

TULIP4041 – The Next Chapter

*The
ULtimate
Intelligent
Peripheral
for the '41*



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Credits due ...

The TULIP4041 project started with a post from Andrew Menahue (UK) in the MoHPC forum in May 2023. This was picked up by Thomas Fänge (Sweden). Both were a tremendous help in getting the project where it is today.

Support and inspiration came from visitors of the various HP websites, forums and various ad-hoc meetings.

Some vital parts of the firmware lean heavily on work from others: Christoph Giesselink (V41, HP-IL and printer simulators), Jean-Francois Garnier (Emu41, HP-IL emulation, PILBox) and Mike (NutEm/PC)

The housing was designed by Andrew Menahue.

TULIP4041, what is it?

Short version, it is (almost) all HP41 peripherals in one:

- *ROM emulator (including Bankswitching)*
- *QROM emulator (MLDL, HEPAX)*
- *User memory emulator (User/Extended/Expanded)*
- *Peripheral emulator (Printer/Blinky, HP-IL, Wand, TIME)*
 - *No 'real' HP-IL or barcodes, in/output only through USB or IR*
- *HP41 bus tracer and HP-IL scope*
- *And more ...*

Many of the above functions have been tested but not fully implemented

From bulb to flower

A Development Board was presented during the 2024 HHC meeting and a module version was planned at that time.

The TULIP module now exists after two prototype iterations and comes with a 3D printed housing.

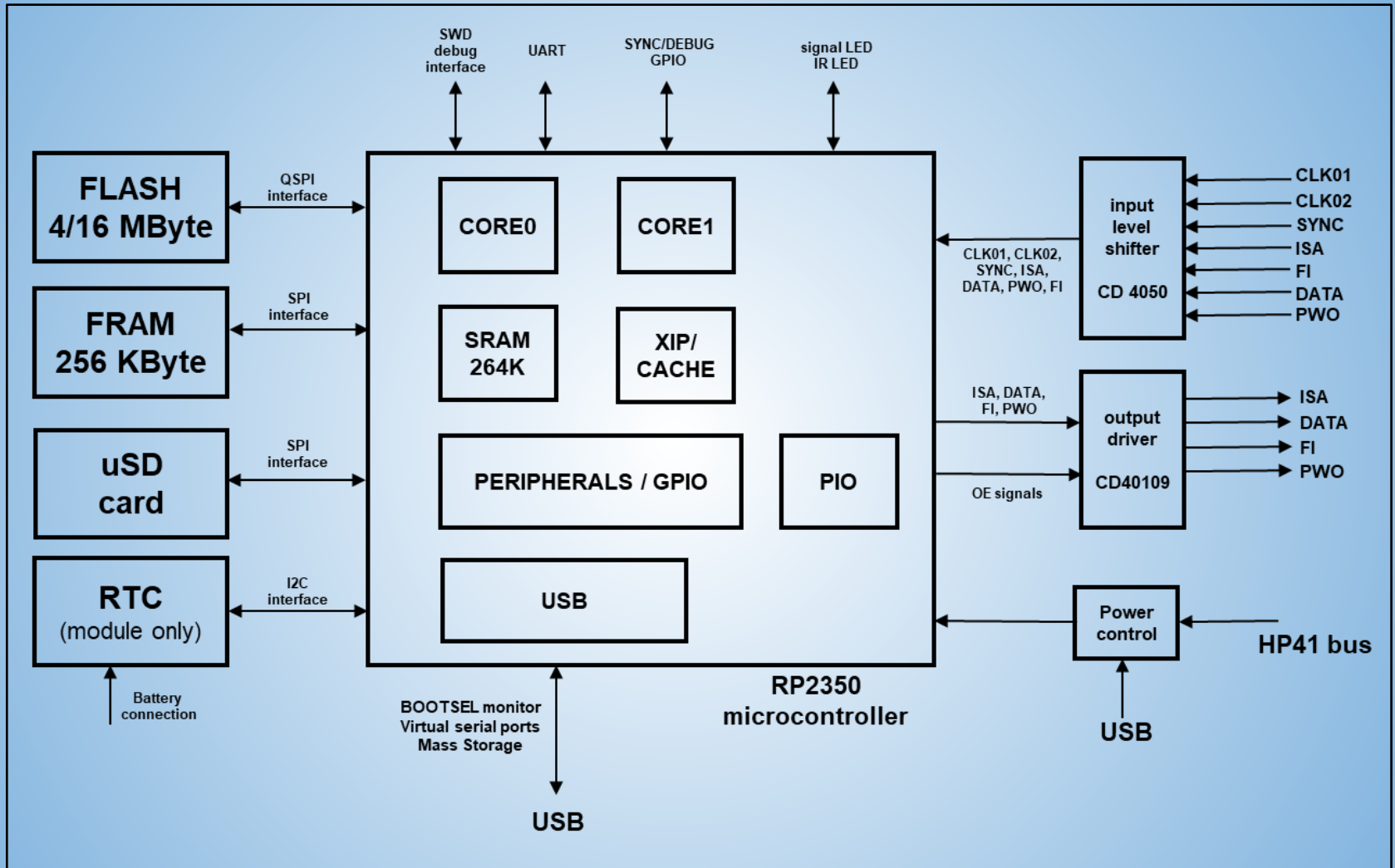
The firmware went through a number of updates already and features are being added about once a month



