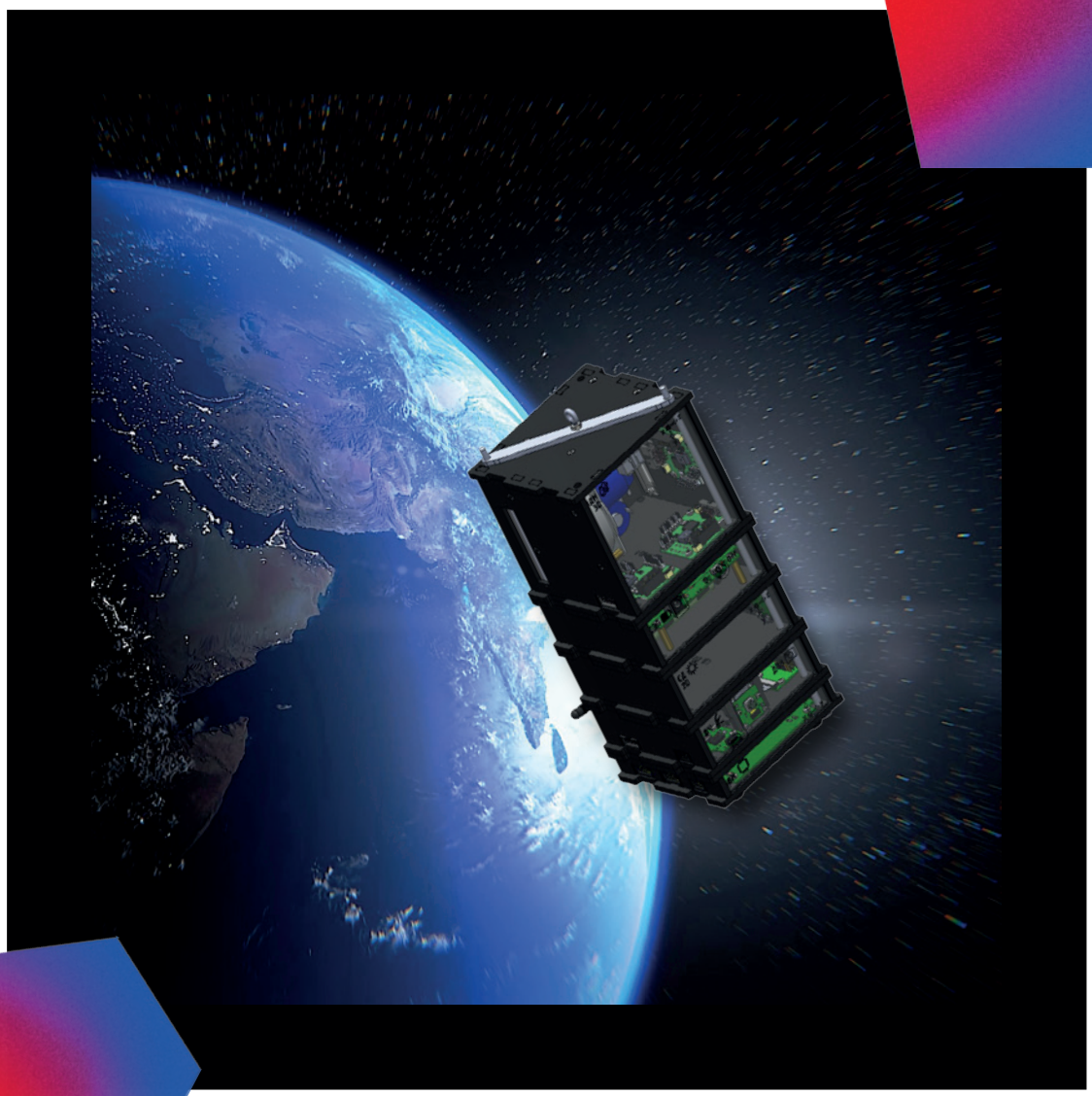
SPUTNIX
BY SITRONICS



OrbiCraft 3D Nanosatellite Functional Kit Assembly Manual

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1. Purpose of the OrbiCraft 3D Functional Kit

Tomorrow's engineers have to be trained from the school age by actively involving them in hands-on experience with hardware that lets them know how real-world satellites operate. With that in mind, OrbiCraft 3D is an excellent tool for constructing functional models of spacecraft. The kit includes all orbiter systems and components to facilitate systemic understanding of spacecraft design, assembly, testing and operation processes in an instructive manner, ultimately enabling students to come up with a simple – yet their own – "orbiter" that they will design, test, launch and operate in "space" (on a dedicated laboratory setup).

