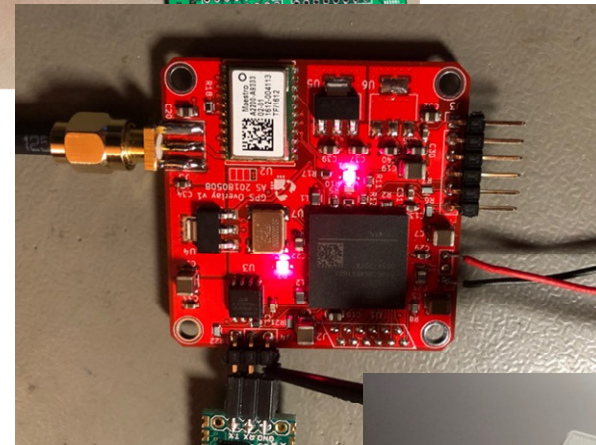
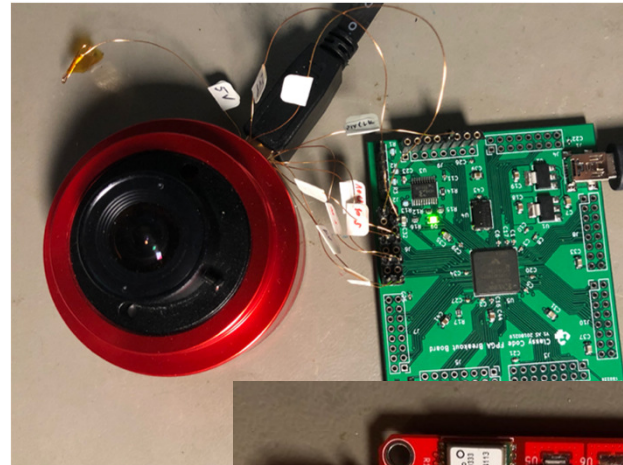


Development of a new Camera with Digital Video Time Insertion

Andreas Schweizer, 27.10.2018

Agenda

- Who am I?
- Motivation
- Proof-of-Concept
 - System Architecture
 - Firmware
 - Hardware
 - Testing, Test Results
- Prototype
- Next Steps
- Demo, Discussion

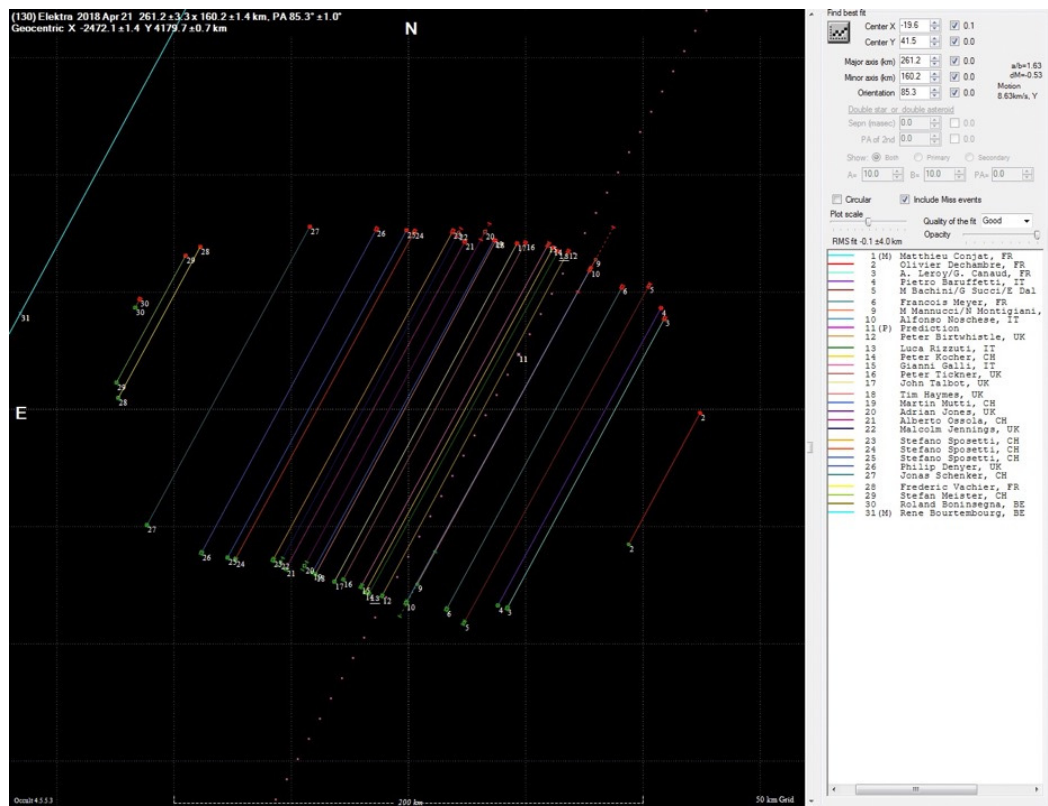


Who am I?

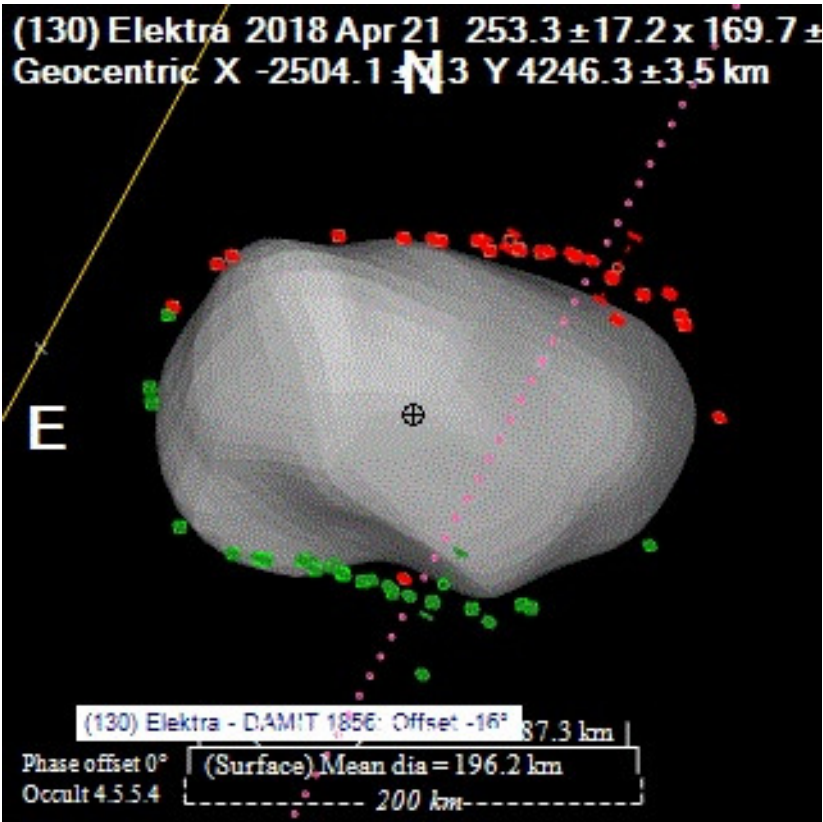
- Born in Bülach ZH, now living in Wettswil ZH
- Married since 2003, 1 Girl (2 ½ years old)
- Dipl. Software Engineer ETH 2003
- Worked in Software Company as SW Architect 2003-2016
- Company with a friend since 2016 (Classy Code GmbH)
- AGZU since ~ 1993
- Technical Support Team Sternwarte Bülach
 - Guided Tours calendar
 - Telescope control system, motor drivers, ...
 - Support for technical projects
- Other hobbies: Amateur radio (HB9DPA), Squash



