DOCUMENT INFORMATION

TITLE: IoT devices and embedded systems with uLisp

AUTHOR: Max-Gerd Retzlaff

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PUBLICATION LOCATION: The document is published on `http://www.defsystem.net` and can be referenced there. The direct link is `http://www.defsystem.net/id/74678c84-e7e3-400f-9558-e4c5f271f3a0`.

MAX-GERD RETZLAFF

IOT DEVICES AND EMBEDDED SYSTEMS WITH ULISP

M5STACK ESP32 BASIC CORE

~40 EUROS (INCL. VAT)

- 240 MHz 32-bit dual-core ESP32 processor (Espressif ESP32-D0WDQ6-V3),
- 520 KB SRAM in total for programs and data,
- 4 or 16 MB Flash memory,
- 2.4 GHz Wi-Fi and Bluetooth with built-in antennae,
- USB-C socket,
- 2 inch TFT LCD display with 320x240 pixels and 262 K colours,
- SD card slot,
- 150 mAh battery,
- 1 W Speaker and microphone,
- 3 buttons

[Retzlaff 2021d]

ESP32 M5STACK ATOM LITE ESP32

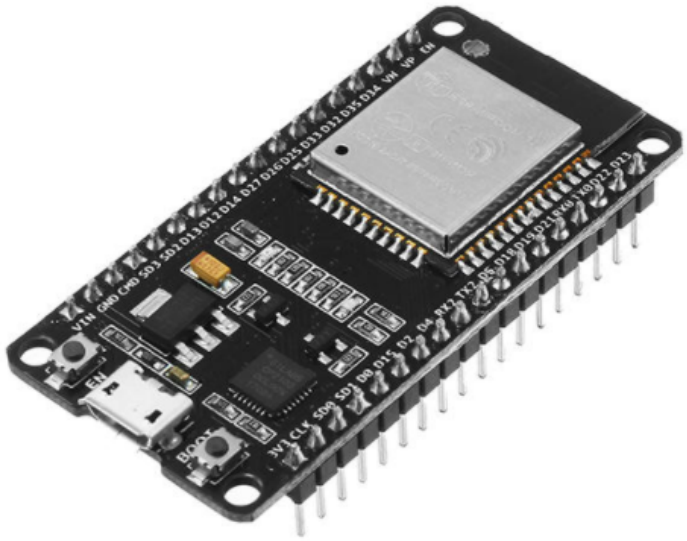
~10 EUROS (INCL. VAT)

- 240 MHz 32-bit dual-core ESP32 processor (Espressif ESP32-PICO-D4),
- 520 KB SRAM in total for programs and data,
- 4 MB Flash memory,
- 2.4 GHz Wi-Fi and Bluetooth with built-in antennae,
- USB-C socket,
- 1 RGB LED (compatible to Adafruit NeoPixel),
- Infrared Transmitter,
- 1 button

[M5Stack 2020]

DOIT ESP32 DEVKIT V1

~6-7 EUROS (INCL. VAT)



- 240 MHz 32-bit dual-core ESP32 processor (Espressif ESP-WROOM-32),
- 520 KB SRAM in total for programs and data,
- 4 MB Flash memory,
- 2.4 GHz Wi-Fi and Bluetooth with built-in antennae,
- USB-C socket

[DOIT 2018]

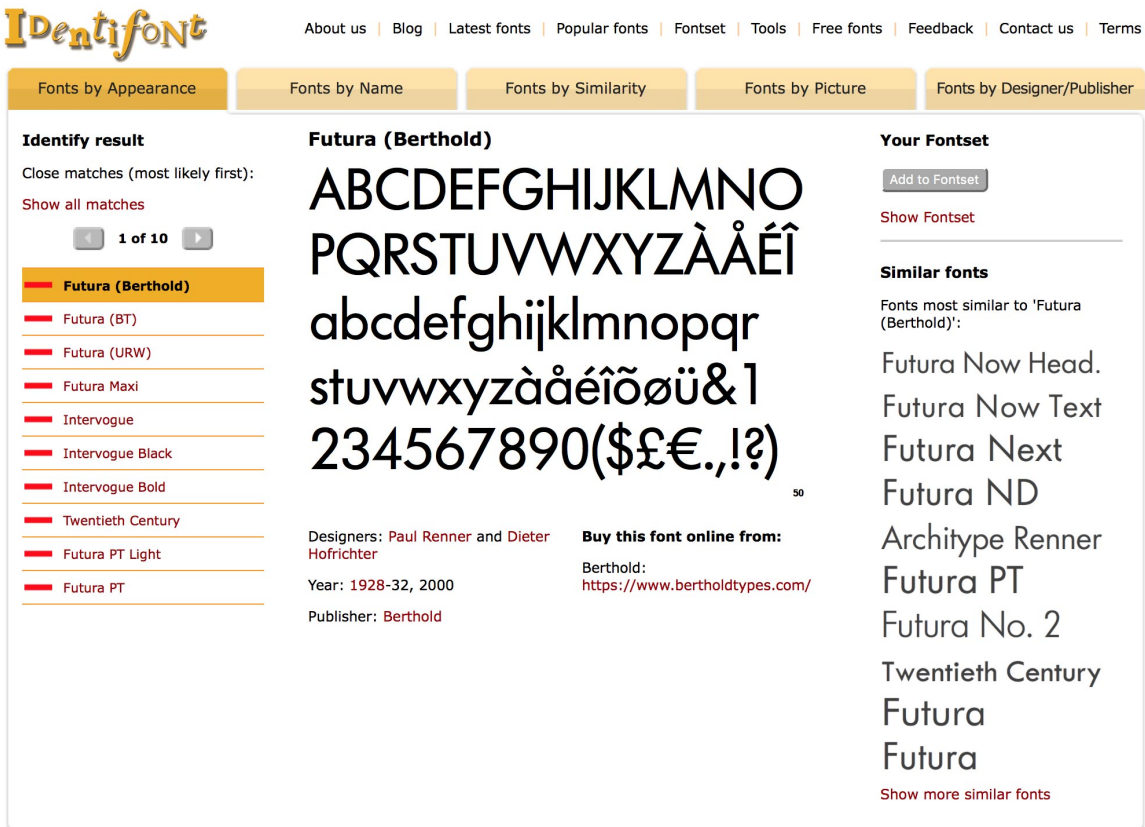
Authored by David Johnson-Davies from Cambridge, UK.

[Johnson-Davies 2021c]

IDENTIFONT

DAVID JOHNSON-DAVIES, 2000

A directory of digital fonts, including features to allow you to identify fonts by appearance, find fonts by name, find picture or symbol fonts, and find fonts by designer or publisher, at `www.identifont.com`.



FONTSCAPE

DAVID JOHNSON-DAVIES, 2000

The largest independent directory of typefaces organized into categories, at `www.fontscape.com`.

