Toggling in a simple program DEC PDP-8 and PiDP-8 using the switch register

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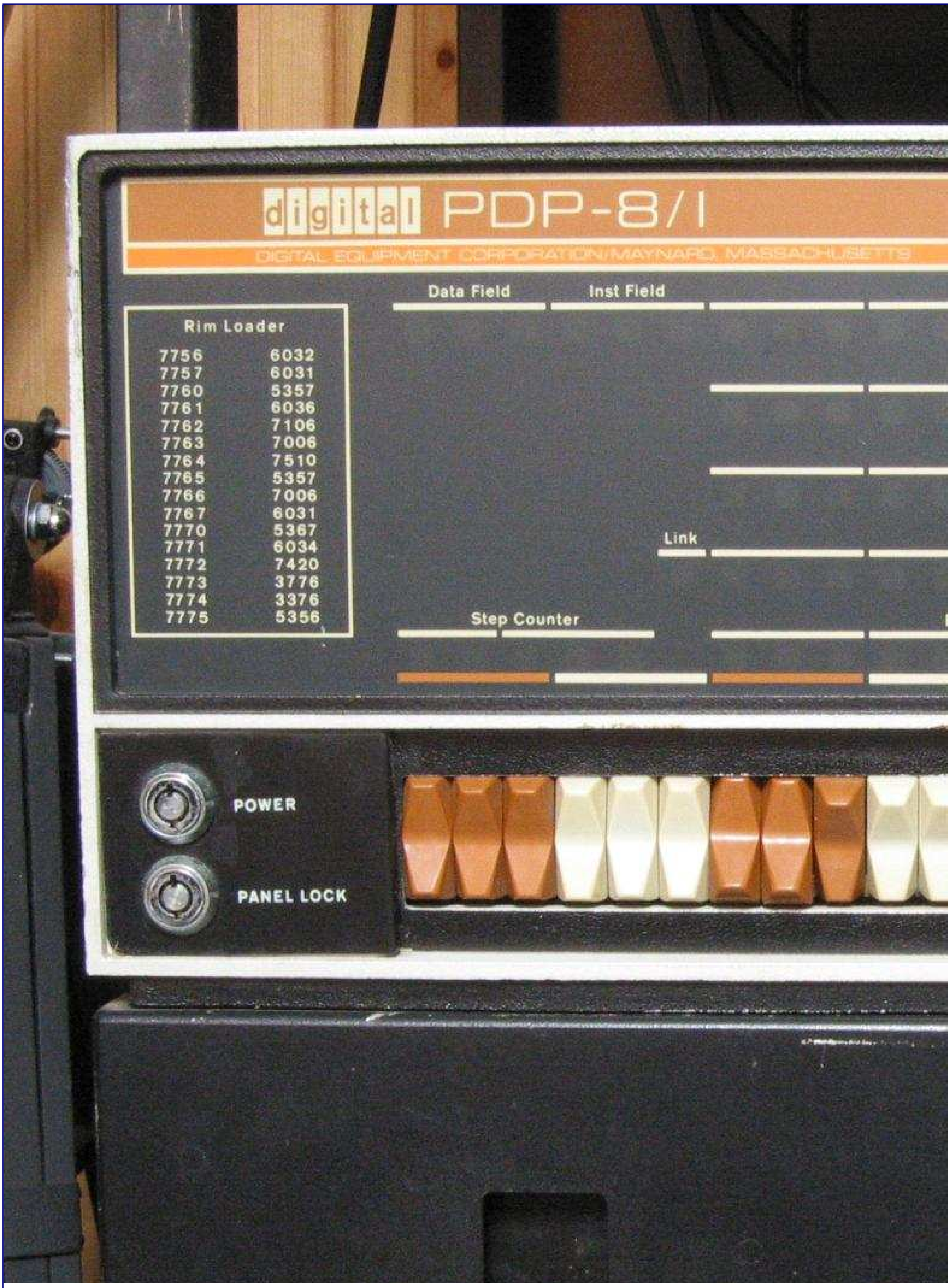

Rim Loader

7756	6032
7757	6031
7760	5357
7761	6036
7762	7106
7763	7006
7764	7510
7765	5357
7766	7006
7767	6031
7770	5367
7771	6034
7772	7420
7773	3776
7774	3376
7775	5356

- An original PDP-8/i.

In this guide I'll show you how to toggle in a simple program on the DEC PDP-8 or the PiDP-8, or in a front-panel simulator named BlinkenBone if you lack the hardware. I have a replica of the PDP-8/I (the PiDP-8) but lacked the actual knowledge on the front panel and switches to get started and do something cool. This guide has step by step instructons, with pictures, and basic explanation. After all, what is an expensive blinking light panel without fun stuff to toggle in?

As you might know, I'm a fan of the PDP line of computers and legacy systems in general. Mainframes, homecomputers, you name it and I probably like it. Add flashing lights, panels and big controls to it and you have my attention in no time.

