Barsotion EA & TA: User manual

Barsotion KOy, 2025

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Overview

EA hardware description

The Barsotion GBK EpsilonAnomalain boards (Barsotion-EA) was created as a part of model rocket project Pike.

EA Concepts

The Pike rocket has the following view:

Рисунок 1: Pike rocket view

The EA board computer (GBK) should be located at the nose of rocket, consist of one board and placed longitudinally. The power source is the 3.7 V 18650 battery with typical capacity around 3000 mA*h. The board computer should contain following sensors:

- Gyroscope & accelerometer (ICM-42688-P was chosen), connected via SPI, that is important because of necessity of ensuring high data read speed;
- Barometer (BMP388 was chosen);
- AH3 air speed sensor connector (4-pin, 3,3V, GND, SDA, SCL);
- Hygrometer (AHT20 was chosen).

The microcontroller should be enough rapid for processing gyroscope's data a few thousand times per second. Reading data from the gyroscope should be synchronized with gyroscope's interrupt channel.

Barometer and hygrometer data reading interrupt synchronization is not needed.

The board computer should contain a flash memory chip, the capacity should not be less than 1 Gbit.

The board computer should have connectors for four MG90S servos. Also it should have a DC-DC boost voltage converter to provide servo feeding. The board computer should can power down servos if they are not used, because servos have a significant static power consumption.

The board computer should can measure battery voltage and have a power-off option, that allows to power down system by the microcontroller command.

The board computer should switch on by special button pressing. It is supposed that the computer will be connected to the battery a long time before the start so that long working not wanted. The computer should be switched on shortly before the start for saving the battery charge.

The computer should have a small seven-segment led indicator on the board for system status indication and also 4 LEDs:

- Power 3.3 V indication LED;
- TXD0 LED;
- RXD0 LED;
- User-driven LED.

The power indication helps to control the computer is working or not, TXD and RXD indication helps to control the data transmission progress. User-driven LED is needed for simplifying the debug process and improving the computer using user's experience.

Also the board computer should have a buzzer that needed to signal when the rocked landed and waits to be found.

EA Realization

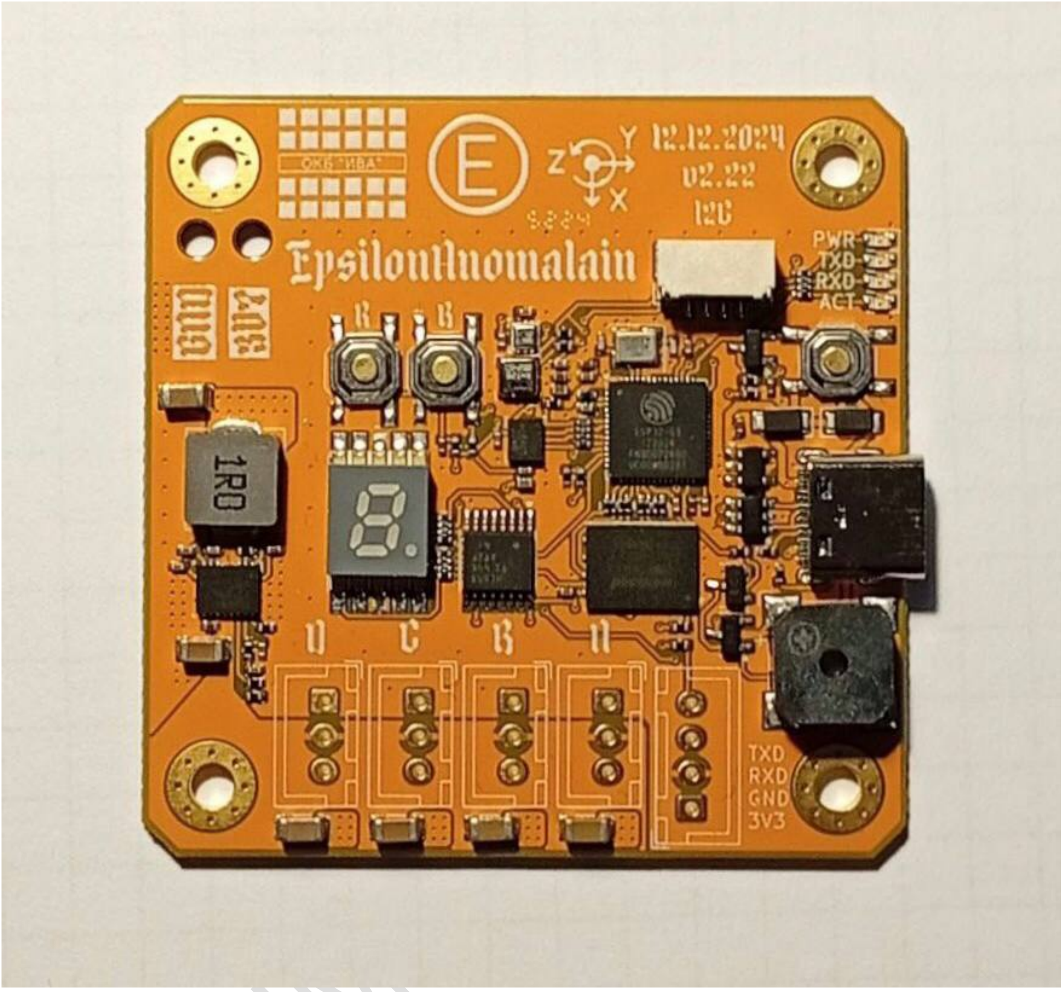


Рисунок 2: EA explained view

The Barsotion-EA has following characteristics:

- Microcontroller: ESP32-S3FN8;
- Gyroscope & accelerometer: ICM-42688-P;
- Barometer: BMP388;
- Hygrometer: AHT20;
- AH3 board I2C connector;
- Buzzer for sound indication;
- Seven-segment LED indicator driven by 74HC595 shift register;
- USB-C for flashing & debug;

- SPI NAND Flash memory chip W25N01GVZEIG, the capacity is 1 Gbit
- DC-DC boost voltage converter based on TPS61088 for servo feeding, the schematic is calculated and topology drawn for continious 3 A current;
- Four servo connectors.

