Embedded-Systems Hands-On

Gruppe 4

TECHNISCHE UNIVERSITÄT DARMSTADT

Sommersemester 2020
Sheet 6

Task 6.1: Filtered PWM signals

6.1a)

For this task a constant capacitance of 10nF was chosen. The resistance of the RC-Filter was parameterized to adapt to the cutoff-frequency. For more details refer to **6_1.sch** and **6_1.dpl**.

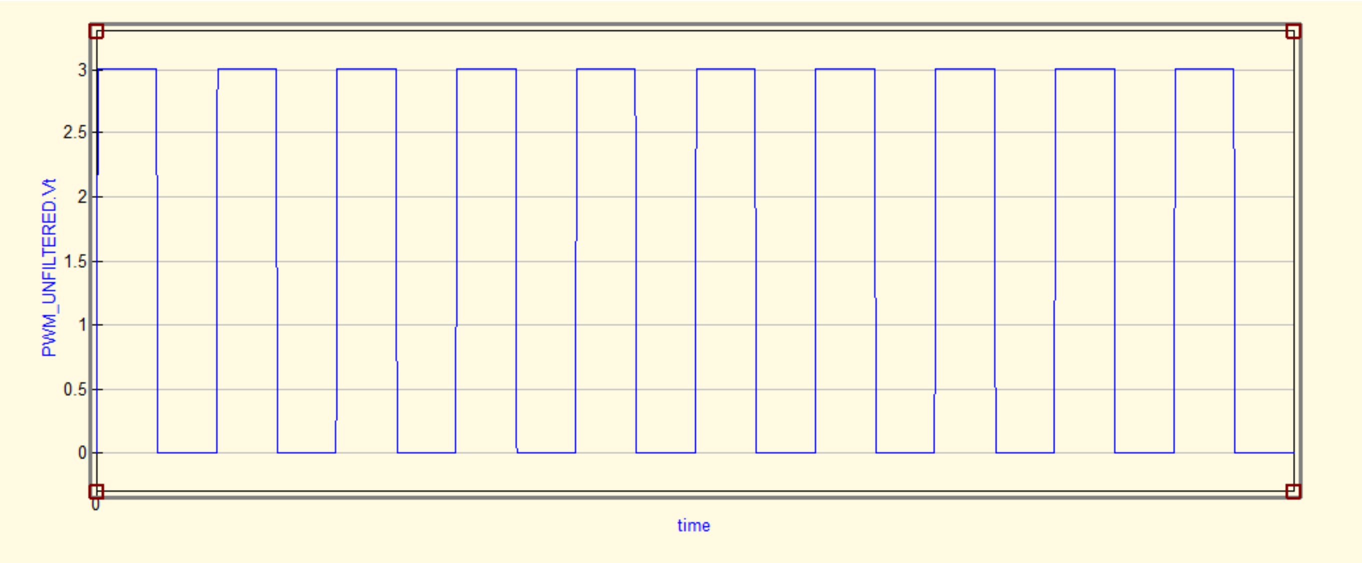

Figure 1: PWM signal voltage before filtration

The chosen PWM duty cycle was 50%.

