S3. POWER MODULE

The power module is used to amplify the PWM signal from the PWM generator. This module also serves as an isolator of PWM generator signals from the main high-voltage power.

Heaters cannot be connected directly to the PWM generator because the output voltage of the PWM generator is only 3.3 volts. The signal from the PWM generator must be amplified to the rated voltage of the heaters. A non-standard voltage of 400V DC is used to power the heaters. Furthermore, control will not occur with a single heater, but rather in pairs, and the load on one channel increases from 1.5 to almost 3 amps. A ready-made device that satisfies these parameters and is compact enough to fit 8 pieces (one module per one pair of heaters) inside a control unit's pressure chamber could not be found on the market. Therefore, to generate a PWM signal powerful enough to drive the heaters, a custom power module was designed.

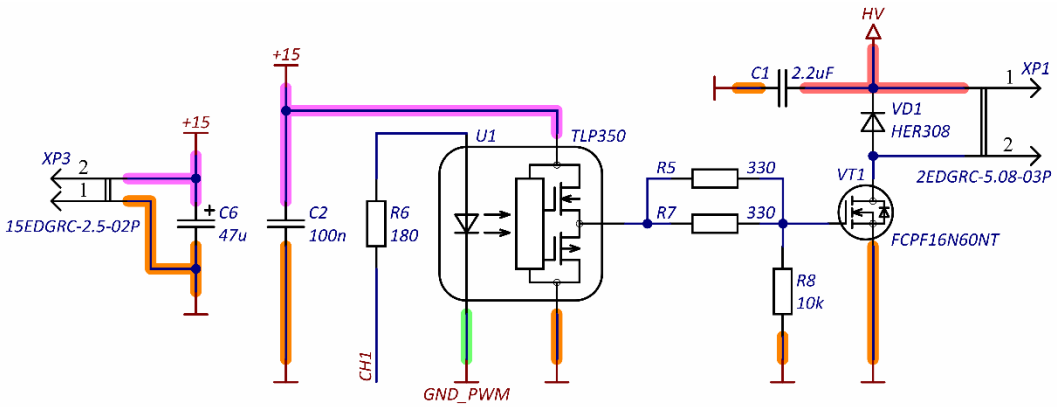

Fig. S11. Circuit diagram of one channel of power module

The N-Channel MOSFET FCPF16N60NT was chosen as the main element for generating the output high-voltage PWM signal. This MOSFET can handle currents up to 16 amps. A large current reserve was chosen based on the fact that MOSFETs will have to operate in a closed case without active cooling. In such conditions, these MOSFETs heat up less when operating in the same modes compared to MOSFETs with 7 amperes (FCPF7N60NT) or less. Moreover, at elevated temperatures, they are able to withstand higher current. The remaining characteristics of the MOSFETs either differ slightly or their differences are not critical for our requirements. To isolate the signal from the PWM generator, TLP350 optocouplers were used. To decouple from high-frequency noise (sharp edges of PWM pulses) a small 2.2 uF film capacitor was used.

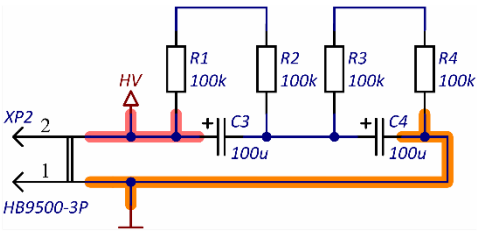

Fig. S12. Circuit diagram of decoupling capacitor

To prevent leaking low-frequency switching noise of PWM controlled heaters which could interfere with other equipment, a decoupling capacitor was added to the circuit. It consists of two general-purpose aluminum electrolytic capacitors designed to withstand high supply voltage. Resistors in parallel to each

capacitor are used to distribute voltage evenly between the capacitors, eliminating voltage imbalance caused by difference in leakage currents of capacitors.

Power modules were grouped by 4 pieces per PCB (Fig. S13).