EA Dimentions

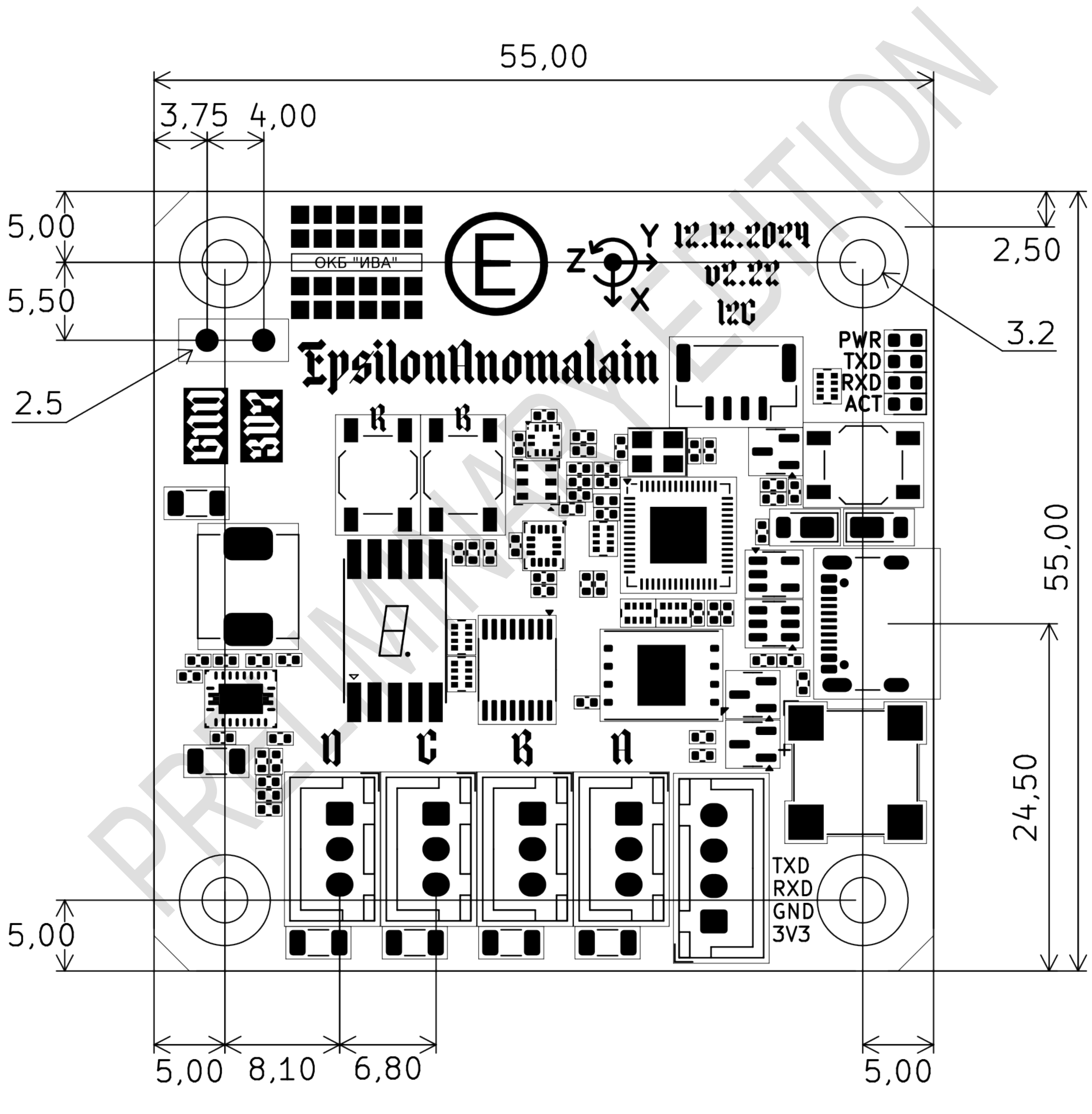


Рисунок 3: EA dimentions

EA Structural schematic

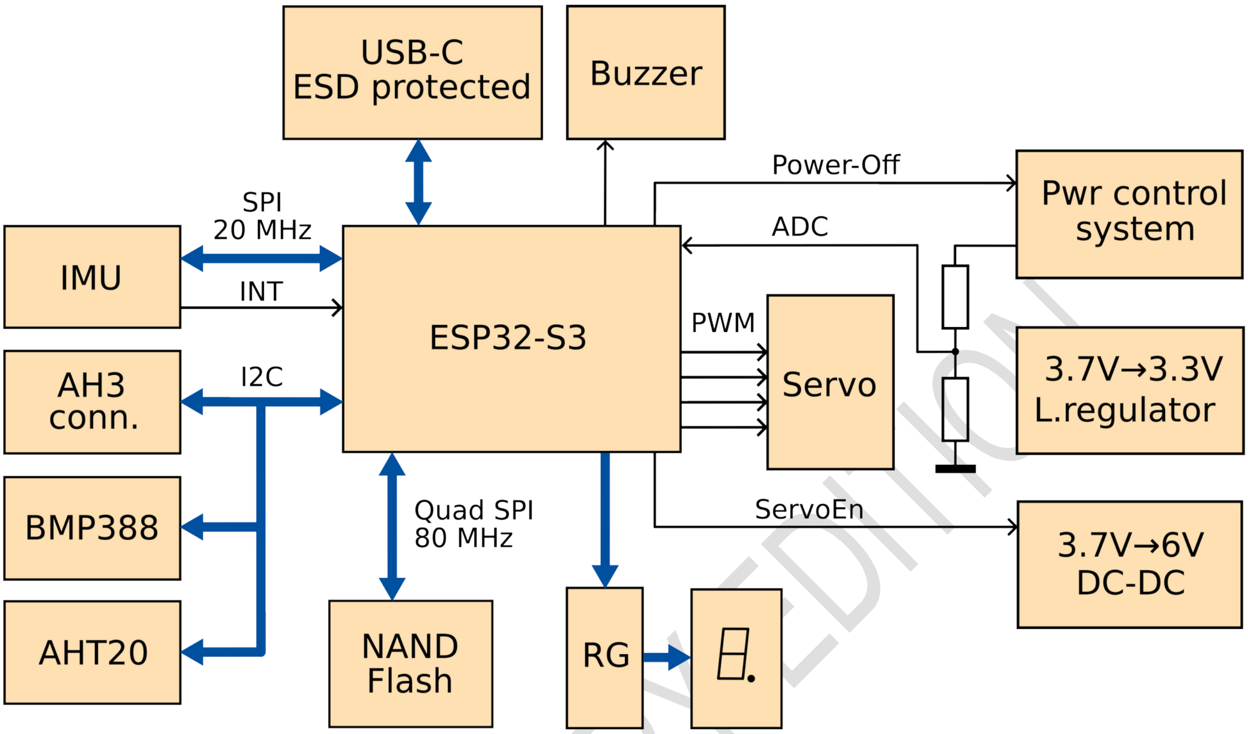


Рисунок 4: EA structural schematic

EA Topology

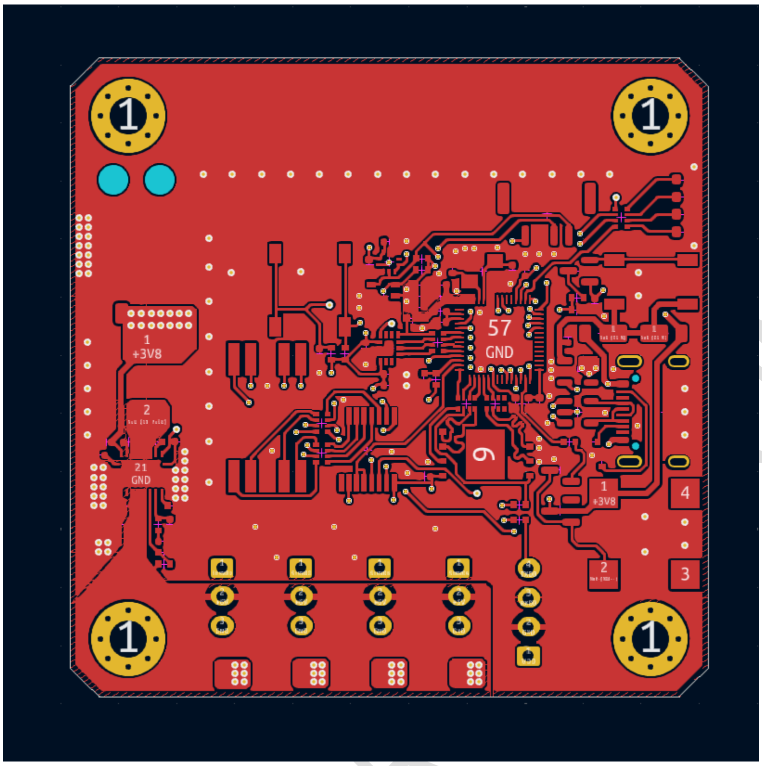


Рисунок 5: EA Layer 1 - Top signal

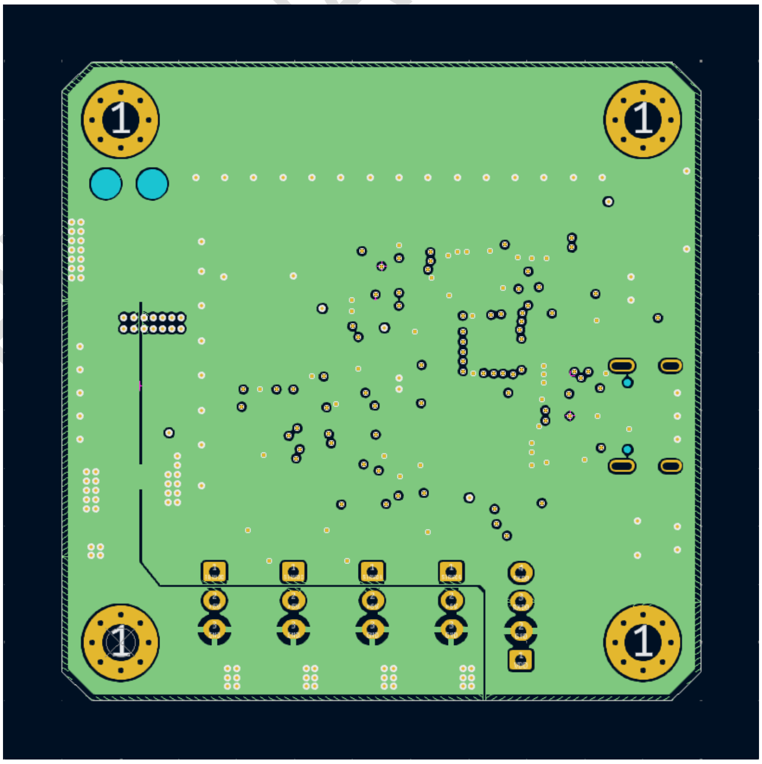


Рисунок 6: EA Layer 2 - GND

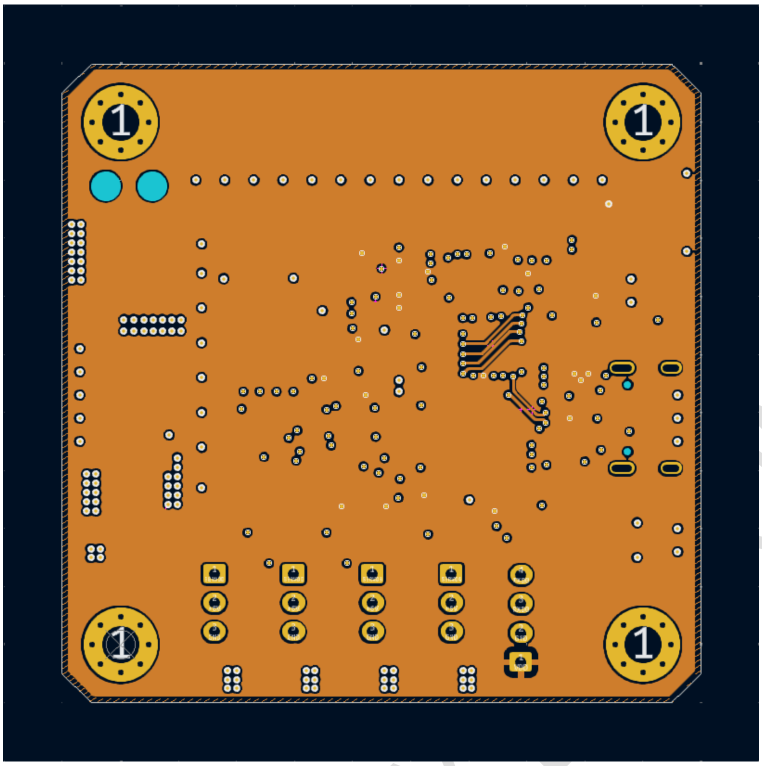


Рисунок 7: EA Layer 3 - Power

