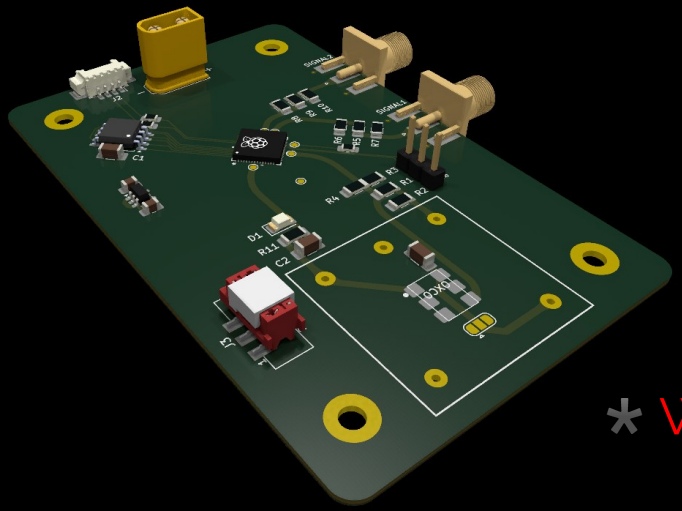
# The cheapest GPSDO yet ..



* Work in progress

Andreas Gibhardt

Dedrone®

# There is a LOT of DIY

- Discrete PLLs / Decimators
- 8 Bit PWMs
- Arduinos
- Long warmups
- Endless debugging

- Afraid of open windows

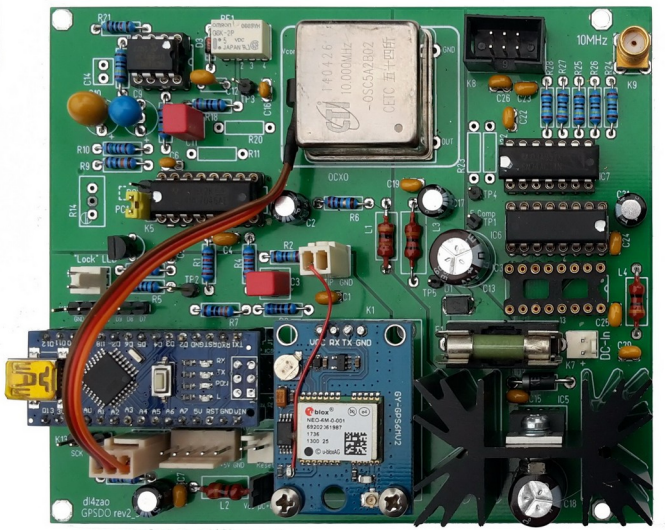
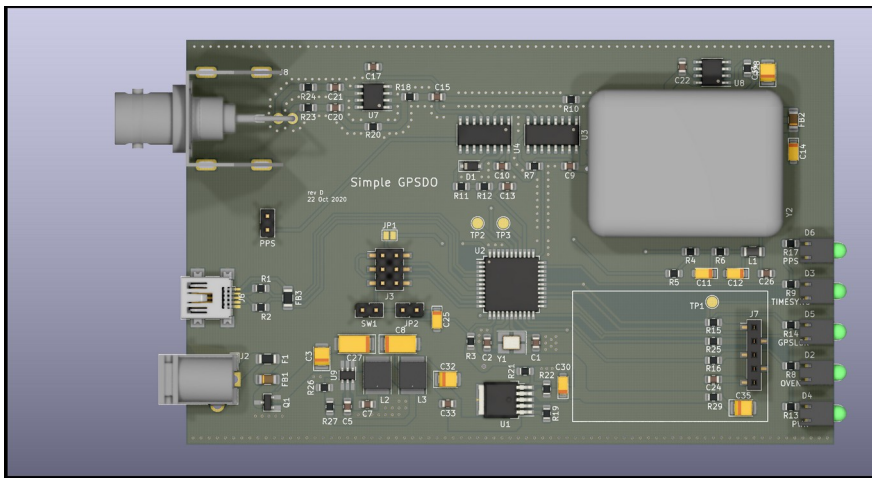