OrbiCraft 3D differs noticeably from its predecessor, the OrbiCraft functional kit, as it adopts an architecture common to real-world CubeSat-type spacecraft and OrbiCraft Pro satellite platforms. Examples of orbiters based on this architecture include CubeSX-HSE and CubeSX-Sirius-HSE research and educational satellites operating on the orbit. In addition, package dimensions have been adjusted to approximate the footprint of a standard CubeSat 3U.

OrbiCraft 3D comes with an UHF transceiver enabling it send and receive data via a UHF channel in the 435-437 MHz frequency band – the one used by most CubeSat orbiters. UHF orbiter control stands out as the most important feature of the functional kit as it operates identically to UHF control of real-world satellites in space. A terrestrial HF receiver with a built-in infrared sensor is also provided for simulated transfers over the X band.

OrbiCraft 3D supports the Houston Control Center professional software used for controlling satellites manufactured by SPUTNIX. Having practiced orbiter control with OrbiCraft 3D, students will master actual spacecraft control much easier in the future.

Working with the OrbiCraft 3D functional kit will foster diverse skills including:

- Structural design
- C++/Python programming
- Circuit design
- Radio engineering and wireless communication
- 3D simulation.

You will learn which sensors are used in the orbiter functional kit, what is their function, how to program them correctly using API library functions, and will understand the algorithm implemented in the functional kit for positioning and stabilizing the orbiter. The functional kit also makes it possible to design one's own orbiter prototype and to develop a space mission project with a payload module based on the Arduino microcontroller.

As you gain new electronics design and programming skills, you will be able to apply your talent to neighboring engineering fields such as robotics, UAVs etc., as well as to take part in design projects and contests at diverse mastership levels.

2. Glossary of Terms

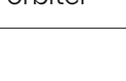
Abbreviation	Meaning
CubeSat	The global standard for small satellites
1U	A standard size of CubeSat, 10x10x10 cm
3U	A standard size of CubeSat, 30x10x10 cm
6U	A standard size of CubeSat, 30x20x10 cm
SB	Solar Battery
OBCU	On-Board Control Unit (orbiter computer module)
AVS	Angular Velocity Sensor
ERS	Earth Remote Sensing
Magnetometer	A magnetic field sensor
Raw	"Raw data" means data output by the sensor that has not yet been processed
RW	Reaction Wheel - an electromechanical device comprising an electric motor with a wheel
HF	High-Frequency
UHF	Ultrahigh Frequency (ultra-shortwave)
PC	Personal Computer
HA SW	Houston Application software

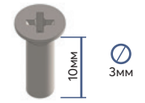
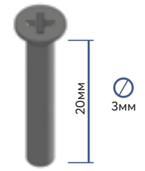
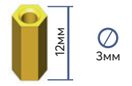
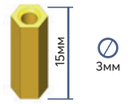
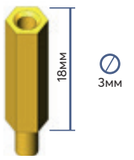
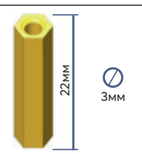
HS SW	Houston Server software
MCC	Mission Control Center
Orientation	Turning the orbiter to face the Earth with the correct side
Stabilization	Suppressing uncontrolled spinning of the orbiter

3. Assembling Modules
3.1. Tools and Parts

When assembling functional kit modules, you will need a screwdriver to mount boards in the housing, and a crimper and wire cutters to crimp ribbon cable connections.

The following parts are used for securing boards and structural members when components of the functional kit are assembled together:

M2x6 cylindrical-head screw	
M3x6 cylindrical screw	
M3x8 cylindrical-head screw	

M3x10 sunk screw	
M3x12 cylindrical-head screw	
M3x20 sunk screw	
PCHSS M3x10 brass stud	
PCHSS M3x12 brass stud	
PCHSS M3x15 brass stud	
PCHSN M3x18 brass stud	
PCHSS M3x22 brass stud	
M4 knurled nut	
M4 nut	
M4 pin	

3.2 Assembling the PSS Module (Power Supply System)

The power supply system comprises a power supply board and rechargeable batteries supplying all OrbiCraft 3D modules with electric power. Batteries are recharged from 220VAC mains by means of an AC power adapter which is included in the package.

Components necessary for assembly - (Fig. 1):

All parts marked as “PSS” (two base plates, two walls, two transparent panels)
The PSS board
- Rechargeable batteries
- Fixtures (PCHSS brass studs – M3x22 – 4 pcs., cylindrical-head screws – M3x6 – 4 pcs., M3x10 sunk screws – 4 pcs.)