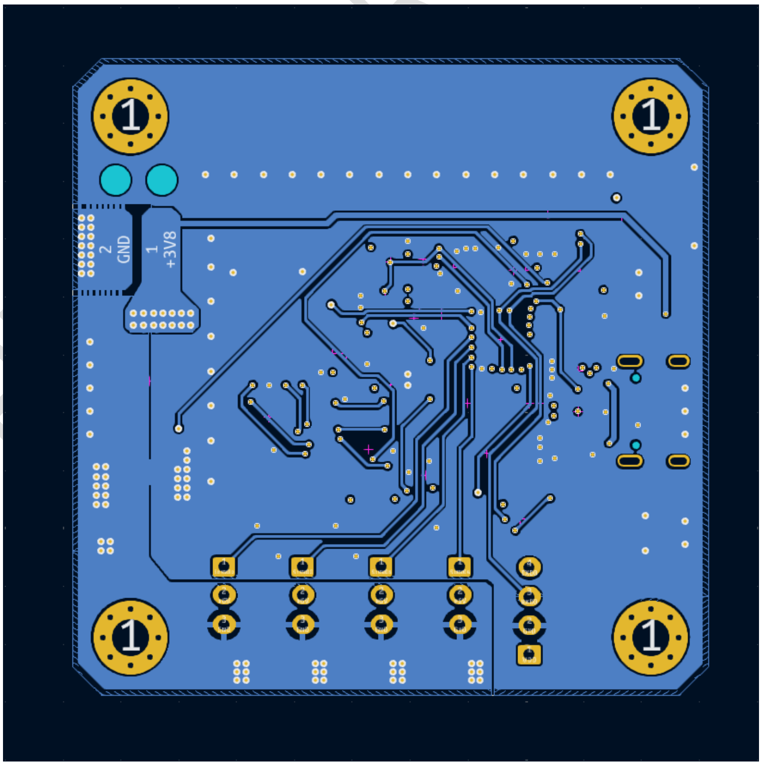


Рисунок 8: EA Layer 4 - Bottom signal

EA Errata

While the EA tests some errors was finded.

EA_ERR1_Anode

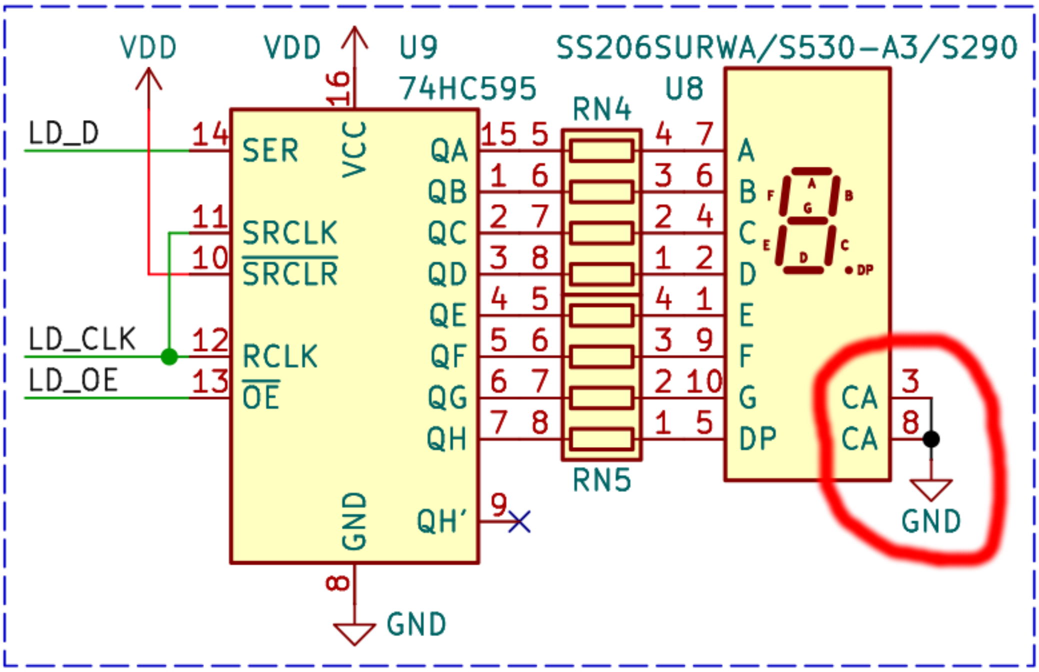


Рисунок 9: EA_ERR1_Anode

The LED module's common anodes should be routed to +3.3 V power supply, however they are wired to the ground. That is a reason why the led indicator on the EA does not work.