FONTIFIER

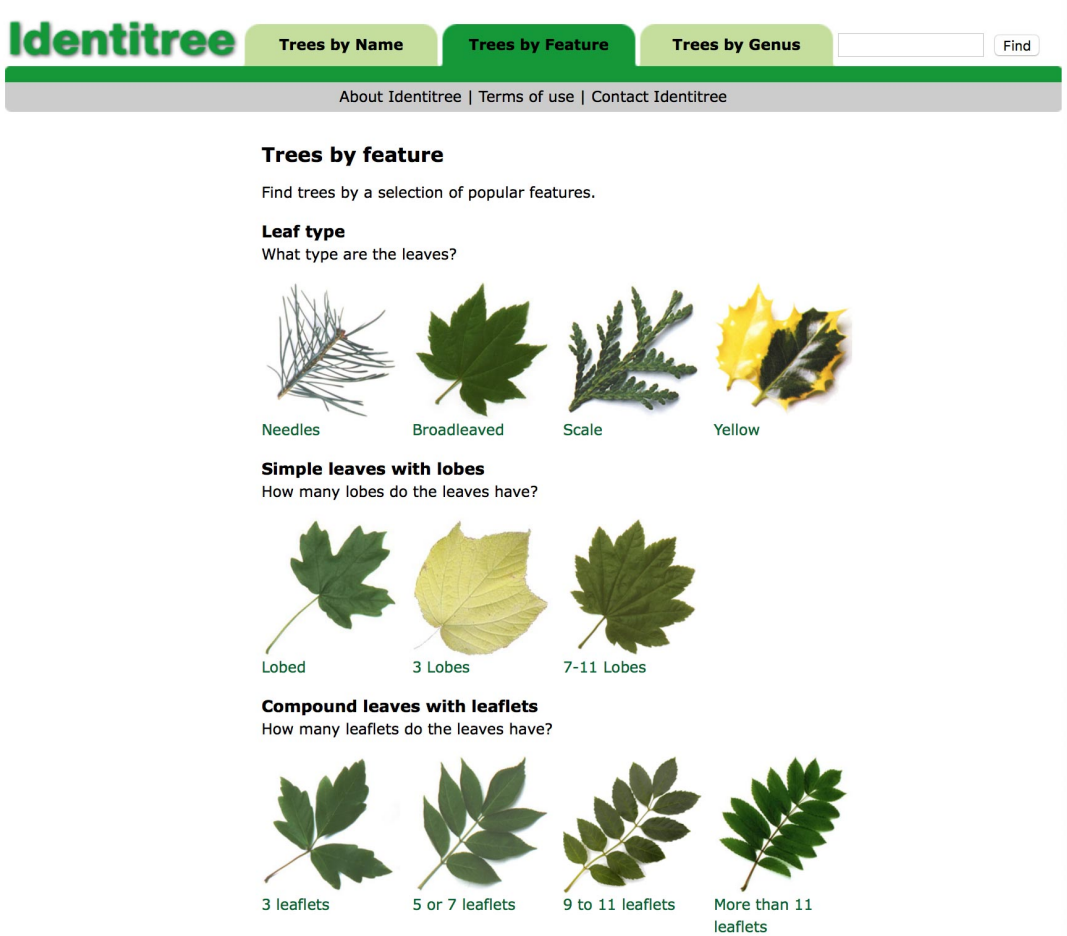
DAVID JOHNSON-DAVIES, 2003

Creates handwriting fonts from templates, at `www.fontifier.com`.

IDENTITREE

DAVID JOHNSON-DAVIES, 2015

An expert system written in Lisp designed to enable users to identify trees from their visual characteristics, available online at `www.identitree.com`.



CL-HTTP

The websites IDENTIFONT, FONTSCAPE, FONTIFIER, IDENTITREE, and also ULISP are all based on: CL-HTTP.

CL-HTTP is the Common Lisp Hypermedia Server, developed by John C. Mallery at the M.I.T. Computer Science & Artificial Intelligence Laboratory.

A CL-HTTP PRIMER by David Johnson-Davies is also served via CL-HTTP at `http://clhttp.plasticki.com/`.

ULISP NAME

"I decided to settle on uLisp, pronounced 'U'-lisp,
rather than μLisp, pronounced mu-lisp,
for two reasons:

- It's clearer what the URL for the website should be.
- The 'μ' character often doesn't look very good on-screen on a page of text.

Also, I was able to trademark "ULISP" as a word."

[Johnson-Davies 2021b]

ULISP

LISP FOR MICROCONTROLLERS

- specifically designed for limited RAM
- main challenge of writing uLisp:
  have it run on the ATmega328 with only 2 kB of RAM
  (and 32 kB of flash program memory)
- 8-, 16-, 32- and 64-bit platforms
- from the Arduino Uno based on the ATmega328 up to the Teensy 4.0/4.1

[Johnson-Davies 2014b]

ULISP

IMPLEMENTATION

- interpreter not compiler
- tail-optimization
  (efficient recursive functions)
- mark and sweep garbage collector
  (Under 1 msec on an Arduino Uno or under 3 msec on an Arduino Mega 2560.)

[Johnson-Davies 2014b]

ULISP

LANGUAGE

- The language is generally a subset of Common Lisp, this is: uLisp programs should also run under Common Lisp.
- major difference: It's a Lisp-1.
  (One namespace for functions and variables.)

[Johnson-Davies 2014b]

ULISP

ORIGINAL OBJECTIVE

"[. . .] a compact Lisp for small microcontrollers that would allow people to use a more advanced language than C for creating hardware-oriented projects. [. . .]

There's no point making uLisp into a full Common Lisp.
It won't make uLisp more likely to be adopted by microcontroller users, and

people with larger processor boards such as the Raspberry Pi can already get a full Common Lisp running under Unix (such as Clozure Common Lisp).

So for each proposed extension I have to think: will this make it more likely that people use uLisp for hardware projects? I think that the way to do this is to make it *appeal to people who haven't encountered Lisp before*, rather than trying to appeal to experienced Common Lisp users."

[Johnson-Davies 2021a]

ULISP VS. COMMON LISP

- major difference: It's a Lisp-1.
  One namespace for functions and variables.
- no macros
- no multiple-values,
  instead: use lists to represent multiple values.

  NOTHING – symbol with no value, equivalent to `(values)` in Common Lisp,
  to suppress output from functions
- no DESTRUCTURING-BIND
- no condition system or exceptions,
  error brings you back to the top-level
- ; (semicolon) – comments end not at the end of the line
  but *before the next opening bracket*

ULISP

GREAT WEB SITE

uLisp Home Reference Forum Search

Lisp for microcontrollers

Lisp for Arduino, Adafruit M0/M4, Micro:bit, ESP8266/32, RISC-V, and Teensy 4.x boards.

News!

New ARM Version 4.1

Like the AVR Version 4.1 of uLisp released earlier this month, the ARM version now adds a **register** function to allow you to read the values of 32-bit processor registers, or write values to the registers. It allows you to control the peripherals in the ARM processor from a Lisp program, or interactively experiment with the peripherals by giving commands at the uLisp prompt.

For more information see: ARM uLisp now also supports the register function.

uLisp® is a version of the Lisp programming language specifically designed to run on microcontrollers with a limited amount of RAM, from the Arduino Uno based on the ATmega328 up to the Teensy 4.0/4.1. You can use exactly the same uLisp program, irrespective of the platform.

Because uLisp is an interpreter you can type commands in, and see the effect immediately, without having to compile and upload your program. This makes it an ideal environment for learning to program, or for setting up simple electronic devices.