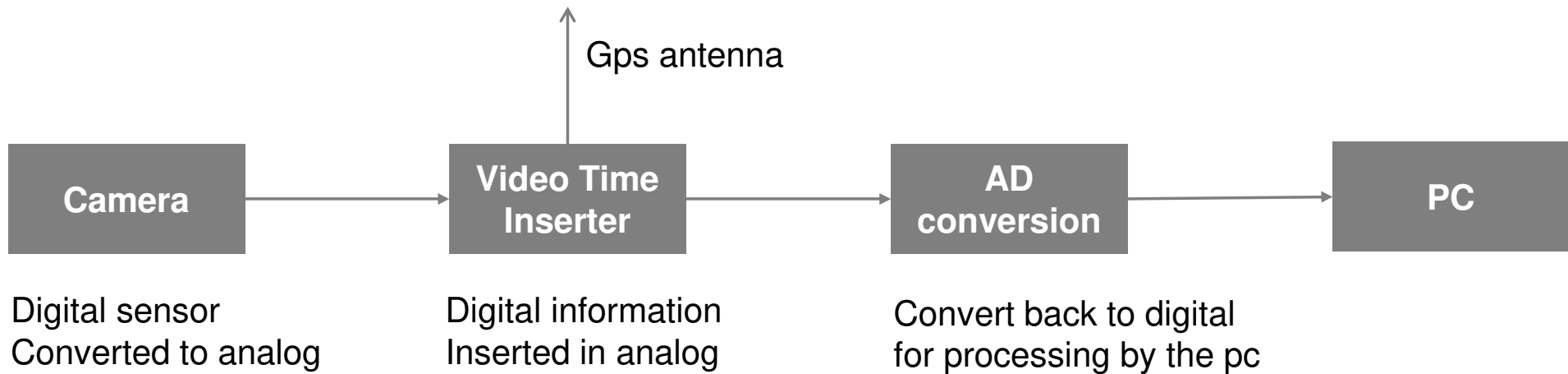
Motivation



(130) Elektra, 21.04.2018



Motivation



«Why not insert the time information
directly into the pixel stream?»

Motivation

Cheap camera to modify for a POC?



ZWO ASI120MM

Sensor: 1/3" CMOS AR0130CS(Mono)