EA_ERR2_Poweroff

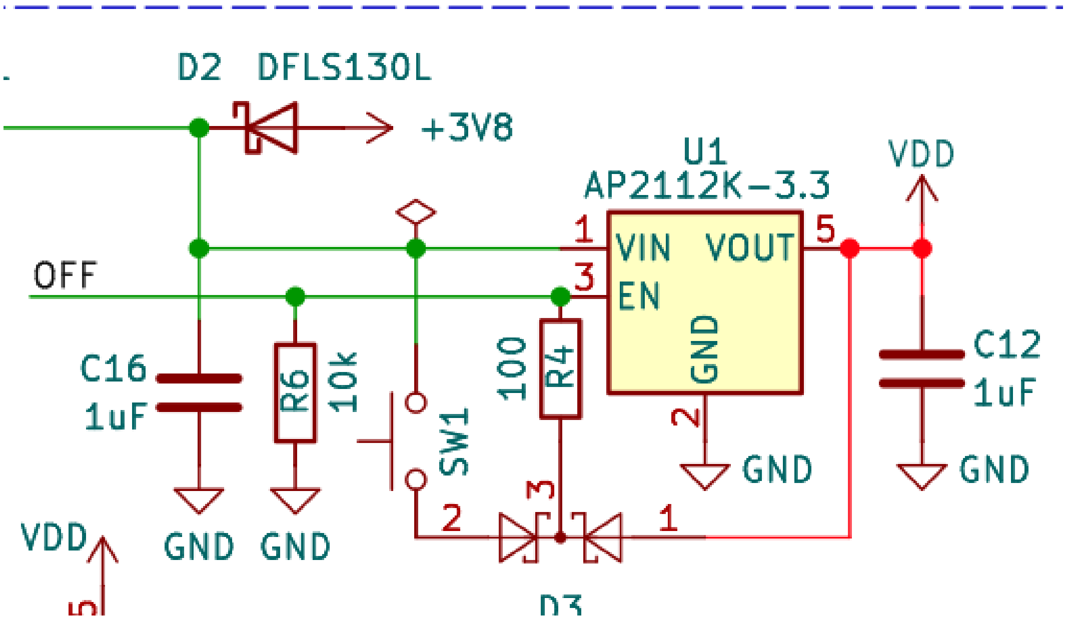
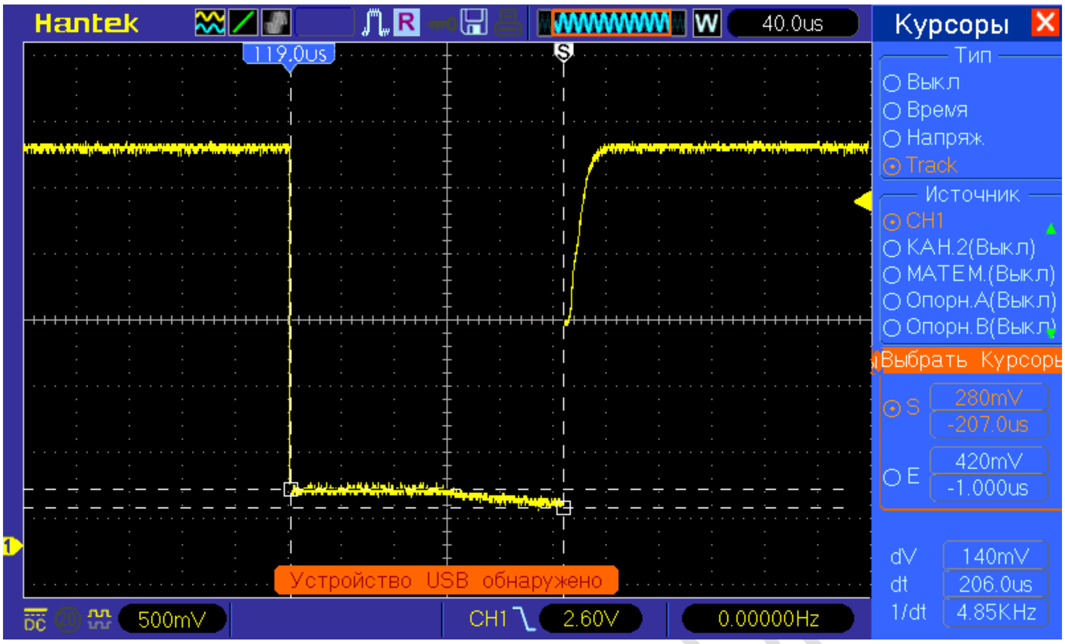


Рисунок 10: EA_ERR2_Poweroff

The EA boards have a hardware ability to power-off themselves by microcontroller command. It is useful if the battery voltage is low.

The power-off function does not work properly. When the OFF pin (GPIO38) is initialized as output and the logic 0 routed to this pin, the voltage on the VDD line decrease down to 1.8-1.9 V level, after that the GPIO block in the microcontroller stops the working, the OFF pin goes to tri-state condition, VDD capacitors' residual charge provides a high level on the regulator's EN pin and the device restarts.



OFF line after POWER-OFF command receiving

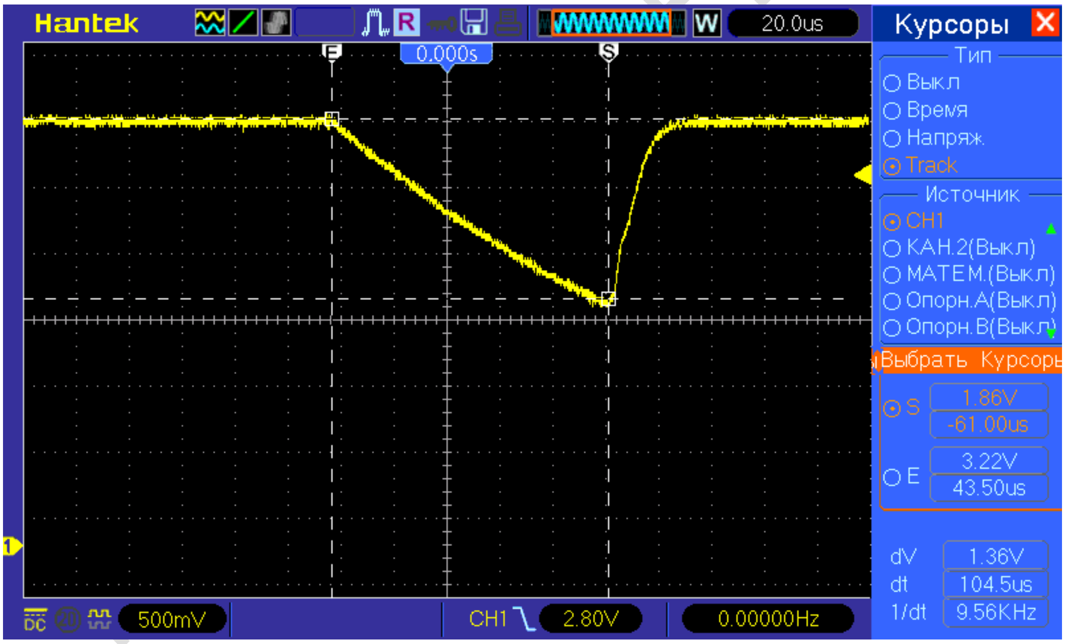


Рисунок 11: VDD line after POWER-OFF command receiving

EA_ERR3_Servo_supply

This error caused from mistake of understanding the TPS61088 EN (Enable) pin function.

The SERVOEN line is wired directly from microcontroller to TPS61088’s EN pin. While the EA developing it means that if the EN pin is not active, there is no voltage on the 6 V output servo feeding line. However the EN pin only enables voltage conversion, not current passing by the converter IC.

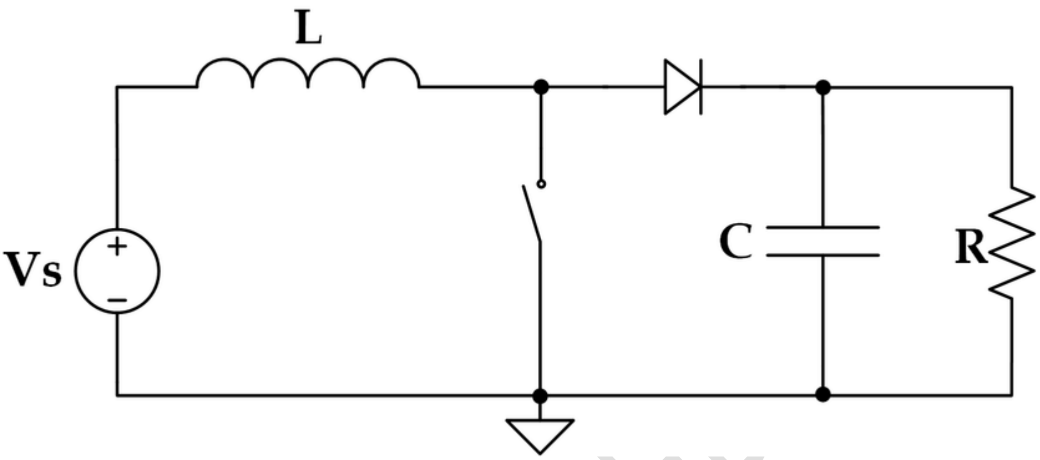


Рисунок 12: Simplified boost converter circuit

EN pin enables driving the switch. If it is not active, switch is always unlocked, so the converter does not work. However the voltage still can pass through the inductor and diode to the servos. The solving of the problem is to add the transistor to the servo feeding circuit that can break the circuit if it is needed.

EA GitHub repository

Barsotion-EA’s KiCad sources, full schematic, pindefs-file are located at a project GitHub repository.

TA hardware description

TA Concepts

The main goal of the TA creation is to fix the EA schematic error and problems. The most of device requirements are the same as for EA. However some extra features was wanted:

- Add the ICM-42688-P ODR frequency quartz stabilization
- Add 2.4 GHz WiFi / Bluetooth / BLE antenna
- Use 4 Gbit Flash chip instead of 1 Gbit
- Change the buzzer connection for allowing the buzzer to work when the board connected to the computer via USB (on the EA board the buzzer can make sound only if the battery connected)

According the EA&TA software architecture, the core 1’s cycle time depends on the ICM-42688-P INT1 pin period that is the same as the maximum of accelerometer & gyroscope’s ODRs. By default, the ODR frequency is generated from internal RC-source with 1% accuracy. Usual way to get the cycle time is considered in subtraction previous system timer’s value from actual. The ESP32-S3’s system timer has 1-microsecond accuracy, that does not allows to use ODR 16 kHz or 32 kHz because their periods have non-integer values in microseconds (62.5 & 31.25 microseconds), that causes bigger integral errors while integrating (the tests show that 8 kHz ODR gives smaller integral errors than 16 kHz, which contradicts the theory of numerical methods). The solving of the problem can be in ODR frequency quartz stabilization. If it is used, the ODR frequency has 10 ppm accuracy, so allows to use a constant as the cycle time value.