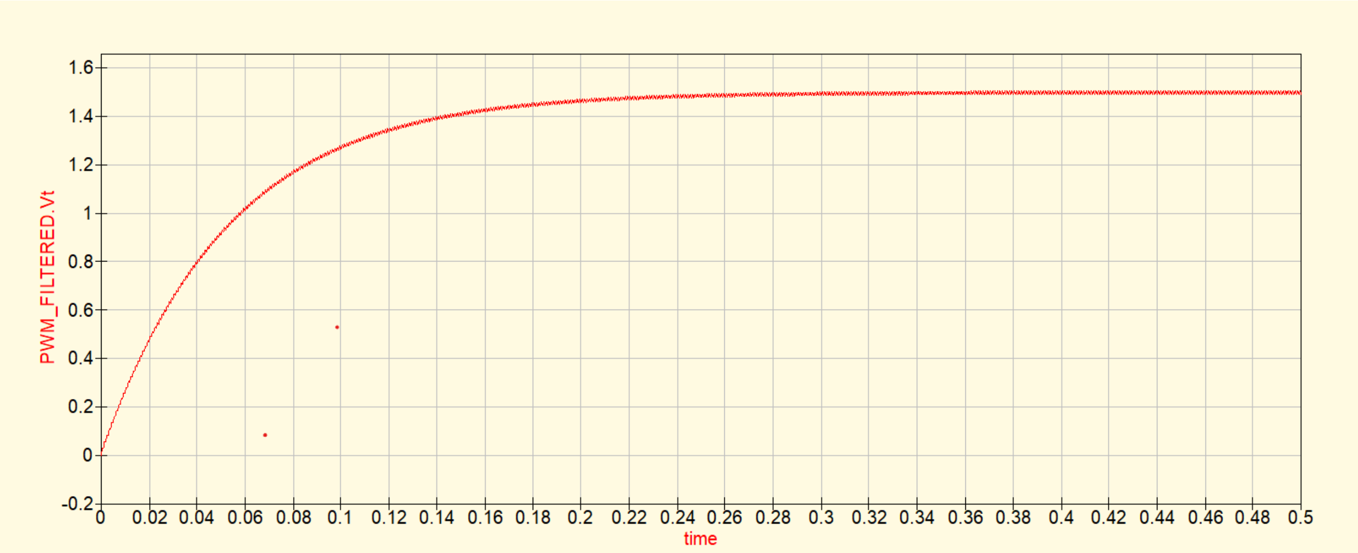

Figure 2: PWM signal filtered

As expected the filtered signal settles at around 1.5V which is as expected the median voltage of a pulse width signal ($U = D \cdot U_{max}$ where D is the duty cycle).

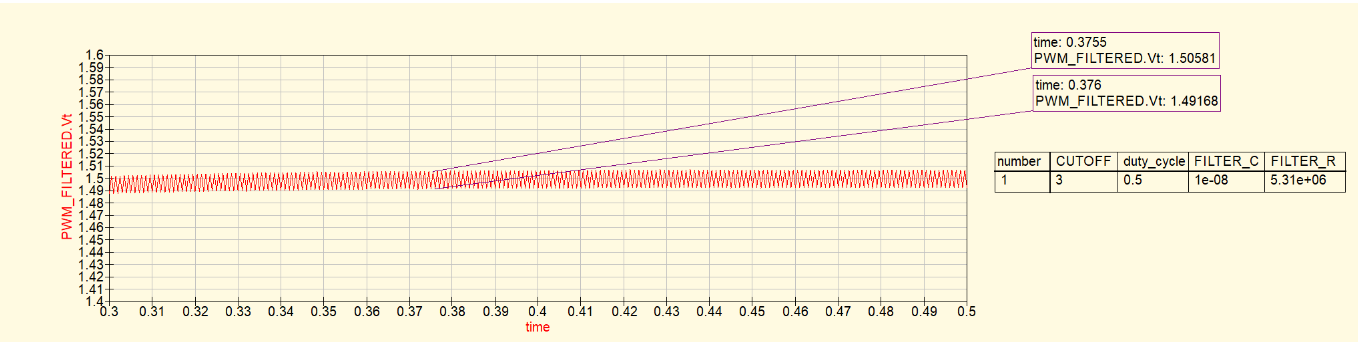

Figure 3: PWM signal filtered and after settlement

Zooming in on the graph shows that after settlement the ripple does not exceed $\frac{3V}{2^8}$ for a cutoff frequency of 3Hz. For cutoff frequencies above 3Hz the ripple exceeds $\frac{3V}{2^8}$.

6.1b)

Refer to **main.cpp**.

Task 6.2: Bipolar Junction Transistor

6.2a)