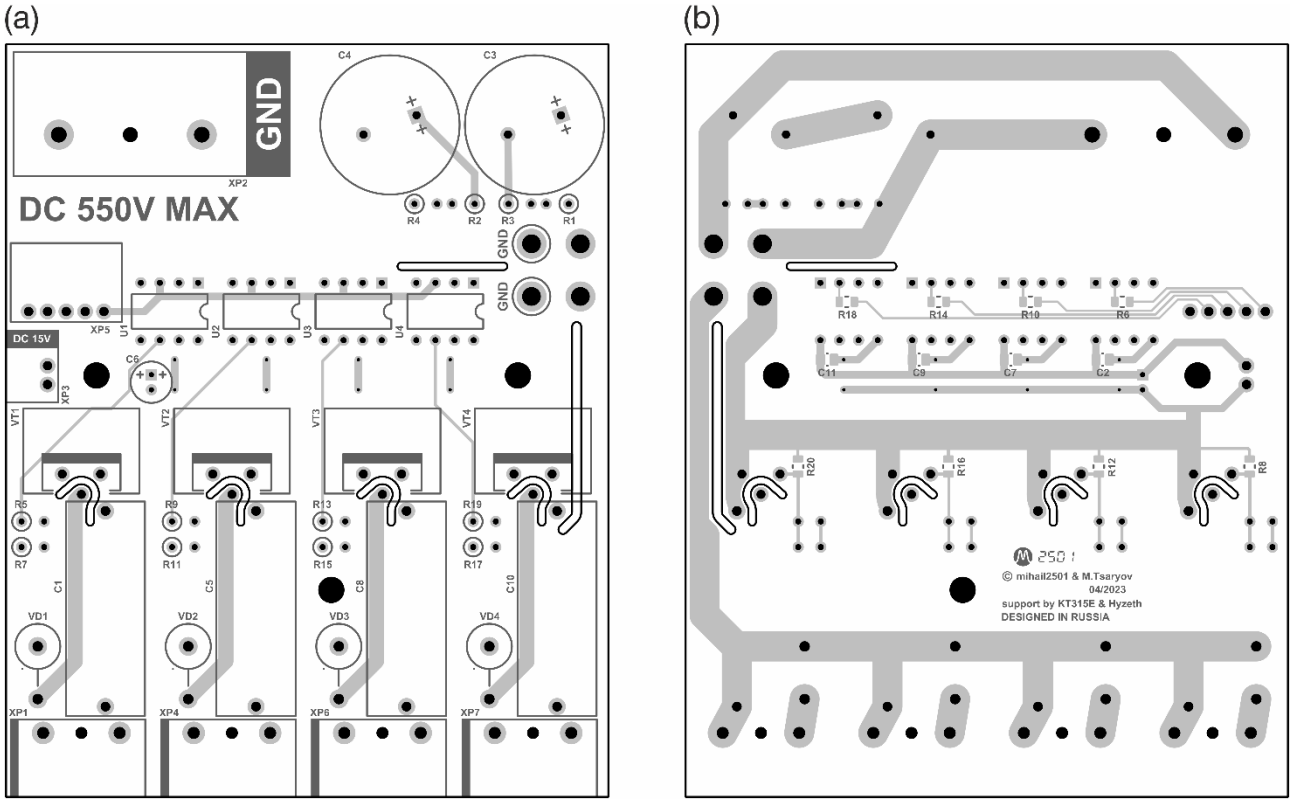

Fig. S13. PCB layout of power module: (a) top layout; (b) bottom layout.

For the second group of power modules, the portion of the PCB containing the decoupling capacitor and power connector needs to be removed. The decoupling capacitor is designed to operate with 8 channels. If the number of required channels increases, a redesign of this circuit portion will be necessary. The PCBs are intended to be mounted on top of each other (Fig. S14 A). To connect high-voltage circuits between PCBs, pads are provided adjacent to the decoupling capacitor (Fig. S14 B).

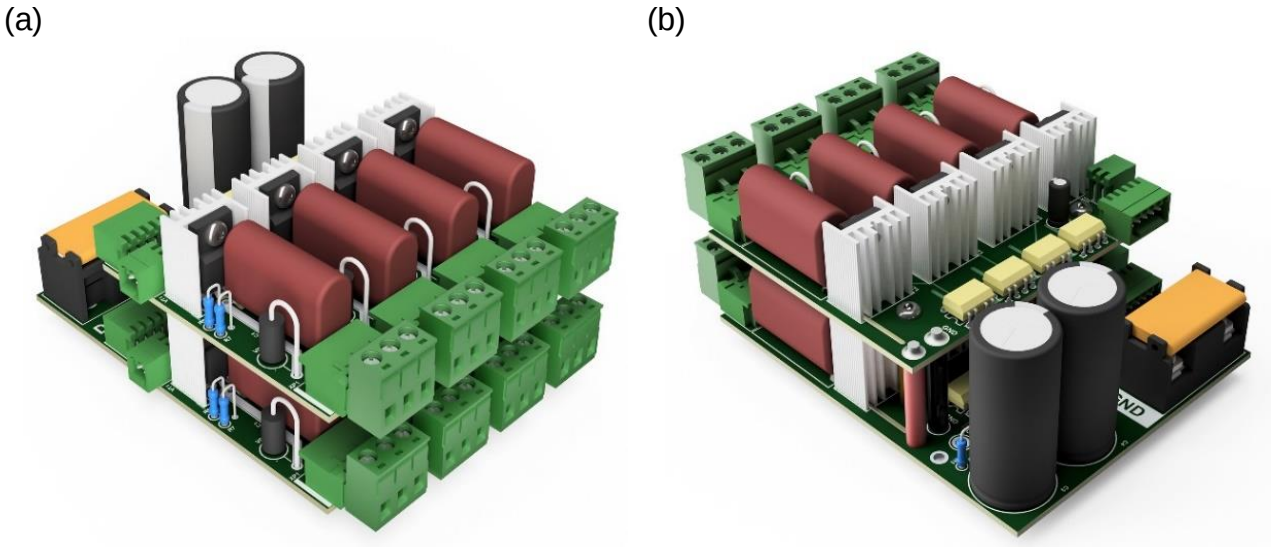

Fig. S14. Power modules mount (render)