TULIP4041 module version status

- *Orders accepted*
- *Hardware design finished and in production*
 - All planned functions
 - 16 MByte FLASH
 - Extra levelshifter for FI input (not used yet)
 - RTC for TIME module emulation
- *Housing design by Andrew Menahue*
 - Designed for resin printing
 - Black and transparant versions available
 - Top in flat version and with bulb for RTC backup battery

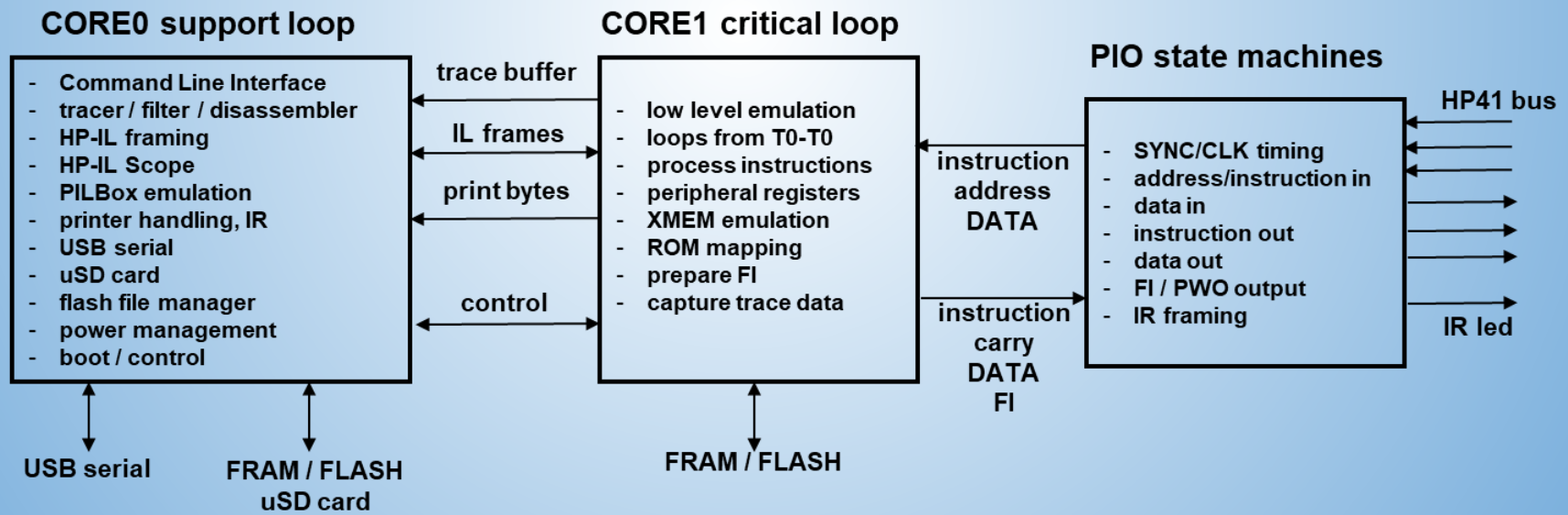
TULIP4041 Block diagram



How does it work?

