

AccessionIndex: TCD-SCSS-T.20250916.002

Accession Date: 16-Sep-2025

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Object name: Linux/4004 board

Vintage: 2025

Synopsis: A replica of the board that hosted the epic first successful boot of Linux on the 4004, the first commercially successful microprocessor.

Description:

This very ambitious project [1] to boot Linux on the Intel 4004 was undertaken by Dmitry Grinberg over an astonishingly short seven month period.

Of the first clutch of microprocessors, only two became standard commercially available products: the Intel 4004 and the Fairchild PPS-25. The Intel 4004 [2] was the world's first commercially successful microprocessor, designed by Federico Faggin, Masatoshi Shima, Ted Hoff and Stan Mazor. To Faggin must go much of the plaudits, for using the silicon gate technology (SGT) he had invented at Fairchild, and for inventing how to use buried contacts and bootstrap loads with SGT, halving chip size and increasing yields. On 15th November, 1971, Intel published the now-famous advertisement in Electronic News (Fig.1), for many beginning the microprocessor age [3][4]. The chipset, marketed as *MCS-4* (see [5] and Fig.2) consisted of:

4001	256 x 8 ROM plus 4-bit I/O port
4002	80 x 4 RAM plus 4-bit output port
4003	10-bit parallel output shift register
4004	4-bit microprocessor
4008	8-bit memory address latch plus I/O port
4009	memory and I/O converter

The MCS-4 design details are well known and will not be repeated here. Suffice to say that the 4-bit 4004 contained just 2300 transistors (Figs.3-4) and executed instructions in 10.7 μ S with a 750kHz two-phase clock. From Dmitry's website [1]:

I booted Debian Linux on a 4-bit intel microprocessor from 1971 - the first microprocessor in the world - the 4004. It is not fast, but it is a real Linux kernel with a Debian rootfs on a real board whose only CPU is a real intel 4004 from the 1970s.

...

Of course, Linux cannot and will not boot on a 4004 directly. ... So, same as before, I would have to resort to emulation. ... After studying the options, it became clear that MIPS R3000 would be the winner here.

...

I have never before seen a CPU that lacked ability to do basic logical operations, until I saw the 4004 manual. The 4004 lacks ability to do any of them. There is no logical AND, no logical OR, and no XOR.

...

It was all worth it though! The boot time dropped to 4.81 days! ... Avoiding checks for need to sign-extend and for size loops added a small additional speed benefit: 4.76 days to boot!

For the full flavour of this *tour de force*, this amazing feat, the reader is encouraged to delve into [1] and peruse the photos of this item shown in Figs.5-10.

Many thanks to Dmitry Grinberg and Brian Coghlan for donating this item.

The homepage for this catalog is at: <https://www.scss.tcd.ie/SCSSTreasuresCatalog/>
 Click 'Accession Index' (1st column listed) for related folder, or 'About' for further guidance.
 Some of the items below may be more properly part of other categories of this catalog,
 but are listed here for convenience.

Accession Index	Object with Identification
TCD-SCSS-T.20250916.002	Linux/4004 board. A replica of the board that hosted the epic first successful boot of Linux on the 4004, the first commercially successful microprocessor, 2025.
TCD-SCSS-T.20250916.001	Intel 4004 and 4040 microprocessors and associated chips. The first commercially successful microprocessors. 1971.
TCD-SCSS-T.20251216.004	Arduino shield for Intel 4040. A board that enables execution of software by the 4040, 2025.
TCD-SCSS-X.20250916.001	Dr.Brian Coghlan's Collection of Early Microprocessors. An extensive and nearly complete set of unused 1970s microprocessor chips, most accompanied with documentation, some with demonstration boards. 1971.

References:

1. Dmitry Grinberg, *Linux/4004*, see:
<https://dmitry.gr/?r=05.Projects&proj=35.%20Linux4004>
 Last browsed to on 16-Sep-2025.
 Also: <https://www.scss.tcd.ie/SCSSTreasuresCatalog/hardware/TCD-SCSS-T.20250916.002/Linux-on-the-Intel-4004-DmitryGrinberg-16Sep2025-Word2025.pdf>
2. Wikipedia, *Intel/4004*, see:
https://en.wikipedia.org/wiki/Intel_4004
 Last browsed to on 16-Sep-2025.
3. Federico Faggin, *Silicon, From the Invention of the Microprocessor to the New Science of Consciousness*, pp.304, ISBN: 978-1949003413, Waterside Productions, USA, 8th February, 2021.
4. RobWalker, *Interview of Federico Faggin*, 9th June, 1998, see:
<https://www.scss.tcd.ie/SCSSTreasuresCatalog/hardware/TCD-SCSS-T.20250916.001/Interview-of-FedericoFaggin-byRobWalker-9Jun1998.pdf>
 Last browsed to on 16-Sep-2025.
5. Intel, *Intel MCS-4 User's Manual*, see:
<https://www.scss.tcd.ie/SCSSTreasuresCatalog/hardware/TCD-SCSS-T.20250916.001/Intel-MCS4-UsersManual-OCR.pdf>
 Last browsed to on 16-Sep-2025.