Lisp is also an ideal language for learning about fundamental programming concepts. It incorporates string handling, list processing, and garbage collection, and so is also an excellent language for expressing complex ideas, such as teaching a robot to solve mazes or finding the shortest route on a map. As well as supporting a core set of Lisp functions uLisp includes Arduino extensions, making it ideal as a control language for the Arduino.

You can download the current version of uLisp free from the Download uLisp page.

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Tiny Lisp Computer
Lisp Badge
Pocket Op Amp Lab

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Arduino Mega 2560
ATmega1284
ATmega4809 boards
AVR DA and DB series boards

32/64-bit platforms

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Adafruit M0 boards
Adafruit QT-Py and Seeduino XIAO
Adafruit M4 boards
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Adafruit nRF52840 boards
BBC Micro:bit
Calliope mini
Maxim MAX32620FTHR
Teensy 4.0 and 4.1
RP2040 boards New!
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Tweetmaze
Mood light
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Simon game
I2C clock
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Ringing the changes
Driving DotStar RGB LEDs
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Mini text adventure game

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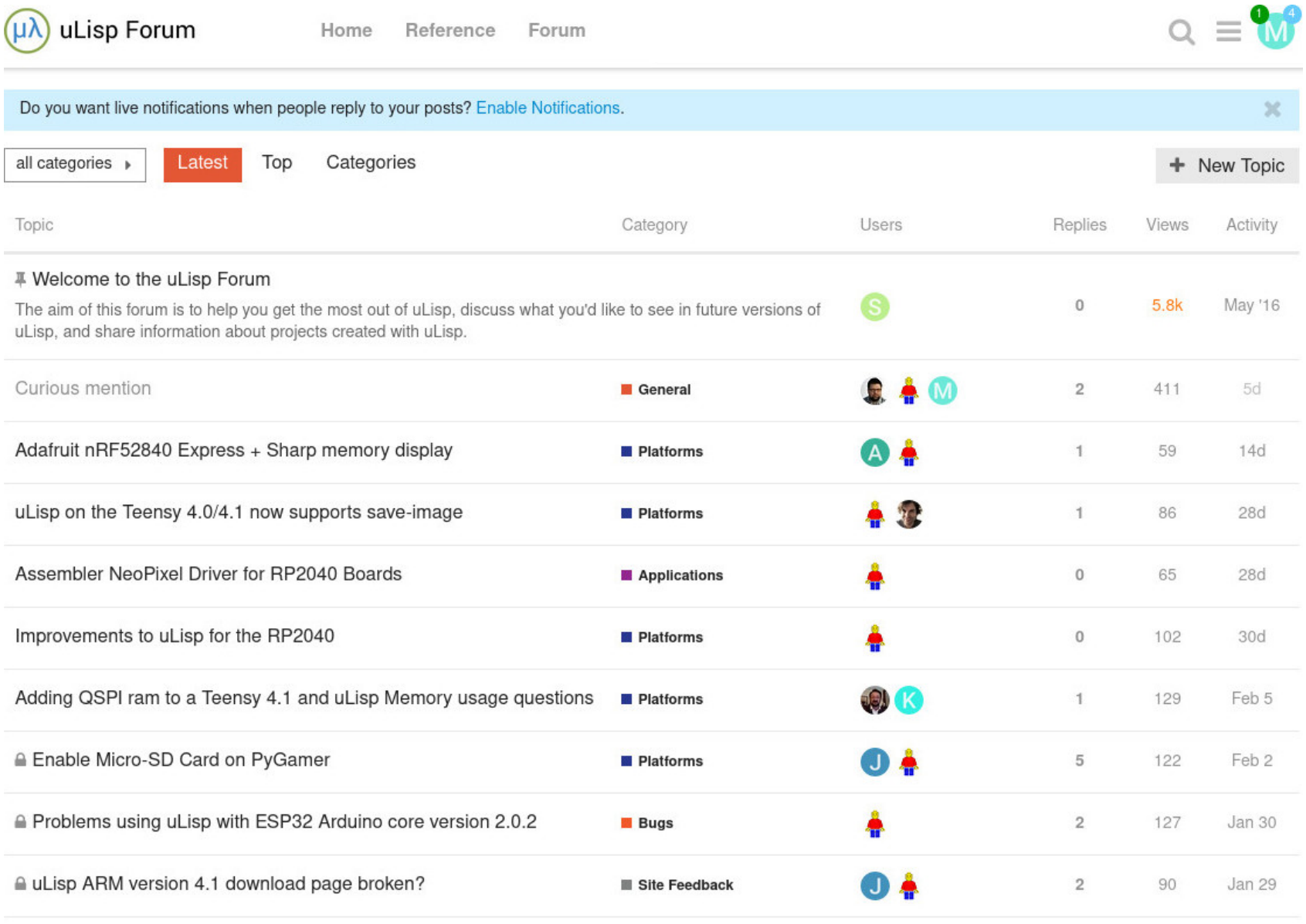
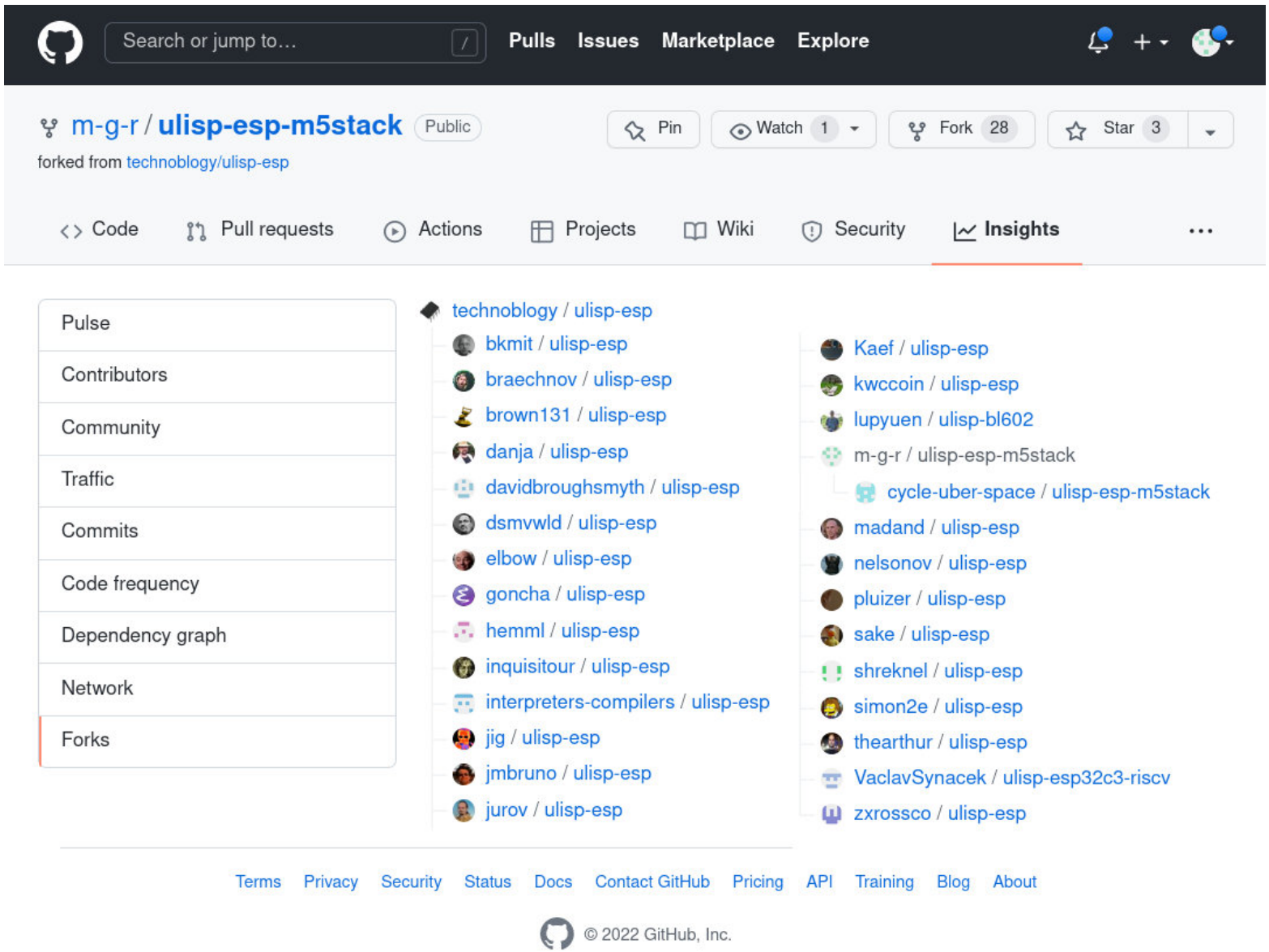
ACTIVE USER FORUM