TULIP Firmware architecture

- Uses both M33 cores @ 125 MHz
- 2 PIO's almost completely used, 1 PIO left
- Almost all GPIO's are used



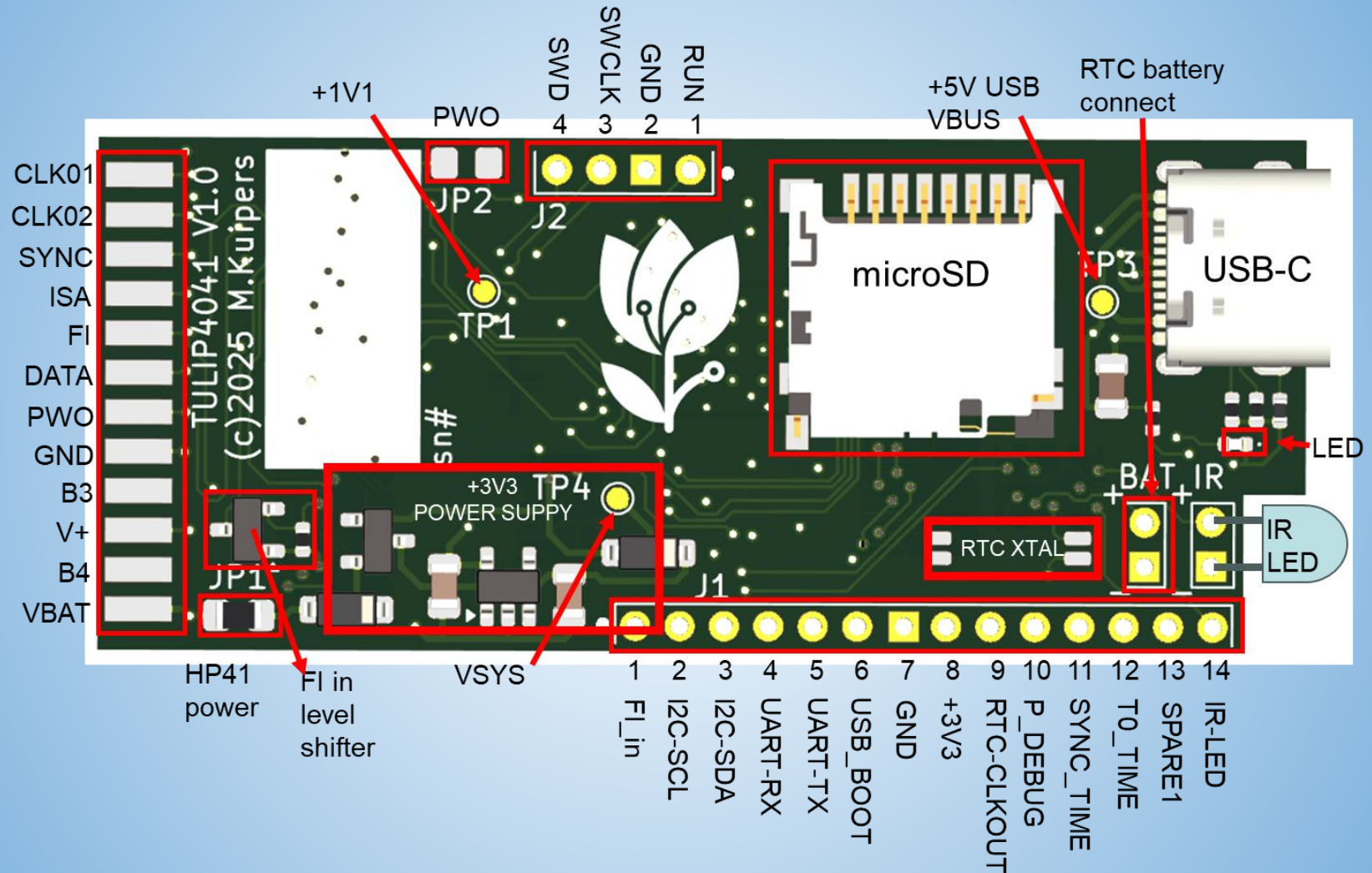
User Interactions

- *All configuration and system control via CLI (terminal access on a dedicated COM port interface via USB)*
 - Importing, plug-/un- plugging, configuring modules & QROM
 - Tracer (bus-level) and debugging
 - HP-IL Frames, “Scope”
 - 82143 printer output
- *IL-Per / pyilper via serial over USB*
 - Virtual HP-IL printer
 - Virtual LIF tape / disk media images for file storage
- *IR Transmit (to IR receiver, later to whistle ptr.)*
- *41 MCODE Module coming later...*