Resolution: 1.2Mega Pixels 1280×960

Pixel Size: 3.75μm

Exposure Range: 64μs-2000s

ROI: Supported

Interface: USB2.0

Bit rate: 12bit output

Adaptor: 2" / 1.25" / M42X0.75

Dimension: φ62mm X 28mm

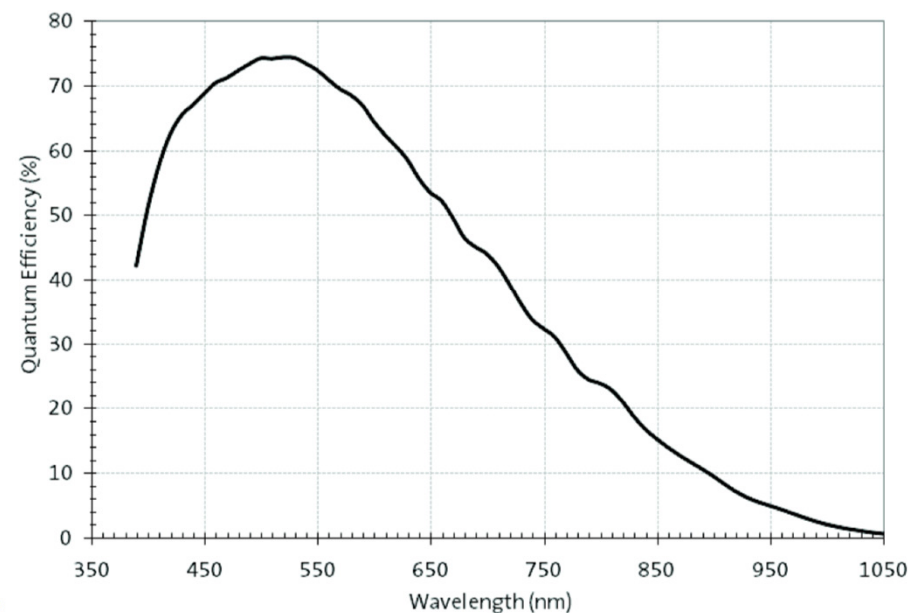
Weight: 100g

Working Temperature: -5°C–45°C

Storage Temperature: -20°C–60°C

Working Relative Humidity: 20%–80%

Storage Relative Humidity: 20%–95%



ASI120MM Sytem Architecture

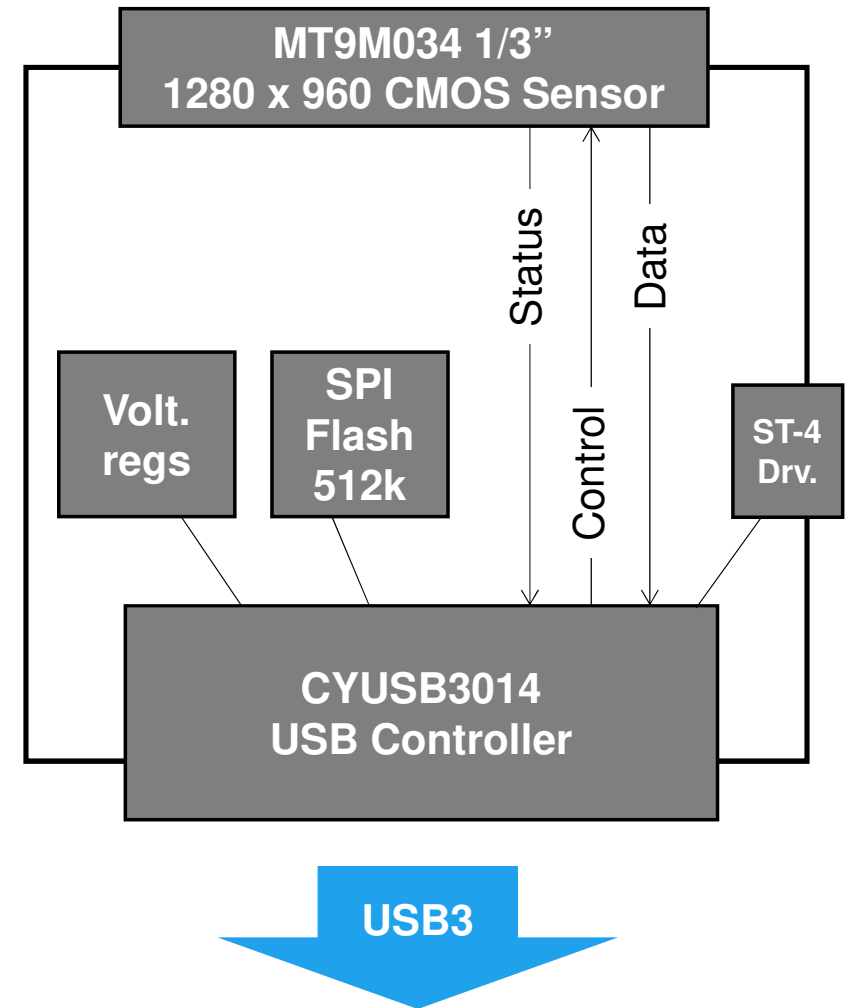
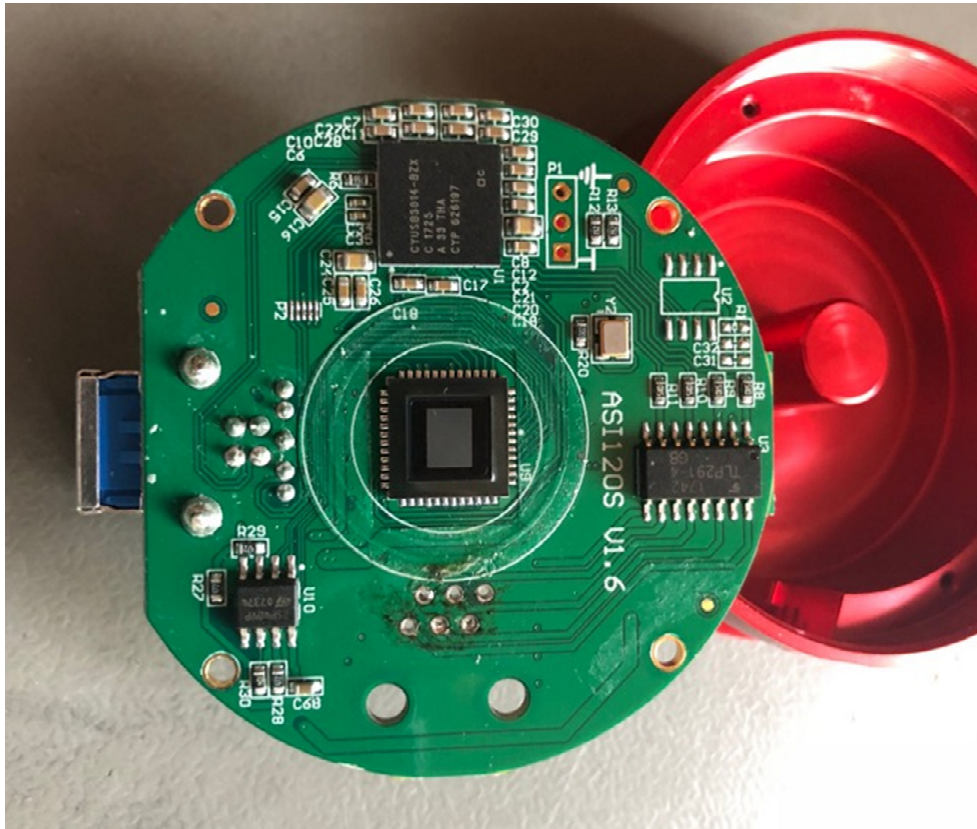