ULISP

ACTIVE GITHUB



CONNECT TO ULISP

Linux with screen:

```
screen /dev/ttyUSB0 115200
```

macOS:

```
screen /dev/tty.usbserial-55D2D232BE 115200
```

Emacs:

```
(defun ulisp-terminal-start ()
  (serial-term "/dev/ttyUSB0" 115200)
  (term-line-mode))

M-: (ulisp-terminal-start)
```

D E M O T I M E

M5STACK STAND-ALONE ULISP COMPUTER MAX-GERD RETZLAFF, MARCH 2021

Batteries are included, which makes it self-contained and take-along.

[Retzlaff 2021e]

GPS-BASED SPEEDOMETER AND CLOCK

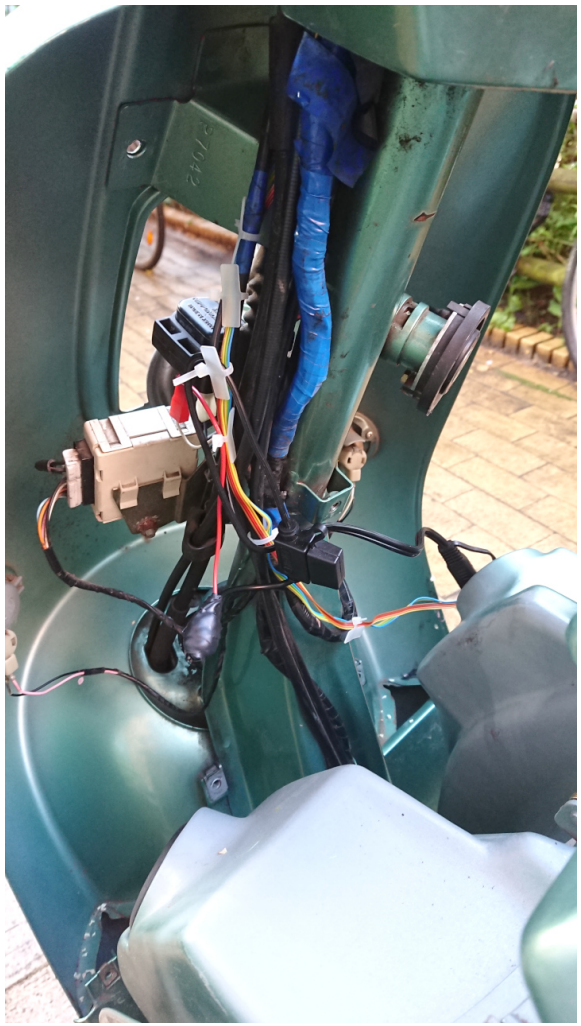
MAX-GERD RETZLAFF, MAY 2021

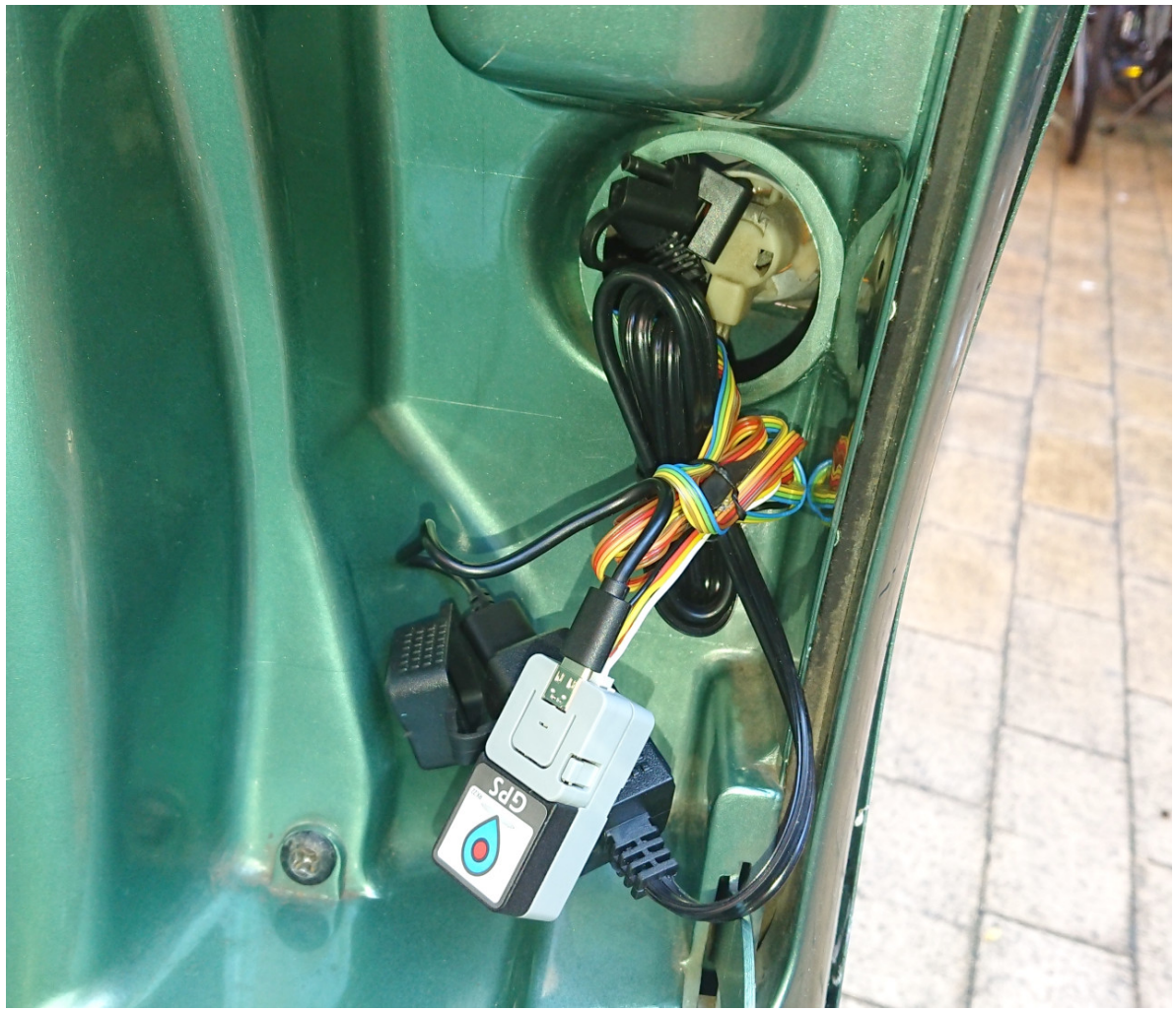
A replacement for the speedometer clock of my Vespa ET4
which often fails as it just uses a tiny battery.