Plus, in previous jobs I've worked on mainframes, VAX and PDP systems and the emulators used to keep those systems running on modern hardware. Think hospitals, banks, insurance companies, train signalling control and the likes. So, the interest did not spawn from nowhere.

Oscar Vermeulen created an amazing replica of the PDP-8/I. It's a front panel with working switches and LED's, plus a simple Raspberry Pi running the SIMH emulator. I've written multiple articles on the PDP and PiDP-8 and I like the device a lot in general.

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Backstory

I did however only use the serial console and SSH to control the PDP-8 computer. Since I'm managing a lot of Linux/UNIX systems that's what I'm familiar with. But, the PiDP-8 (and the PDP-8/I) has a front panel with switches and lights. The lights show the different parts of the system, like the memory, program counter and contents of the registers and the switches allow you to manually control all those aspects.

There is little documentation on using those switches, except for the excellent manuals from DEC. No simple, get started using the switches guide. This page aims to solve that by showing you, step by step, how to toggle in a very, very simple program, by hand. What it does? It manually moves a bit through the Accumulator lamps.

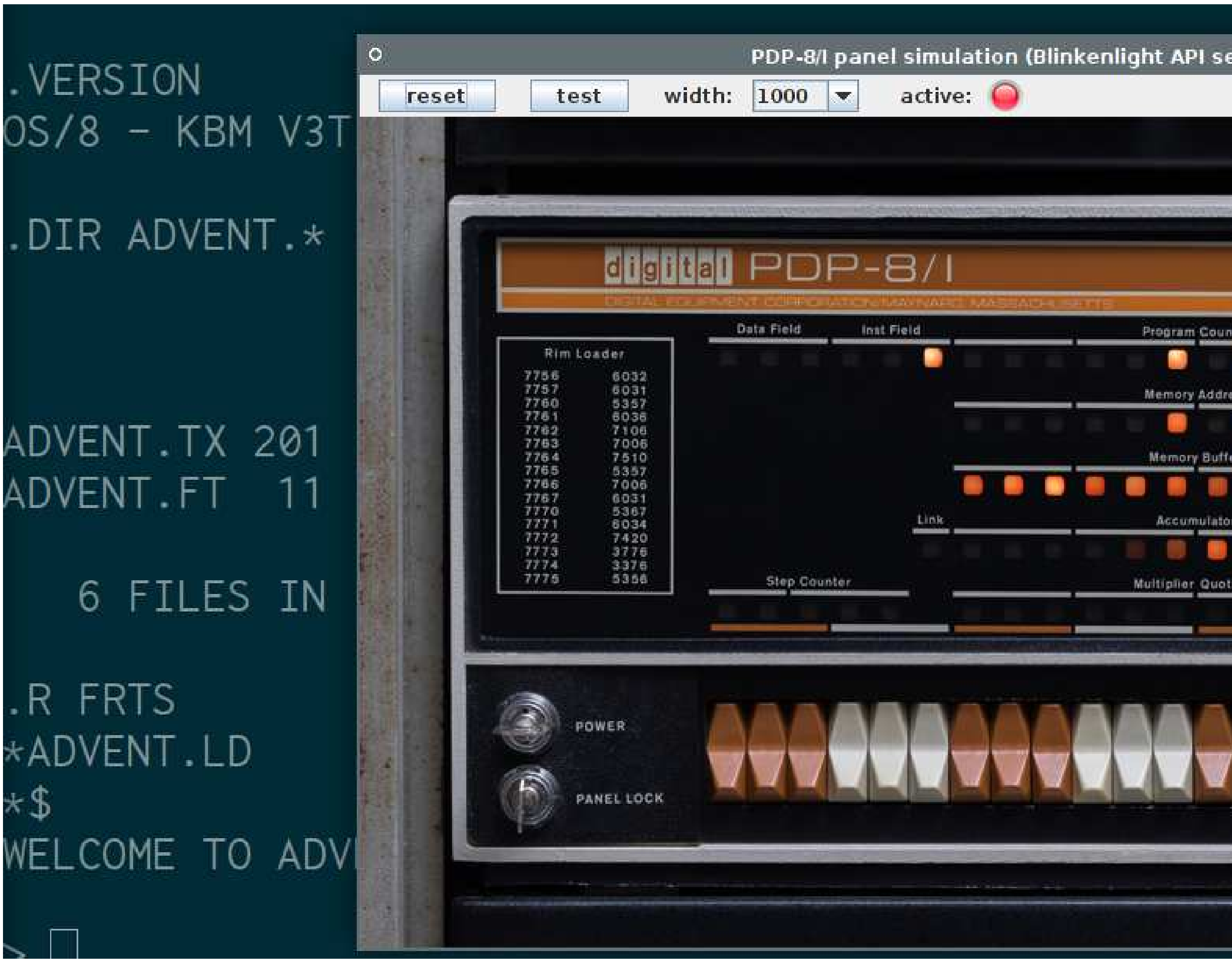
I found the program and tutorial on this page, it is from the BlinkenBone author. This page is based on that, but hopefully, geared more to new users.