Announcing a new era of integrated electronics

A micro-programmable computer on a chip!

Intel introduces an integrated CPU complete with a 4-bit parallel adder, sixteen 4-bit registers, an accumulator and a push-down stack on one chip. It's one of a family of four new ICs which comprise the MCS-4 micro-computer system - the first system to bring you the power and flexibility of a dedicated general-purpose computer at low cost in as few as two dual in-line packages.

MCS-4 systems provide complete computing and control functions for test systems, data terminals, billing machines, measuring systems, numeric control systems and process control systems.

The heart of any MCS-4 system is a Type 4004 CPU, which includes a powerful set of 45 instructions. Adding one or more Type 4001 ROMs for program storage and data tables gives you a fully functioning micro-programmed computer. To this you may add Type 4002 RAMs for read-write memory and Type 4003 registers to expand the input ports.

Using no more than three ICs from this family of four you can create a system with 4096 8-bit bytes of ROM storage and 5120 bits of RAM storage. When you require rapid turn-around or need only a few systems, Intel's erasable and re-programmable ROM, Type 17E1, may be substituted for the Type 4001 mask-programmed ROM.

MCS-4 systems interface easily with switches, key boards, displays, teletypewriters, printers, readers, A/D converters and other popular peripherals.

The MCS-4 family is now in stock at Intel's Santa Clara headquarters and at our marketing headquarters in Europe and Japan. In the U.S., contact your local Intel representative for technical information and literature. In Europe, contact Intel at Avenue Louise 214, B 1050 Brussels, Belgium. Phone 482093. In Japan, contact Intel Japan, Inc., Parkside Plaza Bldg. No. 4-2-2, Sendagaya, Shibuya-Ku, Tokyo 151. Phone 03-409-4747.

Intel Corporation now produces micro computers, memory devices and memory systems at 3065 Bowers Avenue, Santa Clara, Calif. 95051. Phone (408) 246-7367.

intel delivers.

Figure 1: Intel 4004 advertisement, *Electronic News*, 15th November, 1971.

intel MCS-4 MICRO COMPUTER SET

NOVEMBER 1971

- Microprogrammable General Purpose Computer Set
- 4-Bit Parallel CPU With 45 Instructions
- Instruction Set Includes Conditional Branching, Jump to Subroutine and Indirect Fetching
- Binary and Decimal Arithmetic Modes
- Addition of Two 8-Digit Numbers in 850 Microseconds
- 2-Phase Dynamic Operation
- 10.8 Microsecond Instruction Cycle
- Easy Expansion - One CPU can Directly Drive up to 32,768 Bits of ROM and up to 5120 Bits of RAM
- Unlimited Number of Output Lines
- Single Power Supply Operation ($V_{DD} = -15$ Volts)
- Packaged in 16-Pin Dual In-Line Configuration

The MCS-4 is a microprogrammable computer set designed for applications such as test systems, peripherals, terminals, billing machines, measuring systems, numeric and process control. The 4004 CPU, 4003 SR, and 4002 RAM are standard building blocks. The 4001 ROM contains the custom micro-program and is implemented using a metal mask according to customer specifications.

MCS-4 systems interface easily with switches, keyboards, displays, teletypewriters, printers, readers, A-D converters and other popular peripherals.

A system built with the MCS-4 micro computer set can have up to 4K x 8 bit ROM words, 1280 x 4 bit RAM characters and 128 I/O lines without requiring any interface logic. By adding a few simple gates the MCS-4 can have up to 48 RAM and ROM packages in any combination, and 192 I/O lines. The minimum system configuration consists of one CPU and one 256 x 8 bit ROM.

The MCS-4 has a very powerful instruction set that allows both binary and decimal arithmetic. It includes conditional branching, jump to subroutine, and provides for the efficient use of ROM look-up tables by indirect fetching.

The Intel MCS-4 micro computer set (4001/2/3/4) is fabricated with Silicon Gate Technology. This low threshold technology allows the design and production of higher performance MOS circuits and provides a higher functional density on a monolithic chip than conventional MOS technologies.

Figure 2: Intel MCS4 specification, November 1971.