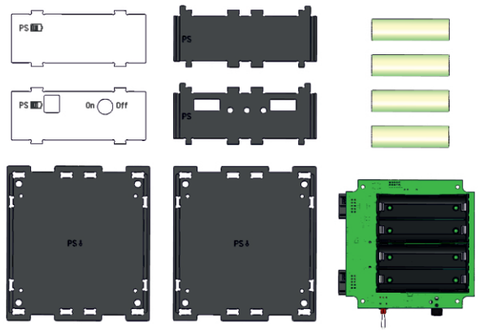


Fig. 1: Module assembly components

Assembly Procedure

1) Take the bottom base plate of the PSS (marked as “PSS ↓”), put four M3x22 PCHSS brass studs on top, secure them from below with four M3x10 sunk screws (Fig. 2):

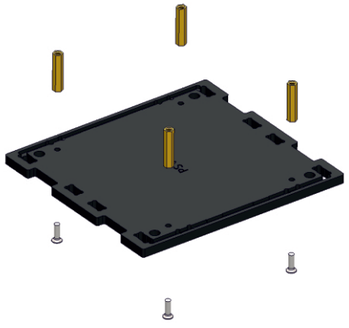


Fig. 2: Securing brass studs

2) Install batteries in dedicated seats of the PSS board. IMPORTANT: observe battery poles when mounting (Fig. 3):

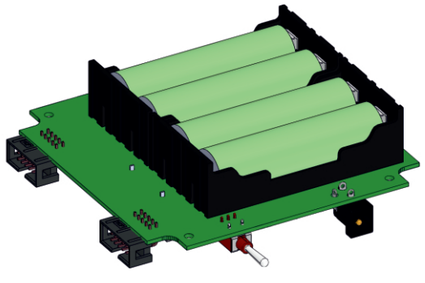


Fig. 3: Mounting a rechargeable battery

3) Install a transparent panel with PSS board connectors passing through its holes (Fig. 4):

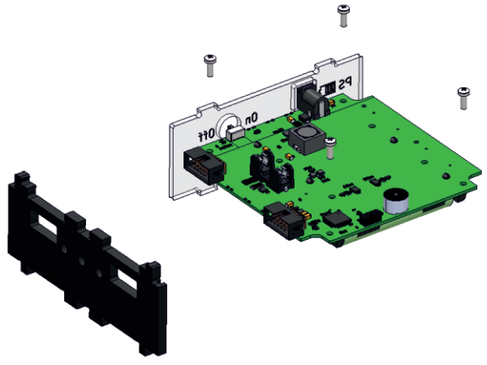


Fig. 4: Mounting a transparent panel

4) Place PSS board connectors into side wall holes while aligning the side surface of the transparent panel with a recess in the side wall (Fig. 5):

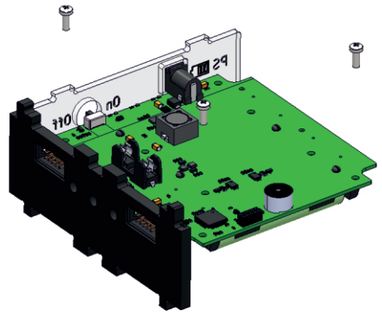


Fig. 5: Mounting a side wall

5) Mount the circuit board together with the side wall, transparent panel and accumulators on the bottom base plate. To do that, align protrusions of the side wall and transparent panel with holes in the base plate and latch them. Fix the board using M3x6 cylindrical-head screws (Fig. 6):

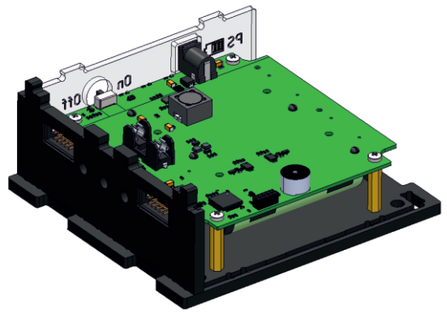


Fig. 6: Mounting the circuit board

6) Fix the second sidewall on the base plate. To do that, align side wall protrusions with holes in the base plate and latch them (Fig. ~~7~~):

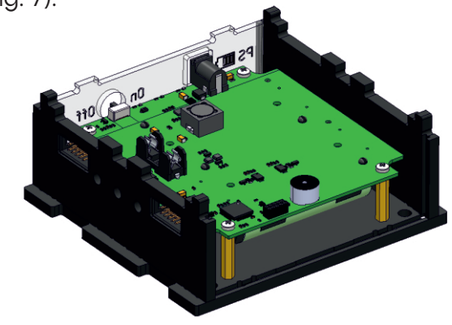


Fig. ~~7~~: Mounting the second side wall

7) Secure the second transparent panel on the bottom base plate. To do that, slide the panel along guide rails in walls until it touches the bottom base plate, then latch it (Fig. 8):

