Cosmac ELF
The ESoCoP version

written by Sergio Gervasini for ESOCOP
The European Society for Computer Preservation
http://www.esocop.org

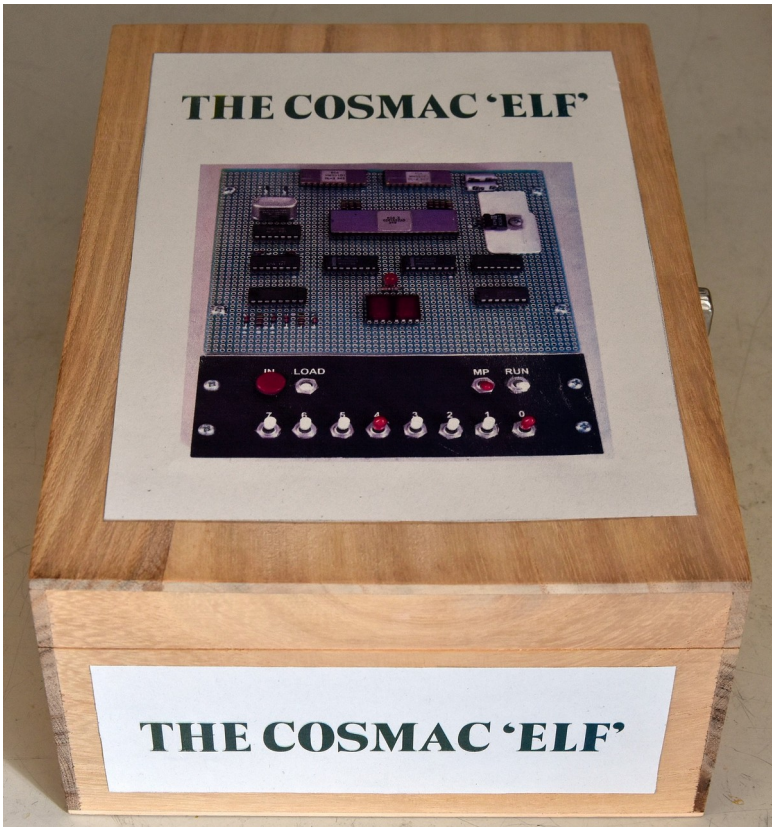


Table of Contents

License

References

The four original articles written by Joseph Weisbecker for Popular Electonics in 1976/77 about Cosmac 'ELF':

https://www.esocop.org/docs/Poptronics-CosmacELF.pdf

The CDP1802's Place in Microcomputing History (and the relative forum):

http://www.cosmacelf.com/

A Paul Schmidt book, containing also schematic, parts list and templates:

http://www.cosmacelf.com/publications/books/cosmac_elf_build_details.zip

Build A Classic COSMAC ELF Microcomputer at the 2016 Vintage Computer Festival Midwest:

http://www.sunrise-ev.com/vcf-elf.htm

A Cosmac ELF by Jim Kearney:

https://www.jkearney.com/elf/

Chip Hall of Fame: RCA CDP 1802:

https://spectrum.ieee.org/chip-hall-of-fame-rca-cdp-1802

The COSMAC history

Cosmac ELF project has been imagined and thought a lot of time before its publication, and it is consequence of Joseph Weisbecker's (creator of the ELF itself) work involved in creating LSI chips and designing Microprocessors.