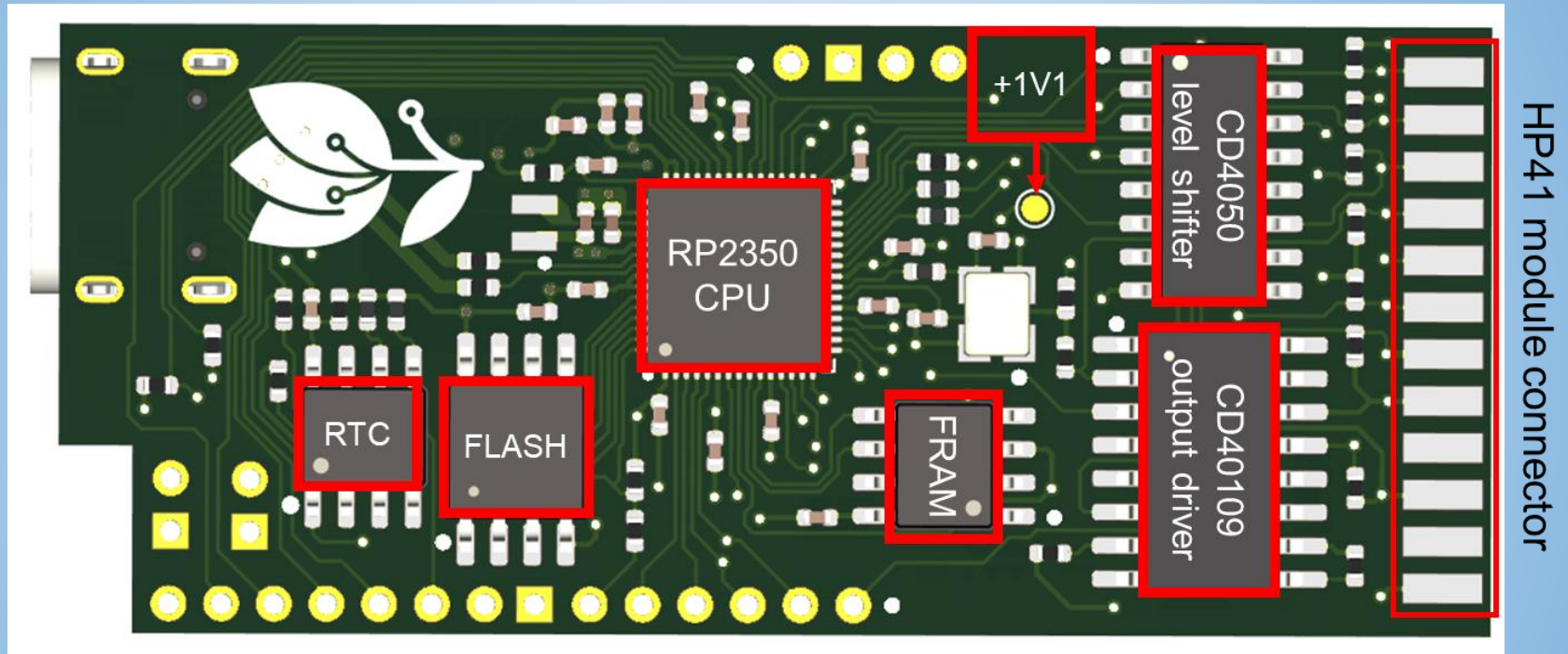
All comms thru the single USB Connection!!

- *5 x Comm ‘channels’ (example: Win11 PC)*
 - COM3: CLI
 - COM4: HP-IL Traffic Frames
 - COM5: Tracer output
 - COM6: HP-IL “Scope” output
 - COM7: Printer output (82143A)
 - Note: actual port #s/names vary by PC/OS
- *SD Card drive access (virtual drive on host)*