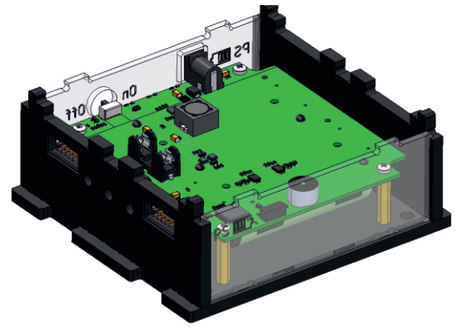


Fig. 8: Mounting the second panel

8) Attach the top cover (marked as “PSS↑”) to the assembled housing. To do that, align holes in the top cover with protrusions of two side walls and two transparent panels and latch them by applying some force. A fully assembled PSS module appears like this (Fig. 9):

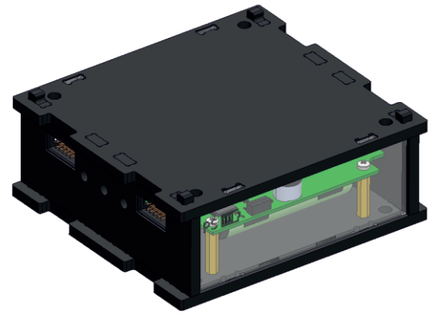


Fig. 9: A fully assembled PSS module

3.3 Assembling the SS Module (Sun Sensors)

A sun sensor is a sensor that determines where sunlight is coming from. The SS module includes four sun sensors enabling OrbiCraft 3D to receive its telemetry and rotate the construction by means of its reaction wheel depending on the angular position of the sunlight source relative to OrbiCraft 3D.

Components necessary for assembly - (Fig. 10):

- All parts marked as “SS” (two base plates, two walls, two brackets, four transparent panels)
- Extra parts (two windows not marked with any text)
- Circuit boards (general-purpose board – 1 pc., sun sensor board – 4 pcs.)
- Fixtures (M3x6 cylindrical-head screws – 12 pcs.)
- A USB cable for connection to the computer.

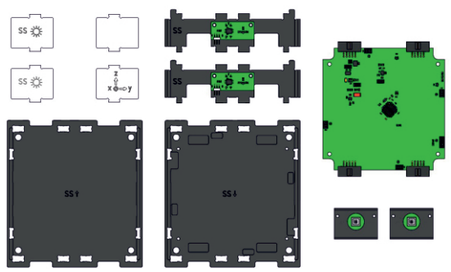


Fig. 10: Module assembly components

Assembly Procedure

1)Mount the general-purpose board on the bottom plate (marked as “SS↓”), then secure the board with four M3x6 cylindrical-head screws (Fig. 11):

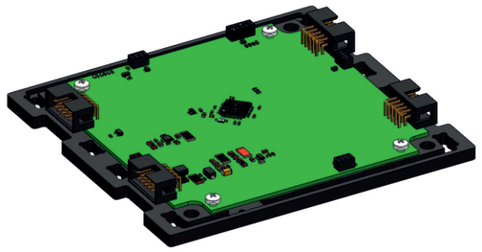


Fig. 11: Installing the circuit board

2) Secure sun sensor boards #1 and #3 to side walls using two M3x6 screws on both sides. Assemble the resulting wall components together with the general-purpose board as indicated on the board: Sensor 1 and Sensor 3 respectively. To do that, align side wall protrusions with holes in the base plate and latch them. Also at this stage, sun sensor connectors have to be inserted into receptacles on the general-purpose board (Fig. 12).

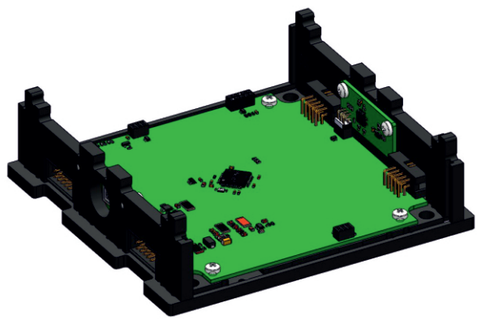


Fig. 12: Connecting a sun sensor board with the general-purpose board

When mounting sensors on the circuit board, pay attention to the number of the sensor being connected and the sensor number indicated on the circuit board. Install sensors in the order of increasing numbers!

