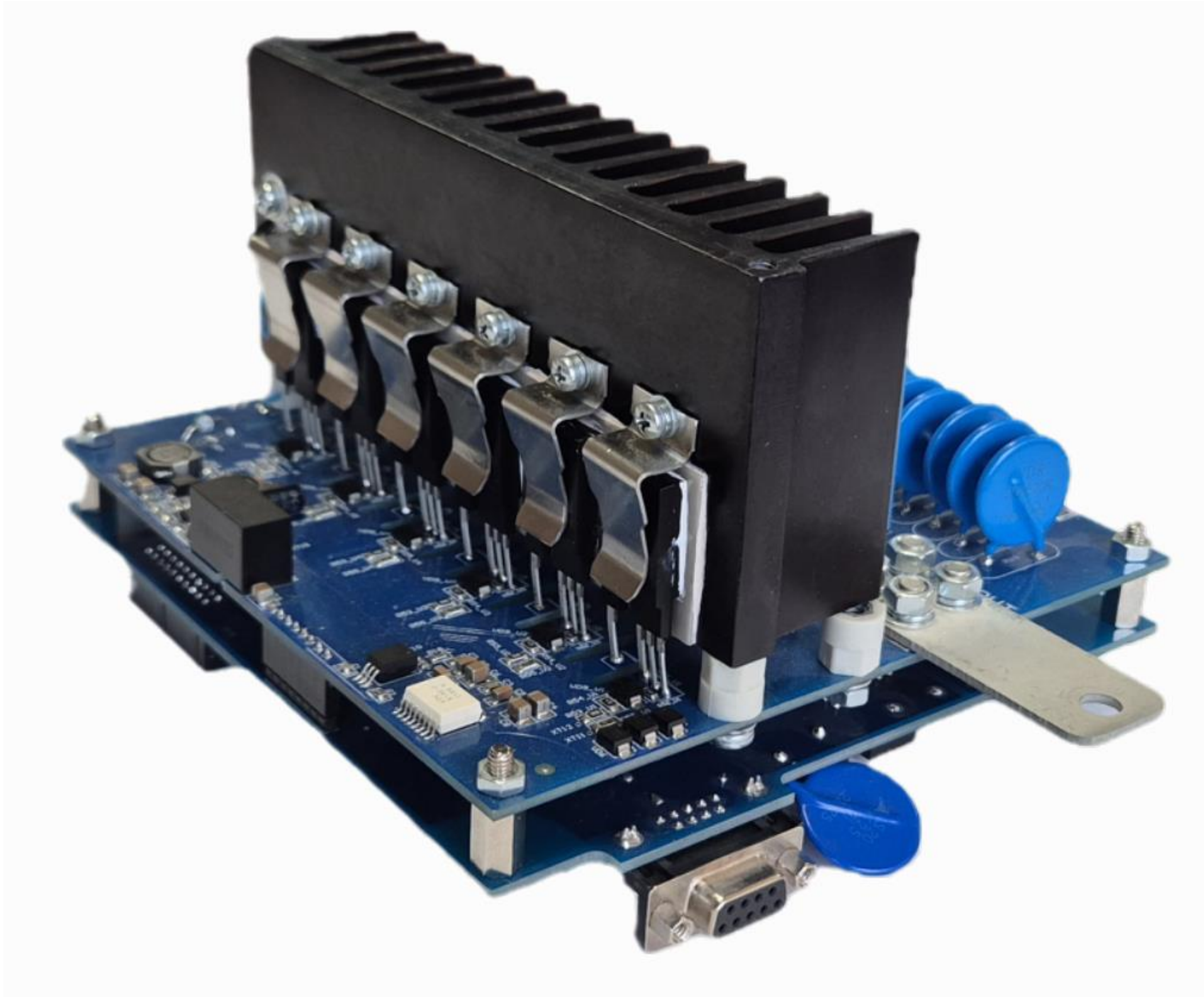


A Solid-State Contactor for DC Electrical Power Systems

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Solid-state contactor prototype