The 2.4 GHz antenna addition is not needed for rocket project tasks, however this requirement was added for getting more experience in high-frequency circuits topology design.

After the EA tests a curious fact was found: there are W25N01 memory chip pin-to-pin compatible chips with more capacity, for example W25N04. So using memory with more capacity is wanted.

TA Realization

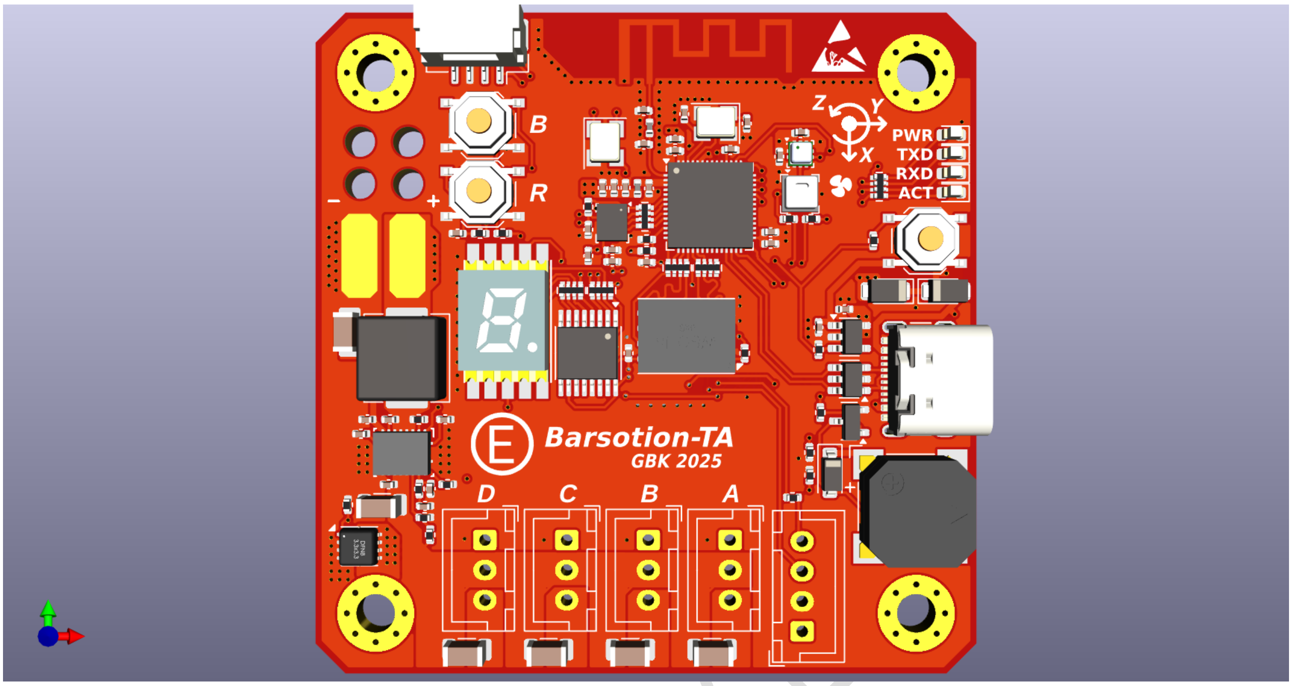


Рисунок 13: TA explained view

Thus, the Barsotion-EA has following characteristics:

- Microcontroller: ESP32-S3FN8;
- 2.4 GHz Wi-Fi / Bluetooth / BLE antenna driven by ESP chip;
- Gyroscope & accelerometer: ICM-42688-P (quartz-stabilized ODR frequency);
- Barometer: BMP388;
- Hygrometer: AHT20;
- AH3 board I2C connector;
- Buzzer for sound indication;
- Seven-segment LED indicator driven by 74HC595 shift register;
- USB-C for flashing & debug;
- SPI NAND Flash memory chip W25N04KVZEIG, the capacity is 4 Gbit
- DC-DC boost voltage converter based on TPS61088 for servo feeding, the schematic is calculated and topology drawn for continious 3 A current;

- Servo powerdown ability thanks to transistor breaking the feeding line;
- Four servo connectors.

TA Dimentions

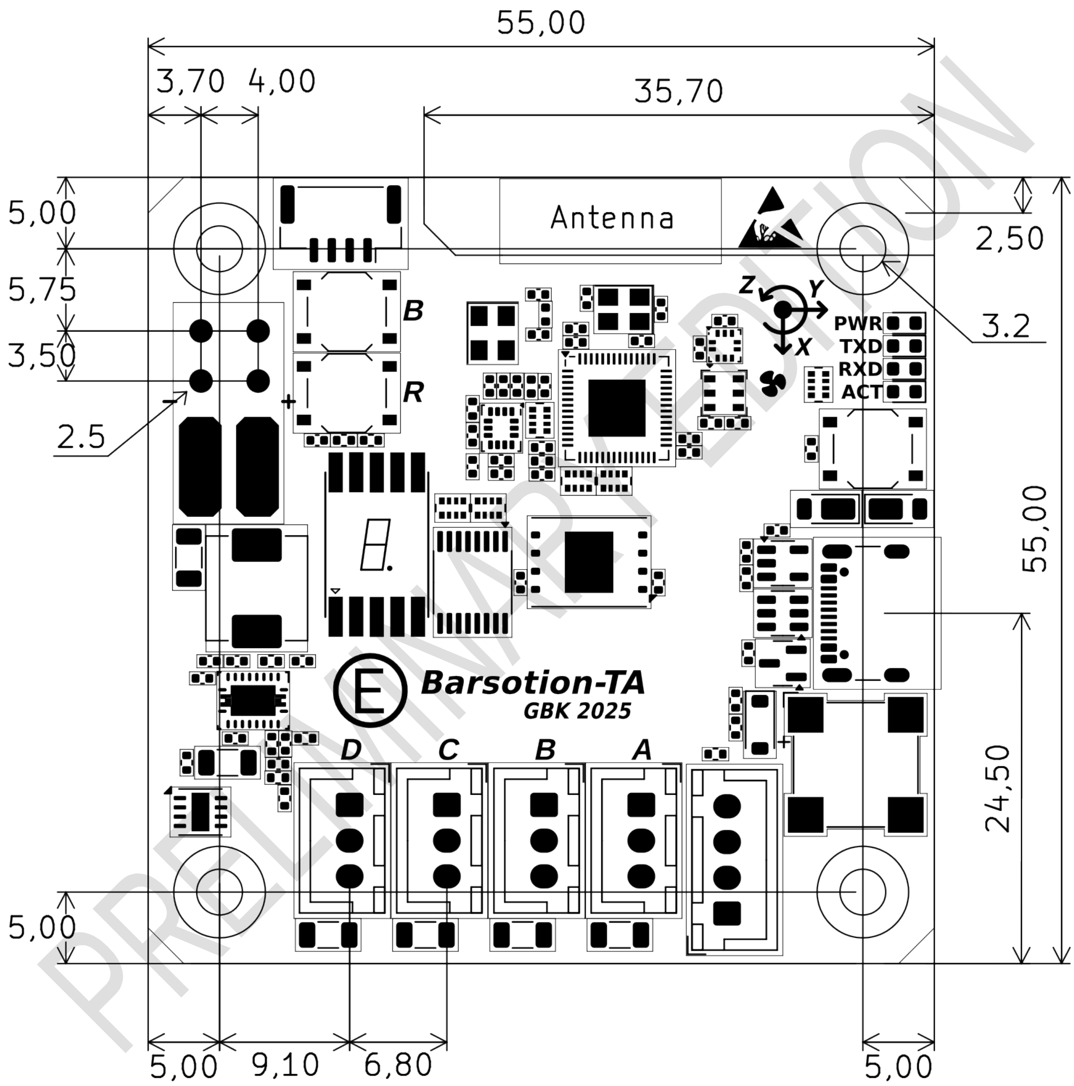


Рисунок 14: TA dimentions

TA Structural schematic

The TA structural schematic is the same as for EA, but the 32.768 kHz quartz oscillator was added.