3) Secure sun sensor boards #2 and #4 to brackets using two M3x6 screws on both sides and connect them to the general-purpose circuit board. To do that, align bracket protrusions with holes in the base plate and latch them. While assembling the connection, mate sun sensor connectors with receptacles on the general-purpose circuit board marked as “Sensor 2” and “Sensor 4” respectively (Fig. 13):

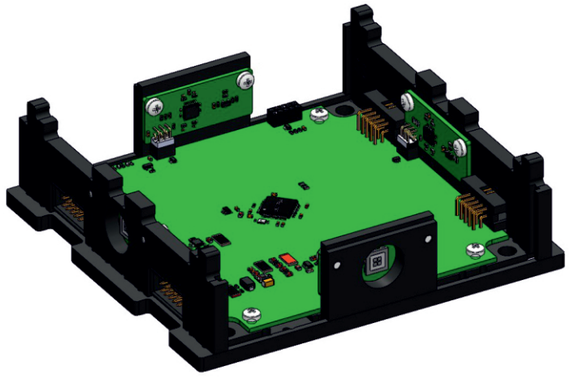


Fig. 13: Connecting a bracket-mounted sun sensor board with the general-purpose board

4) Secure four transparent panels to the bottom base plate. To do that, slide each panel along guide rails in walls until it touches the bottom base plate, then latch it.

Note that the panel with a coordinate system marked on it should be facing the sun sensor #2 (Fig. 14):

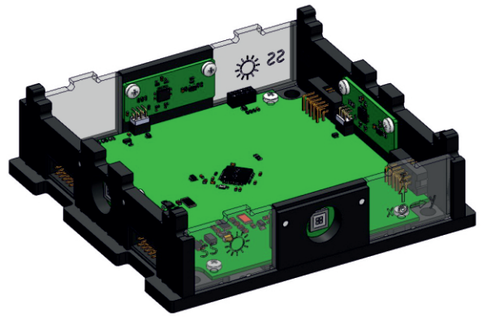


Fig. 14: Mounting transparent panels

5) Attach the top cover (marked "SS↑") to the assembled housing. To do that, align holes in the top cover with protrusions of two side walls and four panels and latch them by applying some force.

A fully assembled SS module looks as follows (Fig. 15):

Fig. 15: A fully assembled module

3.4 Assembling the OBCU Module (On-Board Control Unit)

The on-board control unit is a core module of the nanosatellite functional kit that processes and transmits telemetry data coming from the angular velocity sensor (AVS) and the magnetometer. Its other functions include providing access to the Raspberry Pi circuit board via a Wi-Fi module or a CAN connection and performing nanosatellite orientation calculations using a microcontroller-based orientation and stabilization system (OSS). Furthermore, a Wi-Fi module built into the OBCU enables connection to the computer.

Telemetry means remote acquisition, processing and transmission of data coming from various sensors.

Components necessary for assembly (Fig. 16):

- All parts marked as “OBCU” (two base plates, two walls, two transparent panels)
- OBCU circuit board
- Fixtures (M3x6 cylindrical-head screws – 4 pcs.)

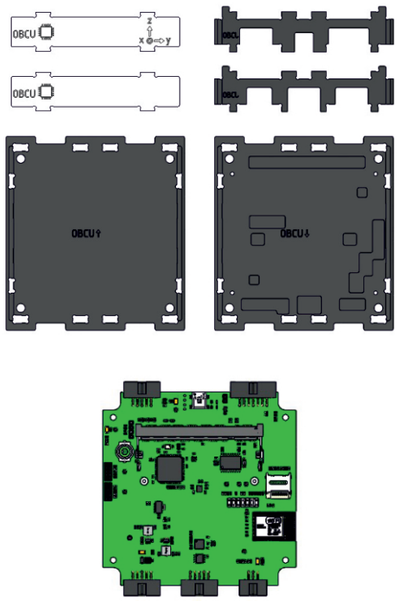


Fig. 16: Module assembly components

Assembly procedure:

1) Place the OBCU board (marked as “OBCU↓”) on the bottom support plate (Fig. 17):

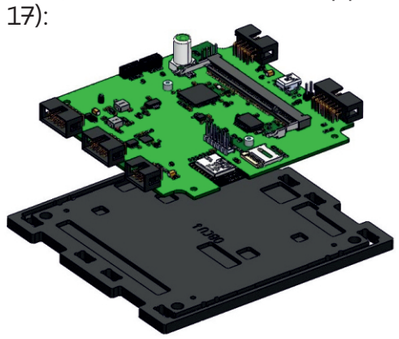


Fig. 17: OBCU support

2) Secure the board to the bottom base plate using M3x6 cylindrical-head screws (Fig. 18)