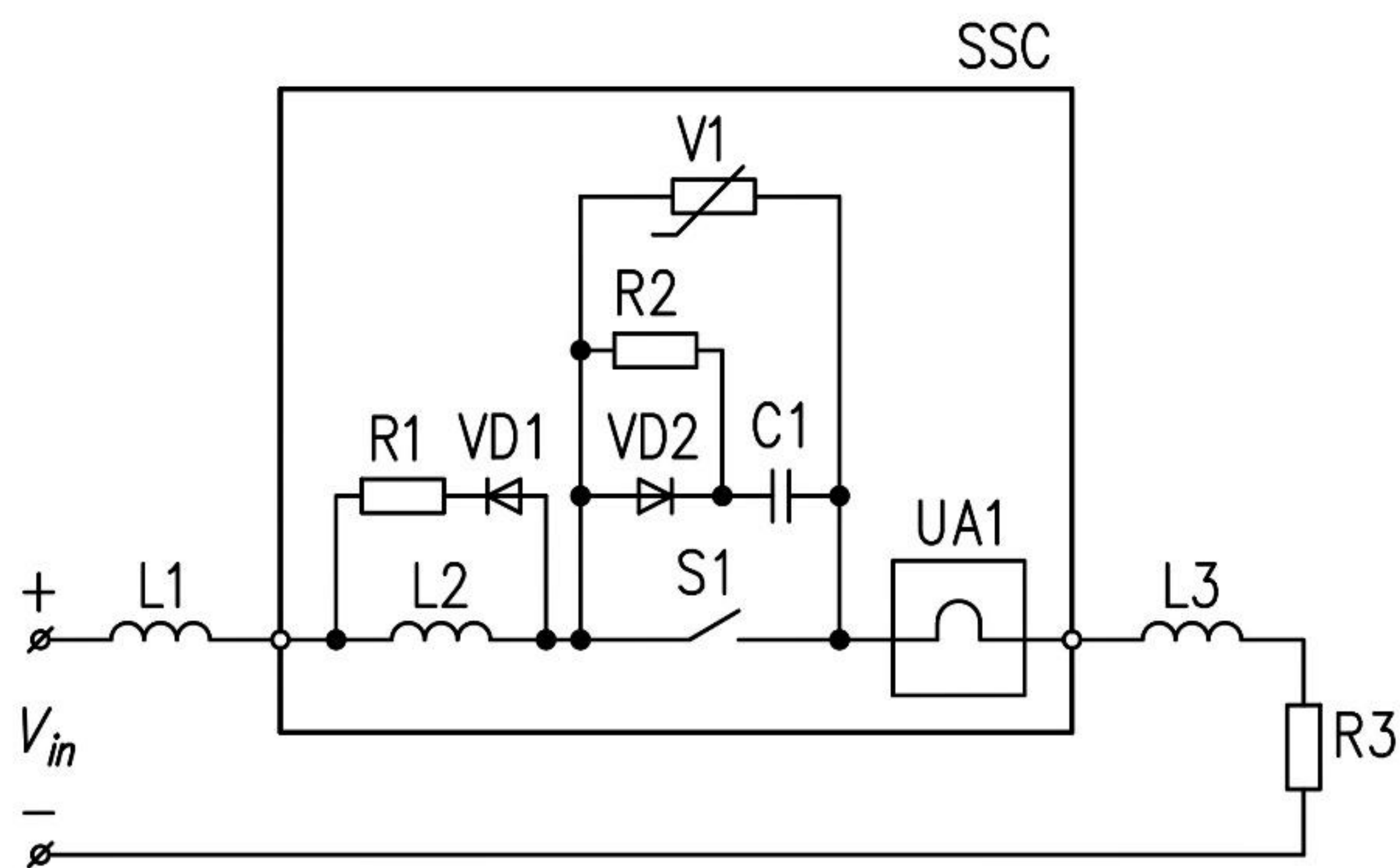
Solid-state contactor is rated for a nominal current of $I_{\text{rated}} = 75 \text{ A}$
at a nominal DC-link voltage of $V_{\text{rated}} = 770 \text{ V}$
The switching frequency under normal conditions is limited to $f_m = 0.5 \text{ Hz}$