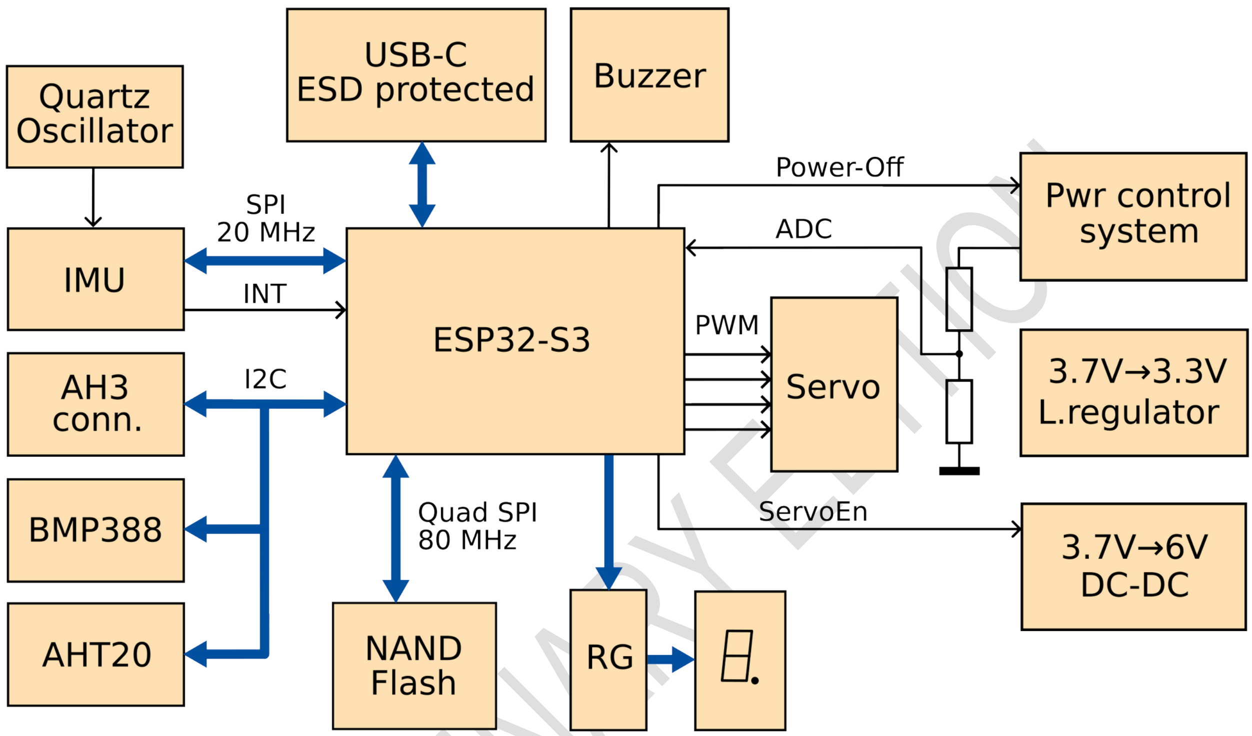


Рисунок 15: TA structural schematic

TA Topology

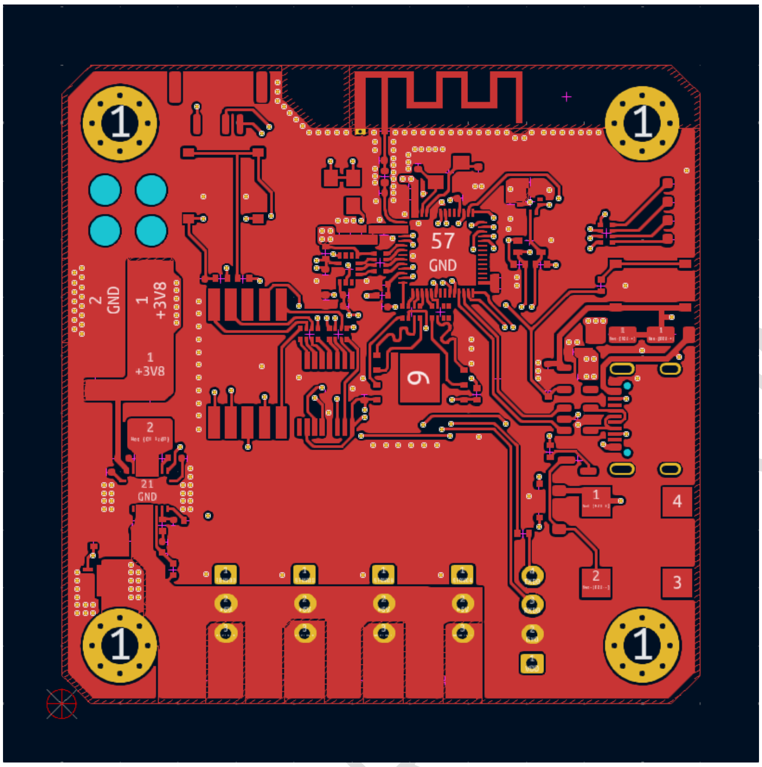


Рисунок 16: TA Layer 1 - Top signal

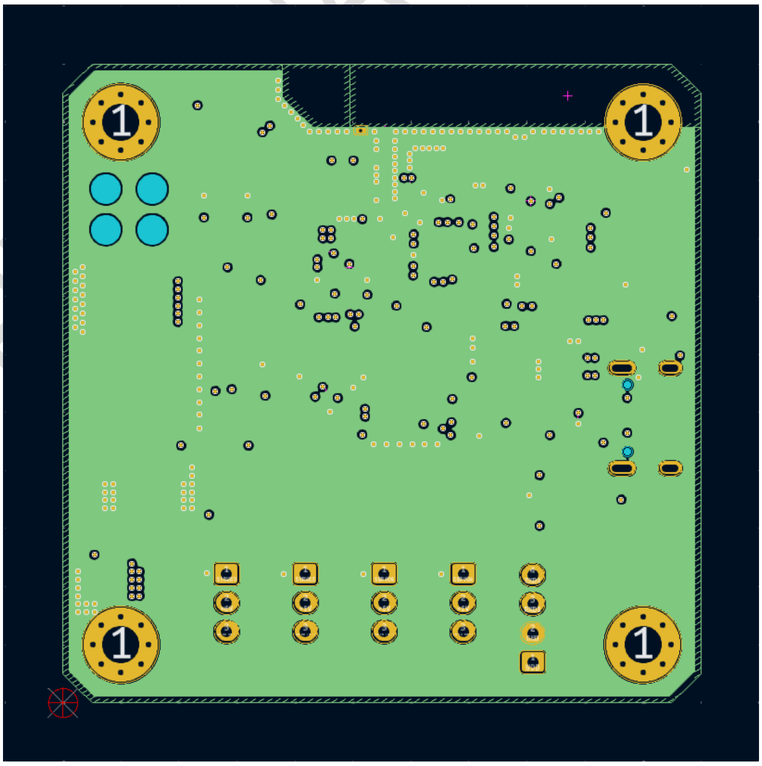


Рисунок 17: TA Layer 2 - GND

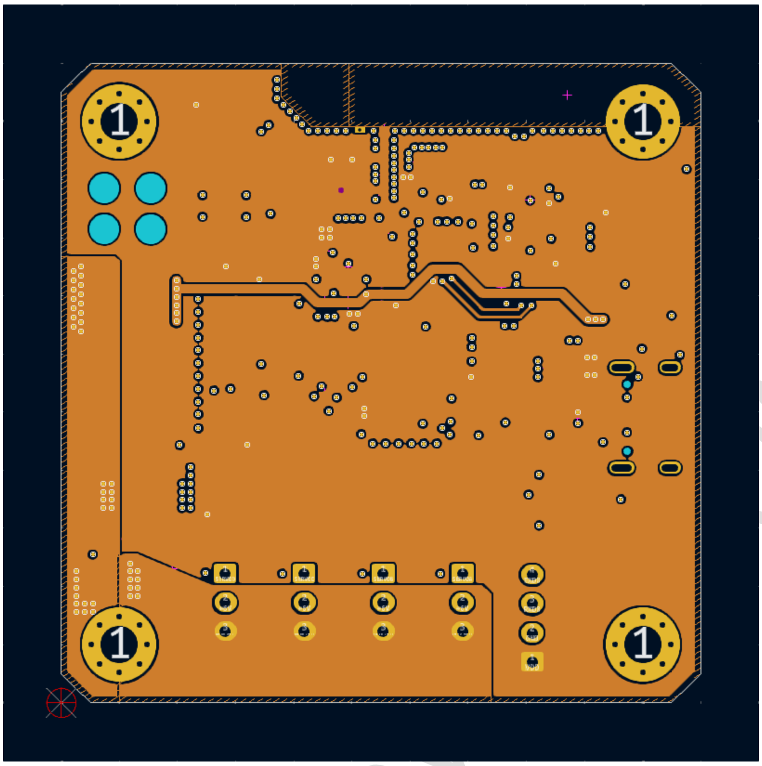


Рисунок 18: TA Layer 3 - Power

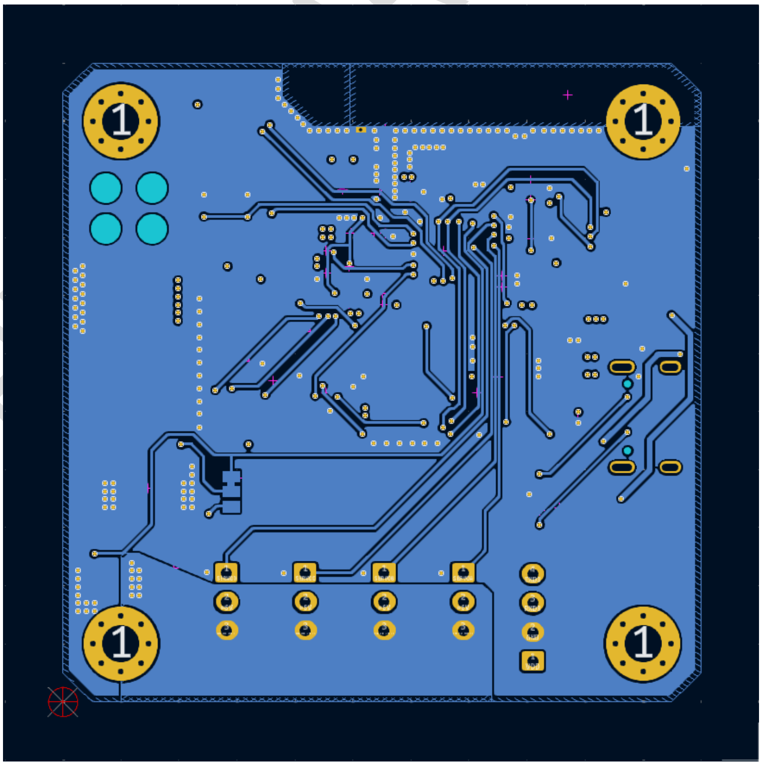


Рисунок 19: TA Layer 4 - Bottom signal

TA GitHub repository