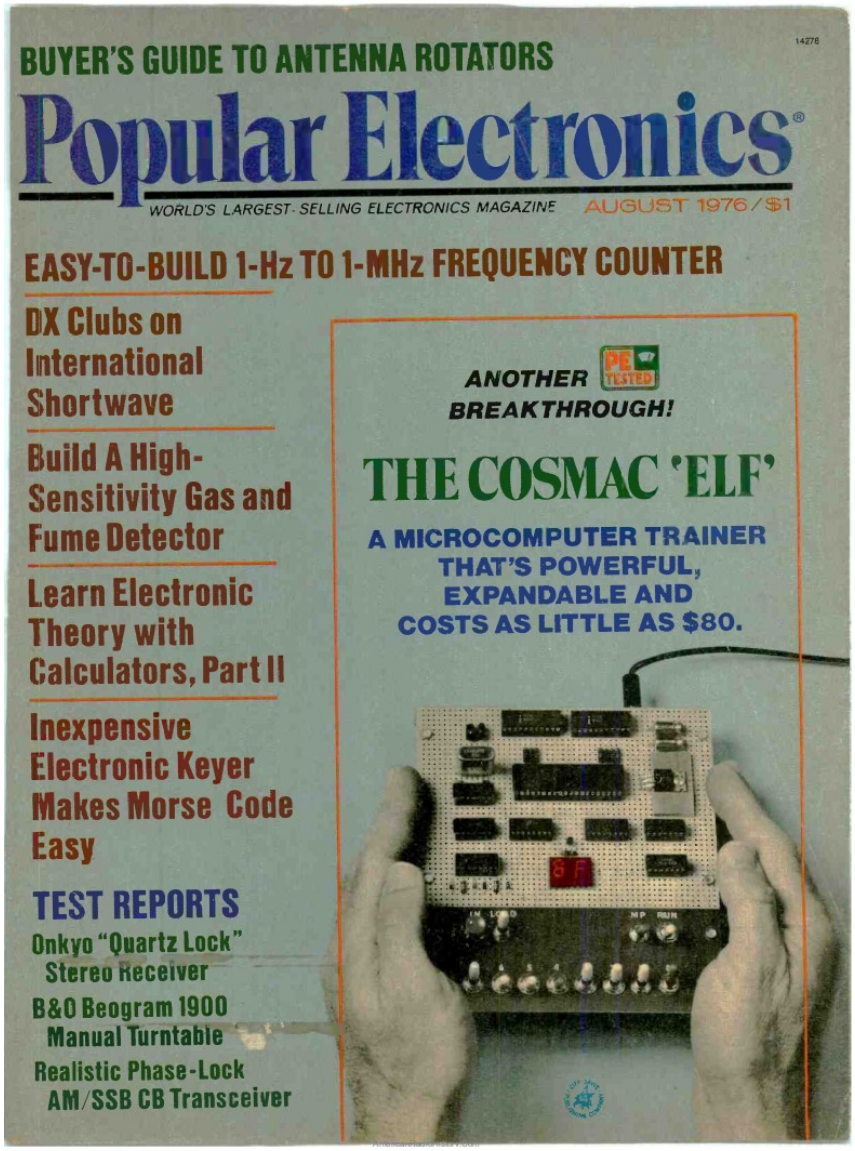
As an RCA engineer, since 1971 he started to develop a 8 bit computer architecture based on logical chips, already with the idea to gather everything in one or two chips.

Later, in that year Intel released the 4 bit 4004 processor, considered the first microprocessor in history, and this persuaded RCA board to carry on Weibecker's project, therefore in 1974 were marketed the microprocessors couple 1801U and 1801R, that in the next year have been joined together in a single chip: the COSMAC 1802.

It was the first processor using CMOS technology ("complementary silicon/metal-oxide semiconductor"), that, differently to all other producers who used MOS technology, drived to a better noise immunity and very low power consumption; CMOS acronym was the base for the COSMAC definition too: "complementary-symmetry monolithic-array computer"

Weisbecker himself did the development board RCA Microtutor, and a demo computer called FRED (Flexible Recreational and Educational Device), that in the commercial version become "Studio II".

Weisbecker was really convinced that processors would become popular, that's why he designed and published in August 1976 on Popular Electronics an article which explaned how to realize a computer based on 1802 processor called ELF, for only $80.



In succeeding articles a lot of expansions were described and realized, and they made the COSMAC ELF a real home computer, starting a sort of open-source hardware community of hobbyists which created several accessories and new expansions.

The COSMAC 1802, despite it's poor market success, has been often exploited in aerospace industry because of its reliability in adverse conditions; for example Galileo Probe, which has been in orbit around Jupiter between 1995 and 2003, had 6 onboard.

Joseph Weisbecker died in November 1990, and his work deserve to be reminded not only because he designed the 1802, but also because he gave his knowledge out to the community, as he was a forerunner of the open-source philosophy.

Design guidelines

Recreating today the Cosmac ELF in the same way it has been originally made is an interesting experience, it let us go over again wireing techniques no more used, but standard of that time, such as wire-wrapping.

