

S2. PWM GENERATOR

In this project, a PWM generator is used to generate independent PWM signals, which are used to control heaters inside the drill head.

During the project development, the following requirements were imposed to the PWM generator:

- 20 independent PWM channels; (although only eight channels are utilized in this project, the PWM generator is planned to be used in the future to control a drill head with 20 heaters)
- the ability to adjust the PWM frequency over a wide range;
- wide input voltage range;
- isolated RS485 interface;
- data transmission via MODBUS RTU protocol.

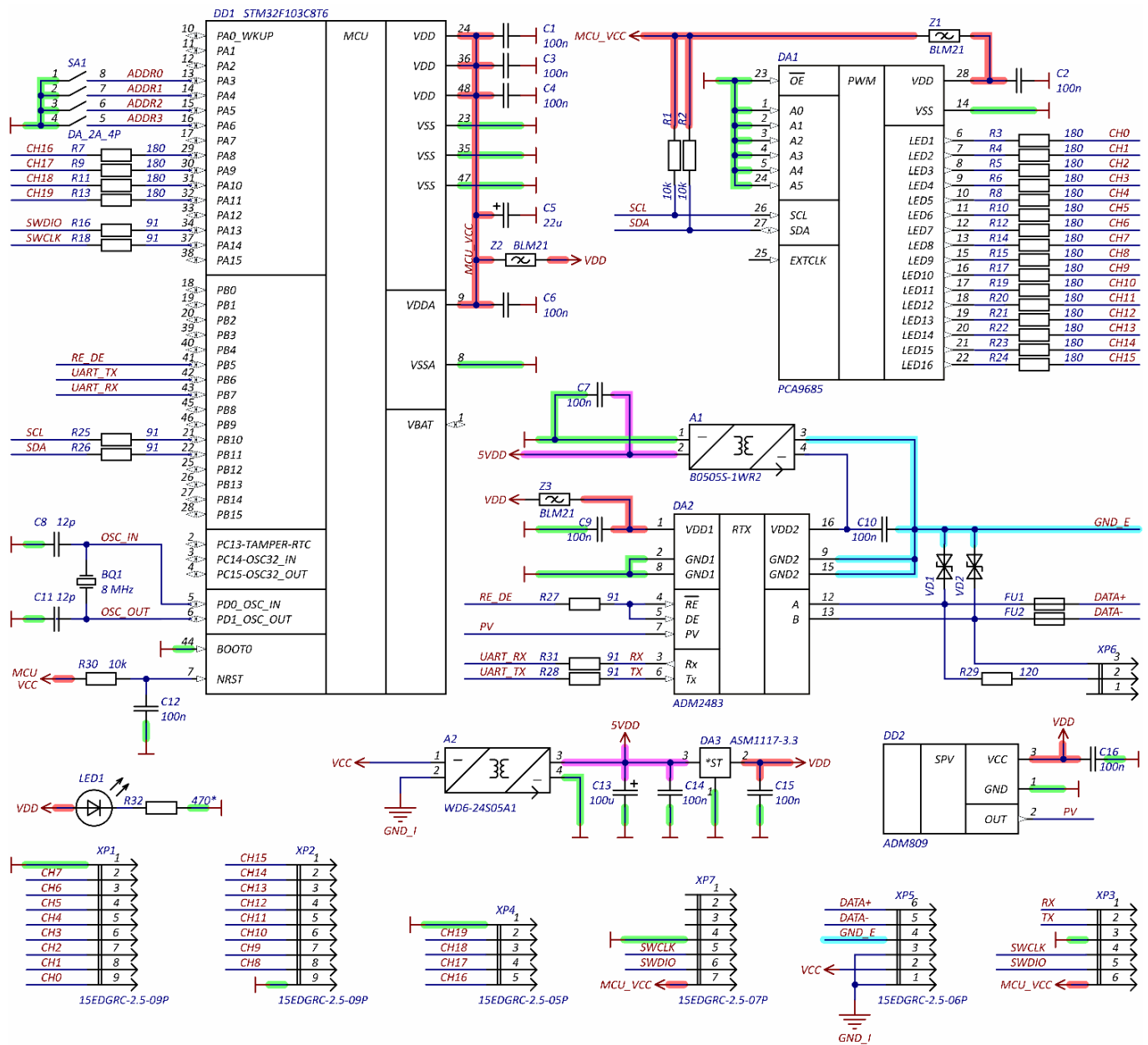


Fig. S7. Circuit diagram of PWM generator

Since no commercial off-the-shelf solutions meeting these parameters were available, a custom PWM generator was designed. The PWM generator is built around the STM32F103 microcontroller and PCA9685 PWM controller. The isolated RS485 interface is based on ADM2483. To accommodate a wide range of supply voltages, a WD6-24S05A1 DC-DC converter was used. The circuit diagram of PWM generator is shown in Fig. S7.

In the MODBUS RTU protocol, a unique address must be assigned to each device connected in parallel. Typically, the address is selected either using the PC software supplied with the device or by the device itself through its controls and displays. Since developing additional software is time-consuming, and this device is not intended to provide any additional indications, displays or buttons, a simple implementation method for selecting an address using 4 dip switches was devised. The combinations of switches and their corresponding addresses are presented in Table S2.