This guide covers the BlinkenBone panel simulator, explains the Switches, explains the Lamps (Register Indicators), explains the program and then starts with the step by step guide to toggle that in.

BlinkenBone

BlinkenBone is another super nice project which provides the front panels of various PDP computers as a JAVA based GUI and backend server. It describes itself as `an architecture to connect simulators of vintage computers with "Blinkenlight panels"`.

If you don't have a PDP-8 or PiDP-8 replica, you can use BlinkenBone to still be able to use the front panel of such an actual machine. This page has a lot of very detailed information on the PDP-8/I and it's front panel. It is a very good read.



```
.VERSION
OS/8 - KBM V3T

.DIR ADVENT.*



ADVENT.TX 201
ADVENT.FT  11

   6 FILES IN

.R FRTS
*ADVENT.LD
*$
WELCOME TO ADV
```

PDP-8/I panel simulation (Blinkenlight API se

width: 1000

Rim Loader

7756	6032
7757	6031
7760	5357
7761	6036
7762	7106
7763	7006
7764	7510
7765	5357
7766	7006
7767	6031
7770	5367
7771	6034
7772	7420
7773	3776
7774	3376
7775	5356

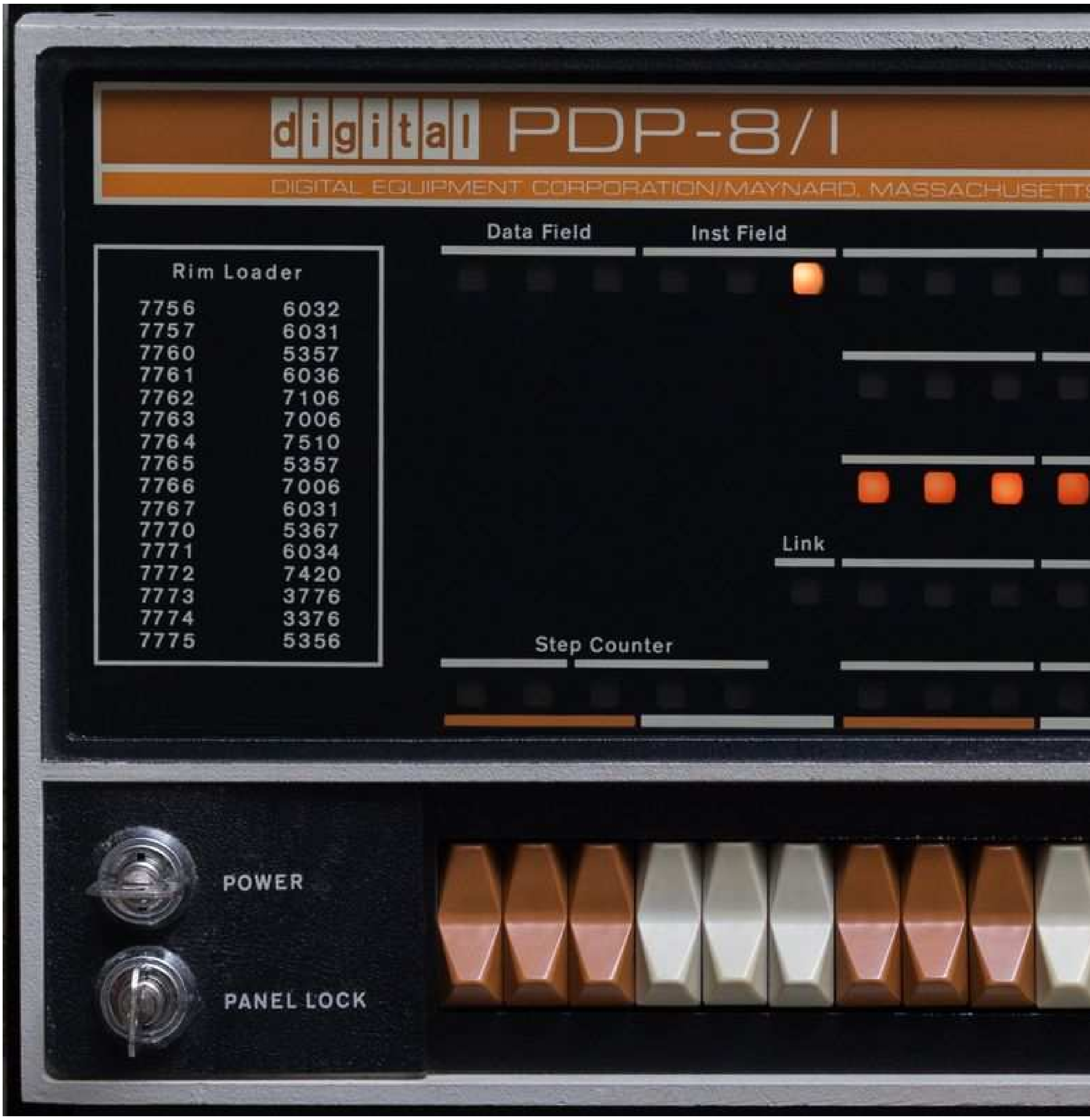
The above picture is a screenshot of BlinkenBone running on my machine showing the PDP-8/I front panel while running Adventure. I have the luck of having an actual replica, the PiDP-8, but for those without one, this is an excellent alternative.