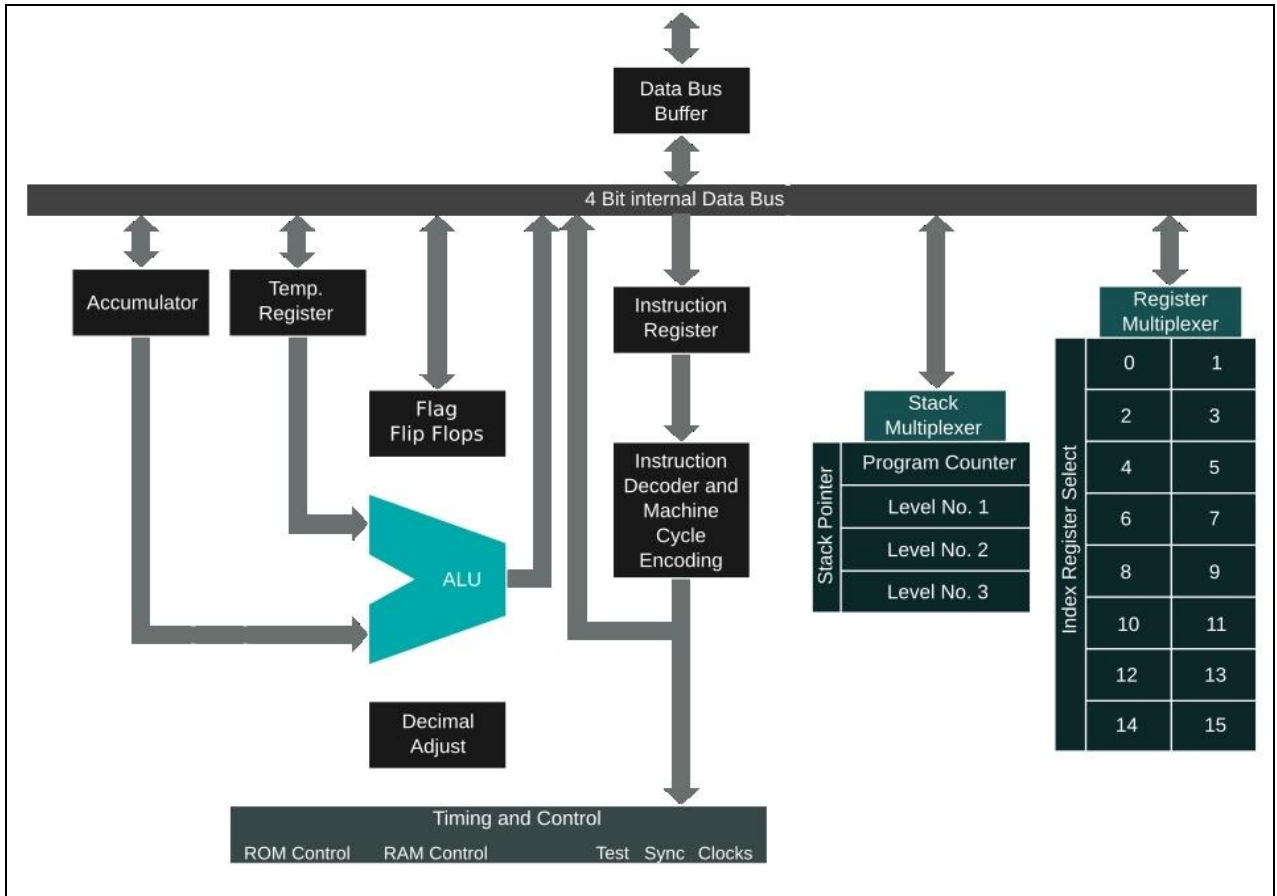


Figure 3: Intel 4004 architecture (from Wikipedia).