Barsotion-TA’s KiCad sources, full schematic, pindefs-file are located at a project GitHub repository.

EA & TA placing

The EA / TA board computer is placed in the nose rocket section as shown at the following renders.

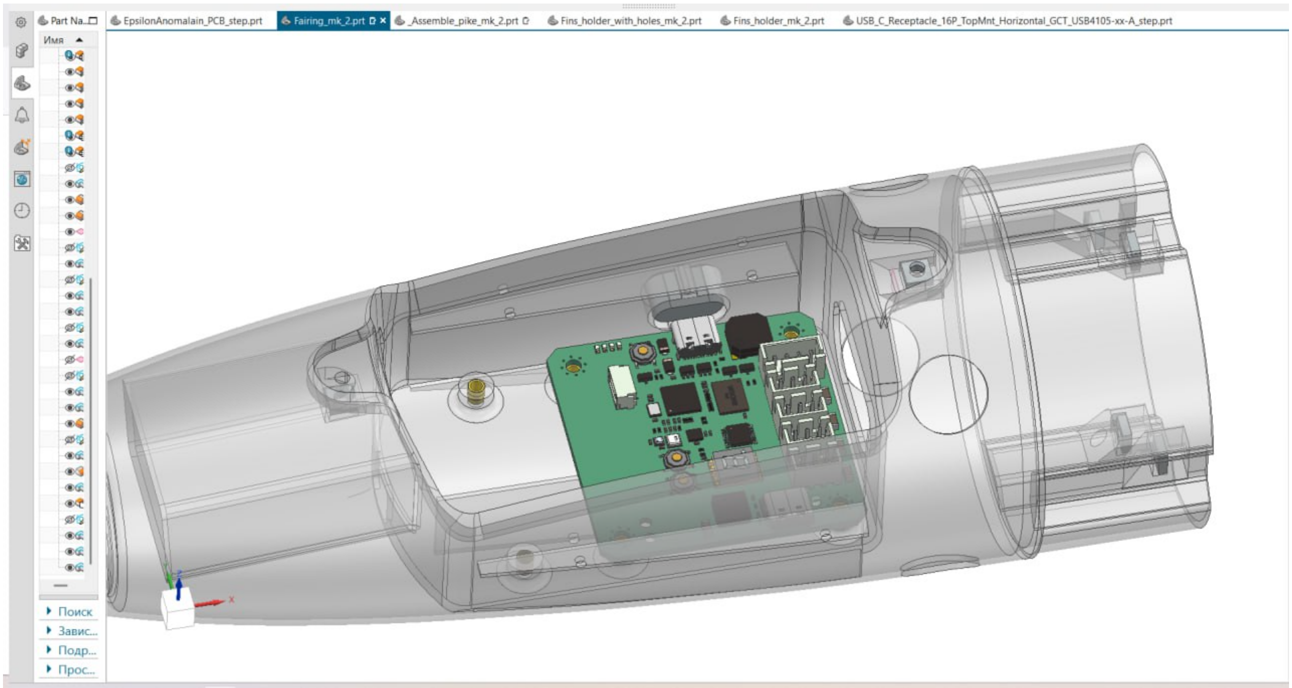


Рисунок 20: EA / TA placing

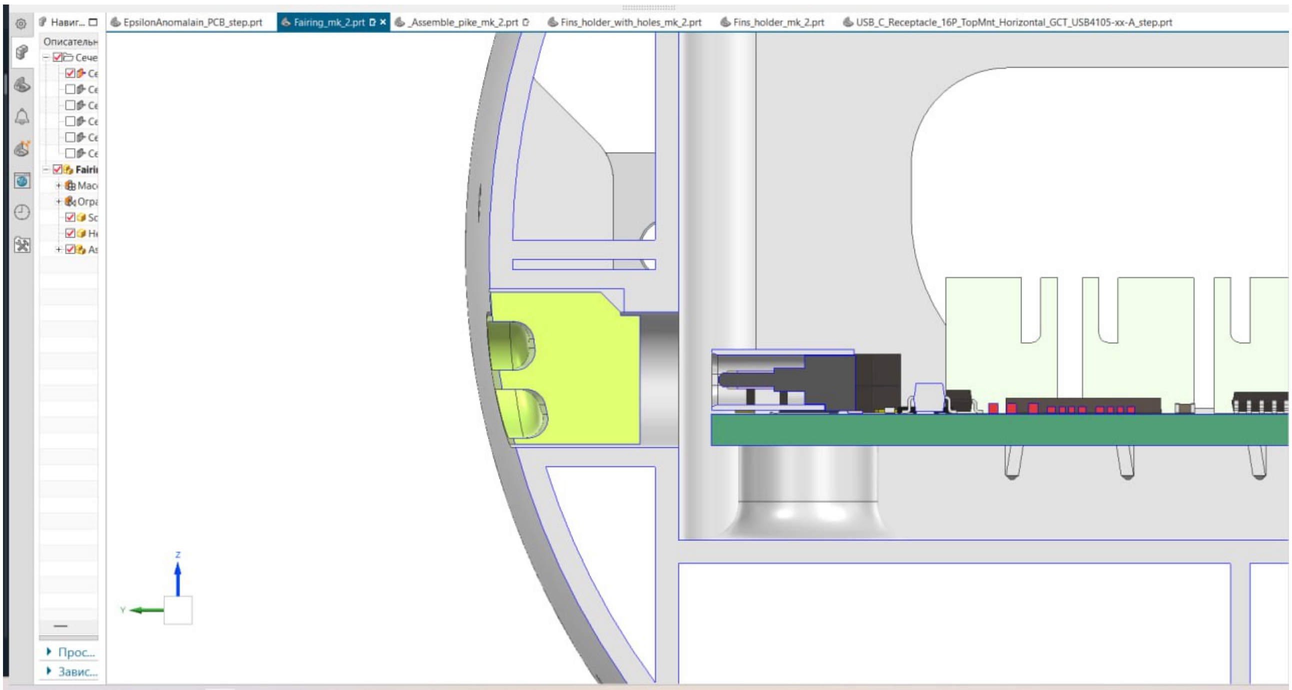


Рисунок 21: USB-C connector hole

EA & TA software packet

Abstract

The EA & TA software packet is a big complex software product.