Image Sensor MT9M034

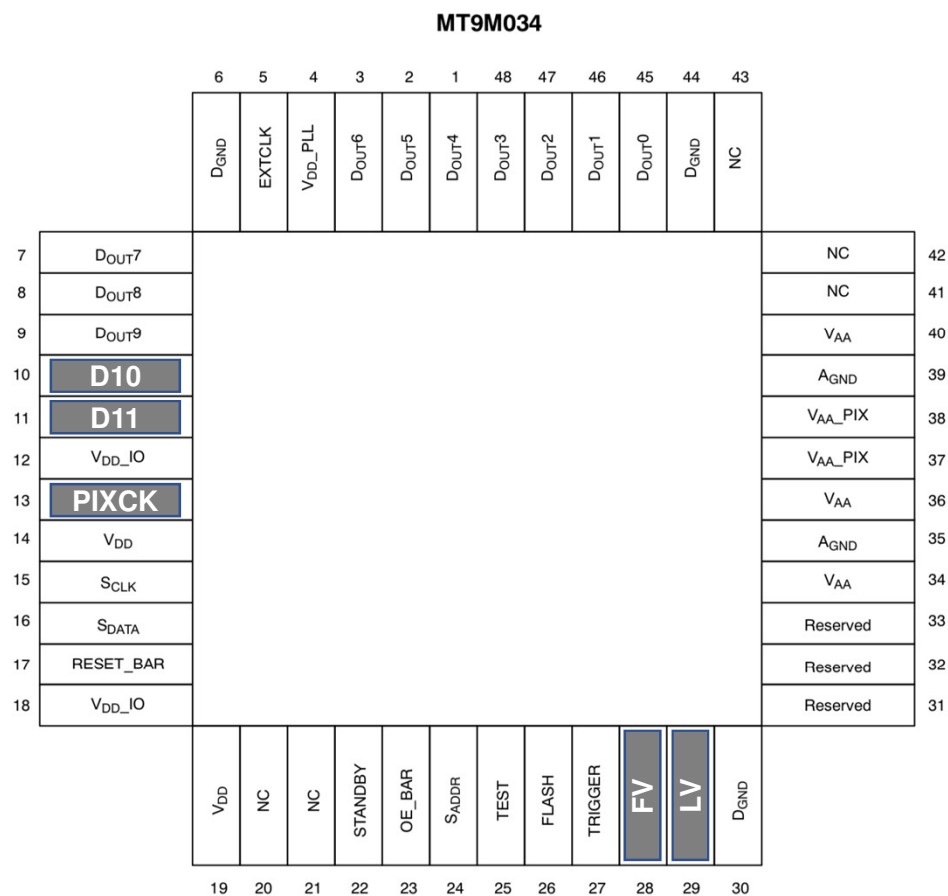


Figure 3. 48 iLCC Package, Parallel Output

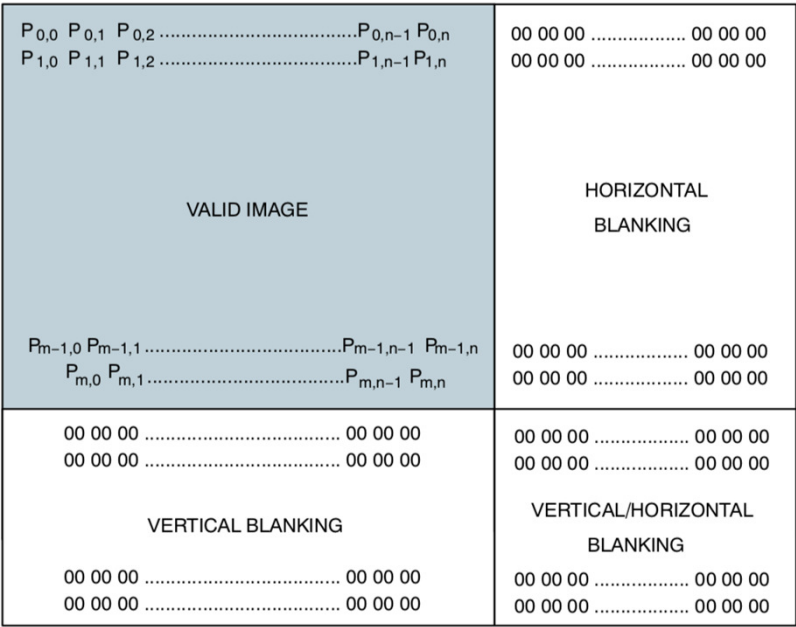