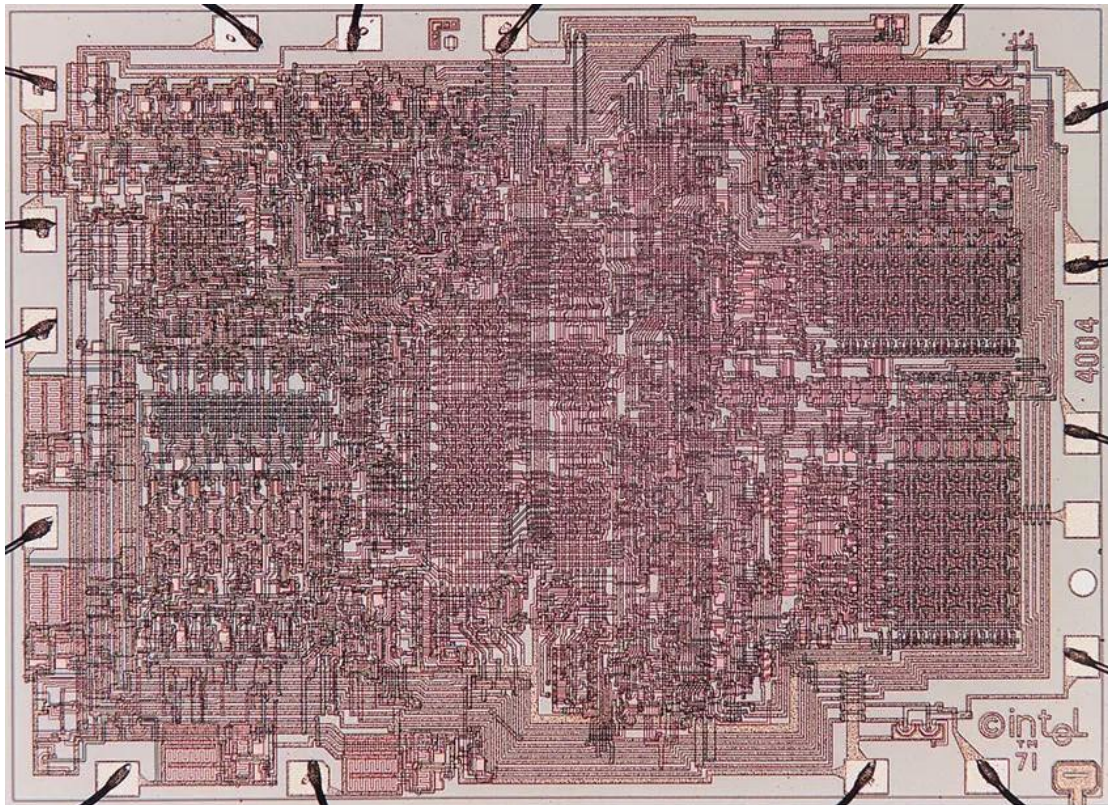


Figure 4: Intel 4004 chip die micrograph.

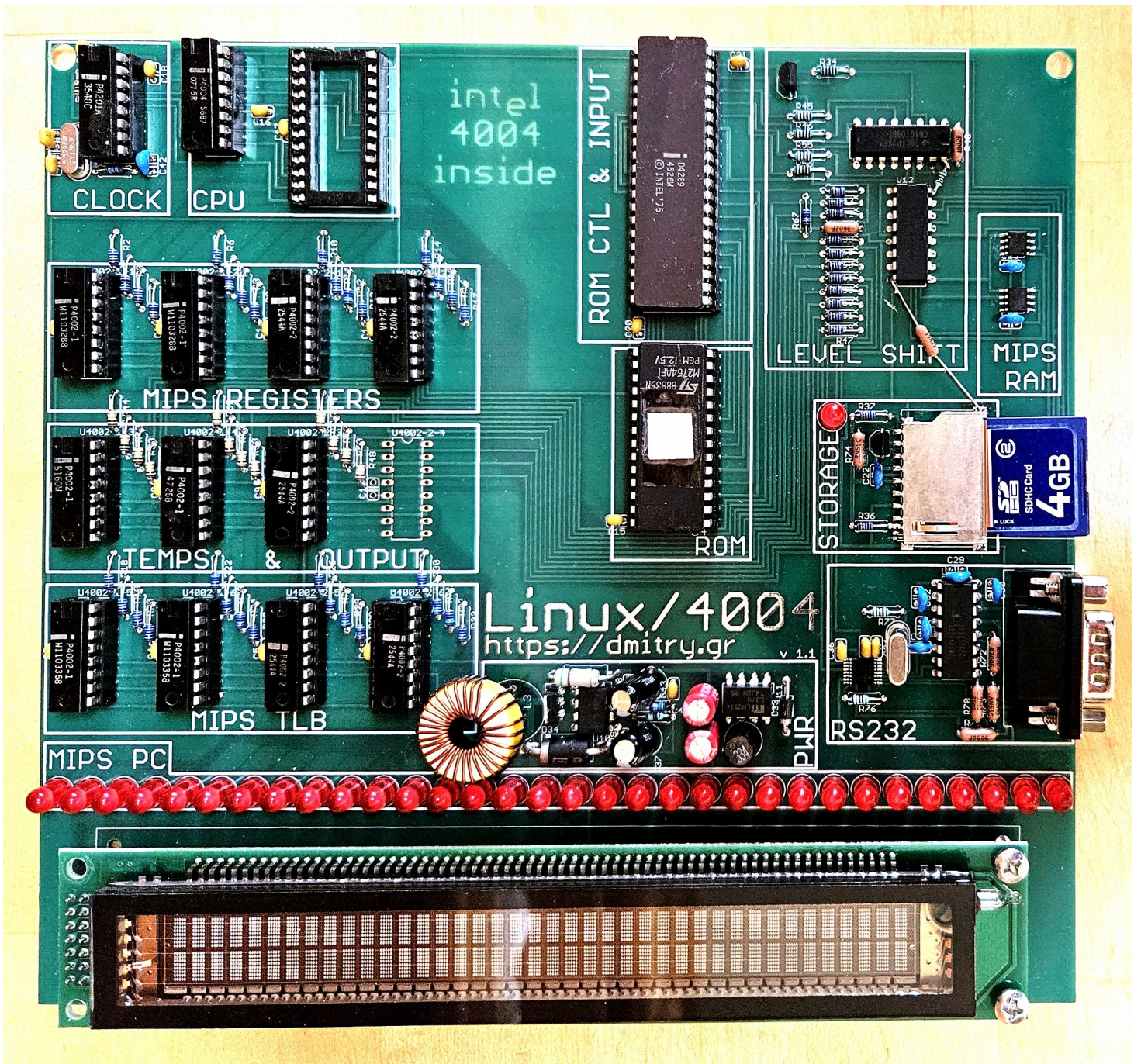


Figure 5: Linux/4004 front view.