The article itself does not state that wire-wrapping "must" be used, but it defines wire-wrapping one of the techniques usable to implement the circuit. We decided to use this technique.

Since doesn't exist any specific construction details, we stuck to the photos, accordingly the main guideline we used has been the aesthetic fidelity, as well as functional, to the original.

Differences

We are used to choose the oldest datecode and in this case we privileged RCA signed chips. In some cases we had to compromise:

- 7805 as a power regulator instead of LM309K originally in the schema (probably wrongly defined)
- MWS5101 memories, instead of 2101
- CD4066 instead of CD4016s (that's because we already had them in the lab drawers...)

Moreover we had availability of ceramic chips such as 1802 and memories, that's why we decided to use those, even if in the original article photos from 1976 chips were plastic.

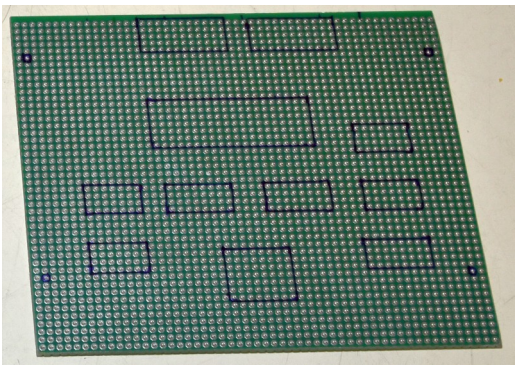
The perforated board is based on double side vetronite instead of the original one, probably based in single side bakelite.

Chip sockets are slightly different from originals, moreover we had to adapt wire wrap sockets strips for memories, since we were unable to find the right sockets.

Switches panel has been done in aluminum by a specialized company , who printed labels directly on the panel and not through dry-transfer lettering kit as described inside the article.

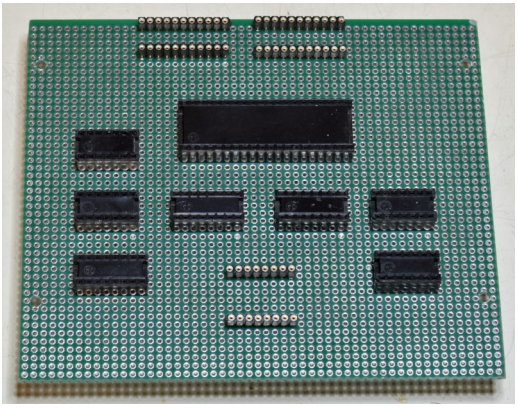
Building the Cosmac ELF

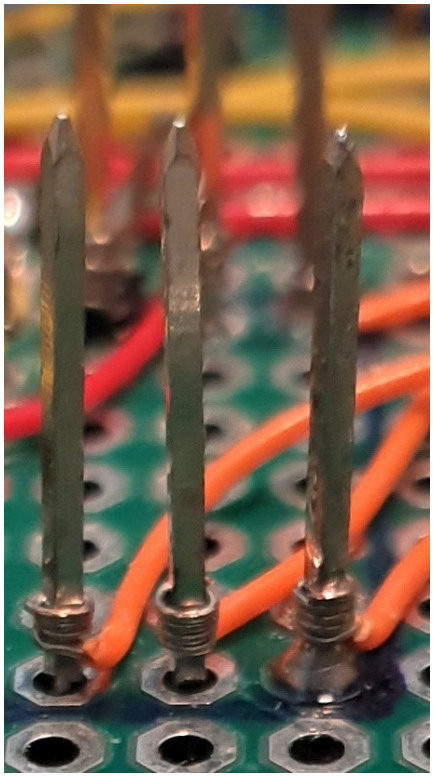
The board



We started from a perforated board with 0.1" (2.54 mm) hole spacing, cutting at 5½"L x 4"W (14 x 10.2 cm). We have drawn directly on it, on the backside, integrated circuits positioning.