Figure 7. Spatial Illustration of Image Readout

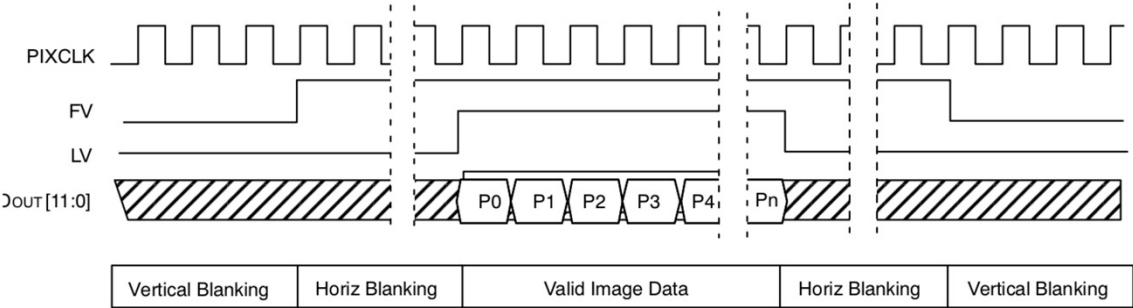
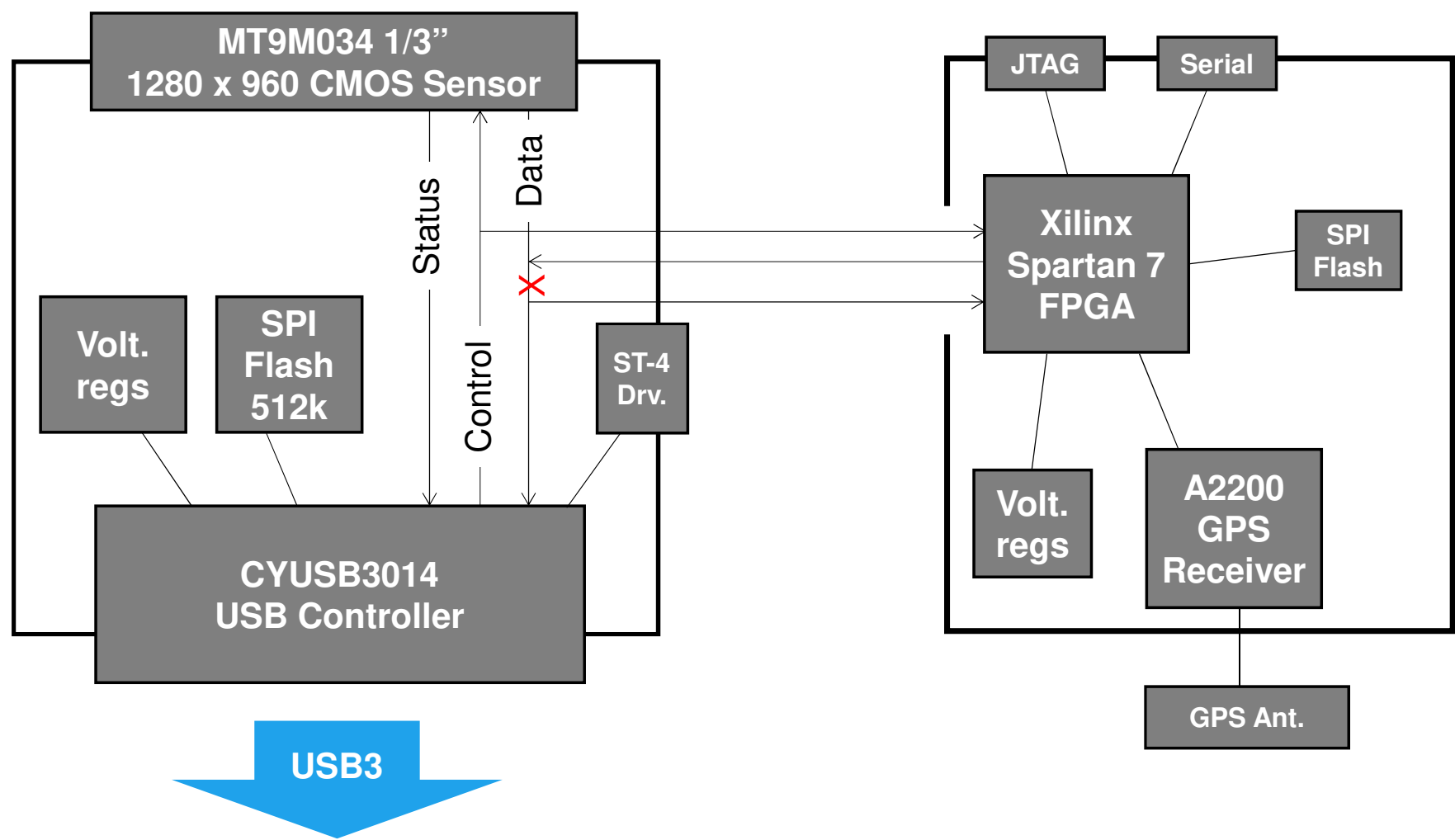
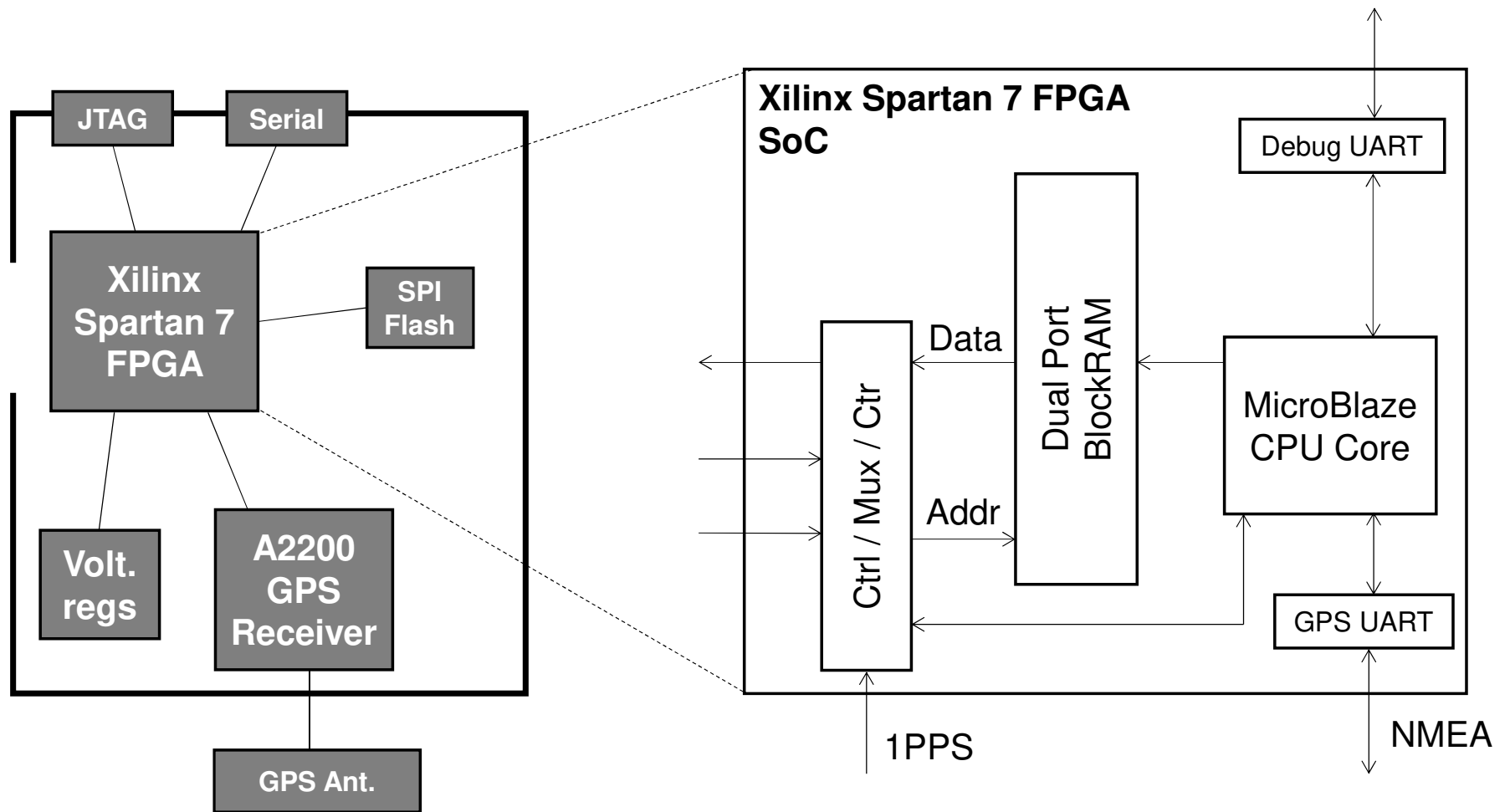