Advantages of a solid-state contactor over an electromagnetic contactor

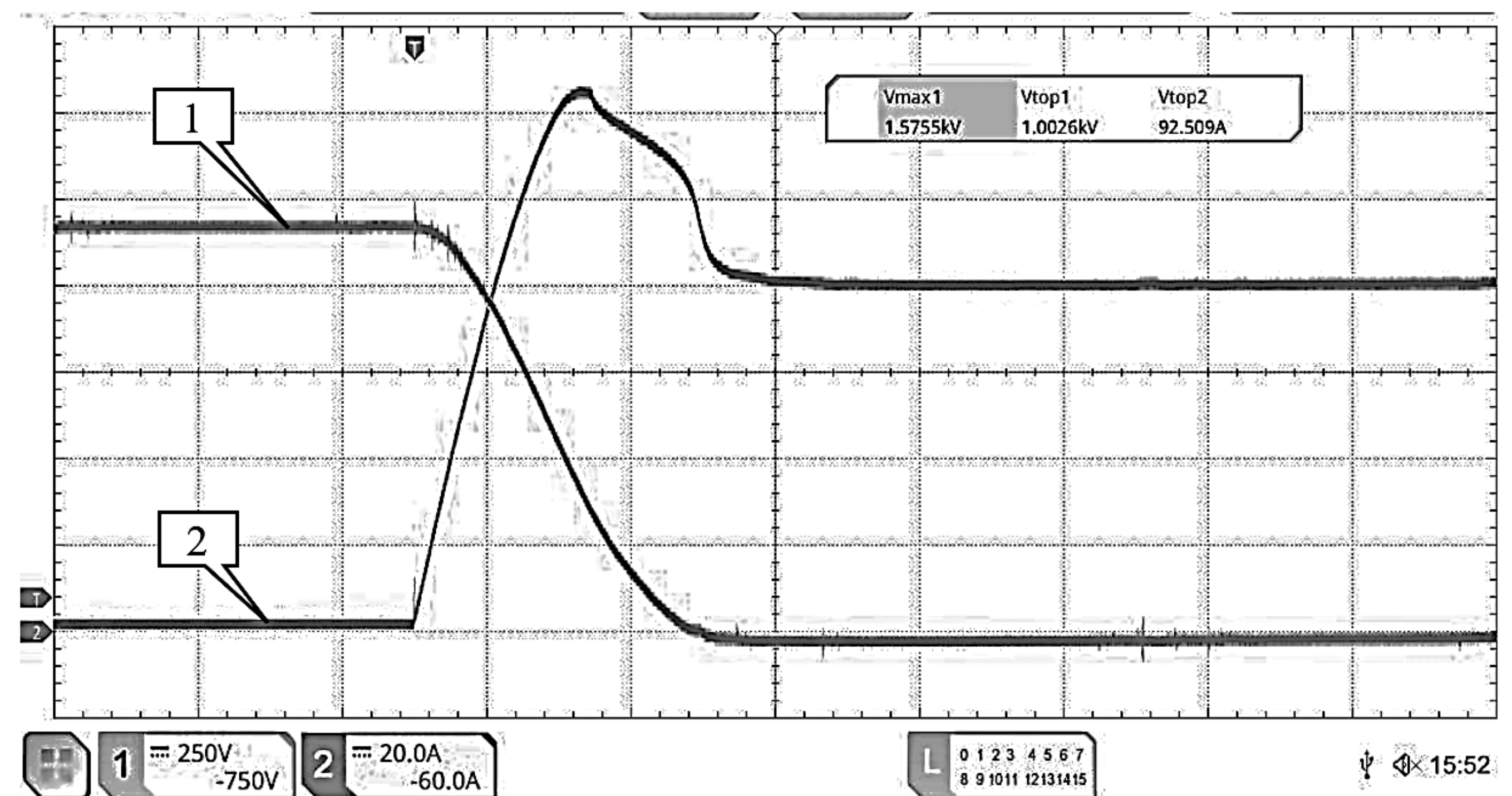
- °High allowable switching frequency at rated current;
- °Unlimited number of switching cycles;
- °No electromagnetic interference from electrical arc;
- °High reliability due to the absence of moving mechanical parts and gradual contact erosion, especially under inductive loads;
- °No restrictions on spatial orientation;
- °The absence of mandatory additional gaps around the arc chamber to prevent fire and ensure safe heat dissipation, as there is no arc chamber;
- °The ability to work in explosive environments due to the absence of high-temperature electric arcs.