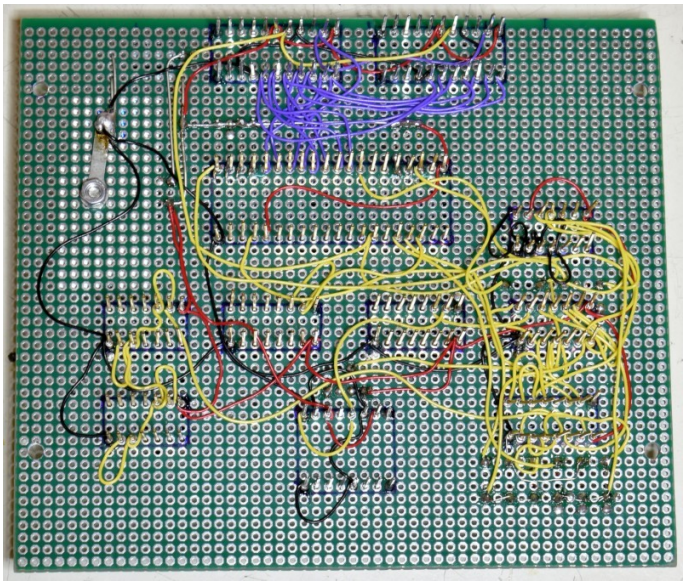
Afterwards we did the holes for screws and we placed the sockets fixing them with a single tin drop at two opposite pins.





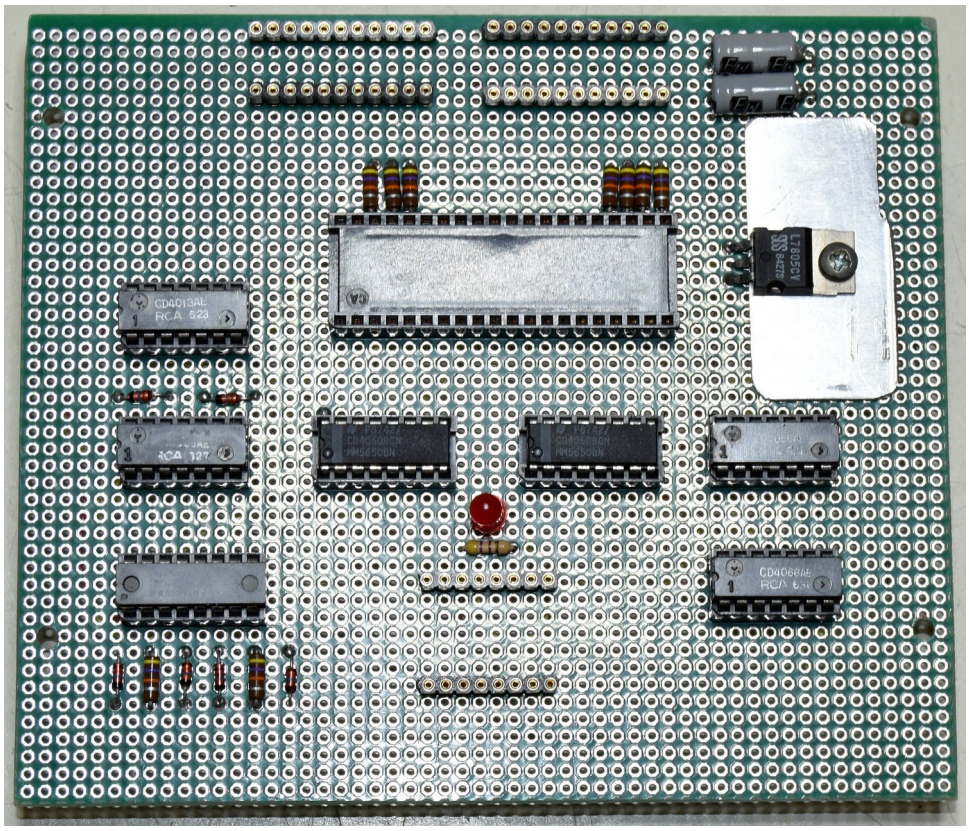
After placing and fixing the voltage regulator and discrete components, we started to cable wires with wire-wrap technique.

We did not have practice ith this technique, whereby we did some experiments before going on.

