PPS-100 power supply control system

The simplified diagram of PPS-100 is shown in Fig. 1. One can see that control system of this source is divided functionally in two independent parts – the Safety Board (SB) and Inverter Control Board (ICB).

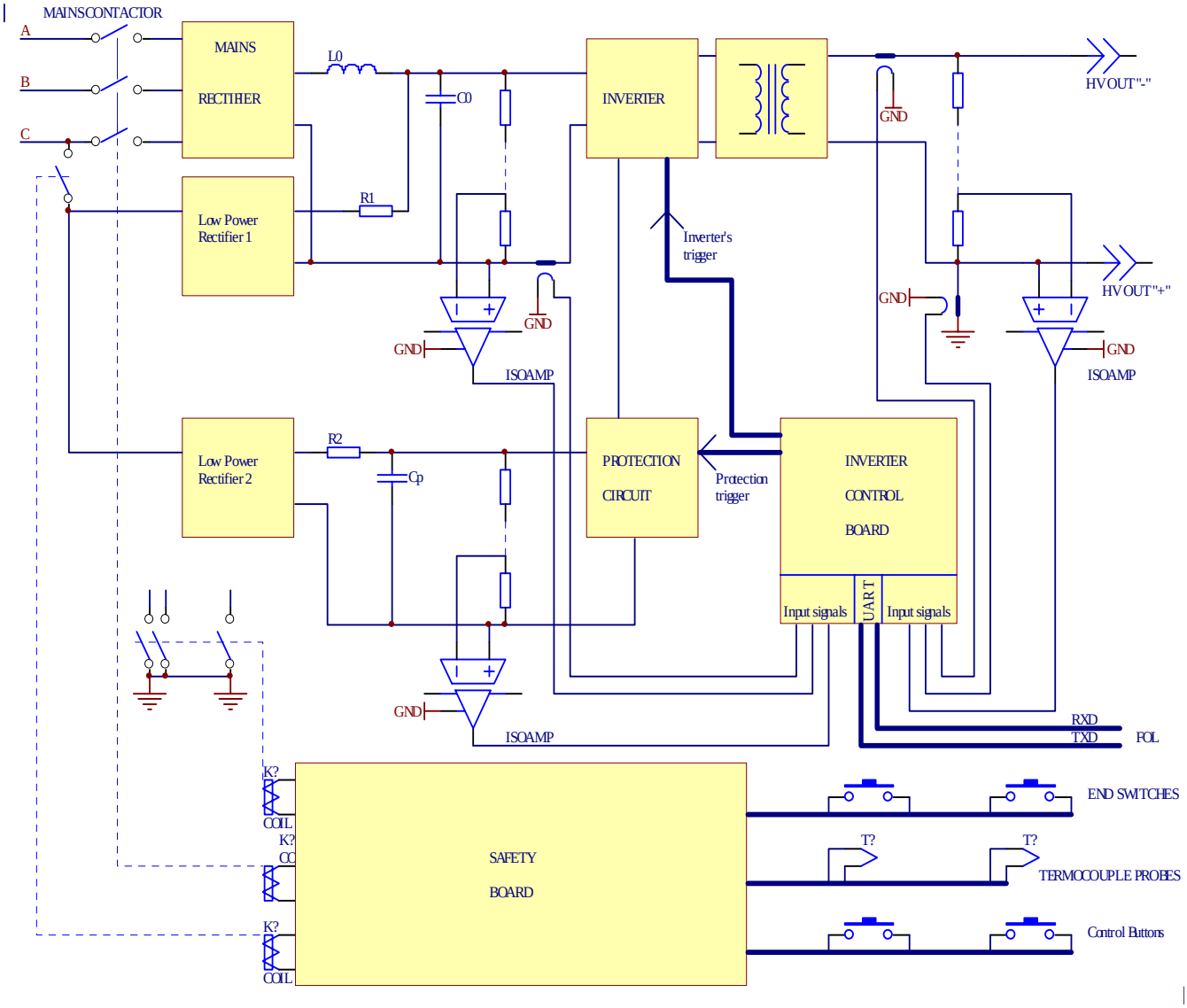

Fig. 1. Simplified diagram of the PPS-100 control

Safety Board (SB)

