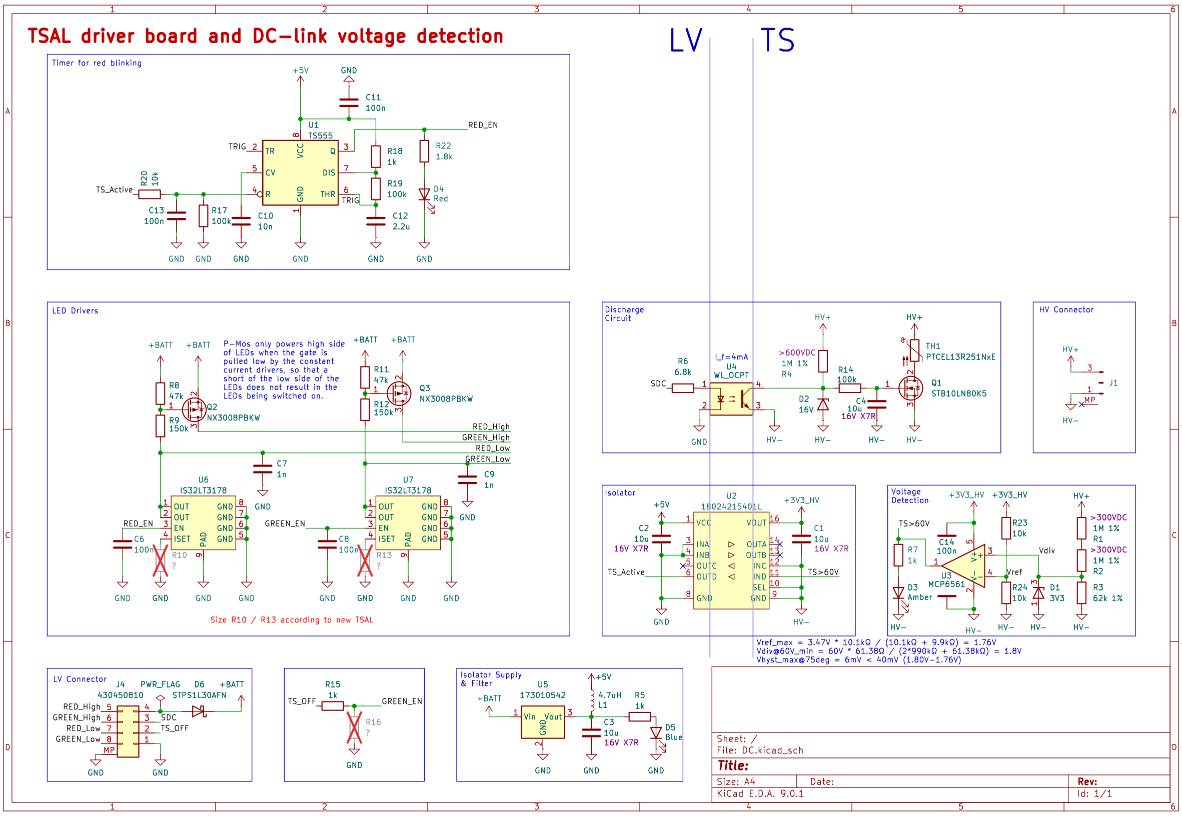

Figure 1: Schematic of the Discharge Circuit PCB

Discharge Time

As seen in the Schematic, for our discharge circuitry a PTC (PTCEL13R251NxE) is used. The total capacitance of the DC-link capacitor from the two inverters that we are using is 200 µF, and the maximum voltage of the accumulator is 403.2V. Using the RC discharging circuit equation, we obtain the highest resistance that the PTC can have so that we are still within the 5s discharge limit.

$$
\begin{aligned}
V_C &= V_0 \cdot e^{-t/RC} && (1)\\
60\,\mathrm{V} &= 403.2\,\mathrm{V} \cdot e^{-5\,\mathrm{s}/(R_{PTC}\cdot 200\,\mu\mathrm{F})} && (2)\\
R_{PTC} &\approx 13123\,\Omega && (3)
\end{aligned}
$$

To Calculate how much discharge attempts we can have before the discharge reaches 5s, we first see at what temperature the PTC the resistance of 13123 Ω have. We can get this from the datasheet of the PTC (fig. 2).

As seen in the datasheet, the temperature is about 165 °C. Assuming that the temperature rises instantly after the discharge, and the heat dissipation is negligible (since the thermal time constant τ_{th} is 130 s). As we are calculating the lest amount of precharge allowed, we assume the temperature of the environment to be 45 °C. Since the thermal capacity C_{th} is 1.45 J/K, we can see that the total energy that we can generate from discharge is $E = 120\,\mathrm{K} \cdot 1.45\,\mathrm{J/K} = 174\,\mathrm{J}$.

We then calculate how much energy in produced in one discharge:

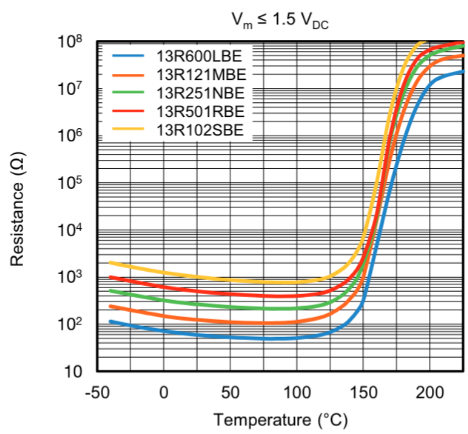

Figure 2: Resistance vs. Temperature for PTCEL13 (typical)

$$E = \frac{1}{2} \cdot C \cdot V^2 \tag{4}$$
$$= 16.26\,\mathrm{J} \tag{5}$$

Therefore, the total amount of discharge we can carry out before the time exceeds 5 s is 174 J/16.26 J = 10.7 — ten times.

Permanent TS Voltage

We can find the equilibrium temperature by finding the temperature at which the heat loss is equal to the power emitted. Using the model for LTSpice from Vishay, we can see what the heat loss is at equilibrium. (fig.) We can see that it is about 2.56 W Since the dissipation factor is 19.5 mW/K, we can calculate what the temperature difference ΔT is.

$$(T_{eq} - 45\,^\circ\mathrm{C}) \cdot 19.5\,\mathrm{mW/K} = 2.56\,\mathrm{W} \tag{6}$$
$$T_{eq} \approx 176.3\,^\circ\mathrm{C} \tag{7}$$

Reference

[1] *Current Transducer HO-S series.* https://www.lem.com/sites/default/files/products_datasheets/ho-50__250-s_v7.pdf, 03.2022

[2] *ADZ SME 200bar.* https://www.adz.de/fileadmin/user_upload/downloads/produkte/SME/ADZ_SME_OperatingManual_DE-EN_A.pdf, 12.2010