[Retzlaff 2021f]

GPS-BASED SPEEDOMETER AND CLOCK

MAX-GERD RETZLAFF, MAY 2021

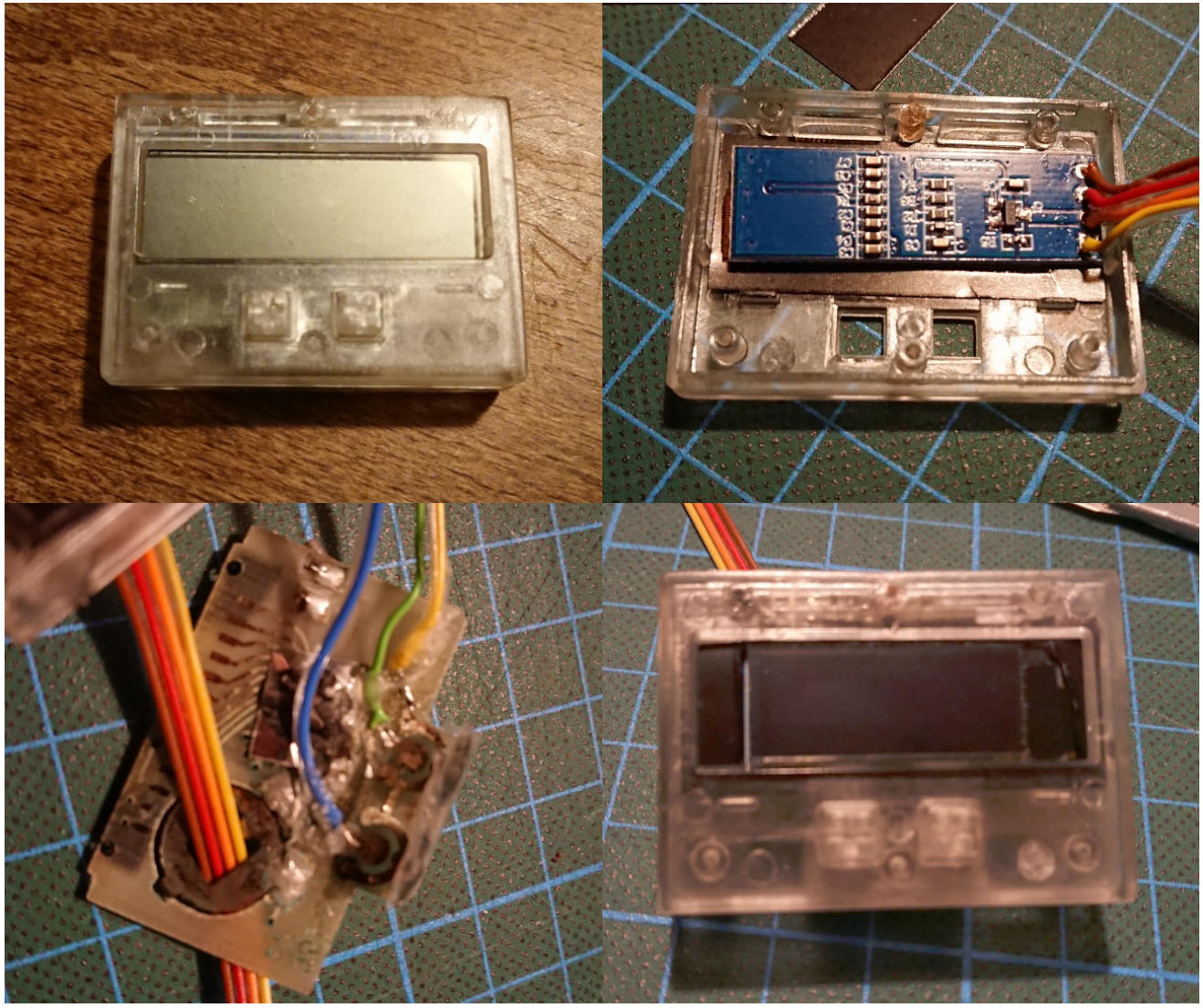




[Retzlaff 2021c]

GPS-BASED SPEEDOMETER AND CLOCK

MAX-GERD RETZLAFF, MAY 2021



[Retzlaff 2021h]

GPS-BASED SPEEDOMETER AND CLOCK

MAX-GERD RETZLAFF, MAY 2021

[Retzlaff 2021g]

PRESENTER FOR "NEXT PAGE"'

MAX-GERD RETZLAFF, MARCH 2022

On the plane trip to ELS 2022 … :-)

[Retzlaff 2022a]