Table S2

Dip switch combinations sets			
Dip switch set	BIN	DEC	HEX
0000	0000 0001	01	01
0001	0000 0010	02	02
0010	0000 0011	03	03
0011	0000 0100	04	04
0100	0000 0101	05	05
0101	0000 0110	06	06
0110	0000 0111	07	07
0111	0000 1000	08	08
1000	1000 0001	129	81
1001	1000 0010	130	82
1010	1000 0011	131	83
1011	1000 0100	132	84
1100	1000 0101	133	85
1101	1000 0110	134	86
1110	1000 0111	135	87
1111	1000 1000	136	88

A standard blue housing for ADAM modules was chosen as the housing for the PWM generator (Fig. S8).

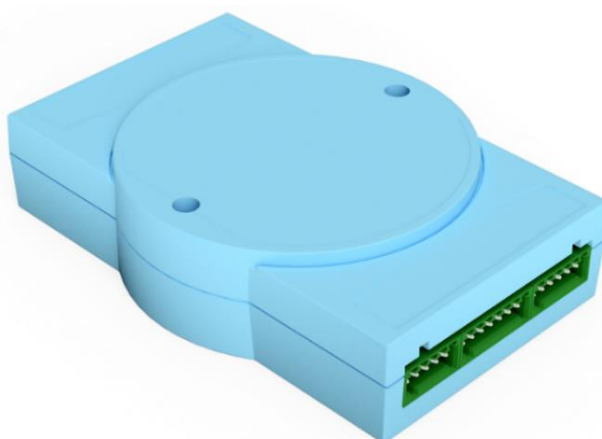


Fig. S8. PWM generator

A PCB was designed for this housing (Fig. S9).

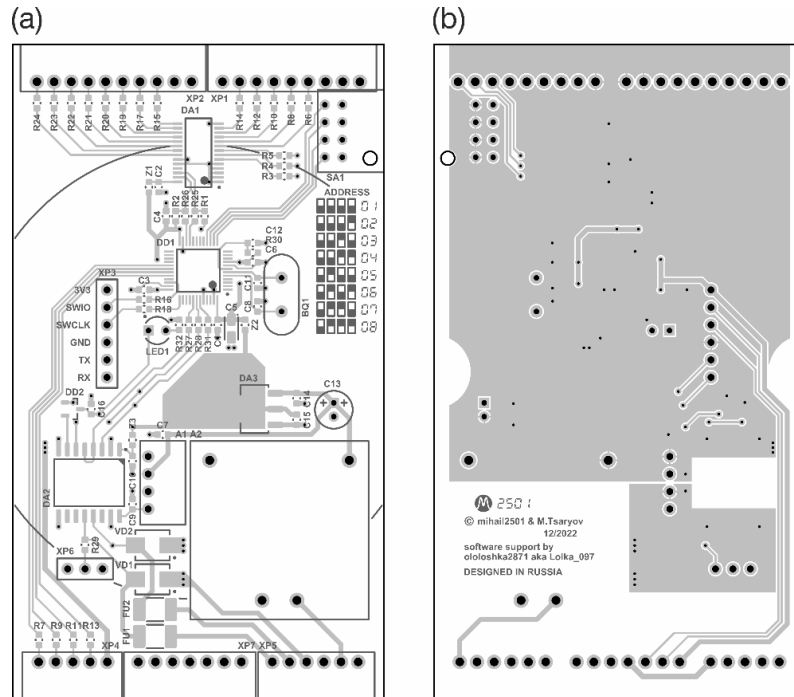


Fig. S9. PCB layout of PWM generator: (a) top layout; (b) bottom layout.

Final specifications:

- input voltage – 9-36 V;
- 16 PWM channels from PCA9685;
- 4 PWM channels from STM32F103;
- adjustable PWM frequency from 50 Hz to 4 kHz;
- isolated RS485 MODBUS RTU with hardware address selection.

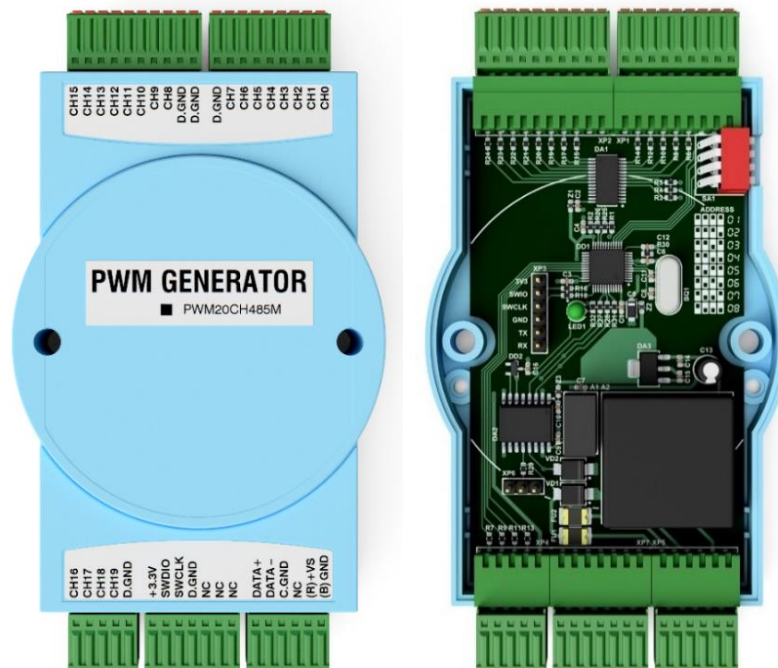


Fig. S10. Final design of PWM generator (render)