer than 549 lines, so use the eight small files. Often my MobaXterm stops sending characters for a few seconds and then resumes, so make sure to wait until the last line is sent. This also can happen during an E8 screen update, so beware.

This link has other and probably better ways to do it. If your method can handle arbitrarily large files, you can use the other source configurations.

Build and Run

```
.R PAL8
*E8<E8DEFS,E8,EA,EB,EC,ED,EE,EF,EG/L          ← either
this...
*E8<E8DEFS,E8BASE,E8FILE,E8SRCH/L             ← or this...
*E8<E8DEFS,E8ALL/L                            ← or this, not
all 3.
*^C
.SA SYS E8;200=1000
.R E8
```

If you are using the default setup, omit `E8DEFS`. The screen will start cleared expect for the mode lines showing an empty text buffer.

Files

- E8 can display and edit OS/8 text files, which contain 7-bit ASCII codes that include lowercase.
- The character parity bit is cleared on input. If your file has the parity bits set, E8 will clear them. Usually this is not a problem, but it could be fixed if it is.
- On input the `CR` code (`^M`, 015_8) is considered new line, and the `LF` code (`^J`, 012_8) is discarded. On output, `CR` is written as `CR`, `LF`.
- I/O to files is one OS/8 block per transfer, sequential over the file, and therefore may be inefficient on real DECtape, if anyone still has such a thing.

Internal Errors

Certain internal errors will print `ASSERT: xxxx` and exit to OS/8. Edits since the last save are lost. Report the address to me. I have never seen this happen, but just in case.

Mode Lines

The E8 mode lines look like this:

```
-**- EFBASE.PA   5123
SEARCH: TOP,
```

The `-**-` on the first line means the buffer has been changed.

Following this (`E8BASE.PA` in this example) is the current file name, if any.

The number after that is the count of characters in the buffer (decimal).

The line below shows occasional status or state displays, and accepts your input for certain commands. In the example shown, the incremental search command prompts with `SEARCH:` and you enter a search string, here `TOP,`.

Entering Filenames

In a single edit session you can create new files and view or edit as many files as you like. When prompted for a filename:

- Names must be alphanumeric, no more than six characters, with an optional extension of up to two characters.
- Lowercase letters are made uppercase.
- Any character that would not result in a legal filename will be rejected.
- The `CR` code (`Enter` on modern keyboards) terminates and accepts the entry.
- `Backspace` clears the filename so you can start over.
- `^G` aborts the operation.
- You cannot enter an OS/8 device name. E8 can currently only access files on `DSK:`.

Incremental Search (^S)

Enter the search string at the mode-line prompt. After each character the cursor will advance to matching text if any, or ring the console bell and reject the character if not. You may enter:

Key	Action

Key	Action
CR	terminate search with mark set to starting point
^S or ^F	find the next occurrence of the search string
BS	erase last search character and back up
^N	match CR (newline) in search text

Query-Replace (ALT-%)

When entering strings at the REPLACE and WITH prompts:

Key	Meaning
CR	Accept string
BS	Delete last character entered
^G	Abort query-replace
^N	Put CR (newline) in string

If REPLACE is null you'll be asked again. WITH can be null. You will be shown successive instances of the replace string, and you can:

Key	Meaning
SP	Replace and continue
n or N	Don't replace and continue
.	Replace and quit
CR	Quit
!	Replace all without asking

Change Protection

If there are unsaved changes in the buffer and you try to exit E8, create a new file, or read in an existing file, you will be offered the opportunity to save the changes. The responses are Y (yes), N (no), or ^G (abort). If you select Y and

there is no filename, you will be asked for one. Only uppercase `Y` and `N` are accepted.

Editing

Like Emacs, E8 is a character editor. All characters are traversed and edited the same way, including `TAB` and `CR`. The other control characters are displayed with the customary `^` prefix, but remember that they are just one character in the buffer.

Limited Undo

If you accidentally delete characters with any sequence of character-deleting commands, you can recover them if you act right away. The deleted characters are lost if you insert any characters or move the cursor. See `ALT-R`.

Commands

Most commands are equivalent or nearly so to Emacs, but some are not, so beware. The `ALT` commands are case-insensitive. The `^X` commands consider control, uppercase, and lowercase letters to be all the same. For example, `^X ^S`, `^X S`, and `^X s` are all the same.