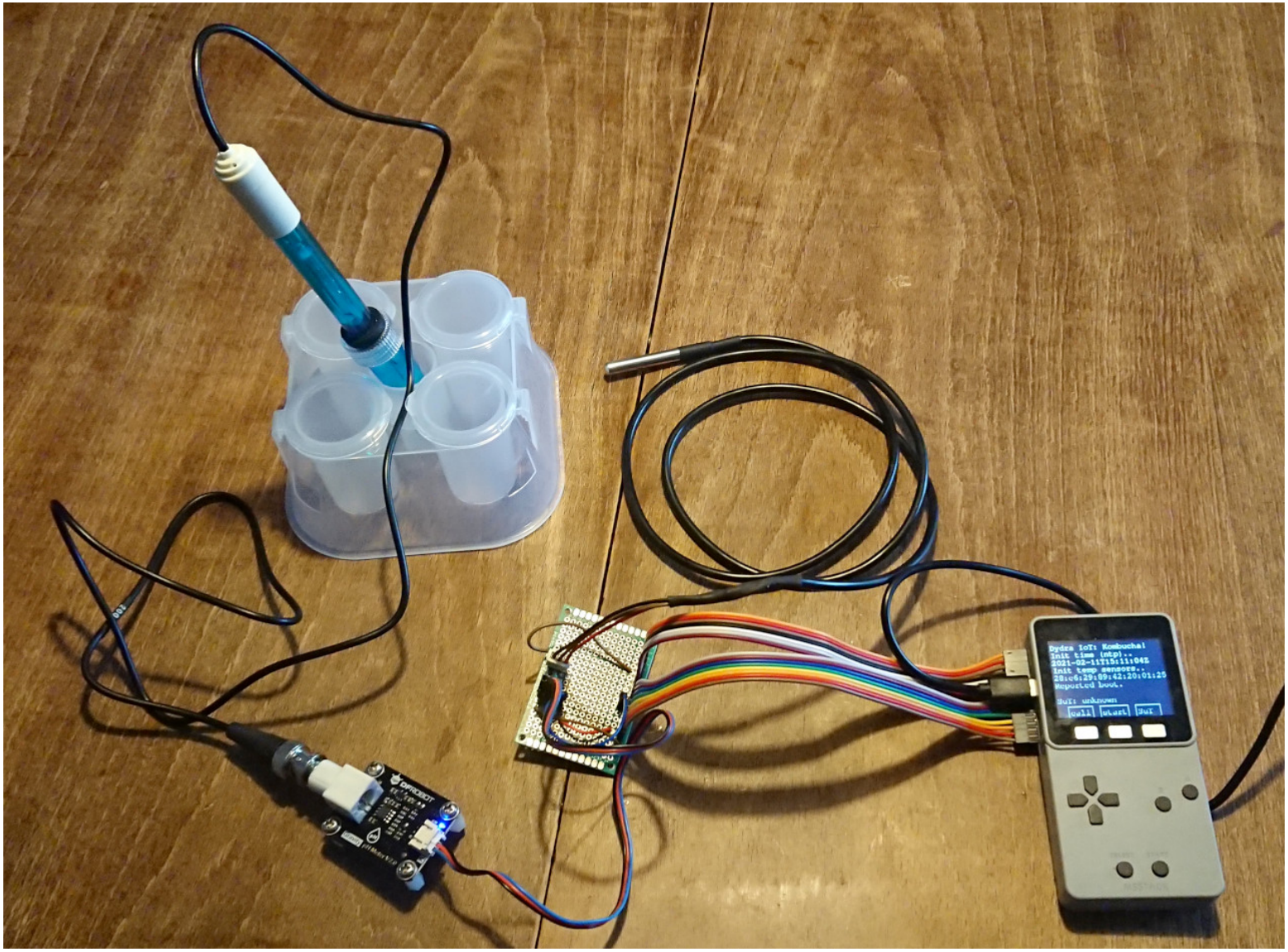
ULISP WITH ANDROID

MARCH 2022

[Retzlaff 2022c]

KOMBUCHA SENSOR DEVICE

MAX-GERD RETZLAFF, FEB. 2021



[Retzlaff 2021a]

KOMBUCHA SENSOR DEVICE

MAX-GERD RETZLAFF, FEB 2021

[Retzlaff 2021k]

KOMBUCHA SENSOR DEVICE

MAX-GERD RETZLAFF, FEB 2021

[Retzlaff 2021k]

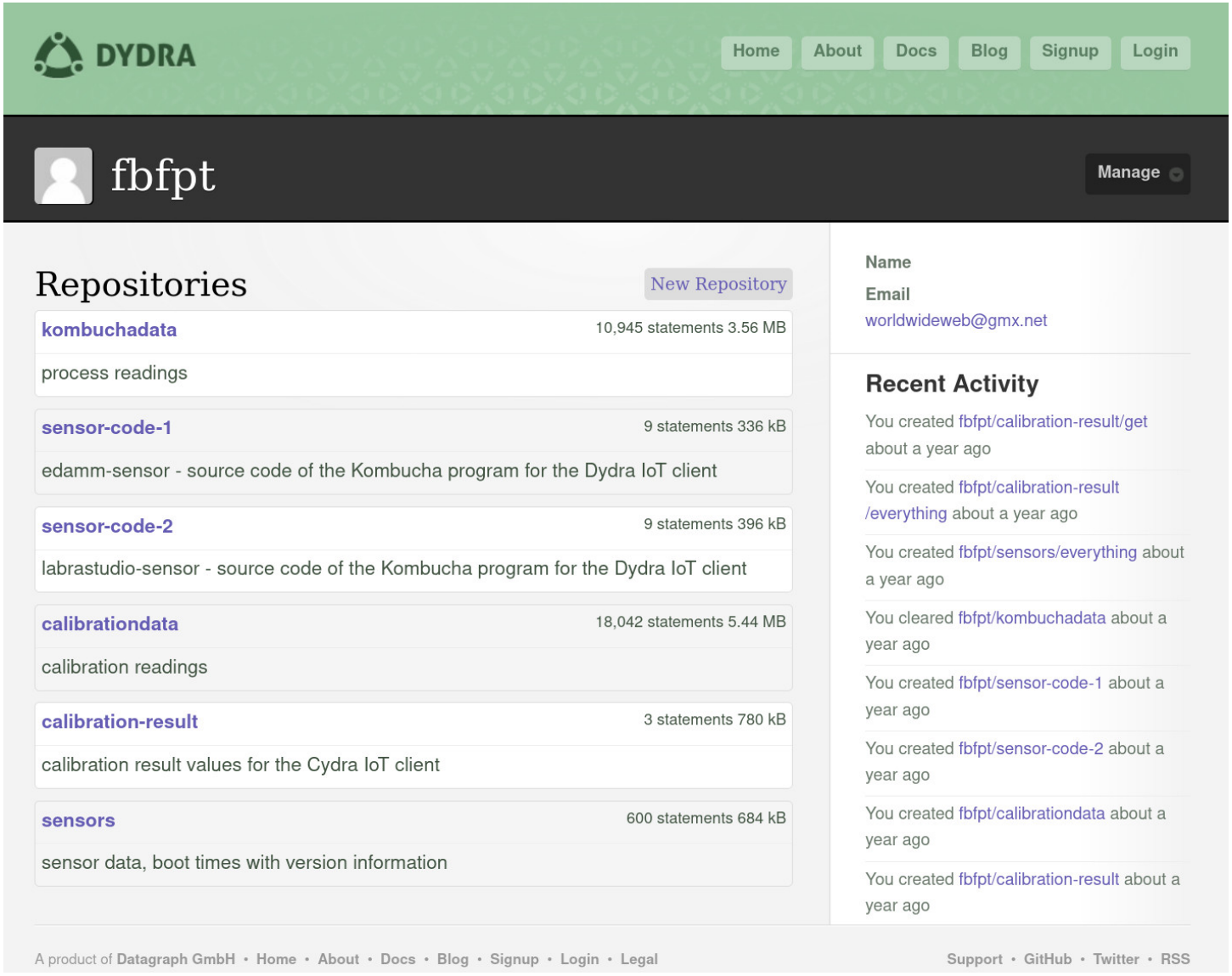
KOMBUCHA SENSOR DEVICE

MAX-GERD RETZLAFF, FEB 2021

[Retzlaff 2021k]

KOMBUCHA SENSOR DEVICE

MAX-GERD RETZLAFF, FEB. 2021



[Retzlaff 2021j]

KOMBUCHA SENSOR DEVICE

MAX-GERD RETZLAFF, FEB. 2021

datagenous · labra.studio

Share...

