Final Presentation: Carrera Car

Embedded Operating Systems

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Recap

Goal:

- Driving as fast as a human

Midterm results:

- 2 driving cars
- Detect curves using accelerometer

Open problems:

- Mapping sensor data to track
- Using track data for speed regulation
- Accelerometer provides random data after some time

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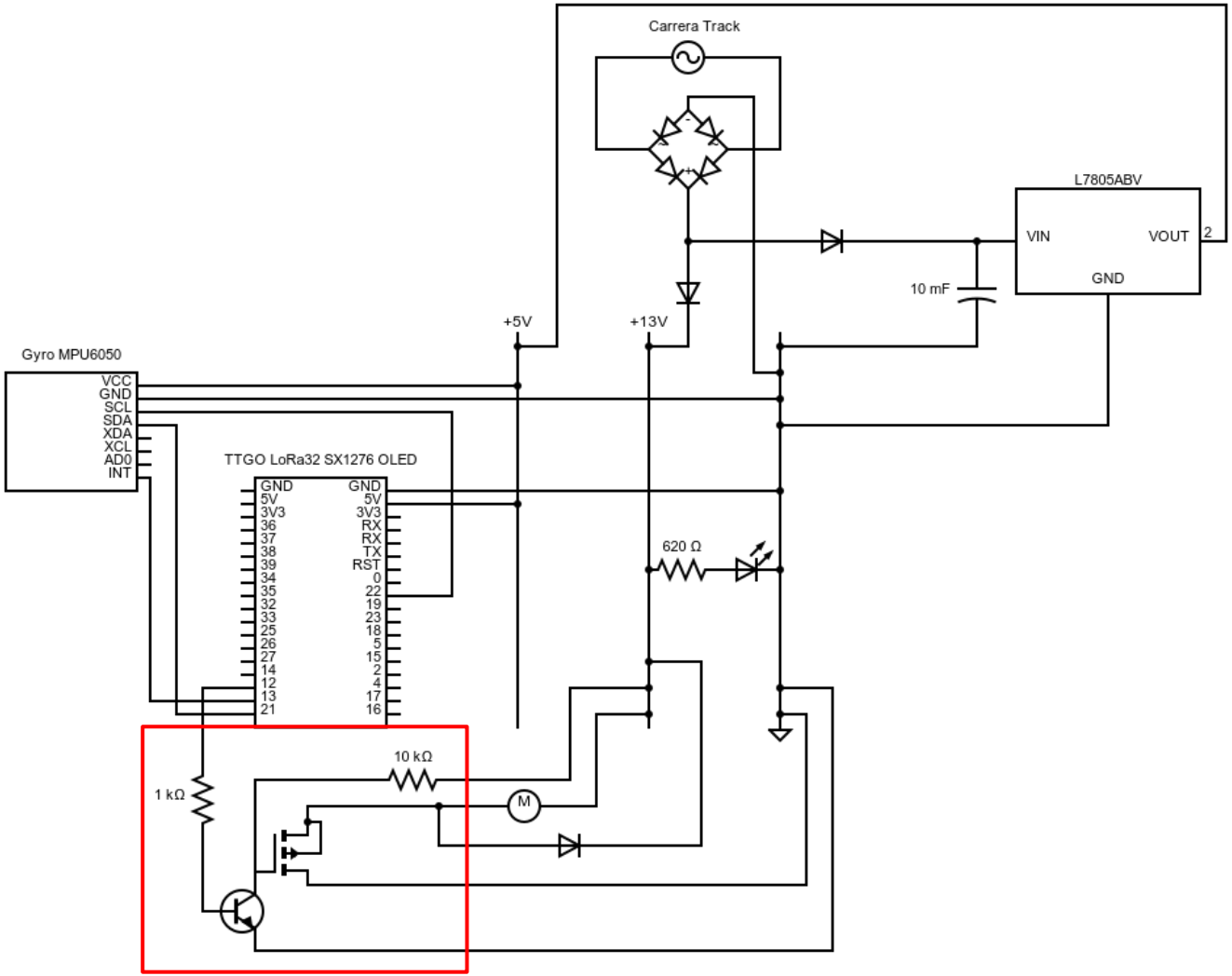
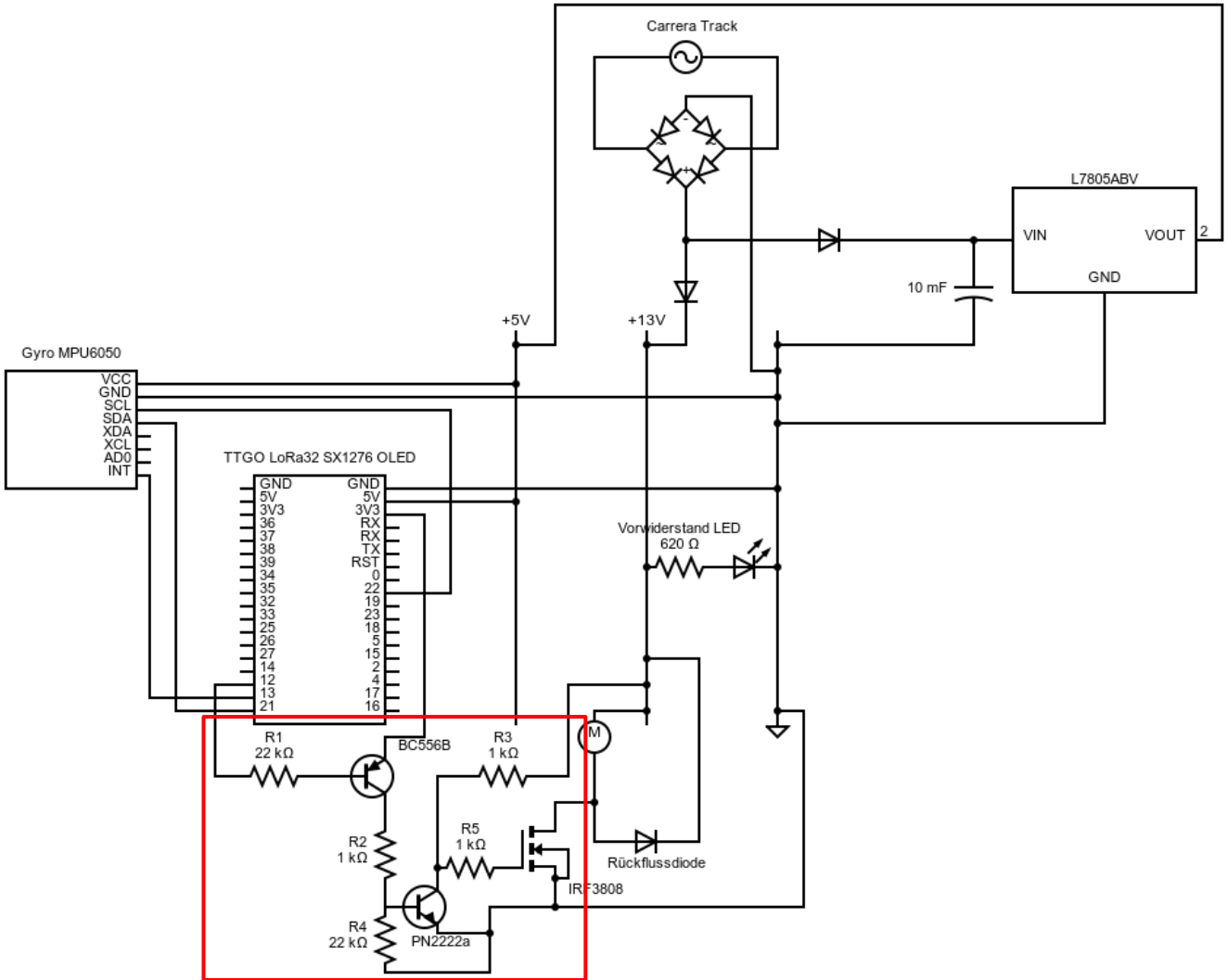
How To Go Fast...