Key/Sequence	Meaning
`^@` or `^SP`	Set the mark to the current position (cursor)
`^A` or `ALT-A`	Beginning of line
`^B`	Back one character
`^D`	Delete forward one character
`^E` or `ALT-E`	End of line
`^F`	Forward one character
`^H` (BS)	Delete backward one character
`^I` (TAB)	Insert TAB

Key/Sequence	Meaning
^J (LF)	Insert CR, TAB
^K	Kill (delete) to end of line; if at end, delete CR
^L	Erase and redraw screen with cursor at the middle line
^M (CR)	Insert CR
^N	Beginning of next line
^O	Open new line (CR, ^B)
^P	Beginning of previous line
^Q	Insert next typed char as is
^S or ALT-S	Incremental search (case sensitive)
^V	Forward one screen
^W	Write region (text between cursor and mark) to the file CLIP.E8 and delete the text in the region.
^Y	Insert the file CLIP.E8 at the cursor
^Z	Exit to OS/8
^\	Scroll up one line, keeping cursor in same position on screen
ALT-%	Query-replace (case sensitive)
ALT-<	Beginning of buffer
ALT->	End of buffer
ALT-B	Back one word
ALT-D	Delete forward one word
ALT-F	Forward one word
ALT-H (BS)	Delete backward one word
ALT-N	Search for the last search or replace string
ALT-Q	Insert next typed character as a control character, e.g. ALT-Q A inserts ^A.
ALT-R	Recover deleted characters if possible
ALT-V	Back one screen

Key/Sequence	Meaning
ALT-W	Write region to the file CLIP.E8; do not delete the region.
ALT-\	Scroll down one line, keeping cursor in same position on screen
^X ^F or ^X F	Open existing file or create new one
^X ^I or ^X I	Insert file at cursor
^X ^R or ^X R	If the previous file read filled the buffer before the end of the file, clear the buffer and read more text from the file starting at some point up to 384 characters before the last one read.
^X ^S or ^X S	Save buffer to current file, prompt for filename if none
^X ^W or ^X W	Write buffer to new filename.
^X ^X or ^X X	Exchange cursor and mark.

Scrolling

By default the scrolling commands ^\ and ALT-\ operate by redrawing the entire screen. With a fast simulator, high-speed communications, and a modern graphics engine the redraw is fast enough to not be noticeable. For slower systems, there is an assembly-time option for using VT-100 scrolling commands so that only one line need be redrawn. It is an option because it may not interact properly with every terminal, and it's usually not needed. It also has to set a terminal scrolling window, which it has to undo by resetting the terminal on exit. So there are opportunities for trouble. It's been tested and works with MobaXterm. If you're using SimH you can see the difference by throttling the simulator down to 300K or so.

To enable VT-100 scrolling, put FSCROL=0 in an E8DEFS.PA file. The terminal must implement the following escape sequences:

Sequence	Action

Sequence	Action
`ESC [` *top*`;`*bot*`r`	set scrolling window
`ESC D`	if cursor is at window bottom scroll window up
`ESC M`	if cursor is at window top scroll window down
`ESC c`	reset terminal

Theory of Operation

Storing and Editing Text

Text is conceptually just a list of character codes. For editing purposes, there are no special characters: newline (CR), TAB, and other control characters are treated like any other (they are displayed differently, of course).

Inserting and deleting occurs at a place in the text called the point. The point is conceptually between two characters, before the first one, or after the last one. The screen cursor is on the character just ahead of the point. All editing operations are built from three fundamentals:

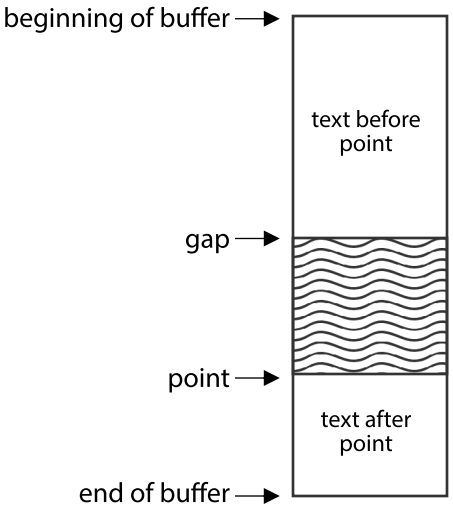
- insert characters at the point;
- delete characters in front of or behind the point; and
- move the point somewhere.

Characters are stored in a text buffer comprising one or more complete fields starting at field 2, one character per word of memory. The fields are considered contiguous—there is no significance to field boundaries. Every word in the buffer can hold a character—there are no special codes, link pointers, or the like.