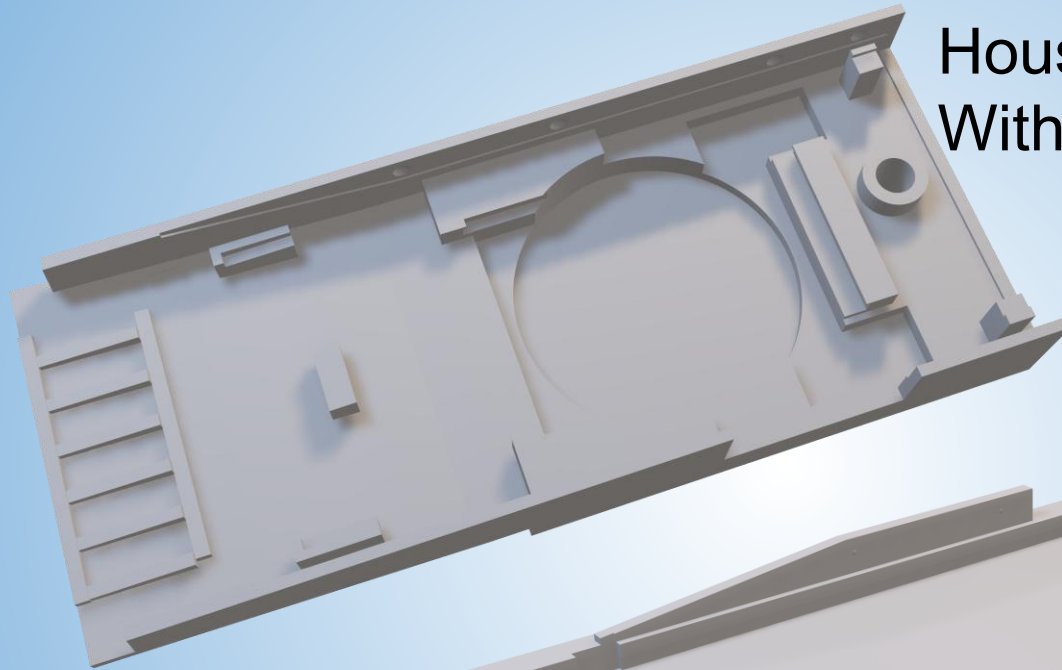
TULIP Module hardware overview



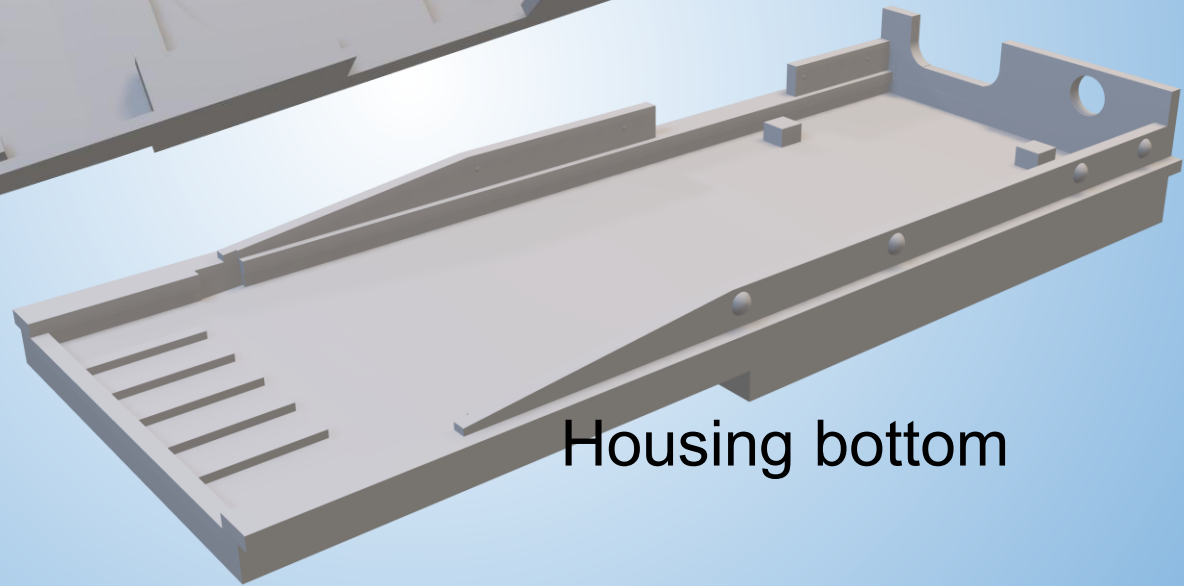
TULIP Module hardware overview



TULIP4041 module version - housing



Housing top
With battery compartment



Housing bottom

TULIP4041, current status (September 2025)

- *TULIP Module hardware available*
- *Housing coming soon (mid September)*
- *Software has a stable base version and is being expanded with roughly monthly updates*
- *Firmware versions for DevBoard and Module updated*
- *Orders are being accepted, shipping expected late September*
- *Price set to EUR 75*
- *Tested with MAXX, 41CL, 2* speedup HP41*

