Project 2: Speed Controller

Part 1:

Code in the encoder.cpp file in method getSpeed().

Part 2:

$\omega(t) = \omega_{max} * (1 - e^{\frac{-t}{\tau}})$

$\omega_{max}(average) = 12.48\frac{rad}{s}$

Measures	Time to get to 63% max Speed in ms
1	45.0
2	44.7
3	43.6
4	43.2
5	44.3
6	43.7
7	43.2
8	44.6
9	44.6
10	44.6
Average / τ	44.15

Part 3:

minimum update rate = $\frac{10}{\tau} = 226.5\ \frac{1}{s}$

$$\frac{1}{f\ pwm} \ll \frac{1}{f\ update} < \frac{\tau}{10} \equiv \frac{1}{f\ pwm} \ll \frac{1}{f\ update} < 4.415\ ms$$

Task	**Timing requirements**	**method to meet the time-critical task**	**Resources (timer, interrupts….)**	**Validation**
Counting encoder pulses	664.45 µs (encoder pulse period (see Project 1))	Encoder.position() and counter variable	Interrupt activates the encoder	Counter is printed
Computing speed using a stable time base	664.45 µs (encoder pulse period (see Project 1))	Measured time between to highs on the encoder	Interrupt activates the encoder	getspeed() is showing the same value as set in setspeed() from Part 4
Updating the control output at a required rate	Minimum update rate ca. 227 Hz	Measuring with 500 Hz	delay(2) from Ardunio.h	Not needed
Storing and transmitting the response to the laptop.	Response need to be as fast as the Updating rate	Output on the monitor	serial.print()	Output on the monitor
Stable PWM output at a suitable rate, observing	2.27 kHz (10* update frequency)	Method Analog.out.init	Timer module of microcontroller	Oscilloscop

Part 4:

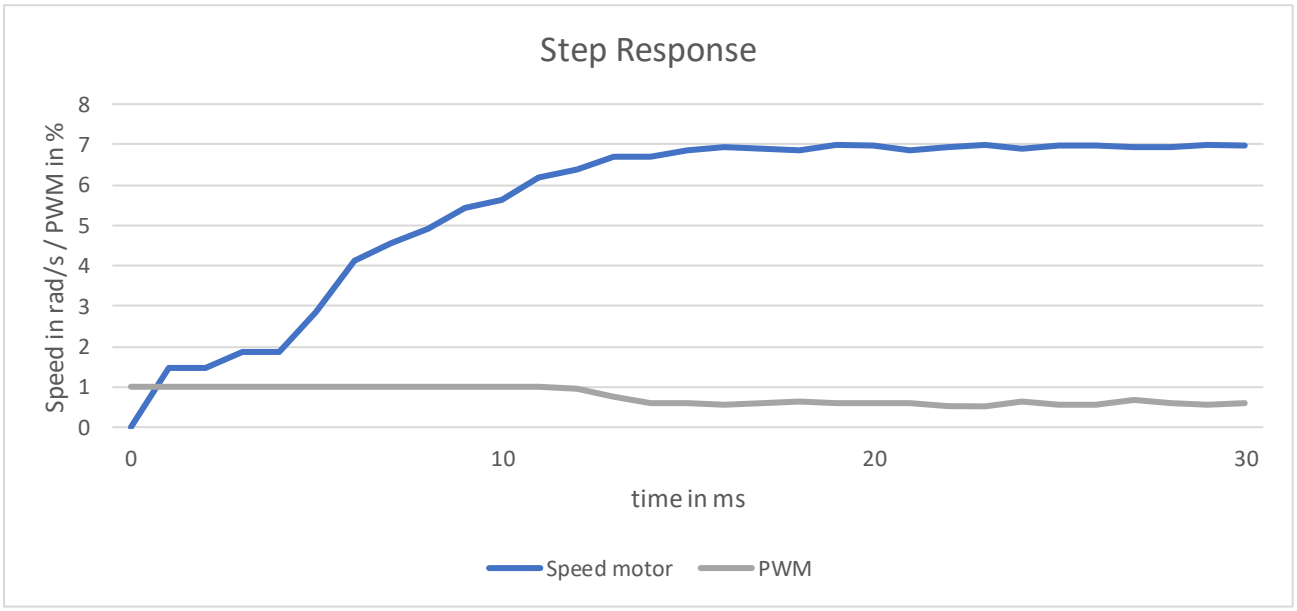
$u(t) = Kp * (r(t) - y(t))$

Reference value (w_ref), actual value (w) and PWM value (duty) with a Kp of 7.
Kp is 7 because Kp of 7.5 leads to stocking in the motor rotation.
Here w is equivalent to the rotational speed $\omega = \frac{2\pi}{T}$.