By m-g-r You Edited Mar 20 Fork of ph sensor calibration runs

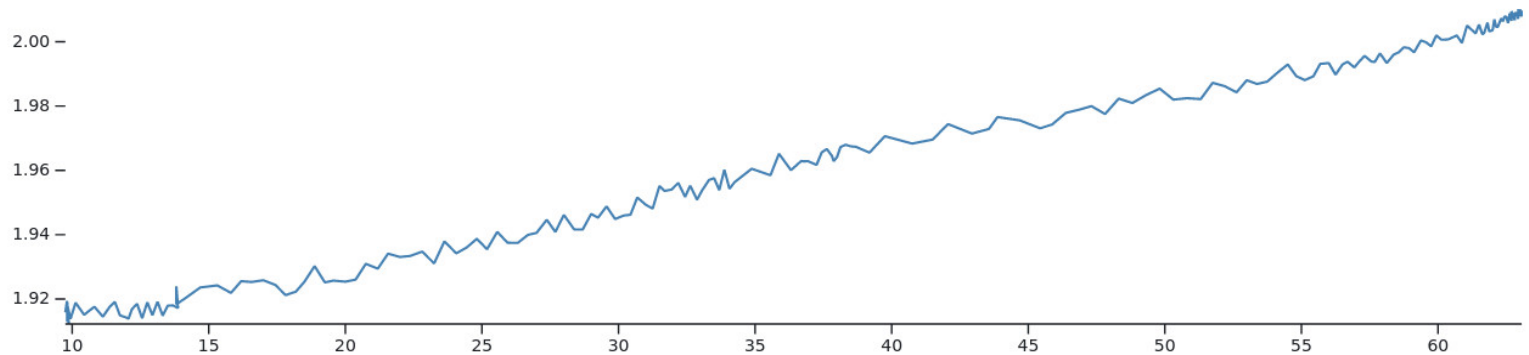
ph sensor calibration runs

All data is stored in: https://nl4.dydra.com/fbfpt/calibration See query:
https://nl4.dydra.com/fbfpt/calibration/@query#calibration_all_get

interactive visualization

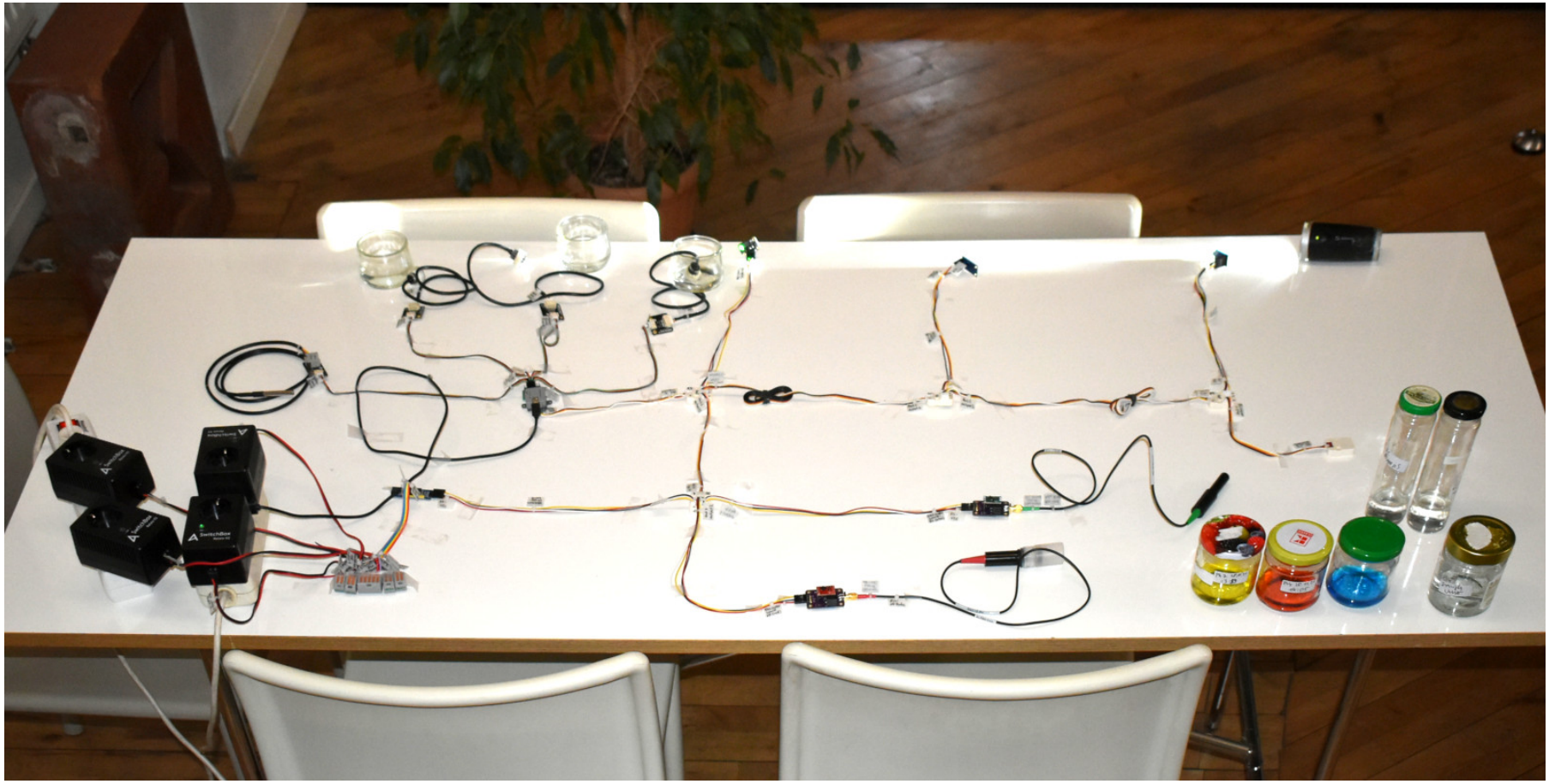
```
showfile = ▶ FileAttachment {name: "ph4.01-red@1.csv"}
```

```
// Apera Instruments calibration solutions:
//showfile = ph7g
showfile = ph4r
//showfile = ph10b
//showfile = ph7g2
// dfrobot calibration solutions:
//showfile = ph4
//showfile = ph7
```



[Retzlaff 2021i]

SENSOR DEVICE FOR AN AUTOMATED IOT DEVICE MAX-GERD RETZLAFF, NOV. 2021



[Retzlaff 2021b]

SENSOR DEVICE FOR AN AUTOMATED IOT DEVICE MAX-GERD RETZLAFF, NOV. 2021

- ten environmental sensors
- four controllable power sockets to activate environmental control measures
- Wi-Fi provisioned via Bluetooth (BLE)
- communication with a REST backend over Wi-Fi via JSON and HTTPs
- JSON protocol based on RelaxNG schemas (json-rnc)
- sends sensor readings to backend
- retrieves commands from a controlling smartphone application (from a different party) to control the actors or to calibrate the more complicated sensors
- liquid temperature sensor connected via one wire bus
- most sensors and actors connected via I2C bus
  with libraries completely written in uLisp

D I S C U S S I O N

[Retzlaff 2022b]