Read this page for installation instructions on BlinkenBone. It is Java software, so it runs on Windows, Mac and Linux. There is also a special Raspberry Pi version. Installation is very easy, download the archive, extract it and run the starting script.

BlinkenBone also has a few other simulated panels, for example for the PDP-11/70, PDP-10 KI10 and a PDP-11/20. Please make some time to play with those since it's awesome.

Jorg Hoppe, behind the BlinkenBone, noted that it is an excellent idea and a great experience to run the BlinkenBone software on a large touchscreen. Quoting, "Operating the panel in original size on a 23 inch screen with your fingers is absolutely worth the extra $$$. (I use an Acer 232TL under Win10).". I did try it myself on a small Asus Transformer tablet running Windows 10, 10 inch, and even that is a very nice experience.

Switches and Lamps



An actual PDP-8/I front panel.

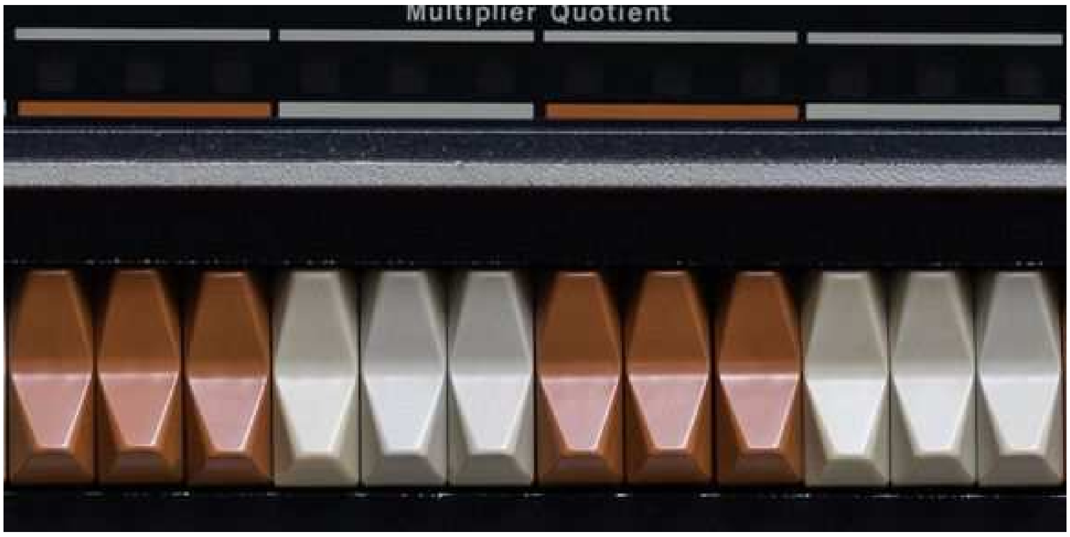
I'll use the term PDP-8 further on in the tutorial, but by that I also mean the PiDP-8 or the BlinkenBone GUI.

The below sections cover the functions of the switches and the lamps. Skip over it if you just want to start toggling.

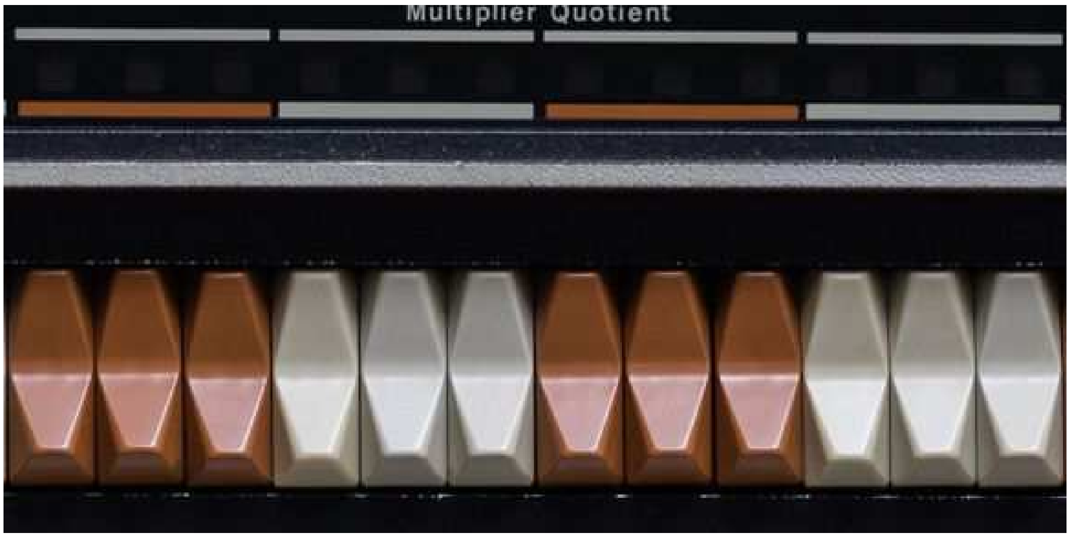
Front Panel switches

The front panel of the PDP-8/I has 26 switches. From left to right, the first three control the `Data Field` (DF). DF determines the core memory field of data storage and retrieval.