Firmware functions implemented

- *Easy firmware update*
- *microSD Card for offline storage of ROM images*
- *Flash File System for storage of pluggable ROM images (.ROM and .MOD files)*
 - Delete and mass import and update
- *Plug ROM and MOD image in any Page/Bank (Page >3)*
 - Autoplug, unplug and reserve Page
 - MOD files plugging supported, including HEPAX
- *CAT function*

HP41 Device emulation implemented

- *HP-IL and PILBox including printer/plotter to virtual device on host PC (pyILPer)*
- *HP82143A printing (to simulator on Host)*
 - Printing to IR receiver
 - Printer buttons simulated
- *Extended Memory (no Extended Functions yet)*
- *Bank Switching*
 - Including ZEPROM Sticky Bankswitching mode (optional)
 - OSX3, Advantage and HEPAX work

HP41 Support functions implemented

- *Near real-time mcode tracing*
 - Basic trace filters to block some system loops or system ROMs
 - Disassembler
 - HP-IL instructions, frames and registers

```
[1] [2] [3] [4] [5] [ 6 ] [7] [ 8] [9] [ 10 ] [ 11 ]
O  0  0193-1  1  201  0.000002C048.0.FD ... R010 C0 FI01234----- ...
    1  0001-1  0  006  0.000052C048.0.FD ... R010 C0 FI----- ?NC GO 0180
    2  0002-1  1  2B5  0.000052C048.0.FD ... R010 C0 FI----- ...
    3  0003-1  0  006  0.000052C048.0.FD ... R010 C0 FI----- ?NC GO 01AD
    4  01AD-1  1  001  0.000052C048.0.FD ... R010 C0 FI----- ...
    5  01AE-1  0  100  0.000052C048.0.FD ... R010 C0 FI----- ?NC XQ 4000
    6  4000-1  1  000  0.000052C048.0.FD ... R010 C0 FI----- NOP
    7  01AF-1  1  2E0  0.000052C048.0.FD ... R010 C0 FI----- DSPOFF

                [ 11 ]                [ 12 ] [ 13 ]
                ?FI 8 ?FRAV            IL> 023 DAB Reg E0 A0* 40 40 01 03 01 00 00
```

- *HP-IL frame tracing*
 - Seperate ILScope window
 - Optional PILBox serial frame tracing

TULIP firmware roadmap

Updates planned for late 2025:



- *FRAM File System*
 - Comparable to FLASH File System
 - Needed for QROM/HEPRAM support
 - Storage of XFUN/XMEM
 - Storage of system settings and tracer filters
- *Support for QROM and HEPRAM*
- *Advanced filters and triggers for mcode tracer*
 - e.g. don't emit mainframe bytes, just my ROM

TULIP firmware roadmap

- *Planned for late 2025/2026*
 - Improved support for Extended Memory + Functions
 - Support for Memory Module (Single and Quad)
- *Planned for 2026 and beyond*
 - Support for Expanded Memory (like HP41CL and MAXX)
 - HP-IL device mode support
 - Reduced power consumption when off



TULIP4041 roadmap and ideas



- *Serial printer*
- *Support for HP82240 IR printer*
- *TIME module emulation*
- *Blinky (HP82242 IR printing module)*
- *Disassembly in HP and ZENROM mnemonics (currently only JDA)*
- *Hard serial connection to PILBox to enable using real HP-IL devices (hardware modification required)*
- *Using the extra FI input in the tracer (requires soldering a wire)*

TULIP4041 roadmap and ideas



- *Serial interface to real (new) PILBox*
 - To control real HP-IL devices, requires hardware modification
- *Wand emulation, paper keyboard in CLI*
- *HP-IL Mass Storage emulation on micro SD card*
- *TULIP ROM*
 - Expanded Memory functions / MAXX emulation
 - custom peripheral functions
 - direct RAW file import/export from/to uSD card
 - HP41 interface to CLI functions
 - plug/unplug ROMs
 - co-processor function access (PNG, math accelerator)

TULIP demonstration

- *CLI overview, system functions*
- *uSD card and File transfer*
- *FLASH functions*
- *Import functions*
- *Plug/unplug modules*
- *HP-IL, printing*
- *Mcode tracer*

Wrap up

TULIP4041 is for me a very exciting project, its functionality goes beyond what I ever thought possible.

All sources, documentation and schematics are open source.

The HP41 is truly a system that will keep on running

Sources: <https://github.com/mjakuipers/TULIP-DevBoard>

Info/orders: tulip@kuiprs.nl