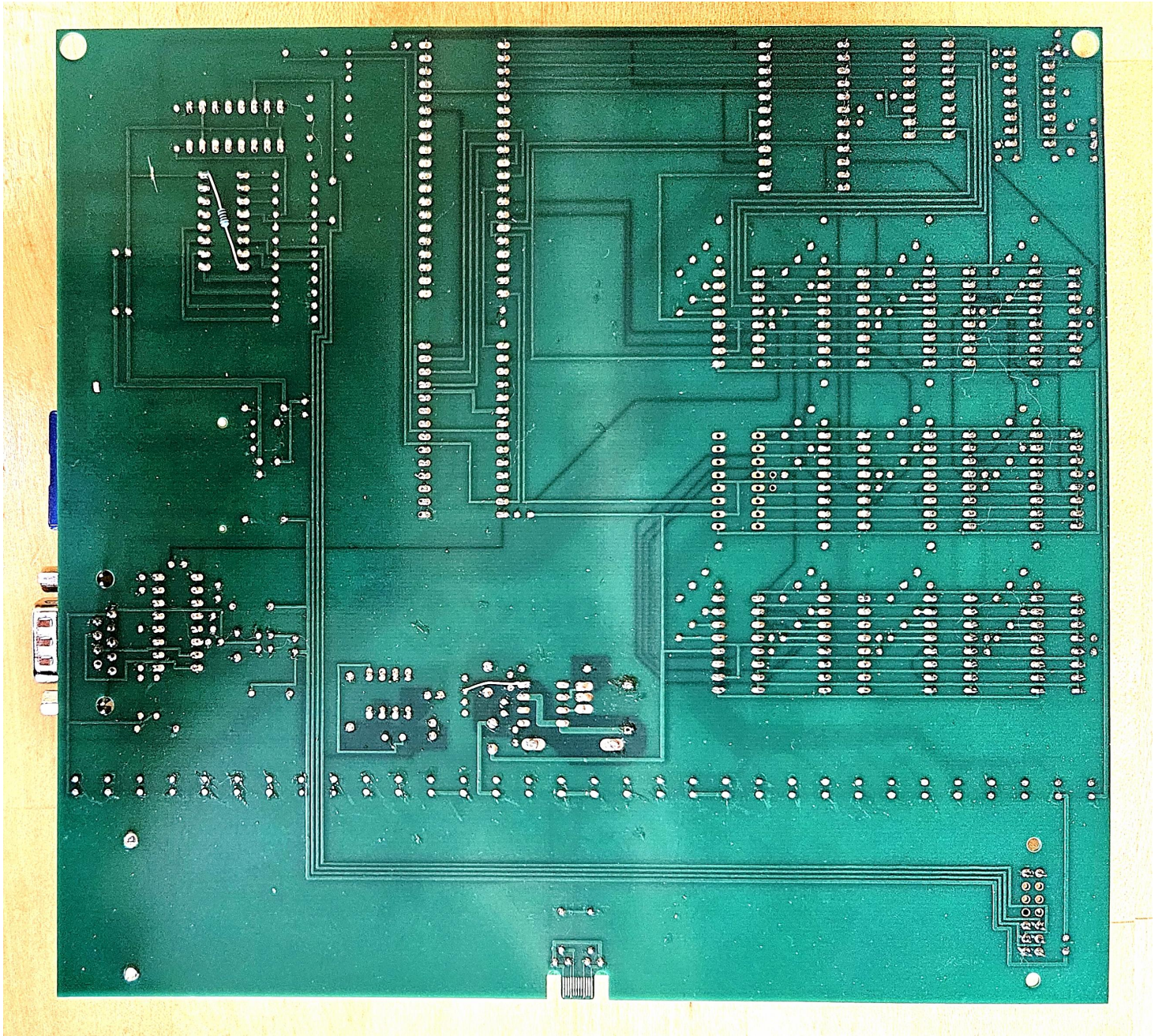


Figure 6: Linux/4004 rear view.