SB controls the state of electromechanical cabinet with PPS-100 device placed in it. SB input signals are signals from end switches of the Safety Disconnector (SD), doors, mains contactor, crowbars, water flow probe, air probe (the so-called “SB-signals”) and temperature sensors in the cabinet. The analogue signals from temperature sensors are measured with 10-bit accuracy. It allows tracing the power elements heating dynamics and prevents its overheating. In addition SB measured the ground current and switching the inverter off in case of its appearance. It provides the safe operation of power source and excludes any risk of electric shock for the staff. SB controls the Mains Contactor switching off/on and crowbars lift/drop. The SB commands are entered by keys of the Local Control Panel (LCP). There are “ON” and “OFF” keys on LCP turning on and off the three-phase supply in the cabinet. The current state of cabinet and inverter is displayed by LEDs on LCP.

The SB operation scenario is the following: the Mains Contactor is open and the crowbars are closed (droped) until the power supply is applied to the control electronics rack. After supplying the control electronics rack (switch “Power” on LCP) the SB wakes up and begins monitoring end switches and other probes. Simultaneously the air vent in the cabinet turns on and the valves supplying water for elements cooling are unlocked. The presence/absence of water and air is controlled by SB and indicated on LCP. If all the cabinet doors are closed, the cabinet is supplied by air and water, and if the temperatures of controlled elements are in permissible limits the SB is ready to the cabinet turn on. In this state full SD closure (by rotating the steering wheel clockwise against stop), being controlled by end switch will lead to lift of the crowbars. The successful crowbars lifting is checked by SB and indicated on LCP. If the crowbars are raised the SB becomes ready to three-phase voltage supplying of the cabinet.

In this state the voltage is supplied of the cabinet by pressing “ON” button on control panel. Just after pressing this button SB switches on the low-power rectifier charging the capacity C_0 of rectifier filter through R_0 resistor up to the magnitude of mains voltage (Fig. 1). After time interval $\tau = 5 \cdot R_0 \cdot C_0$ the high-current mains contactor is closed applying the voltage to three-phase rectifier. It prevents from the transient, charging C_0 to the doubled mains voltage.

Missing even one of SB signals or if the temperature of any controlled objects leaves the permissible limits will lead to momentary disconnection of mains contactor and crowbars drop. The crowbars lifting is blocked until full opening and next closing of SD.

The SB operational diagrams are shown in fig. 2, and its scheme is given in fig. 3. The entire controlling device is realized on PLD MAX7064 from Altera and AT90S8535 microcontroller (from Atmel).