The second three control the `Instruction Field` (IF). IF determines the core memory field from which instructions are to be taken.



The third, fourth, fifth and sixth pair of switches control the `Switch Register` (SR). The Switch Register provides a means of manually setting a 12-bit word and load that into the PC (program counter) by pressing the `Load Add` key or load the content into the `MB` (Memory Buffer) and core memory with the `Dep` key.



The last switches are, from left to right, in order the following.

- `Start`: Starts the program by turning off the program interrupt circuits clearing the AC (Accumulator) and L (Link), setting the Fetch state, and starts the central processor.
- `Load Add` (Load Address): This key transfers the content of `SR` (Switch Register) into `PC` (Program Counter), the content of `INST FIELD` switches into `IF`, the content of the `DATA FIELD` switches into `DF`, and clears the major state flip-flops.
- `Dep` (Deposit): This key transfers the content of `SR` (Switch Register) into `MB` (Memory Buffer) and core memory at the address specified by the current content of `PC` (Program Counter). The major state flip-flops are cleared. The contents of `PC` (Program Counter) is then incremented by one to allow storing of information in sequential core memory addresses by repeated operation of the `Dep` key.
- `Exam`: This key transfers the content of core memory at the address specified by the content of `PC` (Program Counter), into the `MB` (Memory Buffer). The content of the `PC` (Program Counter) is then incremented by one to allow examination of the contents of sequential core memory addresses by repeated operation of the `Exam` key. The major state flip-flop register cleared. The `MA` (Memory Address) indicates the address of the data in the MB.
- `Cont` (Continue): This key sets the RUN flip-flop to continue the program in the state and instruction designated by the lighted console indicators, at the address currently specified by the `PC` (Program Counter) if key `SS` (Single Step) is not on.
- `Stop`: Causes the RUN flip-flop to be cleared at the end of the instruction in progress at the time the key is pressed.
- `Sing Step` (Single Step): This key causes the RUN flip-flop to be cleared to disable the timing circuits at the end of one cycle of operation. Thereafter, repeated operation of the `Cont` key steps the program one cycle at a time so that the operator can observe the contents of registers in each major state.
- `Sing Inst` (Single Instructon): This key allows execution of one instruction. When the computer is started by pressing the `Start` or `Cont` key, the `Sing Inst` key causes the

RUN flip-flop to be cleared at the end of the last cycle of the current instruction. Thereafter, repeated operation of the `Cont` key steps the program one instruction at a time.

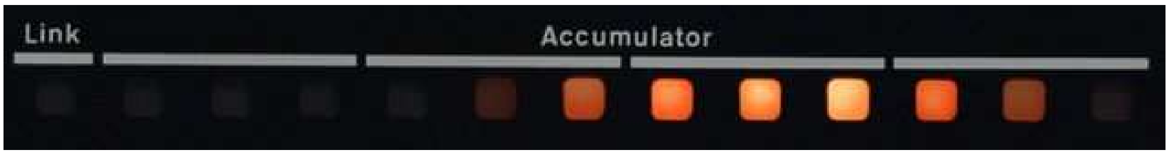
Register Indicators Lamps

The Lamps are called `Register Indicators`. These are also explained below, from top to bottom.

- `PC` (Program Counter): The `PC` contains the location of the next instruction to indicators be performed.

- `MA` (Memory Address): Indicate the content of `MA`. Usually, the contents of `MA` indicators denote the core memory address of the word currently or previously read or written. After operation either the `Dep` or `Exam` key, the contents of `MA` indicate the core memory address just examined or deposited into.

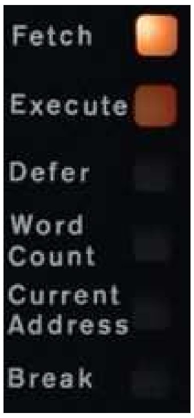
- `MB` (Memory Buffer): Indicates the content of `MB`. Usually, the contents of `MB` indicators designate the word just written at the core memory address in `MA`.



- `L` (Link): Indicates the content of `L`.
- `AC` (Accumulator): Indicates the content of `AC`.

- `MQ` (Multiplier Quotient): Indicates the content of the multiplier quotient. `MQ` holds the multiplier at the beginning of a multiplication and holds the least-significant half of the product at the conclusion. It holds the least-significant half of the dividend at the start of division and holds the quotient at the conclusion.