Foto:DC5WW

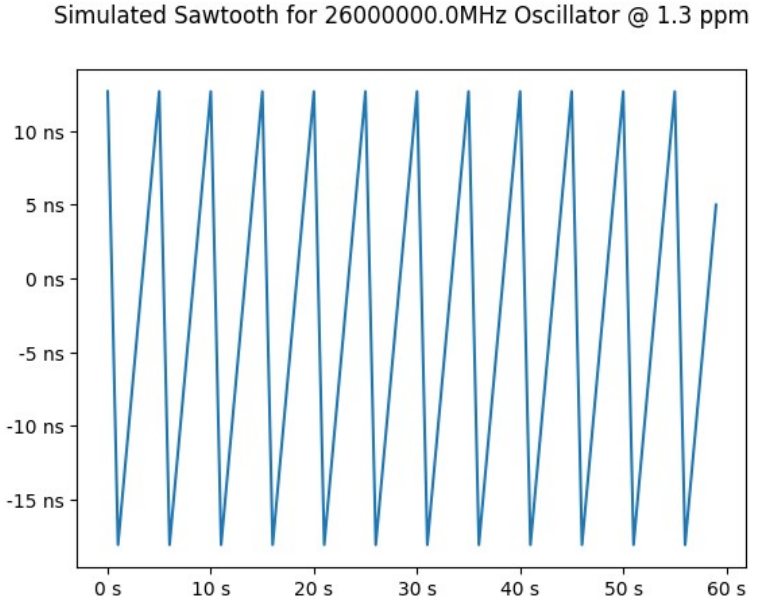


# Goals

- **No** clock bias drift
- **Quick** warmup
- **Correct** sawtooth effect
- **Minimal** BOM

  ..

- **0.5 ppb** even with an open window



# **The neat Trick –** Discipline the receiver

The LEA-M8F is the only Ublox model that is disciplining its own clock directly

- The receiver internally knows its clock bias down to Pico Seconds
- Not too many analog problems
- Very short warmup because of this
- The LEA-M8F has the wrong rate (30.72MHz) and is not recommended for new designs anymore