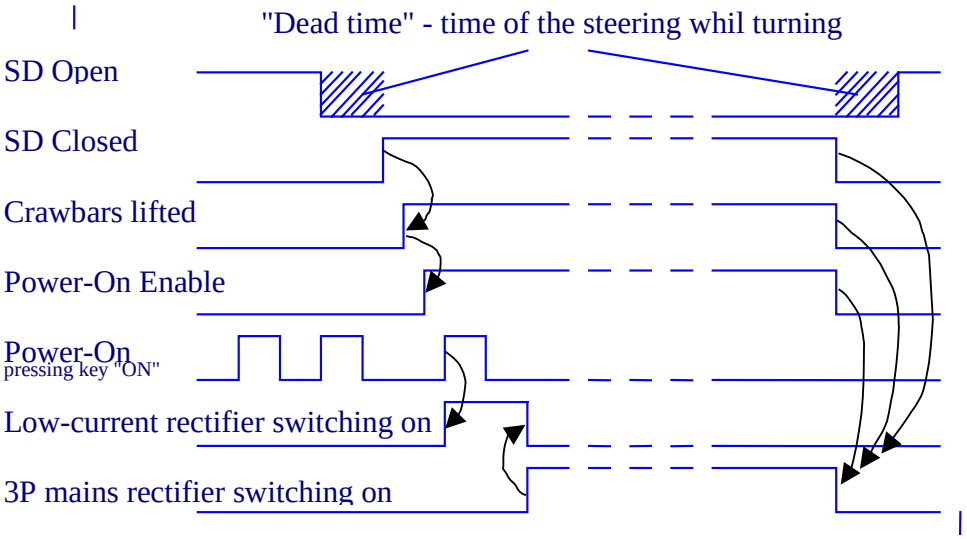

Fig. 2. SB operational diagrams

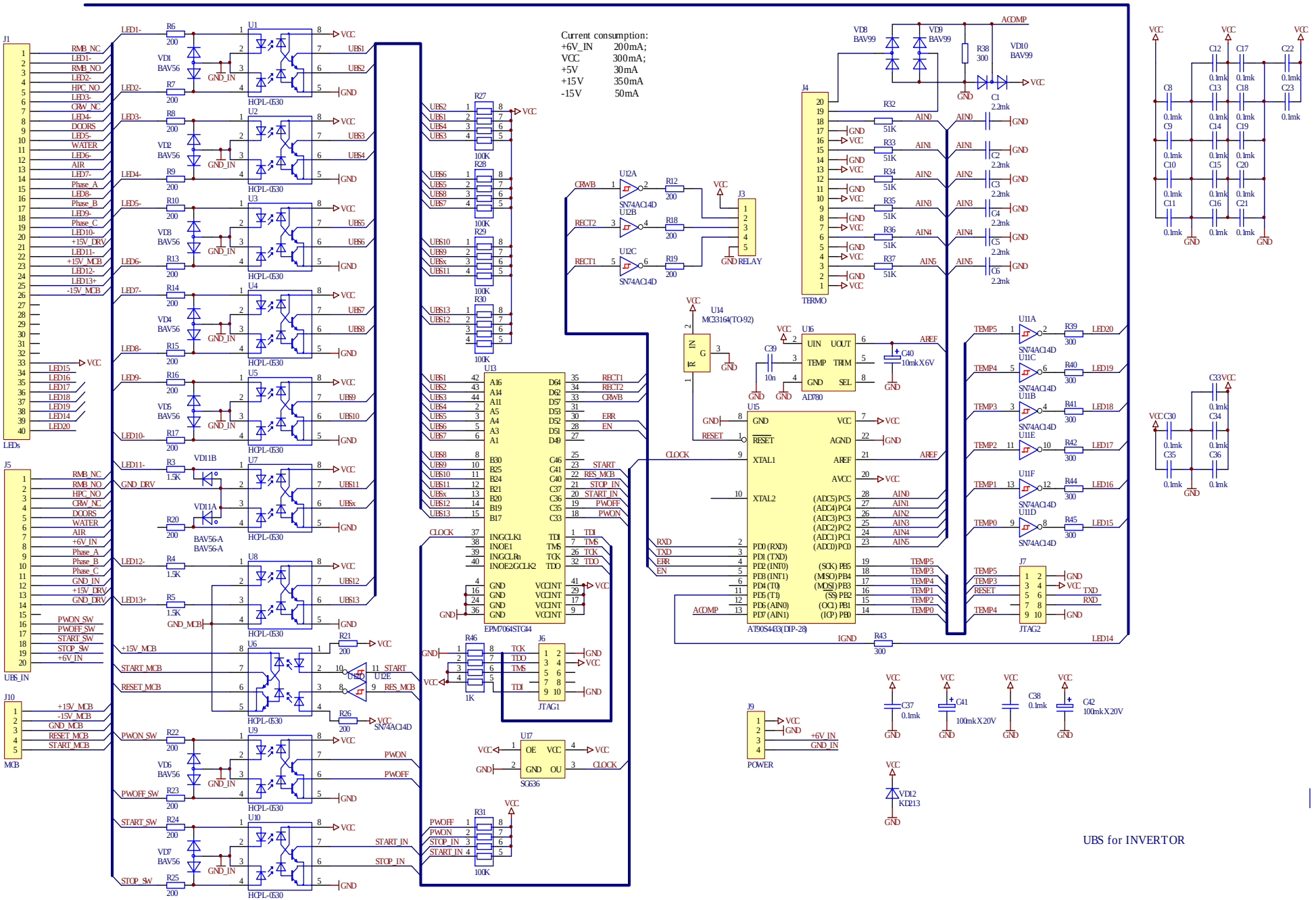

Fig. 3. Safety Board

Inverter Control Board (ICB)

The main functional part of PPS-100 source is SCR inverter, operating in constant mains power consumption mode. The maximum operating frequency of the inverter is 2500 Hz. It has the electronic protection system.

The schematics diagram of inverter control system is shown in Fig. 4. The currents and voltages of the main elements of inverter are measured by ICB based on AT90S8535 microcontroller through galvanically insulated amplifiers. All the signals change slowly and are measured by 10-bit ADC built-in microcontroller. The signal of inverter current is applied to fast comparator of the same controller. The inverter frequency, and hence the power consumption are set by 16-bit word receiving through UART to microcontroller from controlling computer. ICB is connected to computer by optical-link, thus providing high noise-immunity and bit-rate. The inverter controlling triggers are formed by 16-bit timer of microcontroller in 10-2500 Hz range with 0.5 Hz step. Inverter switching on and off can be done both by keys from control panel and through UART by computer. The work scenario of ICB is the following: after pressing “START” button on LCP the ICB checks the voltage on capacitor C_{Pr} of protection system and if it is normal the inverter operation is allowed on the minimal operating frequency (10 Hz). After receiving through UART of new value of frequency $\boldsymbol{f}$, ICB increases smoothly the triggers frequency from $\boldsymbol{f_{MIN}}$ to $\boldsymbol{f}$ with 1000 Hz/s rate.

The currents and voltages are being monitored by microcontroller during its operation. If even one parameter leaves the permissible limits then the SCR’s triggers will be blocked. If the current of inverter exceeds the maximum permissible value the comparator trigging the protection system. After that the inverter operation is blocked until switching off and switching on again by “STOP” and “START” buttons.