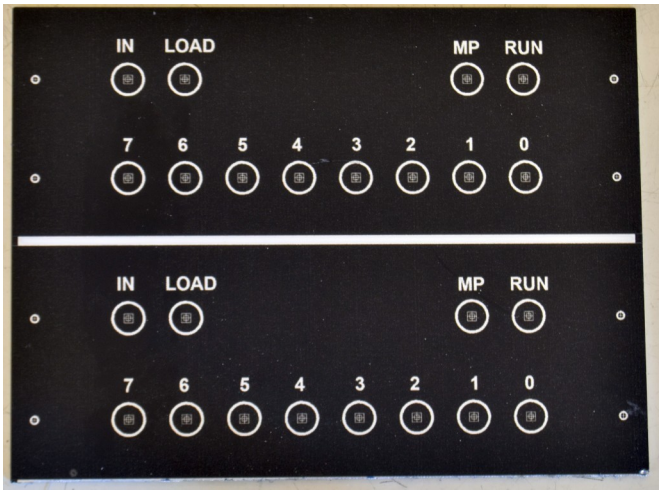


We used different colours depending of signal type; this is the result of a few working hours. Probably is not a professional work, but result is quite good.

Here it is our board with some of the chips installed, ready to be assembled with the aluminum switches panel:



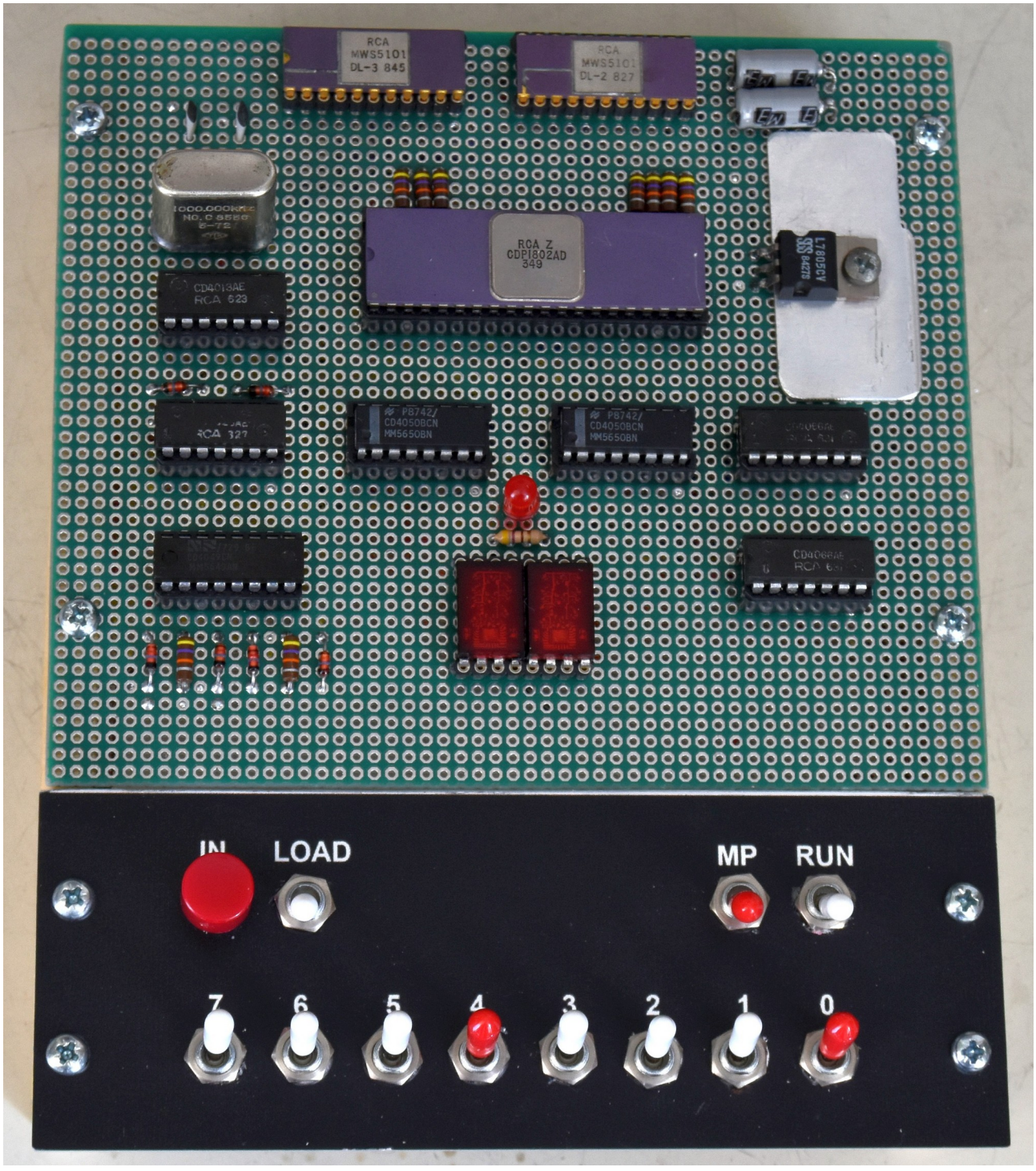