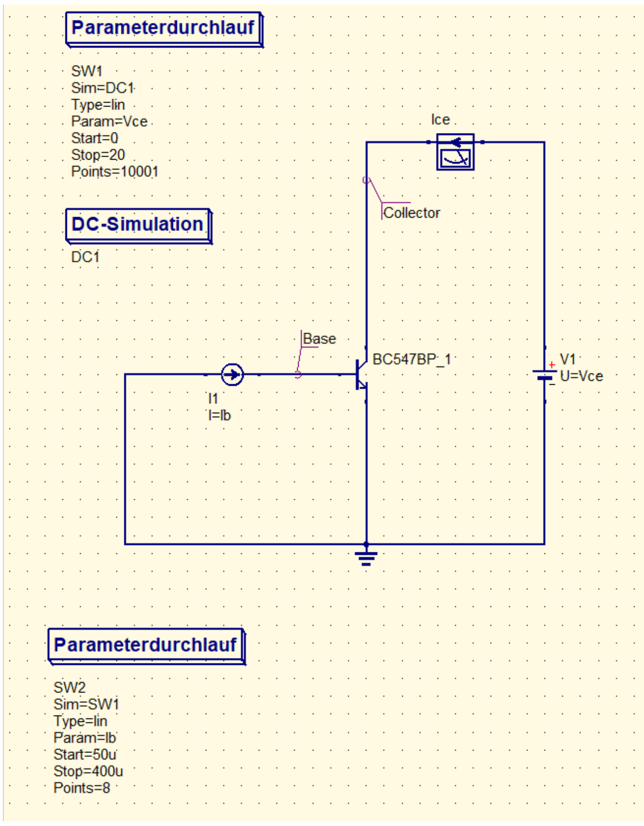

Figure 4: Circuit for measuring the transistor characteristics

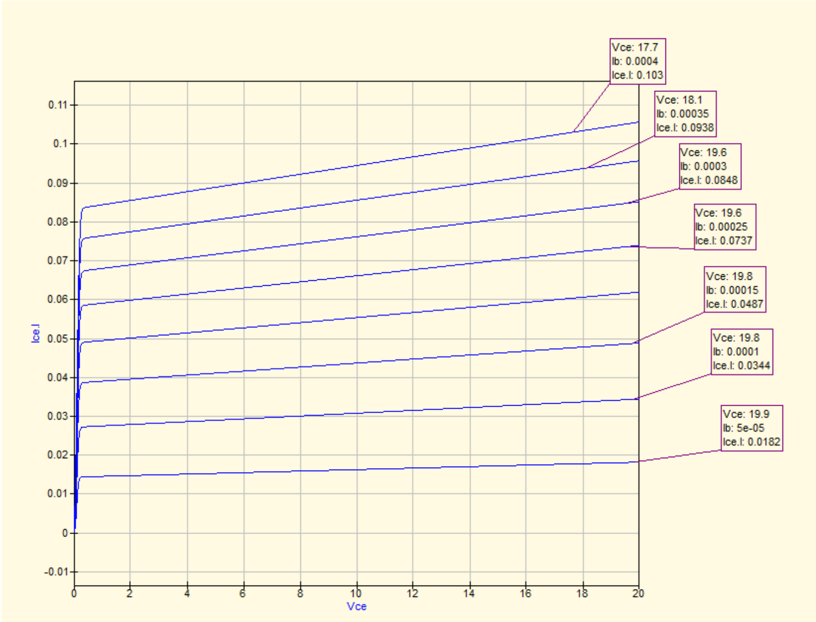

Figure 5: transistor characteristics

The simulated transistor characteristics differ from the characteristics provided in the datasheet. This may be caused by many factors. First of all the model which Qucs uses to simulate may not be accurate (enough). Then there is the problem of static properties of the simulation. For example the temperature can be set for the simulation but it does not change during the simulation which may lead to inaccurate results. Also the numerical (in-)stability of methods used to calculate the simulation may lead to differing results. Refer to **Transistor_Sim.sch** and **Transistor_Sim.dpl**.

6.2b)

With Shockley's diode equation($I = I_S \left(e^{\frac{U_F}{nU_T}} - 1 \right)$ where $U_T = \frac{k_B \cdot T}{e}$, k_B the Boltzmann constant) the saturation current of the LED can be calculated. From the data sheet we can extract $I = 20mA$, $U_F = 3.4V$ and $T = 25°C = 298.15K$. With that follows:

$$U_T = \frac{8.617333262 \cdot 10^{-5} \frac{eV}{K} \cdot 298.15K}{e} \approx 0.025692579120653V$$

$$\rightarrow I_S = \frac{20mA}{e^{\frac{3.4V}{0.025692579120653V - 1}}} \approx 3.6735159673007923e - 31A$$

The remaining parameters were extracted from the LED libraries. Refer to **LED.sch** and **LED.dpl** for plots of the LED characteristics.

6.2c)

Refer to **TRANLED.sch** and **TRANLED.dpl**.