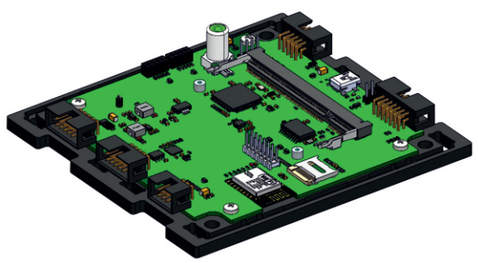


Fig. 18: Mounting the circuit board

3) Secure side walls to the base plate. To do that, align side wall protrusions with holes in the base plate and latch them (Fig. 19):

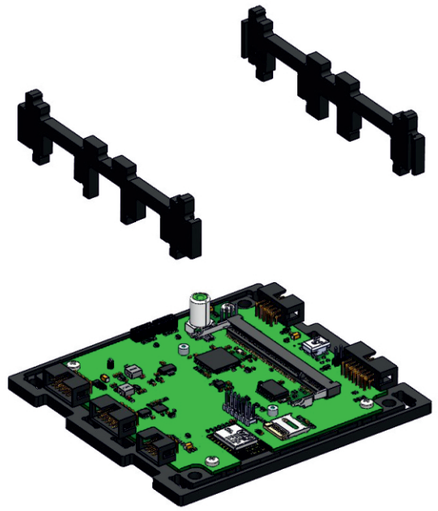


Fig. 19: Mounting and securing side walls

4) Secure two transparent panels to the bottom base plate. To do that, slide each panel along guide rails in walls until it touches the bottom base plate, then latch it. Observe panel arrangement and axial alignment as shown in the drawing below (Fig. 20):

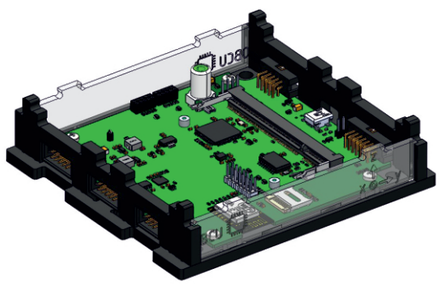


Fig. 20: Mounting two transparent panels

5) Attach the top cover (marked as “OBCU↑”) to the assembled housing. To do that, align holes in the top cover with protrusions of two side walls and two panels and latch them by applying some force (Fig. 21):

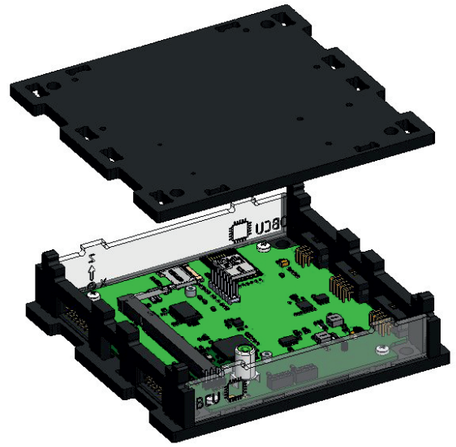


Fig. 21: Installing the top cover

A fully assembled OBCU module appears like this (Fig. 22):

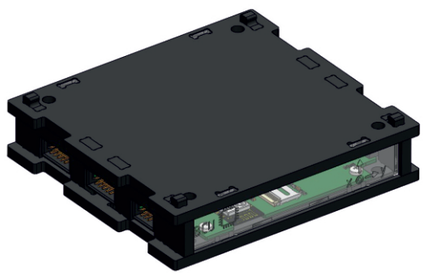


Fig. 22: A fully assembled OBCU module

3.5 Assembling the ERS (Earth Remote Sensing) Module

The Earth remote sensing module includes a camera and UHF (ultrahigh frequency) and HF (high-frequency) built-in transceivers. The camera takes a picture which is stored in a Raspberry Pi CM module and is transmitted to the MCC by means of an HF (simulating the X frequency band), UHF (435...437 MHz) or Wi-Fi module. The UHF module also makes it possible to receive telemetry from the orbiter functional kit in Houston Application software without a Wi-Fi connection.

Components necessary for assembly (Fig. 23):

- All parts marked as “ERS” (two base plates, two walls, two transparent panels), camera bracket
- Circuit boards (UHF board, HF board, camera, camera adapter board)
- Antenna
- Fixtures (M3x6 cylindrical-head screws – 7 pcs., M2x6 – 6 pcs.)