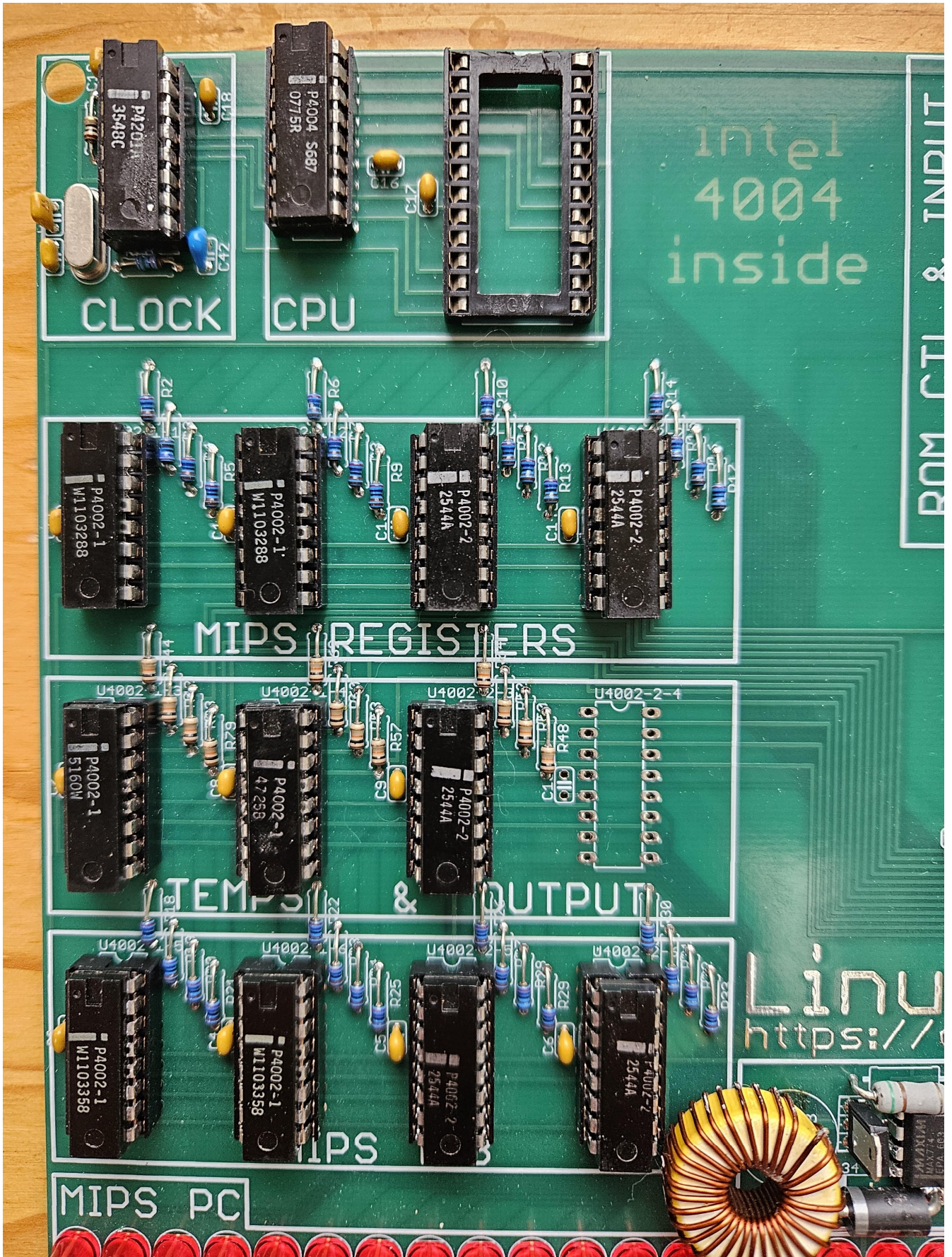


Figure 7: Linux/4004 front top-left closeup view.