Major state indicators

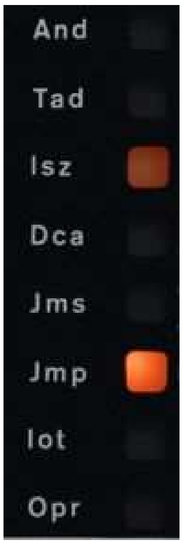


These lamps indicate that the processor is currently performing or has performed such a cycle. `Fetch` for example indicates that the processor is currently performing or has performed a `Fetch` cycle.

Miscellaneous indicators

- `Ion`: Indicates the status of the `INT.ENABLE` flip-flop. When lit, the interrupt control is enabled for information exchange with an I/O device.
- `Pause`: Indicates the status of the `PAUSE` flip-flop when lit. The PAUSE flip-flop is set for 2.75 microseconds by any `IOT` instruction that requires generation of `IOP` pulses or by any `EAE` instruction that requires shifting of information.
- `Run`: Indicates the status of the `RUN` flip-flop. When lit, the internal timing circuits are enabled and the machine performs instructions.

Instruction indicators



These lamps indicate that the processor is currently performing or has performed such an instruction. For example, `And` indicates that the processor is currently performing or has performed an `And` instruction.

The above sections were slightly adapted from this page.

The program to blink lamps

The program we are going to toggle in is a very simple program. It sets a bit in the accumulator and `HALT's`. When we, the user, press the `Cont` switch, it shifts the bit to the left in the `AC`, and so on.

We are going to use an assembler to assemble the assembly code into binary. In this case we are using `palbart`. You can download palbart here and read more on it here. In case the download site ever goes down, I've mirrored the C code here and the linux executable here.

Below you can find the assembler code of the program:

```
/ shifter - manually move a bit through the Accumulator lamps
*100                    / start addr
        CLA CLL IAC     / Link=AC=0, AC++. AC now 1
LOOP,
        RAL             / rotate the bit left through AC and Link
        HLT             / wait for user to CONTinue
        JMP     LOOP    / again
$
```

There are comments in the code, and if you want to read more about the PDP-8 assembly instruction set on this page named "What is the PDP-8 instruction set?". By reading that you understand the code above a bit more.

Make sure you have downloaded `palbart`. Save the above code, for example in a file named `shifter.pal`. Then run it through the assembler:

chmod +x ./palbart ./palbart shifter.pal

A file "shifter.lst" is produced:

```
/ shifter - manually move a bit through the Accumulator lamps        Page 1

    1              / shifter - manually move a bit through the Accumulator lamps
    2
    3        0100  *100                    / start addr
    4 00100  7301          CLA CLL IAC     / Link=AC=0, AC++. AC now 1
    5              LOOP,
    6 00101  7004          RAL             / rotate the bit left through AC and
Link
    7 00102  7402          HLT             / wait for user to CONTinue
    8 00103  5101          JMP     LOOP    / again
    9
   10              $
      No detected errors
      No links generated
```

The first collumn represents the `Address` and the second column represents the (binary) `Contents` of that register.

Step by step

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So, we have the memory addresses and the data, but how do we toggle that in? Start by firing up your `PiDP-8`, PDP or start up the BlinkenBone.

After downloading and extracting BlinkenBone, navigate to that folder and, on Ubuntu, start the `prepare.sh` script to install dependencies:

```
sudo bash prepare.sh
```

On other distro's, install `java` and `rpcbind`.

Start the PDP-8 with the `ADVENT` disk coupled:

```
sudo bash pdp8i_os8advent.sh
```

A Java window with the front panel opens, and the terminal starts up the SIMH emulator. Wait a few moments until it is finished. The terminal shows the following:

```
WELCOME TO ADVENTURE!!  WOULD YOU LIKE INSTRUCTIONS?

>
```

Above is a video of a screen recording showing the front panel while ADVENT is running. If it's not loading, view it on Youtube.

Toggle!

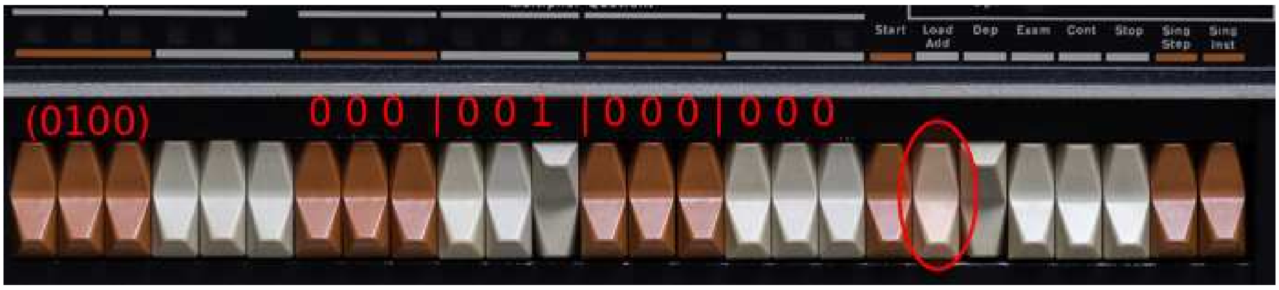
Now on the panel (PDP-8, PiDP-8 or emulator) toggle the `Stop` switch. By toggle, I mean, push it so that it changes state and push it again so that the state is back as it was before the first toggle.