Device connection for flashing & communication

EA / TA device PC connection shown at figure. Only one USB-C cable is necessary for connection.

Software building & device flashing are proceeded via Espressif IDE (Eclipse-based). It is recommended to restart device in BOOT-mode before flashing (press “R” button on board when “B” button is pressed).

Communication with device is possible via serial terminal on PC or special command-line utility (see EA & TA PC interface).

Communication is proceeded via a set of ASCII-commands. It can be easily entered to serial terminal. The EA / TA device is ready to receive commands when it has sent a command line marker: “> “.

Command summary

Command	Description
SAP	SERVOA add a small positive offset (servo A bias plus)
SAM	SERVOA add a small negative offset (servo A bias minus)
SBP	SERVOB add a small positive offset (servo B bias plus)
SBM	SERVOB add a small negative offset (servo B bias minus)
SCP	SERVOC add a small positive offset (servo C bias plus)
SCM	SERVOC add a small negative offset (servo C bias minus)
SDP	SERVOD add a small positive offset (servo D bias plus)
SDM	SERVOD add a small negative offset (servo D bias minus)
SZERO	Reset zero offsets for all the servos and print
SPRINT	Print the servo angles (is needed if the servos were rotated manually and you need to check the zero-angles)
TWI-VERIFY	Check the connection of all the supported I2C peripherals

TWI-RESET	Reset the I2C bus
DISK-INFO	Print information about the disk: manufacturer, type, capacity, packet len, number of written packets, disk's percent of usage
DISK-ERASE	Erase the disk. Checks the number of written packets and packet len, then erases the required amount of 128-kiB blocks
BOOT-ENTIRE-READ	Reads the disk's boot entire and prints the information about entire encoding version, type of the device (EA or TA), device unique id, packet length, number of written packets, imu calibration coefficients
PACKET-LEN	Prints the log packet len
PACKET-WROTE	Prints the number of written packets
ACTION	Switches the computer to active mode
POWER-OFF	Device power down
HELP	Prints available commands
MM-DISK_READ	Reading disk's binary data
MM-PACKET-LEN	Same as PACKET-LEN, but does not beepes at the end
MM-PACKET-WROTE	Same as PACKET-WROTE, but does not beepes at the end

Servo control commands

SxP, SxM commands Created to calibrate servos zero state before flight. This commands, when received, add a small offset to the servo zero state and print zero state to the servos.

SZERO commads resets all the extra offsets added by SxM & SxP commands and prints zero state value to servos.

SPRINT command prints zero state to the servos. It is needed if servos angles have already calibrated, but were changed manually so it is necessary to set calibrated zero state value to servos.

I2C control commands

TWI-VERIFY command checks the BMP388 and AH3 connection and prints connection status to the serial.

```
>
> TWI-VERIFY
BMP connected ok.
AH3 connected ok.
>
```

Рисунок 22: TWI-VERIFY command response

TWI-RESET command resets the I2C bus. It is needed if the connection was lost but then .

Disk control commands

DISK-INFO command prints to the serial disk connection status, disk type (from JEDEC ID), capacity information, and if the boot entire is formatted, boot entire information: number of written packets, disk usage status.

```
> DISK-INFO
Device: 25N01, 1Gbit SPI NAND Flash
Packet size: 100
Packet wrote: 3
Wrote: 0.29KiB, 0.00% of total flash
```

Рисунок 23: DISK-INFO command response

PACKET-LEN command reads the packet length value from the disk's boot entire and prints it to the serial.

PACKET-WROTE command reads the number if written packets from the disk's boot entire and prints it to the serial.

BOOT-ENTIRE-READ command reads the boot entire and writes full information about if to the serial. It prints:

- Boot entire structure version (only 0x01 is today exists)
- Board type (EA or TA)
- Device unique ID (each board computer should have an unique number)
- Log packet length
- Number of written packets
- IMU calibration parameters

```
> BOOT-ENTIRE-READ
Encoding version:       1
Device:                 EA
Device unique ID:       1
Log packet size:        100
Log packet wrote:       3
IMU calibration parameters:
- gyro_bias:    x:0.000000      y:2.870526      z:0.000000
- gyro_eps:     x:2.876356      y:1.572361      z:0.000000
- accel_eps:    x:0.000000      y:0.000000      z:-0.000000
- calibrating temperature: 0.000000 *C
```

Рисунок 24: BOOT-ENTIRE-READ command response

DISK-ERASE command erases all the log area of disk. Erasing is necessary before writing information in Flash memory. DISK-ERASE command reads number of written packets and packet length values from boot entire and erases strictly necessary amount of blocks that save user’s time and device resource.

MM-PACKET-LEN command does the same as PACKET-LEN, however it does not beeps the buzzer. This command is needed for EA & TA PC interface. “MM” means “machine mode”.

MM-PACKET-WROTE command does the same as PACKET-WROTE, however it does not beeps the buzzer. This command is needed for EA & TA PC interface.

MM-DISK-READ command

EA & TA board computers architecture allows to write a big amount of log data. When there are more than hundred megabytes of log data, their reading becomes a difficult task.

The Barsotion DeltaAnomalain board computer used to send log data to PC via serial interface as CSV-strings, so the packets were read, then converted to CSV-string and sent via UART.

This way was not effective because CSV-strings wear more than binary data. EA & TA software packet send packet data in binary form.

MM-DISK-READ command, when received, checks the disk connection and then responds OK, if the connection is valid. Then the board computer waits to sending any bytes via USB. When byte is sent, it sends a packet binary raw data as an answer. It sends packet 0 contents after start, then the address is incremented.

MM-DISK-READ command is used by EA & TA PC interface and allows read log data via USB at the maximum possible speed about 50 kilobytes per second.

EA & TA PC interface

For the purpose of reading logs automatically and simplification EA & TA user experience, a gbk-oracle utility was created.

GBK Oracle utility usage

GBK Oracle utility needs the Python 3 installed on the PC.

The standard launch query look like as shown below.

```
$ python3 gbk-oracle -p /dev/ttyACM0 --output-dir .
```

Utility’s ‘--output-dir’ parameter is optional. It sets directory where the log file will be written. By default it is the same directory when program source file is located.

The ‘-p’ parameter defines serial port name. It is usually /dev/ttyACMx for Linux and COMx for Windows systems.

Optional ‘-b’ parameter sets the baudrate. It is maybe useless because USB interface do not mind about baudrate in CDC mode, data samples are transmitted by packets.

GBK Oracle commands

The GBK Oracle utility commands are mostly the same as EA & TA software packet serial interface commands, but there is a new command – DISK-READ.

GBK Oracle utility allows to enter commands . For example for command DISK-READ four writing forms are allowed

- DISK-READ
- DISK_READ
- disk-read
- disk_read

Then the full list of GBK Oracle commands is presented. In the following table ‘xxx-xxx’ form of commands is used in goal to separate GBK Oracle commands from EA & TA software packet commands.

Command	Description
sap	SERVOA add a small positive offset (servo A bias plus)
sam	SERVOA add a small negative offset (servo A bias minus)
sbp	SERVOB add a small positive offset (servo B bias plus)
sbm	SERVOB add a small negative offset (servo B bias minus)
scp	SERVOC add a small positive offset (servo C bias plus)
scm	SERVOC add a small negative offset (servo C bias minus)
sdp	SERVOD add a small positive offset (servo D bias plus)
sdm	SERVOD add a small negative offset (servo D bias minus)
szero	Reset zero offsets for all the servos and print
sprint	Print the servo angles (is needed if the servos were rotated manually and you need to check the zero-angles)
twi-verify	Check the connection of all the supported I2C peripherals
twi-reset	Reset the I2C bus
disk-info	Print information about the disk: manufacturer, type, capacity, packet len, number of written packets, disk’s percent of usage
disk-erase	Erase the disk. Checks the number of written packets and packet len, then erases the required amount of 128-kiB blocks
boot-entire-read	Reads the disk’s boot entire and prints the information about entire encoding version, type of the device (EA or TA), device unique id, packet length, number of written packets, imu calibration coefficients
packet-len	Prints the log packet len
packet-wrote	Prints the number of written packets
action	Switches the computer to active mode
power-off	Device power down
help	Prints available commands
disk-read	Reading disk’s data into the file
exit	Quit the program
quit	Quit the program

Revision history

Date	Modification
Apr 29, 2025	Document creation

Contacts

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