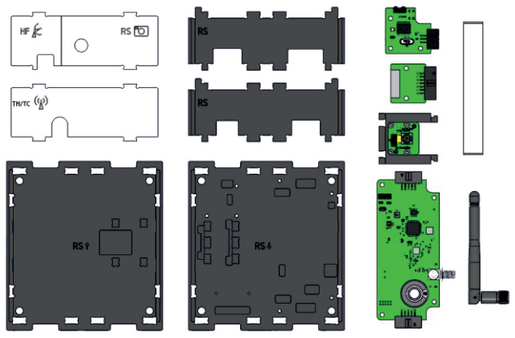


Fig. 23: Module assembly components

Assembly procedure:

1) Place the UHF board on the bottom plate (marked as “ERS↓”), then secure the board with four M3x6 cylindrical-head screws (Fig. 24):

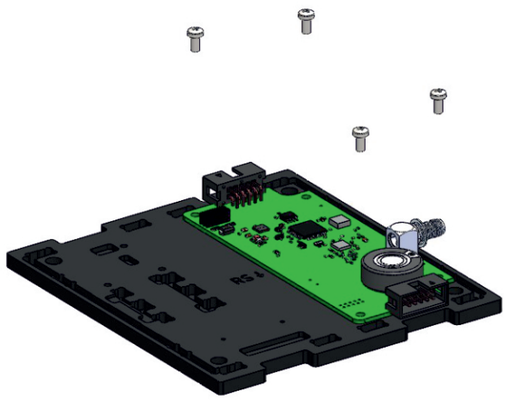


Fig. 24: Installing the UHF circuit board

2) Connect the antenna (Fig. 25) to the UHF board:

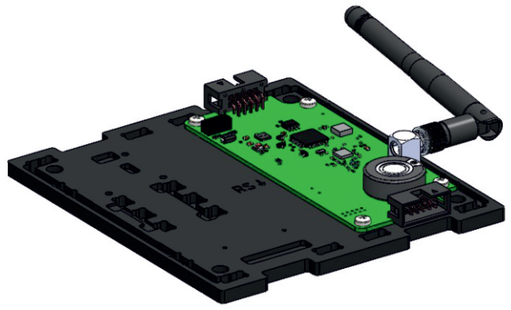


Fig. 25: Connecting the antenna

3) Place the HF board to the bottom base plate and secure it using M3x6 cylindrical-head screws (Fig. 26):

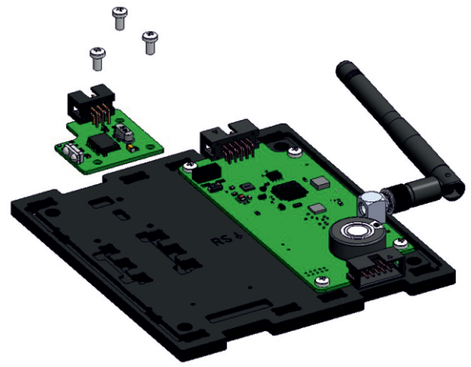


Fig. 26: Installing the HF circuit board

4) Assemble the camera together with the bracket using four M2x6 screws (Fig. 27):

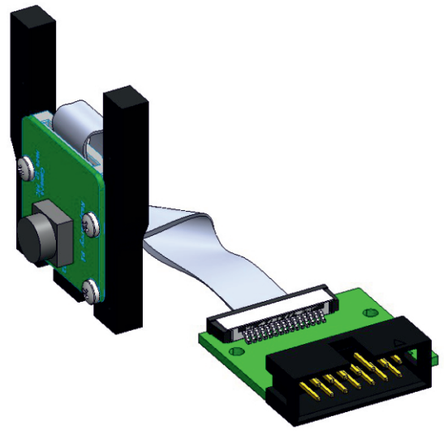


Fig. 27: Camera assembly

5) Mount the bracket with the camera on the bottom base plate. To do that, align bracket protrusions with holes in the base plate and latch them. Place the adapter board to the bottom base plate and secure it using M2x6 cylindrical-head screws. A ribbon cable is used to connect the camera with the adapter board (Fig. 28):

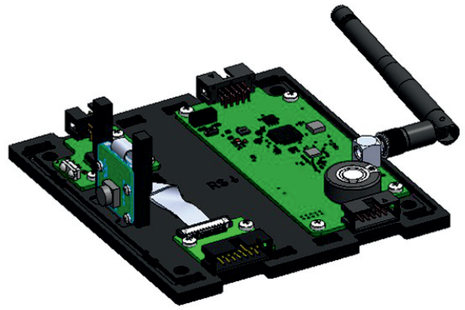


Fig. 28: Mounting the camera on the module base plate

6)Mount side walls. To do that, align side wall protrusions with holes in the base plate and latch them (Fig. 29):