Assembly

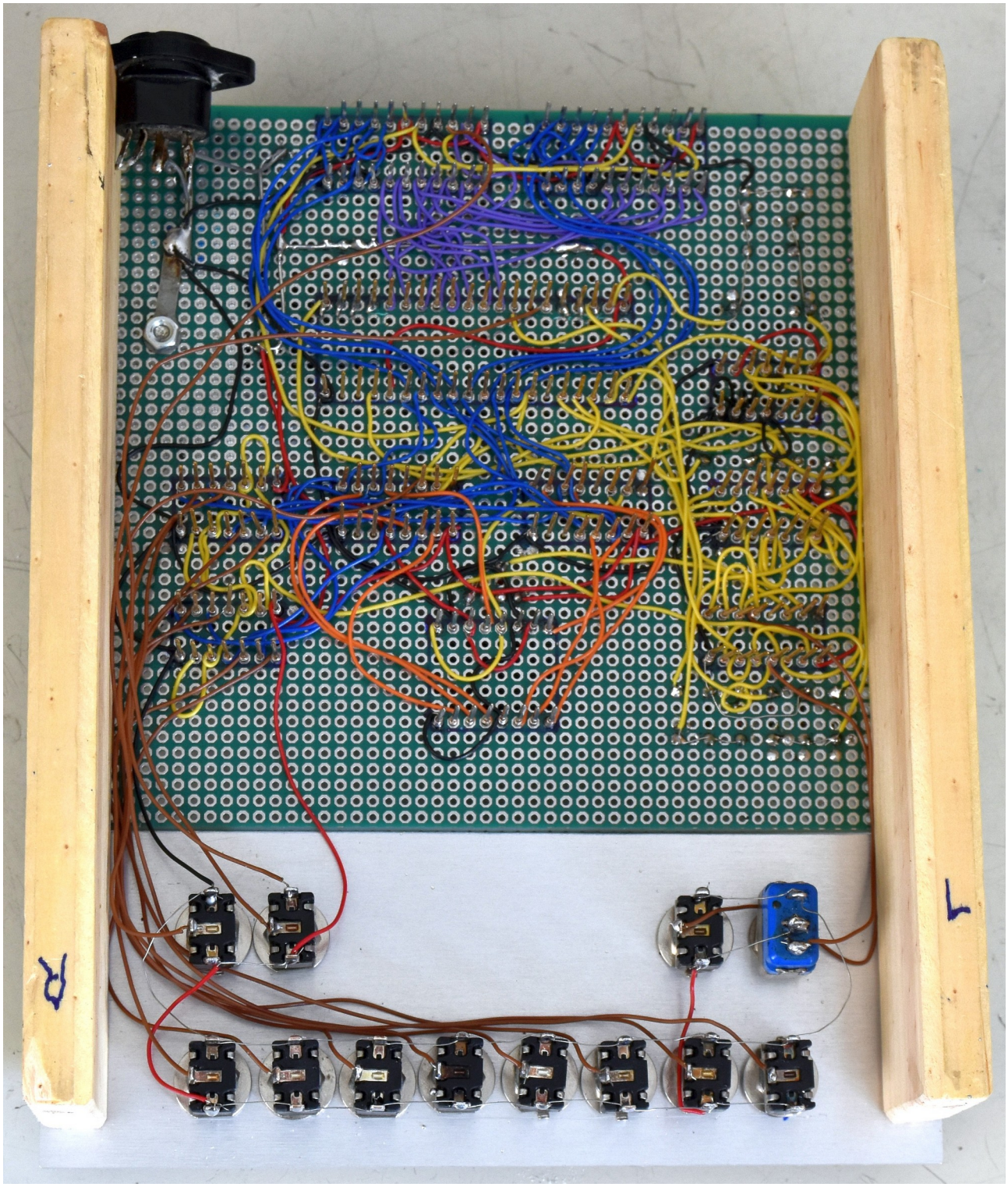


We did cut two wood pieces in order to create the lateral support, then we cut and drilled the switches panel. We decided to create three different panels from a single aluminum plate, cutting it accordingly.
The two remaining panels will be used in other replicas that we'd realize in the future.