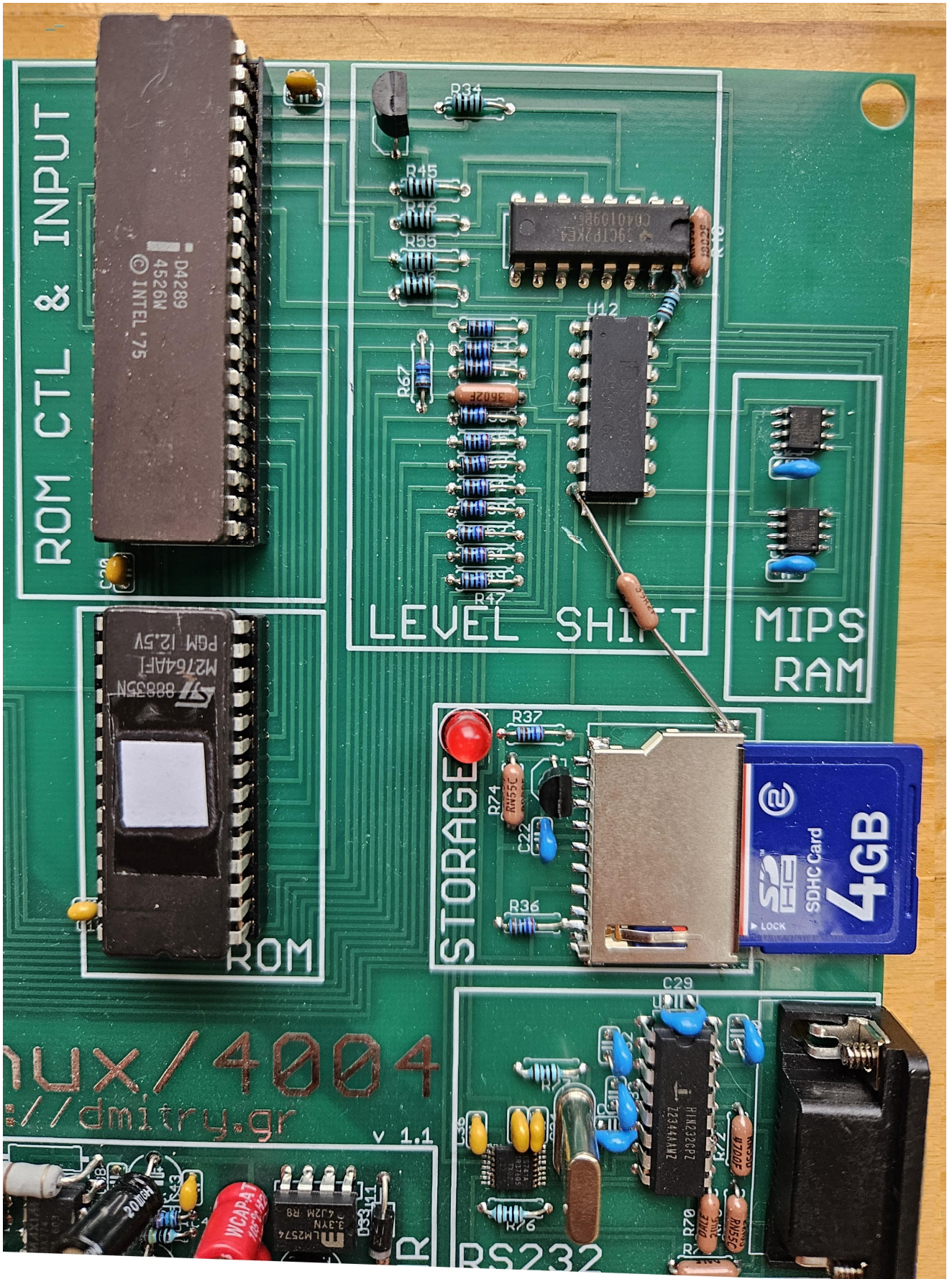


Figure 8: Linux/4004 front top-right closeup view.