Application

- °Aerospace;
- °Aviation;
- °Electric vehicle;
- °Mining industry;



Topology of the A Solid-State Contactor



Current switching oscilloscope

The expressions (3)–(7) and (10) enable the determination of the component parameters for the SSC snubber protection circuit, taking into account the most severe operating conditions

The peak voltage appearing across $C1$ is expressed as:

$$V_{\max} = V_{\text{rated}} + \sqrt{V_{\text{rated}}^2 + \frac{I_{\text{rated}}^2 (L_1 + L_3)}{C_1}}, \quad (1) \quad \text{where } V_{\text{rated}} \text{ and } I_{\text{rated}} - \text{rated input voltage and output current of SSC}$$

The required capacitance of the snubber capacitor $C1$:

$$C_1 \geq \frac{I_{\text{rated}}^2 (L_1 + L_3)}{V_{V1}^2 - 2V_{V1}V_{\text{rated}}}. \quad (3)$$

The maximum allowable power dissipation in the varistor under this condition is given by:

$$P_{m1.V1} = \left(\frac{I_{\text{rated}}^2 (L_1 + L_3)}{2} - \frac{C_1 V_{V1}^2}{2} \right) f_m, \quad (4)$$

For a given maximum allowable varistor power dissipation $P_{m2.V1}$, the required capacitance is obtained from the energy balance:

$$C_1 \geq \frac{I_{\text{rated}}^2 (L_1 + L_3) V_{V1} f_m - 2P_{m2.V1} \Delta V}{V_{V1}^2 (2V_{\text{rated}} - V_{V1}) f_m}, \quad (5)$$

The snubber resistor $R2$ must be selected so that, after the SSC turns on, the voltage across $C1$ decays from V_{V1} down to V_{rated} within a specified minimum time interval $\Delta t_{\min}$.

$$R_2 \leq \frac{\Delta t_{\min}}{C_1 \ln (V_{V1}/V_{\text{rated}})}, \quad (6)$$

$$R_2 \geq \frac{V_{V1}}{I_{\text{Peak.max}}}. \quad (7)$$

The actual energy dissipated in $R2$

$$P_{\max.R2} \geq \frac{I_{\text{rated}}^2 (L_1 + L_3) V_{V1}^2 f_m}{2V_{V1}^2 - 4V_{V1}V_{\text{rated}} + 2V_{\text{rated}}^2}. \quad (10)$$

A salient feature of the SSC is its capability to clear a fault current within 1–2 μs after the onset of a short circuit. To prevent the infinite value of the di/dt value, a current limiting reactor $L2$ was introduced into the circuit.

$$\text{The inductance } L2 \text{ is obtained as: } L_2 = \frac{V_{\text{rated}} \Delta t_{\text{cs}}}{I_{\max} - I_{\text{rated}}}, \quad (11)$$

The following inequality, which ensures sufficient demagnetization of choke $L2$ over the available pause time, must be satisfied:

$$R_1 \geq \frac{V_{\text{rated}} \Delta t_{\text{cs}}}{(I_{\max} - I_{\text{rated}}) \Delta t_p} \ln \left(\frac{I_{\max}}{I_{\text{rated}}} \right). \quad (12)$$