**32.17.3 UBX-NAV-CLOCK (0x01 0x22)**

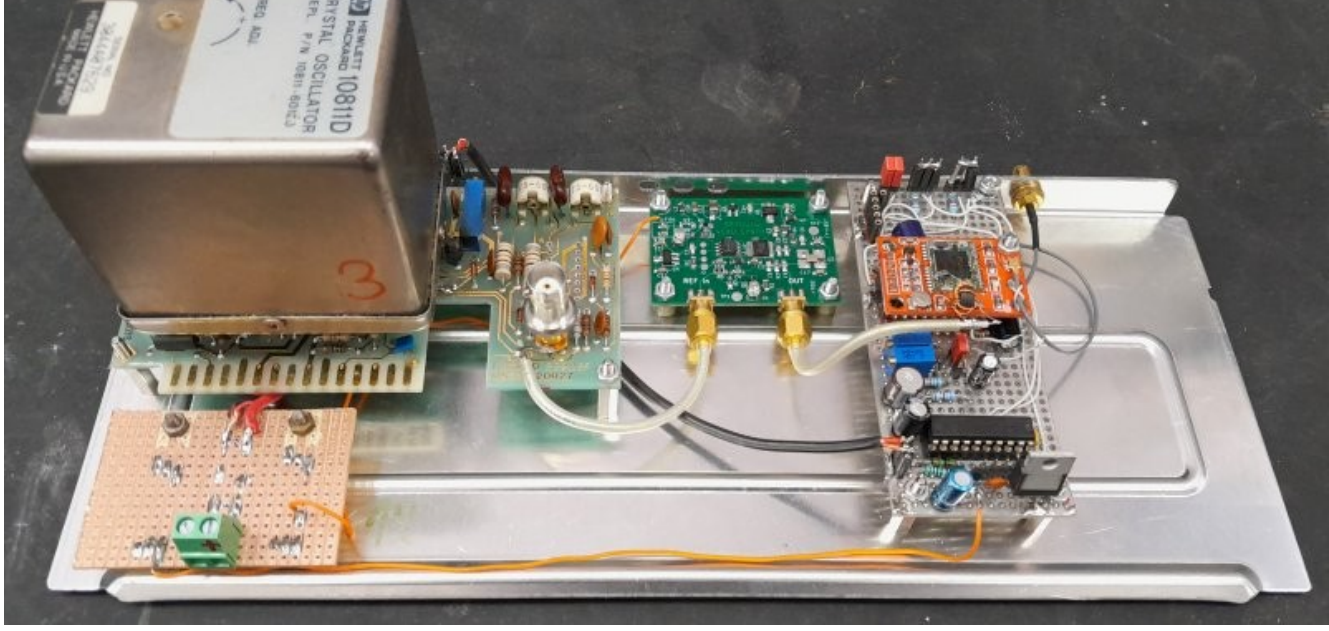
**32.17.3.1 Clock solution**

| | | | | | | |
|---|---|---|---|---|---|---|
| Message | **UBX-NAV-CLOCK** | | | | | |
| Description | **Clock solution** | | | | | |
| Firmware | Supported on:<br>• u-blox 8 / u-blox M8 protocol versions 15, 15.01, 16, 17, 18, 19, 19.1, 19.2, 20, 20.01, 20.1, 20.2, 20.3, 22, 22.01, 23 and 23.01 | | | | | |
| Type | Periodic/Polled | | | | | |
| Comment | - | | | | | |
| | Header | Class | ID | Length (Bytes) | Payload | Checksum |
| Message Structure | 0xB5 0x62 | 0x01 | 0x22 | 20 | see below | CK_A CK_B |

Payload Contents:

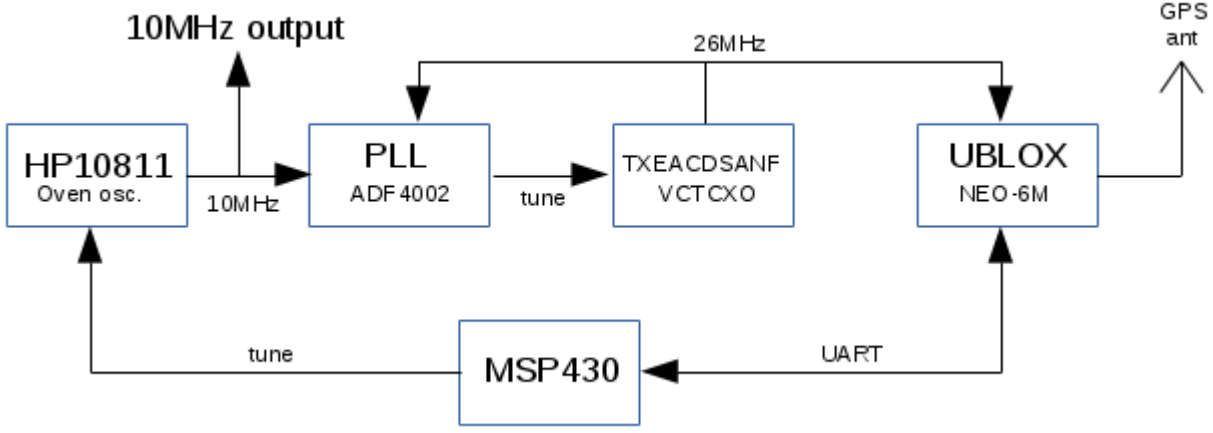
| Byte Offset | Number Format | Scaling | Name | Unit | Description |
|---|---|---|---|---|---|
| 0 | U4 | - | iTOW | ms | GPS time of week of the navigation epoch. See the description of iTOW for details. |
| 4 | I4 | - | clkB | ns | Clock bias |
| 8 | I4 | - | clkD | ns/s | Clock drift |
| 12 | U4 | - | tAcc | ns | Time accuracy estimate |
| 16 | U4 | - | fAcc | ps/s | Frequency accuracy estimate |