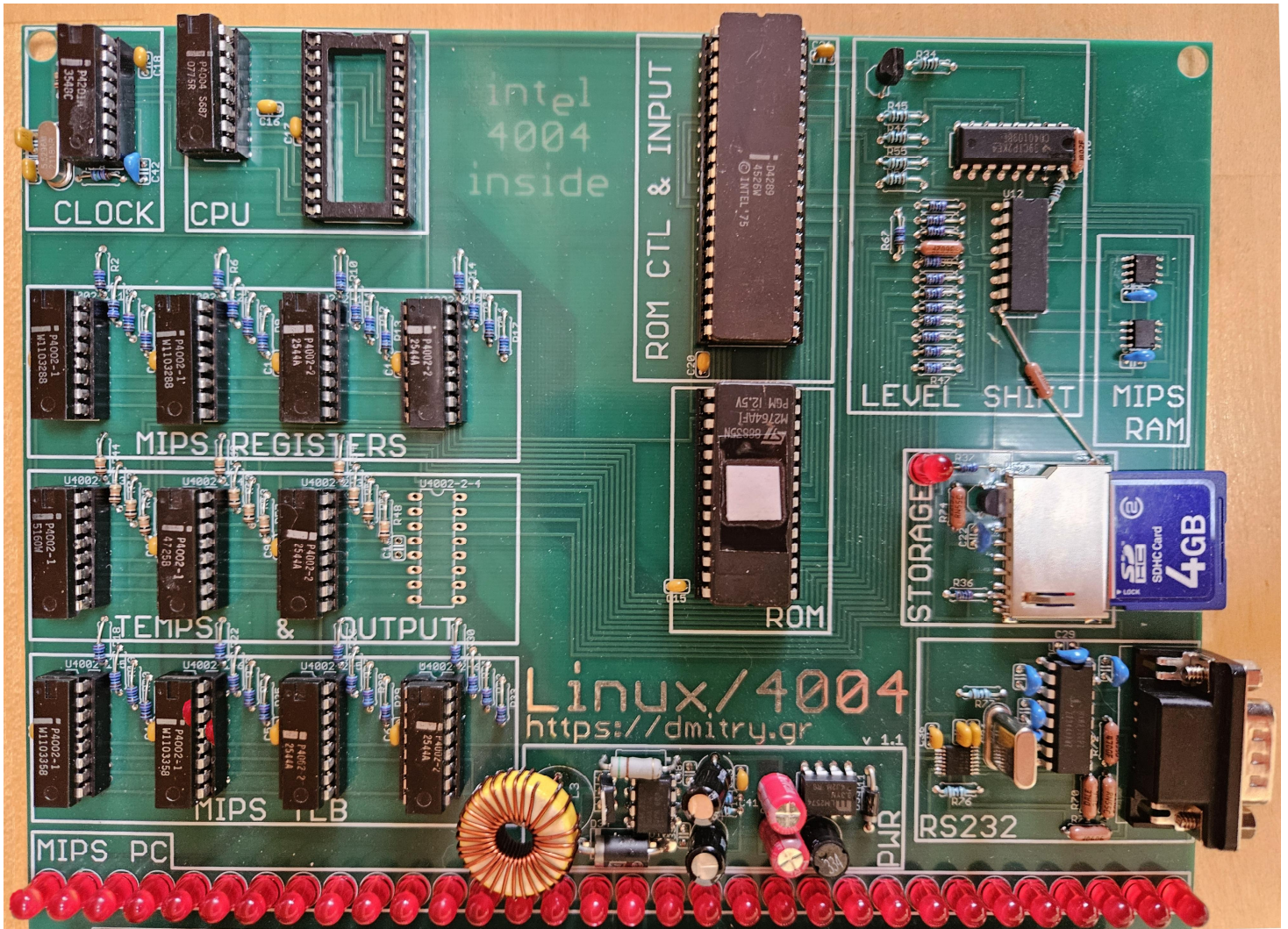


Figure 9: Linux/4004 upper front closeup view.

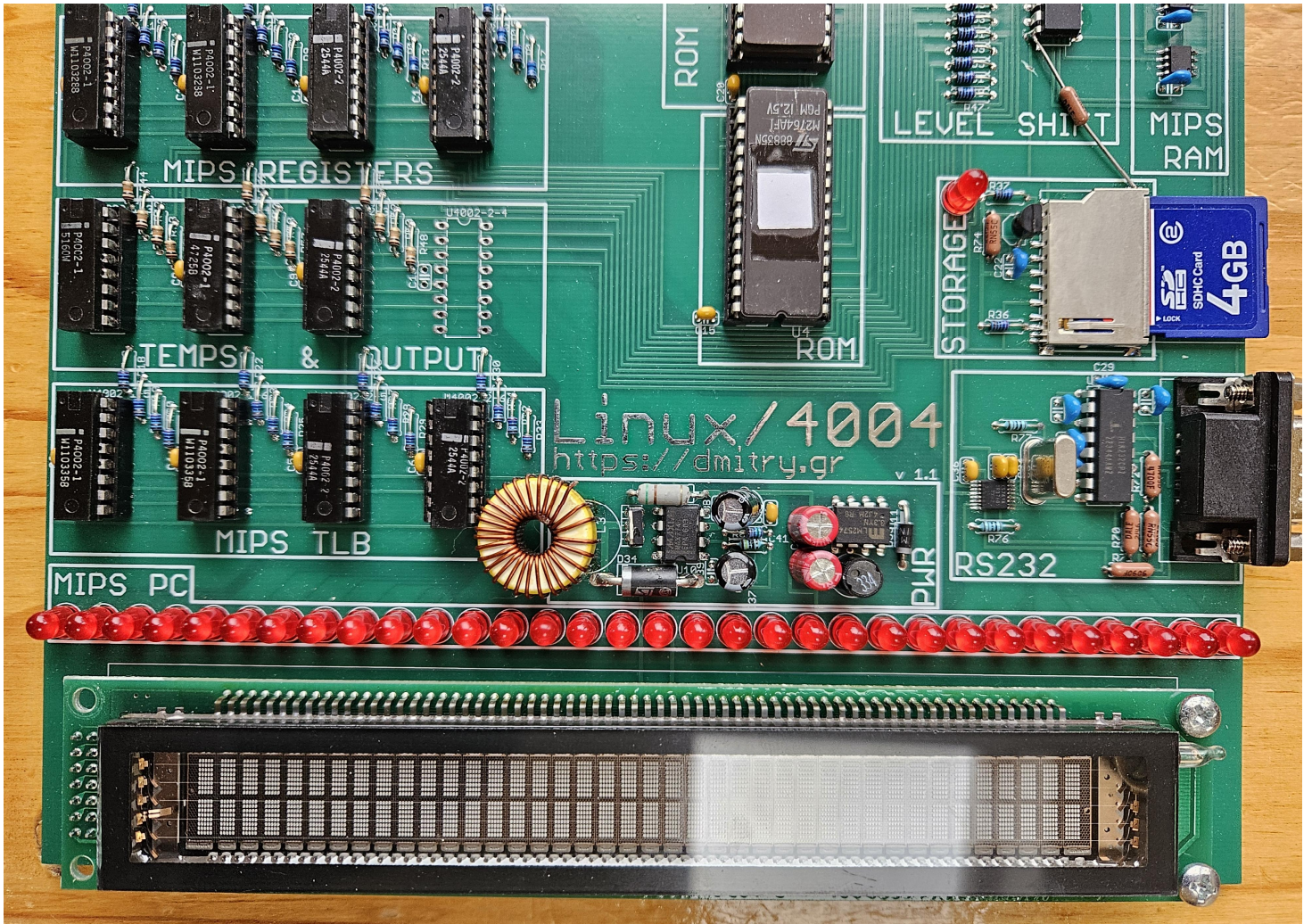


Figure 10: Linux/4004 lower front closeup view.