Self Built Car vs Carrera

- Our car is slower with the same motor
- Determined as a hardware issue
  - Still slow when disabling PWM and setting motor pin to HIGH
  - Applying 5V to motor pin doesn’t change anything
  - Manually applying 12V to the motor increases torque considerably
  - Circuit diagram reveals Driver-Mosfet was used incorrectly

https://youtu.be/M6coudTHvN8


Carrera Track
L7805ABV
VIN
VOUT
GND
2
10 mF
+5V
+13V
Gyro MPU6050
VCC
GND
SCL
SDA
XDA
XCL
AD0
INT
TTGO LoRa32 SX1276 OLED
GND
5V
3V3
36
37
38
39
34
35
32
33
25
26
27
14
12
13
21
GND
5V
3V3
RX
RX
TX
RST
0
22
19
23
18
5
15
2
4
17
16
620 Ω
10 kΩ
1 kΩ
M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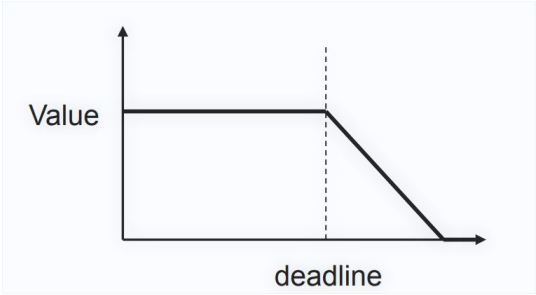
4
17
16
Vorwiderstand LED
620 Ω
M
R1
22 kΩ
BC556B
R3
1 kΩ
R2
1 kΩ
R5
1 kΩ
Rückflussdiode
IRF3808
R4
22 kΩ
PN2222a


The Road Ahead...

Idea

- Create track map
  - Drive at constant safe speed (predetermined)
  - Save driven track
  - Determine track layout from history
- Use map to adjust speed
  - If curve ahead => slow down
  - If straight ahead => drive faster