# Lets DIY This!



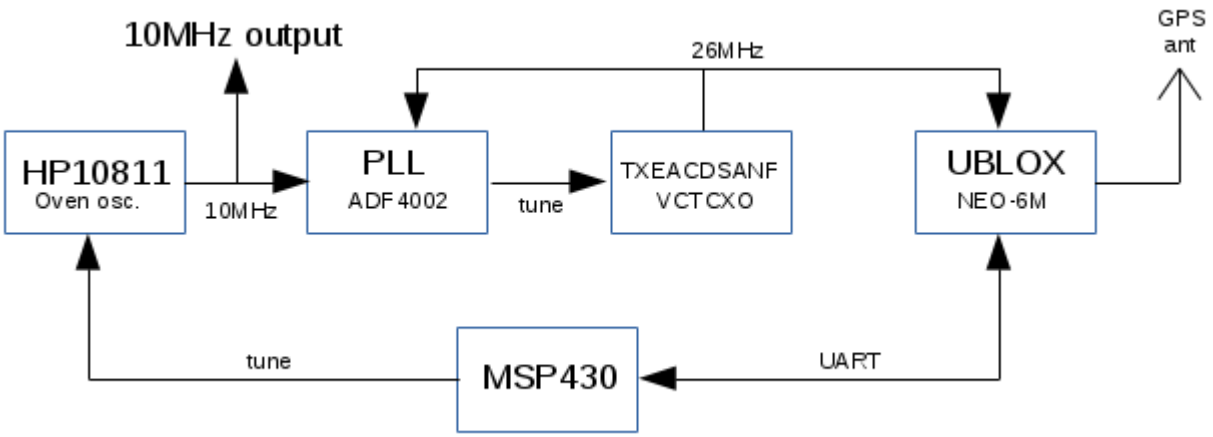

Or read **Marko Ceboklis'** blog first, unlike me who discovered it yesterday.

Its a **great** analysis to this approach.