Figure 8. Default Pixel Output Timing

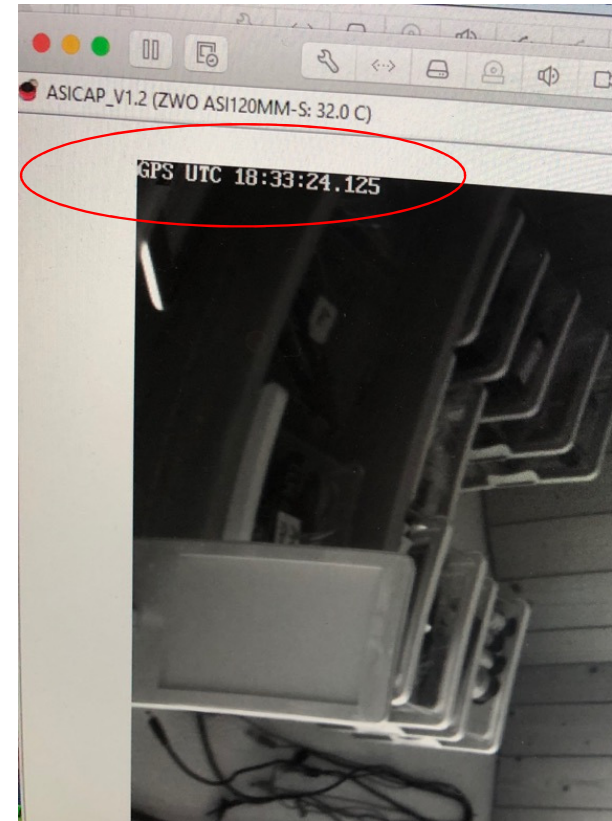
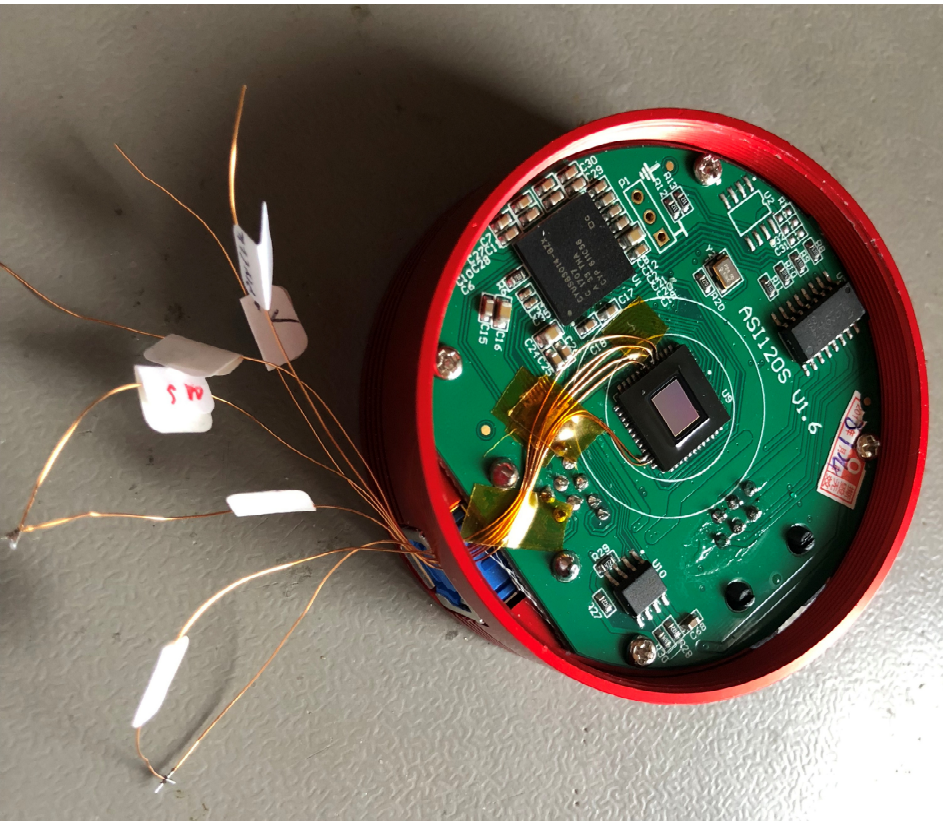
PoC Sytem Architecture