After toggling the `Stop` switch, the Lamps should stop moving. We've stopped the execution of ADVENT and OS/8.

The `Switch Register` switches are Octal. In this case that means that they represent 0 to 7 (8 possibilities). From left to right, a pair of three switches represent the values `4`, `2` and `1`. If you toggle the rightmost switch, it contain the value `1`. If you toggle the middle switch and the rightmost switch, it will contain the value `3` and so on. Below is a picture to make it more clear:

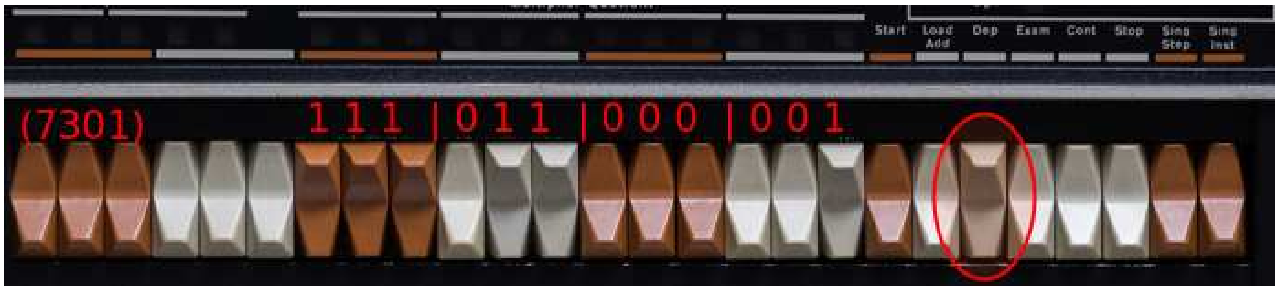
Do note that the `Dep` switch is in the oposite position. In the pictures below it looks like it's always toggled, and that is the case, so don't worry.

After we toggled the STOP switch, we can start toggling in the program. The first thing we do is toggle in the value 100 and then toggle the Load Add switch to set the start address in the PC (program counter):

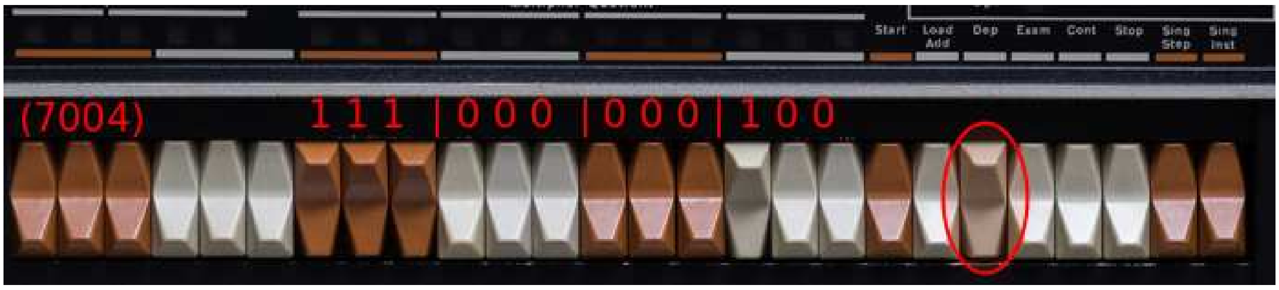


The octal value 100 is represented by the switch positions 000 001 000 000.

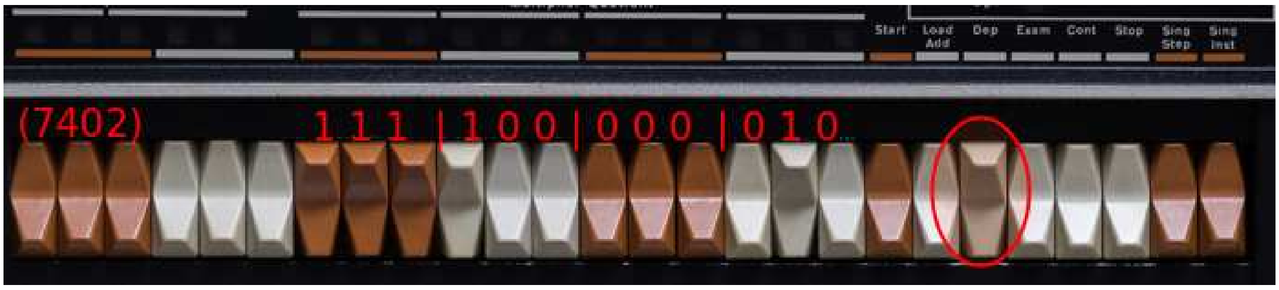
The second instruction we toggle in is 7301 (Link=AC=0, AC++. AC now 1). The octal value on the switches it: 111 011 000 001. Do note not to toggle the Load Add switch, but the Dep switch. I made that mistake a few times at first. We are not loading that address, but we are depositing the value in the address we loaded earlier. Below is a picture:



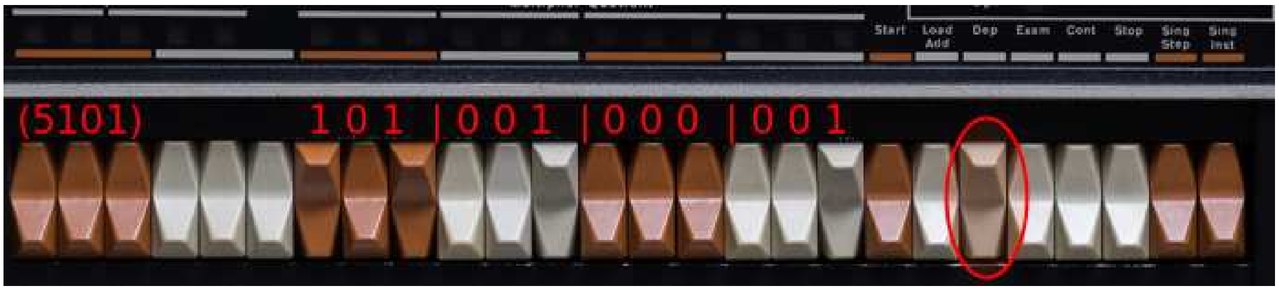
The third instruction we toggle in is 7004 (rotate the bit left through AC and Link). The octal value is: 111 000 000 100. Picture below:



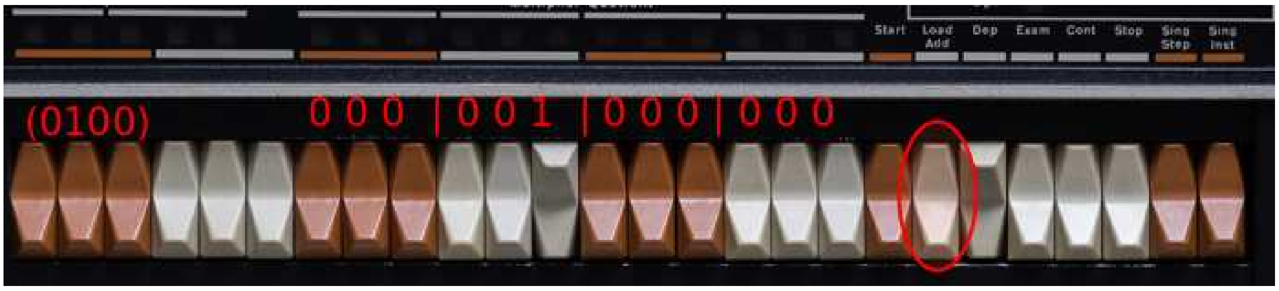
The fourth instruction is 7402 (wait for user to CONTinue). The octal value is: 111 100 000 010. Picture below:



The fifth instruction is 5101 (JMP to LOOP, start over). The octal value is: 101 001 000 001. Picture below:

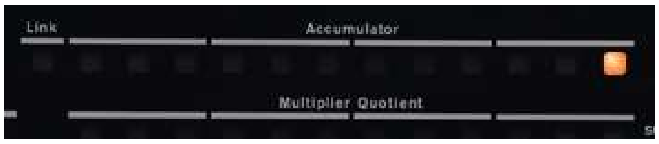


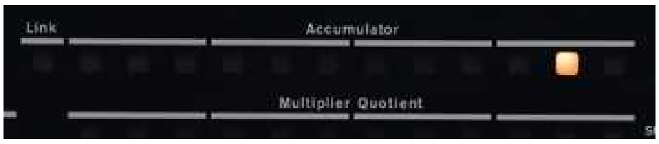
The sixth instruction we are toggling in is the same as the first, 0100. Toggle the `Load Add` switch to set the start address in the `PC` (program counter):

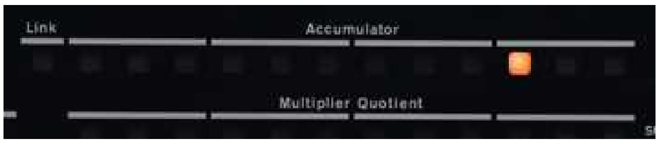


Now the program is in the memory of the PDP. By toggling in 0100 and then loading that address, we make sure that when we toggle START, the PDP starts execution there.

So, the next thing to do is toggle the `START` switch. What happens is that the on the Accumulator lamp row, all lamps turn of and one lights up. Then nothing happens. Toggle the `Cont` switch, then the Lamp turns off and the Lamp left of it lights on. See the three examples below:







The basic flow is: set a bit, then start the loop which shifts that bit, then halts until the user toggles the continue switch.

Here below is a recording showing the emulator running this program:

If it's not loading, view it on Youtube here.

That's all there is. I hope you have enjoyed this guide and enjoyed playing with the PDP-8.