Once everything has been assembled and every cable for the switches has been wired, we added a back connector for the power and reused a 9v power supply we already had in the lab.

Here it is the final result:

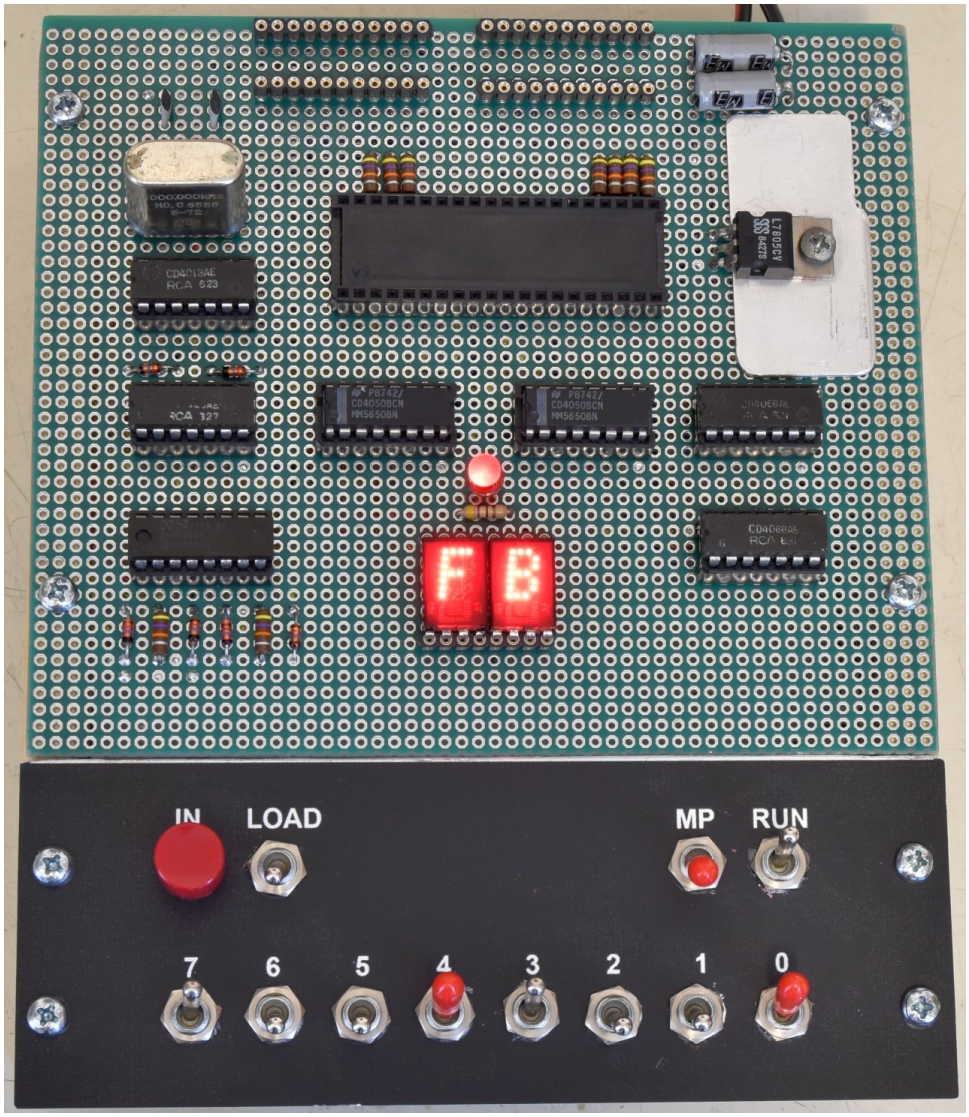




Testing

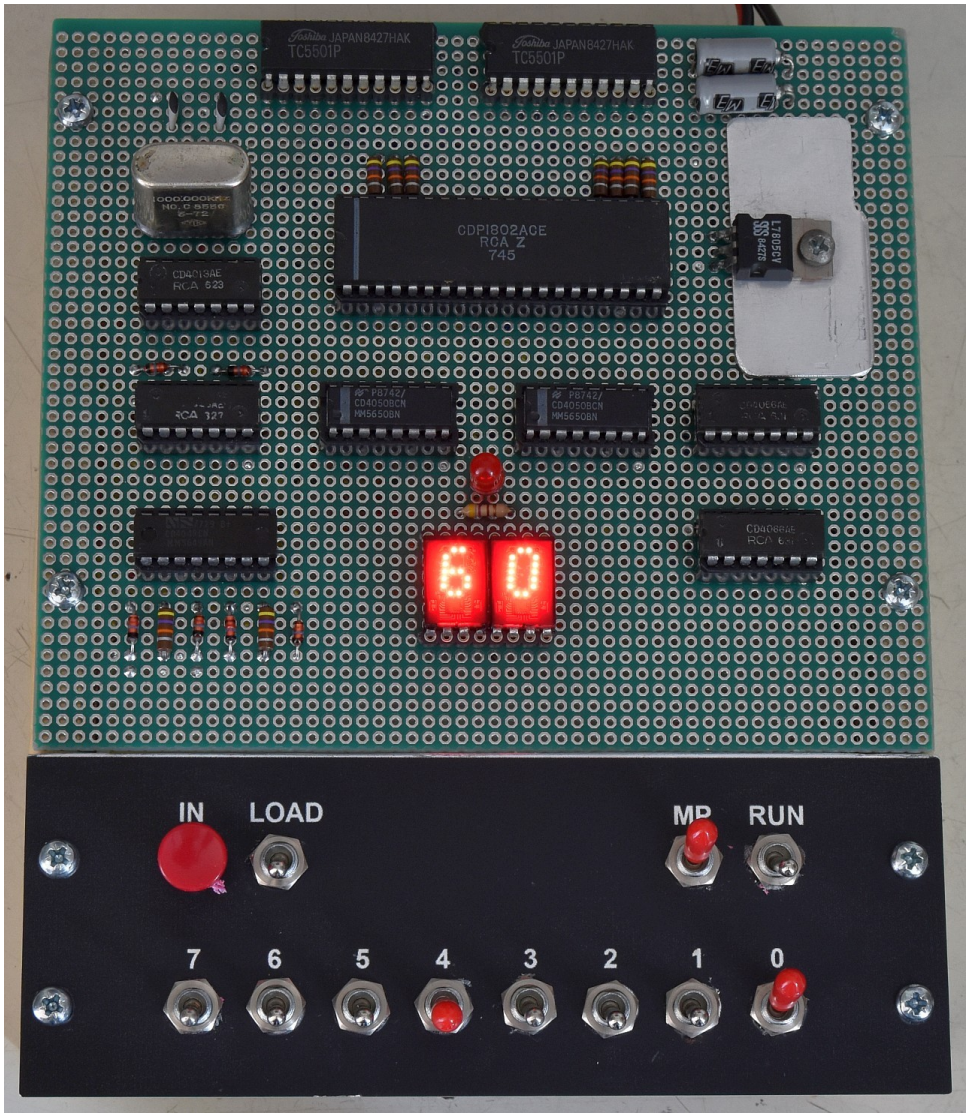
We did control every single wiring before testing without chips that the voltage was actually 5v and correctly reached every socket.

Then we installed chips and display, leaving out only CPU and RAM, to test a fast power up and display operation.



Final test

Finally we installed CPU and RAM, in plastic chip in order not to damage the ceramics, and we tested the final result with example softwares we found in the original articles.



Result has been very satisfying and we have been pleasantly surprised in how to load programs, it has been quite simple despite we thought it was creepy hard.

Programming the 1802 is very efficient, it permits to create complex things with a small number of instructions.

The final touch

Such a particular object could not stay without a proper box protecting it. We built a wood box with correct size to hold a small power supply too.