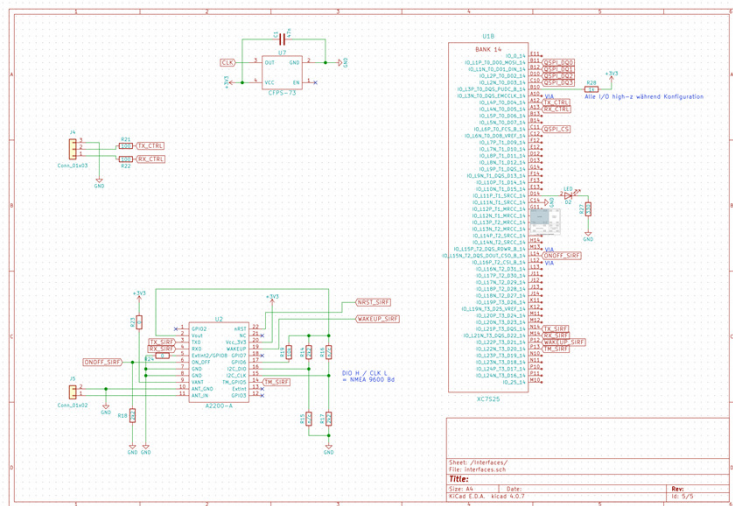
PoC Sytem Architecture



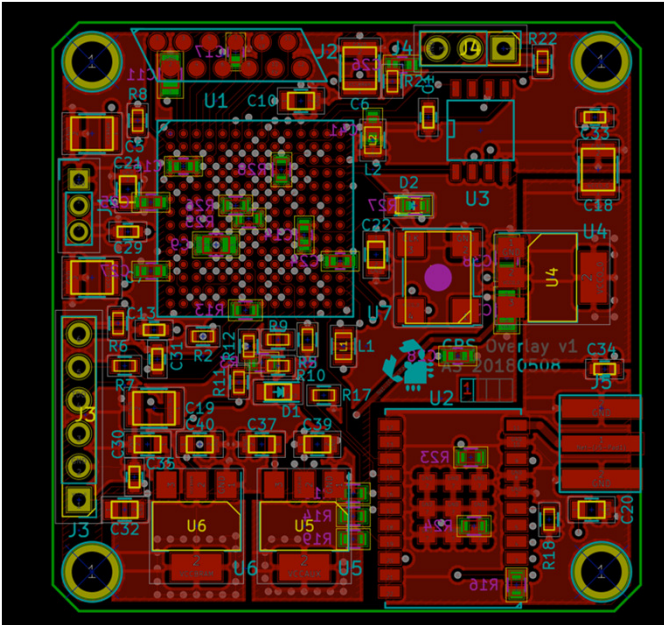
PoC Quick Test



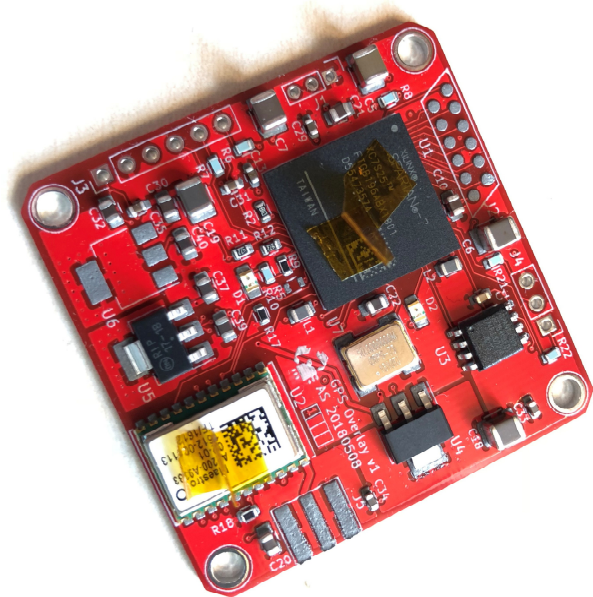
PoC PCB Design



Schematics



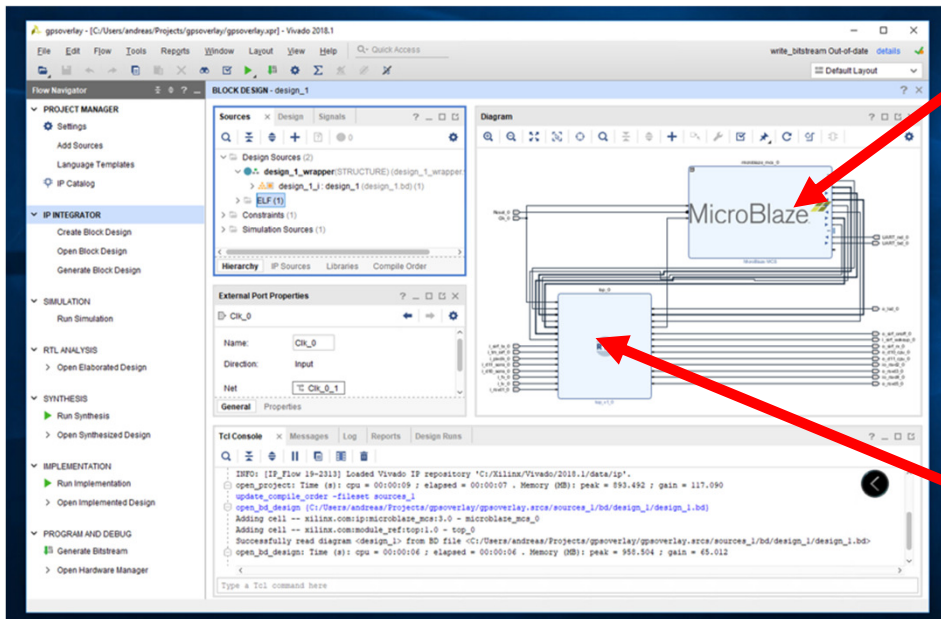
→ Layout



→ Board

PoC Firmware + HDL Code

Vivado



```
gpsoverlay.sdk - C/C++ - application/src/main.c - Xilinx SDK
File Edit Navigate Search Project Run Xilinx Window Help

Project Explorer
application
  Binaries
  Includes
  Debug
  src
    cbuf.c
    cbuf.h
    font.c
    led.c
    led.h
    main.c
    platform_config.h
    platform.c
    platform.h

main.c
gHofExtIntCalls++;
uint32_t interruptFlags = REG_INTERRUPTS;
if (interruptFlags & REG_INTERRUPT_START_OF_FRAME) {
    // REG_SCR &= ~0x00000004; // Test-Output oRsvd3
    REG_SCR |= 0x00000100; // Test-Output oRsvd2

    // REG_FRAME_NR enthält 24 bit binär.
    // Lesen bestätigt den Start-of-Frame Interrupt.
    uint32_t frameNr = REG_FRAME_NR;
    // Lesen in Reihenfolge yymmdd, dann hhmmss, dann ms
    uint32_t yymmdd = REG_GPS_00YYMMDD;
    uint32_t hhmmss = REG_GPS_00HHMMSS;
    uint32_t ms = REG_GPS_MS;

    // Daten sofort ins BlockRAM zum Anzeigen
    // YYMMDD
    write21212(vymmdd, 11);
}
```

C Code

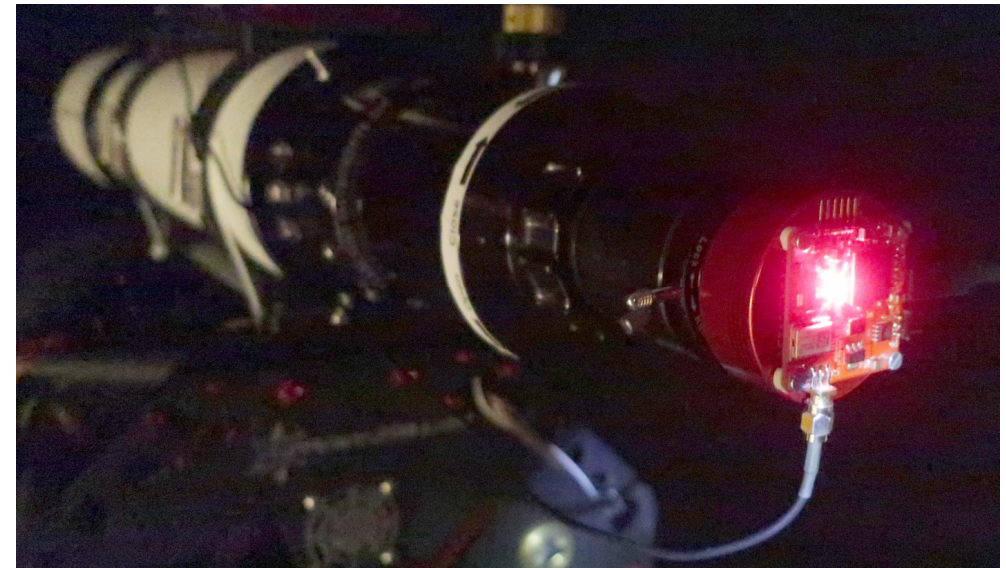
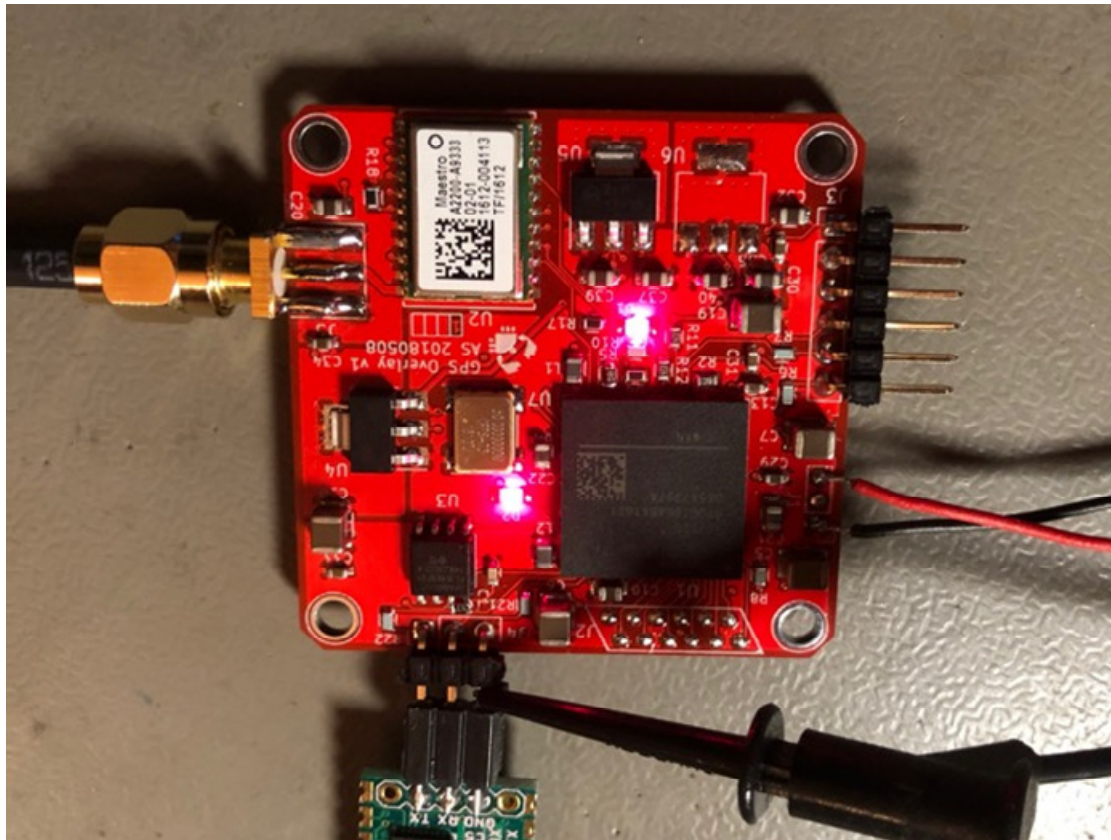
```
Diagram x top.vhd x
C:/Users/andreas/Projects/gpsoverlay/gpsoverlay.srccs/sources_1/imports/Desktop/top.vhd

1 library IEEE;
2 use IEEE.STD_LOGIC_1164.ALL;
3 use IEEE.NUMERIC_STD.ALL;
4
5 library UNISIM;
6 use UNISIM.VComponents.all;
7
8 entity top is
9 Port (
10   clk: in std_logic; -- 50 MHz clock from oscillator
11   o_led: out std_logic;
12   -- i/o
13   i_io_addr_strobe: in std_logic;
14   i_io_address: in std_logic_vector(31 downto 0);
15   i_io_write_strobe: in std_logic;
16   i_io_write_data: in std_logic_vector(31 downto 0);