Monitor output:

```
w_ref: 8.00, w: 7.48, duty: 0.06
w_ref: 8.00, w: 8.16, duty: 0.01
w_ref: 8.00, w: 6.60, duty: 0.83
w_ref: 8.00, w: 6.64, duty: 0.71
w_ref: 8.00, w: 7.12, duty: 0.50
w_ref: 8.00, w: 6.88, duty: 0.67
w_ref: 8.00, w: 6.56, duty: 0.74
w_ref: 8.00, w: 6.78, duty: 0.67
w_ref: 8.00, w: 6.95, duty: 0.63
w_ref: 8.00, w: 6.84, duty: 0.72
w_ref: 8.00, w: 6.90, duty: 0.64
w_ref: 8.00, w: 6.80, duty: 0.68
w_ref: 8.00, w: 6.64, duty: 0.68
```

Step Response:



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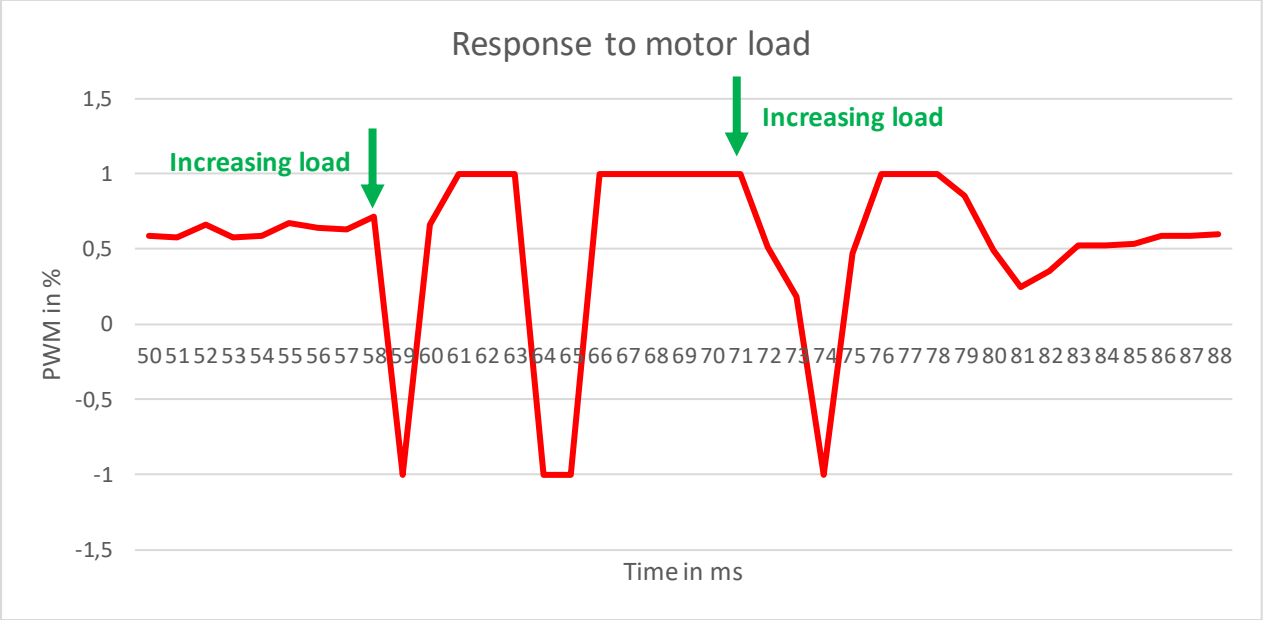
Response to motor load:



After shortly increasing friction on the tire at 58 ms, the PWM firstly goes down and then tries to correct the value to the reference speed. Therefore, the PWM turns to 1. After exceeding the reference speed, the PWM decreases. Same on the second load at 72 ms. After exceeding the reference speed in 76 ms the controller tries to stay at the reference speed.

Github Link: https://github.com/Marlenexyz/EMBE-Group

YouTube Link: https://www.youtube.com/watch?v=DSs6kUWA5Ww