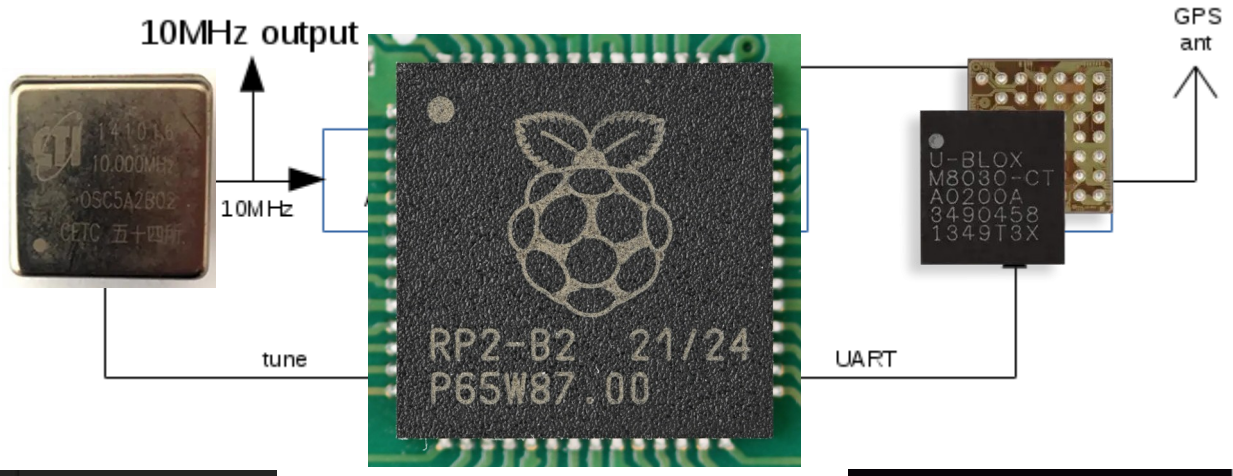

* https://lea.hamradio.si/~s57uuu/mischam/gpsy/index.html

# Let’s make it even simpler ..

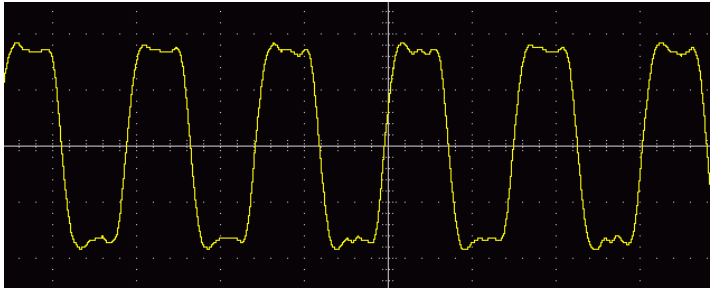


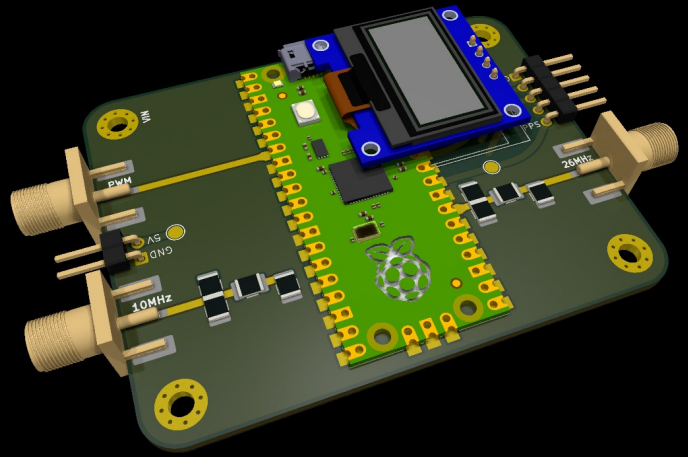

* https://lea.hamradio.si/~s57uuu/mischam/gpsy/index.html

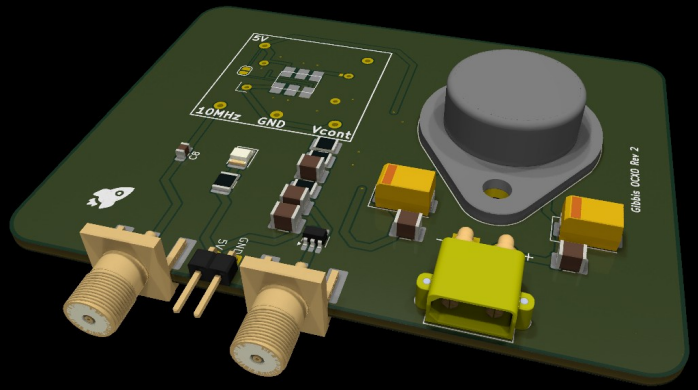
# The rp2040 is Awesome!




```
Requested: 104.0 MHz
Achieved:  104.0 MHz
REFDIV:    1
FBDIV:     104 (VCO = 1040.0 MHz)
PD1:       5
PD2:       2
```