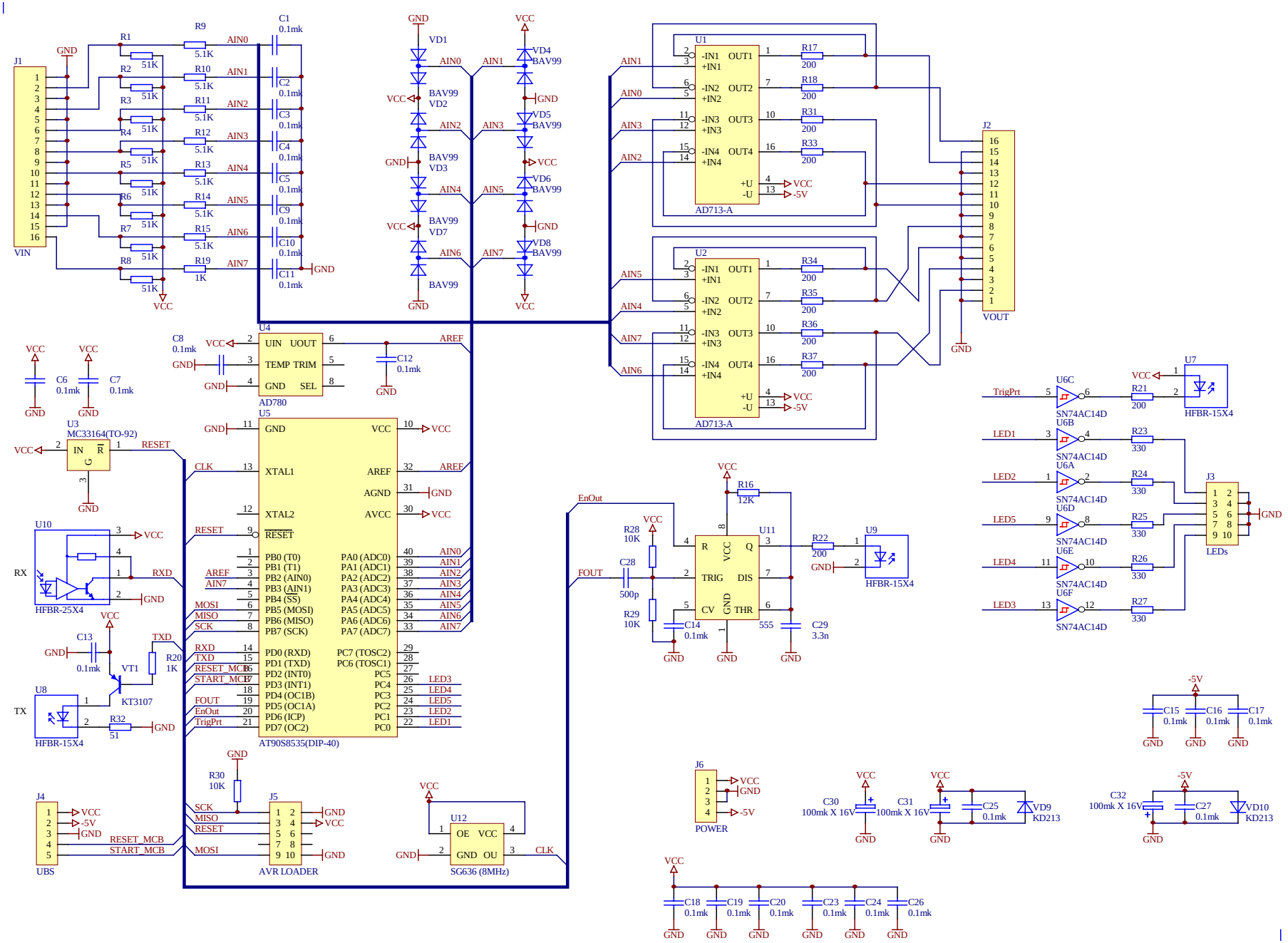

Fig. 4. Inverter Control Board

Safety of the PPS-100

№	Probe name		Scenario	Indication	Probe location
1	Doors interlocking (end switches of all doors are series interconnected)		Forbids ascent an crowbars; forbids connecting of mains contactors	LED (Red)	Doors of all cabinets
2	Water pressure probe			LED (Red)	Water input into the charging device cabinet
3	Air pressure probe			LED (Red)	Air input into the charging device cabinet
4	Block-contacts of Safety Disconnector	Unlock		LED (Green)	Doors of charging device cabinet
		Lock	Allows ascent an crowbars	LED (Red)	
5	Block-contacts of crowbars	Down	Forbids connecting of mains contactors	LED (Green)	Into the charging device cabinet
		Up	Allows connecting of mains contactors	LED (Red)	
6	Block-contacts of mains contactor	Connect	Allows operating of charging device	LED (Red)	Into the charging device cabinet
		Discon-nect	Forbids operating of charging device	LED (Red)	
7	Inverter overvoltage		Forbids inverter operating	LED (Red)	Probes on the main elements of charging device
8	Inverter undervoltage			LED (Red)	
9	Storage overvoltage			LED (Red)	
10	Inverter protection fail		Forbids inverter operating and inhibit triggers of protection circuit	LED (Red)	
11	Inverter overcurrent		Forbids inverter operating and starts triggers of protection circuit	LED (Red)	
12	Temperature probes		Forbids ascent an crowbars; forbids connecting of mains contactors	LED (Red)	On the perimeter of the oil tank – 2 probes; on the inverter’s heat sink – 1 probe;