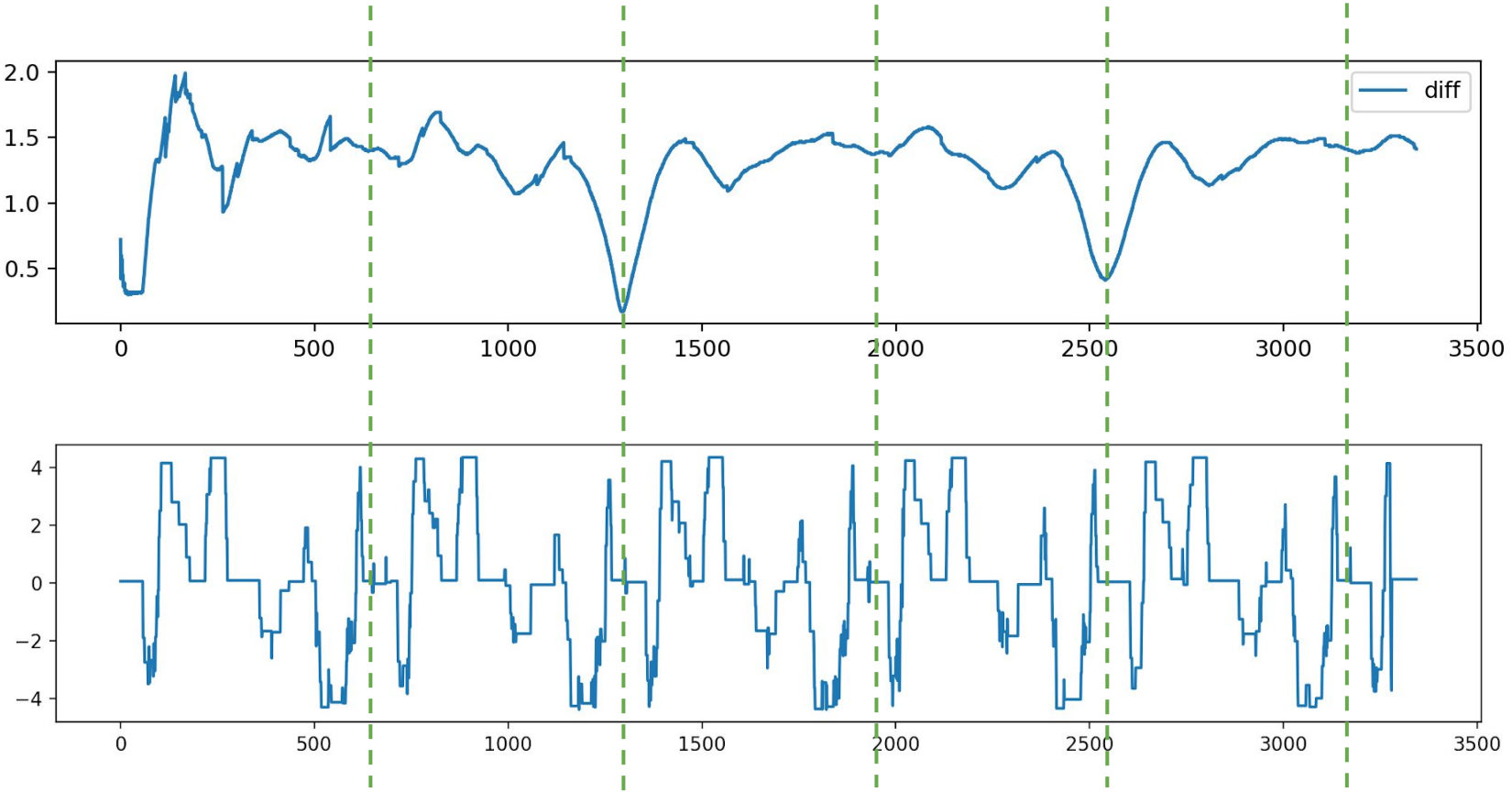
Mapping the Track



- Drive at constant safe speed (predetermined)
- Save driven track
  - Get gyro value => **Time Constraint** (faster computation = better resolution)
  - Save value in collection => **Memory Constraint**
- Determine track layout from history
  - After a delay diff first and second half
  - If difference is under a threshold => even number of laps

Memory Constraint

- Arduino Nano has only 2KiB memory
- 2KiB = 512 Floats
- Need around 1300 Floats for two laps
- Solution: Run length encoding (RLE)
  - Successive Gyro values are very similar => Either curve, or no curve
  - Only necessary to store changes above threshold
  - We now need about 400 values for 5 laps => 2 Laps in ½ of RAM
- No longer a problem on ESP32, however:
  - Reduces time to diff laps - Helps with **Time Constraint**
  - Smoothes noisy data

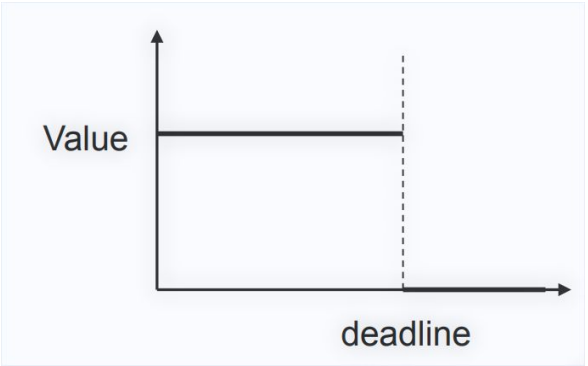


400 RLE Entries for 3500 measurements

Speed Adjustment

- Update guess of current position based on RLE track data diffing
- Brake if in front of curve, top speed when on straights

- Our only hard Real-time deadline
  - If we don’t brake in front of curves, our data is useless
- Factors to consider
  - Length of RLE - diffing takes longer
  - Hardware components may need time to react
  - No other tasks run on the microcontroller
  - Debugging outputs may take time



Debugging

- Microcontroller on wheels
  - Not possible to keep stable connection to PC
  - Static testing not useful => Cannot mock input & output
- Ideas
  - Use Wifi/BT
    - Energy constrained, only 10 mF capacitor
  - OLED display
    - Hard to read while driving
    - Updating takes ~10ms - decreases gyro resolution considerably
  - *printf*-Debugging
    - Save data at runtime
    - Has lowest impact on behavior (ESP has enough memory)
    - Stop & Print after button press

Learnings

- Software can only use given hardware (and not make it faster)
- Board with better specs than needed very helpful for development
- Debugging can have considerable impact in real-time environment
- Memory constraints can make some solutions impossible

Results

Goal:

- Driving as fast as a human

Midterm results:

- A fast driving car
- Detect curves using accelerometer

Open problems:

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  - fixed by using a different library and using gyro data