T H A N K Y O U

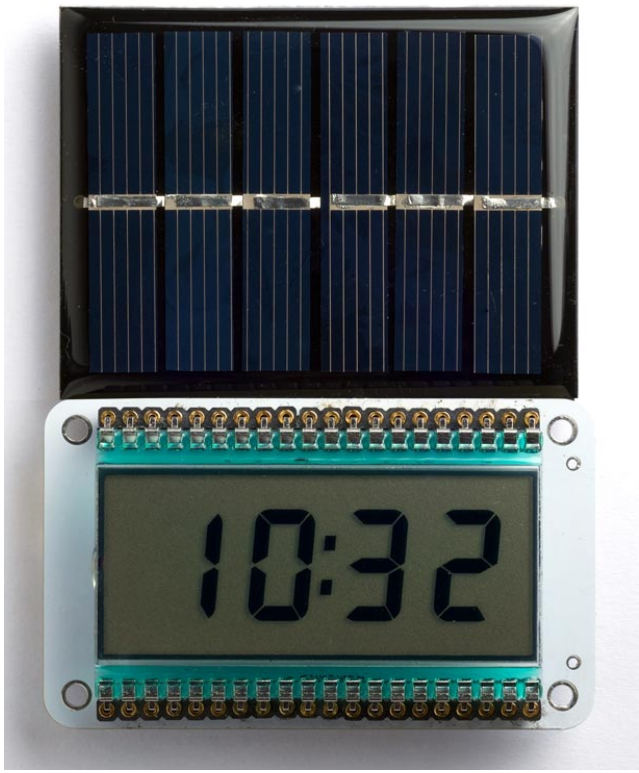

defsystem
Defining connected systems
Max-Gerd Retzlaff, Diplom-Informatiker

A P P E N D I X

SOLAR CLOCK

DAVID JOHNSON-DAVIES, 2021

A low-power LCD clock, with an average current consumption as about 9μA at 3.3V, designed to run from a solar cell allowing indefinite off-grid operation.



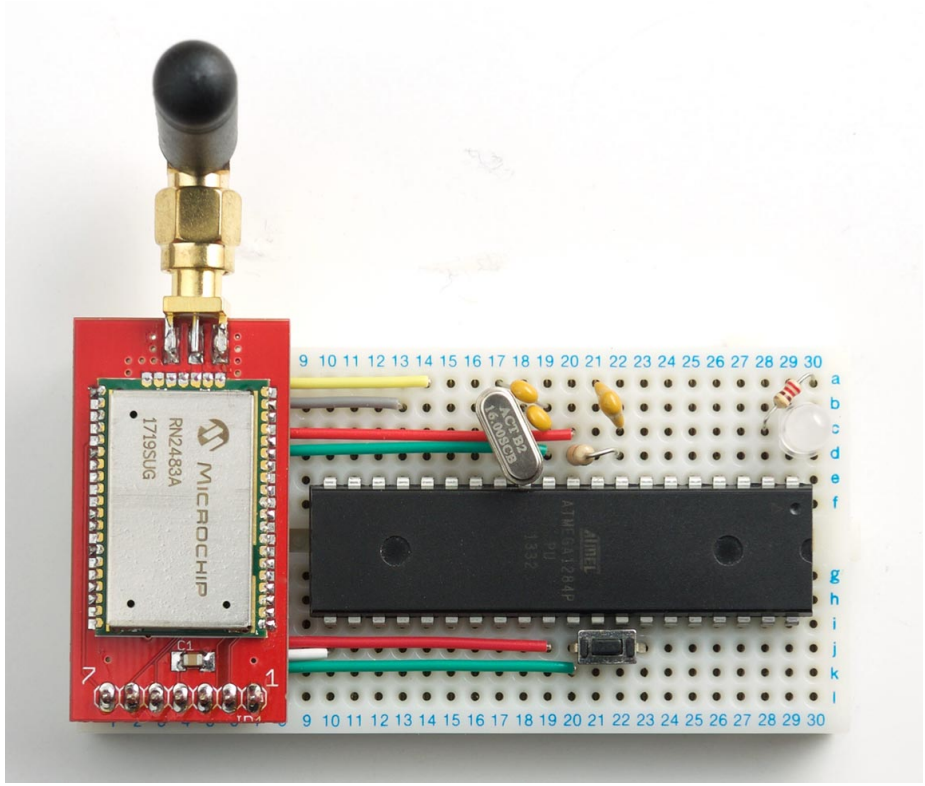
[Johnson-Davies 2021d]

LORAWAN NODE USING ULISP

DAVID JOHNSON-DAVIES, 2017

A LoRaWAN node, based on a Microchip RN2483A interfaced to an ATmega1284, and controlled by a program written in uLisp, capable of sending data to The Things Network.

See also `http://www.ulisp.com/show?1XWL`.



LISP BADGE

DAVID JOHNSON-DAVIES, 2019

A self-contained computer with its own display and keyboard, based on an ATmega1284 microcontroller, that can be programmed in uLisp, a subset of Common Lisp.

See also `http://www.ulisp.com/show?2L0C`.

IMPLEMENTATION ACKNOWLEDGEMENTS

Nurullah Akkaya's article "A micro-manual for LISP Implemented in C"
in early stages of designing the interpreter.

Bob Nystrom's article "Baby's First Garbage Collector"
for the garbage collector.

Section "A Properly Tail-Recursive Interpreter"
in Peter Norvig's classic book "Paradigms of Artificial Intelligence Programming"
for help with making the interpreter tail-recursive.

User clawson on AVR Freak (`https://www.avrfreaks.net/`)
when designing a procedure name lookup table in program memory.

B I B L I O G R A P H Y

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Johnson-Davies 2019
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Johnson-Davies 2021b
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Johnson-Davies 2021c
JOHNSON-DAVIES, David: *Picture of David Johnson-Davies*. Photography, 2021. Personal correspondence.

Johnson-Davies 2021d
JOHNSON-DAVIES, David: *Picture of the Solar Clock by David Johnson-Davies*. Photography, 2021. Personal correspondence.

M5Stack 2020
M5STACK: *Picture of M5Stack Atom Lite ESP32*. Promotional picture, 2020.

Retzlaff 2021a
RETZLAFF, Max-Gerd: *Picture of a Kombucha sensor device*. Photography, 2021.

Retzlaff 2021b
RETZLAFF, Max-Gerd: *Picture of a sensor device for an automated IoT device*. Photography, 2021.

Retzlaff 2021c

RETZLAFF, Max-Gerd: *Picture of assembly of the Scooter Lisp computer*. Photography, 2021.

Retzlaff 2021d

RETZLAFF, Max-Gerd: *Picture of M5Stack ESP32 Basic Core*. Photography, 2021.

Retzlaff 2021e

RETZLAFF, Max-Gerd: *Picture of M5Stack stand-alone uLisp computer*. Photography, 2021.

Retzlaff 2021f

RETZLAFF, Max-Gerd: *Picture of replaced speedometer clock with Scooter Lisp*. Photography, 2021.

Retzlaff 2021g

RETZLAFF, Max-Gerd: *Picture of replaced speedometer clock with Scooter Lisp #2*. Photography, 2021.

Retzlaff 2021h
RETZLAFF, Max-Gerd: *Picture of the replacement of the display of the speedometer clock*. Photography, 2021.

Retzlaff 2021i
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