```

VHDL Code

PoC Testing



PoC Timestamp Format

GPS UTC 2018-07-22 18:00:21.967-21.994 101500 - 12m N47.3419138 E008.4730658 01 11 17 18 23 03 09 22 31 14 32 19

GPS: GPS-Empfänger empfängt Daten

XXX: Schaltsekunden noch nicht empfangen

UTC: Schaltsekunden empfangen, GPS-Zeit korrekt

YYYY-MM-DD HH:MM:SS.millisec: Start der Integration

-SS.millisec: Ende der Integration

Frame-Nummer

Genauigkeit des GPS-Fixes

GPS-Koordinaten

Empfangene Satelliten inkl. SNR ----->

PoC Testing



PoC Testing



**Accurate to
~ 20ms
with the FV
signal**

**Could be
improved by
using the
FLASH signal**

PoC Test Results + Feedback

- Start time accurate to ~20ms
- End time based on frame rate instead of exposure time!
- Timestamp not readable if binning is active
- Loss of GPS almanach, GPS-UTC difference on shutdown

- Accuracy: Use FLASH signal instead of FV
- GPS: Use buffer battery, include GLONASS
- Include digital timestamp in SER file?

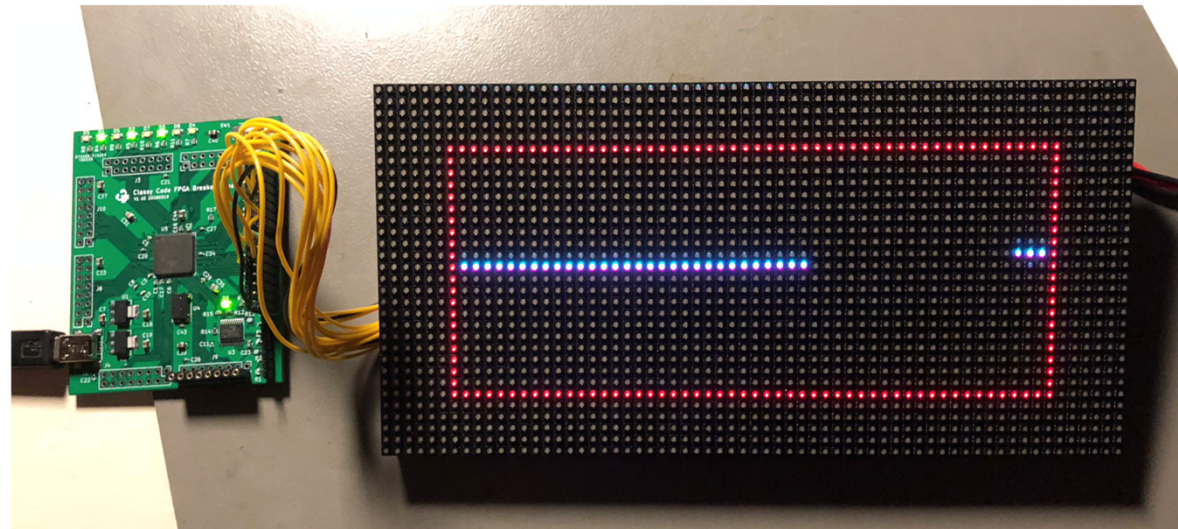
Next Steps

- PoC → works!
- **Camera Prototype**
 - Software + Hardware Development
 - More testing
 - Detail decisions (filter glass, M42 mount, alternative sensors, ...)
- **Kickstarter Project**

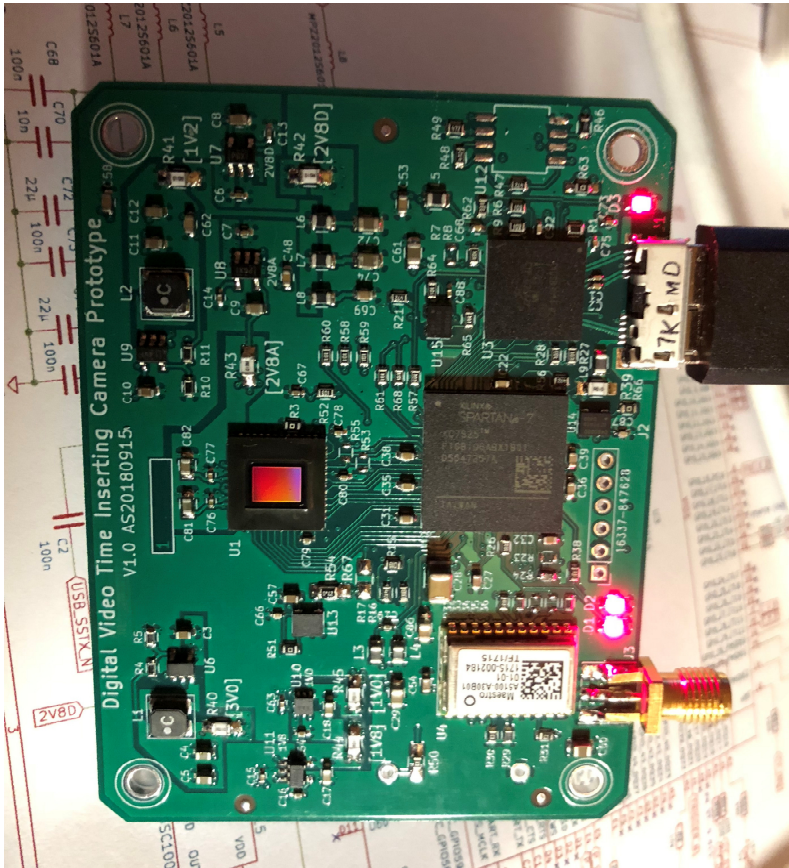
Next Steps – Testing

More tests planned with the **camera prototype**:

- Gerhard Dangl (EXTA)
- GPS LED Panel (side project ;-)
- Peter Schlatter (Uni Bern) if possible
- Christoph Bittner (QHYCCD174 GPS) if possible
- ...



Next Steps – Camera Prototype



Next Steps – Kickstarter Project

- Design Decisions
- Cost Calculations
- Supplier Evaluation
- Project Plan
- Prototype V2
- KickStarter Campaign

~ **400...500 CHF**
per Camera
@ 100 PCS ?

Warranty + Support	10k
Reserve	5k
CE Certification	5k
USB ID	5k
Assembly	5k?
Mechanical Parts	5k?
PCB + Components	12k
R & D, FAT	«0»

Demo + Discussion