Inserting and deleting are fast, O(1) operations (independent of the number of characters in the buffer). Moving the point is O(n), where n is the distance to be moved. On a real 8/I, moving forward takes 20 cycles (30 μs) per character

and backward 29 cycles (43.5 μs) per character (plus some small constant overhead). Typical operations move the point small distances (one character, line, or screen) and are fast. The worst case is moving from the end of a full buffer (24K characters) to the beginning, which takes slightly over 1 second.

Text buffer memory looks like this:



Almost all actions operate on text that is exclusively either ahead of or behind the point, the characters of which are always contiguous in memory. Only rare actions cross the gap (e.g. writing the text to a file). The gap structure makes everything simple and fast.

Display

Display is completely separate from and independent of editing. The editing commands know nothing about the display and contribute no information to it. The display code does not know what editing commands have been issued since the last display. Its job is to make the display match the current contents of the text buffer, with few unnecessary characters transmitted to the console terminal. This complete separation simplifies the code and avoids all manner of potential bugs that would arise from editing and display miscommunication—no communication, no communication bugs.

A complete copy of the screen is kept in field 1. The first step in a screen update is to determine what character in the text buffer should be top of screen (TOS), so that the point is visible. TOS is always either at the beginning of the buffer, or just after a newline. If the point is visible with the current TOS, it is kept. Otherwise it is chosen to place the point somewhere on the screen's middle line if possible.

Once TOS is established, text lines are processed one at a time and independently. Each line is first rendered to a one-line buffer in field 1, whose size is the width of the screen (`SCRWD`). Rendering converts tabs to spaces, adds the `^` prefix to control characters, and enforces the `SCRWD-1` limit on visible text. The rendered characters are terminated with one of two codes, both negative, indicating that the line does or does not extend beyond the limit. Rendering is the most time-consuming part of screen update, so the inner loop is carefully crafted for speed.

Each rendered line is then compared to the appropriate line of the screen copy. If a mismatch is found at some position, the screen cursor is set to that position and the rest of the characters from the render buffer are sent to TTY and replace the screen copy. After all those characters have been sent and copied, if the screen copy shows that the rest of the screen line is not blank, an escape sequence is sent to clear to end of line.

Each line of the screen copy also has two negative termination codes, different from the render codes, that indicate whether a > does or does not appear in the last column. The render and screen termination codes tell whether > needs to be added, removed, or left alone.

The inner loop is optimized for characters comparing equal and is only nine memory cycles on an 8/I. The use of distinct termination codes avoids having to also test for end of render or screen line in the inner loop.

After the text buffer has been processed, the two mode lines at the bottom of the screen are rendered and updated in the same way. Finally, the screen cursor is set to the point position.

Screen update can be aborted safely after each line. If a character is received on the console terminal during an update, it is aborted. The screen will settle on the correct display as soon as update catches up with character input.

Every character written to the screen goes through this update process. Nowhere is a character written directly. The only direct write to TTY other than screen update is the BELL code.

Code Organization

All executable code is in field 0. The last page of fields 0 and 1 holds core-resident OS/8. The two pages just below that in field 0 hold the `DSK:` device handler. The screen copy and render buffer can use the entire rest of field 1 (31 pages, 3968 words).

Every subroutine that implements an editor command skip-returns if successful, even if failure is impossible (e.g. move to end of buffer can't fail). Many other utility subroutines also skip-return on success. This allows what in modern high-level languages would be a catch-throw mechanism—failures can unwind up to whatever code can deal with them, and unwinding all the way to top level just rings the console bell. If a subroutine that logically can't fail takes the non-skip return, a fatal assertion failure is reported.

15-bit addresses and 24-bit integers are always stored little-endian. The high-order word of a 15-bit address is a `CDF` instruction.

File Output Size

OS/8 does not protect the file system from an application writing beyond the end of the allocated blocks for an output file. When writing a file, E8 calculates the number of OS/8 blocks needed and asks for one more than that number. Bugs may cause the calculation to be inconsistent with the number actually needed. E8 counts written blocks and aborts the file write if there is an attempt to write more than OS/8 allocated (which should be the number asked for). After a write the calculated and actual values are displayed in the

mode line. They should always be equal. The one extra asked for allows some overwrite to be tolerated without harm, and the calculated/actual values will be off by one to show what happened. I have never seen any errors in calculating file size, but be aware and report inconsistencies.

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