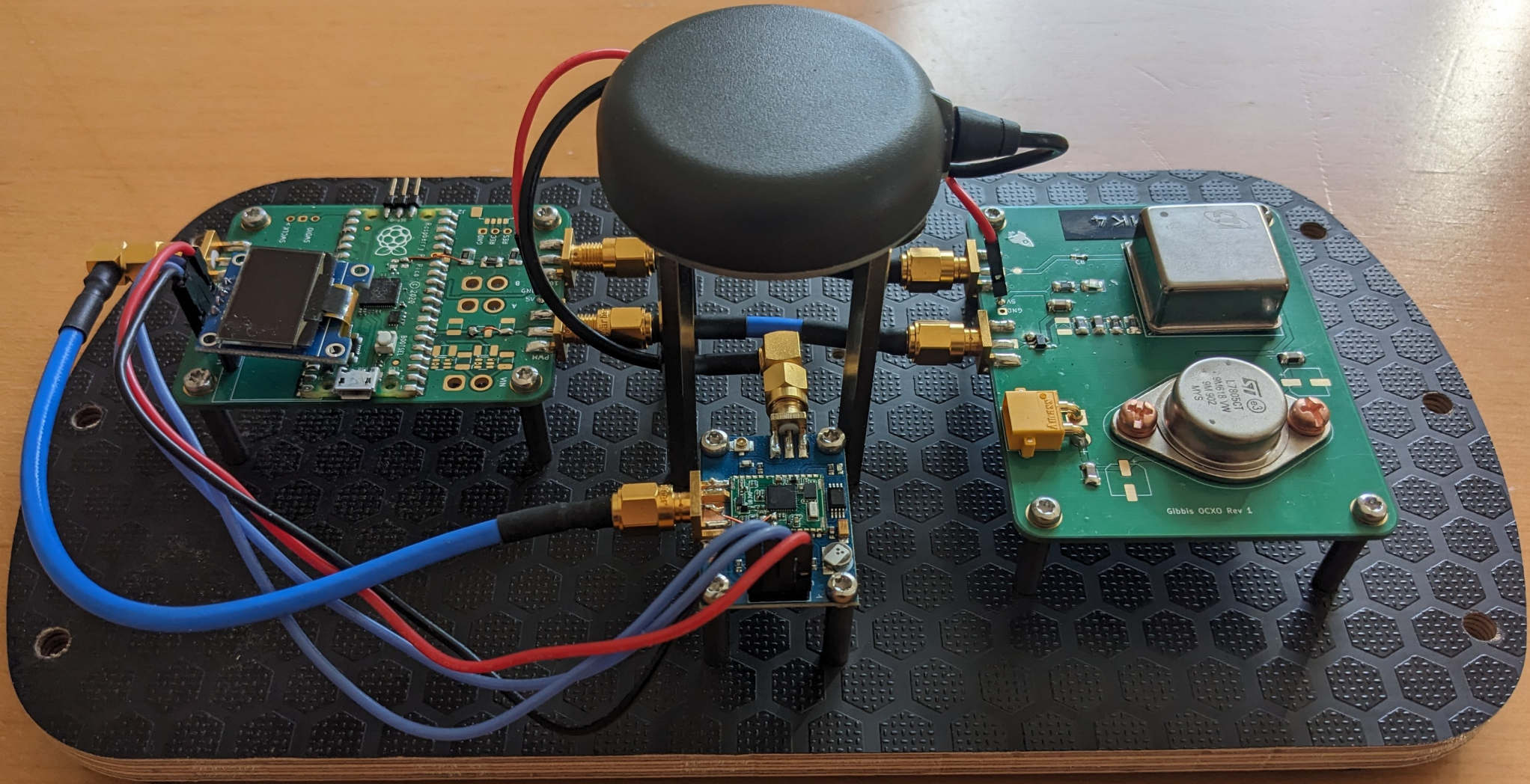




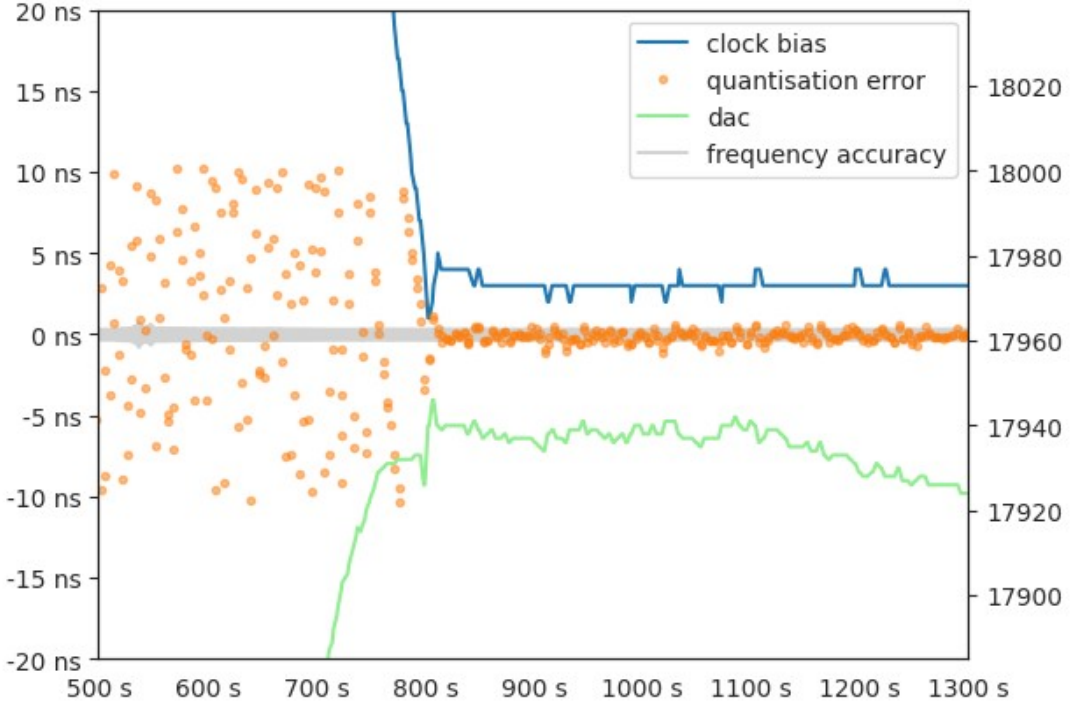



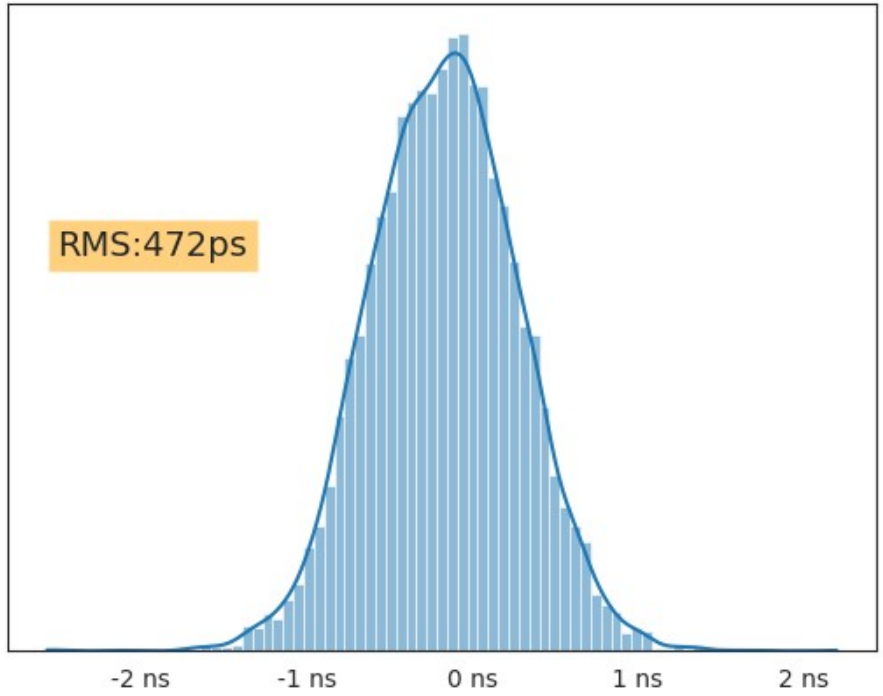

- OCXO + 16Bit PWM DAC
- Resampling to 26MHz via rp2040 Clock PLL
- Configuration of GPS also via rp2040

Dedrone®


L7805CT
Gibbis OCXO Rev 1

# Results




* There is a problem in the control loop ▯ the performance will be even better in the future

# Results

## Timing performance data

| | | |
|---|---|---|
| Timing accuracy | RMS | 30 ns |
| | 99% | < 60 ns |
| | Granularity | 21 ns |
| | Compensated | 15 ns[1] |

[1] Quantization error information can be used to compensate the granularity related error of the timepulse signal

# Results

## Timing performance data

| | | |
|---|---|---|
| Timing accuracy | RMS | 30 ns |
| | 99% | < 60 ns |
| | Granularity | ~~21 ns~~ **1 ns** |
| | Compensated | 15 ns[1] |

[1] Quantization error information can be used to ~~compensate~~ the granularity related error of the timepulse signal **correct**

Dedrone®

built in 2024 BEST PLACES TO WORK

Find the Files soon at **github.com/gibbi/**
We do fun stuff like this all day and **we are Hiring!**
I have leftover PCBs if you want one!

# Thank you !

reach out to **andreas.gibhardt@dedrone.com**

TOP 100 INSPIRING™ WORKPLACES 2024 WINNER NORTH AMERICA