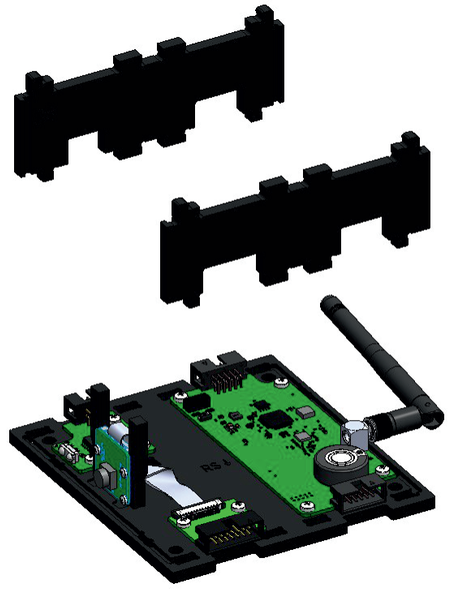


Fig. 29: Mounting side walls

7) Secure two transparent panels to the bottom base plate. To do that, slide panels along guide rails in walls until they touch the bottom base plate, then latch them (Fig. 30):

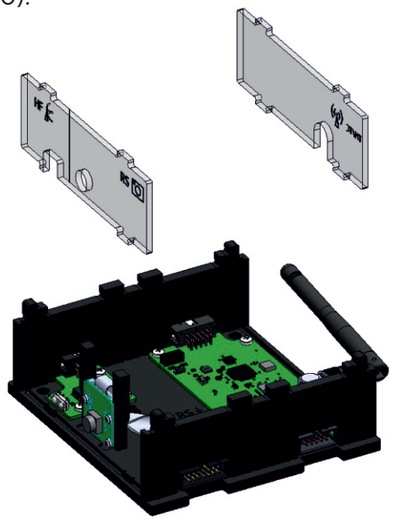


Fig. 30: Mounting transparent panels

8) Attach the top cover (marked as “ERS↑”) to the assembled housing. To do that, align holes in the top cover with protrusions of two side walls and two panels and latch them by applying some force (Fig. 31):

Fig. 31: Installing the top cover

A fully assembled ERS module appears like this (Fig. 32):

Fig. 32: A fully assembled module

3.6 Assembling the Payload Module

The orbiter carries mission-specific equipment that serves its main objective. This equipment, known as payload, is what the satellite was designed to carry in the first place.

The basic version of the OrbiCraft 3D functional kit contains one type of payload – the camera integrated in the ERS module. Users can design their own payloads using the Arduino breadboard platform and software, supplied as a part of the payload module.

Data communications between the Arduino microcontroller and the on-board computer take place using an extension board (a so-called Shield) that mates with the microcontroller mainboard. The extension board contains a connector for interfacing with the cable network using a standard ribbon cable from the functional kit. A total of six sensors can be connected to the Troyka Slot Shield board to be used for various projects based on the Arduino platform.

Components necessary for assembly (Fig. 33):

- All parts marked as “Payload” (two base plates, two walls, two transparent panels)
- Extra parts (guide rails – 4 pcs., cover – 1 pc., detent – 1 pc., bracket for the Arduino MEGA2560 board – 1 pc., bracket for the Troyka Slot Shield board – 1 pc.)
- Circuit boards (payload board – 1 pc., Arduino MEGA2560 board – 1 pc., Troyka Slot Shield board – 1 pc.)
- Fixtures (M2x6 cylindrical-head screws – 9 pcs., M3x12 – 6 pcs., M3x8 – 2 pcs.)

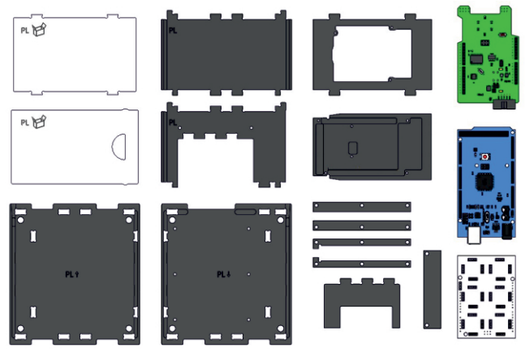


Fig. 33: Module assembly components

Assembly Procedure

1) Position L-shaped guide members on the bottom base plate (marked as “Payload ↓”):

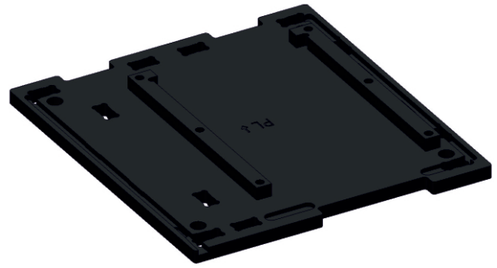


Fig. 34: Installing L-shaped guide members

2)Place straight guide rails on top of them and hold them down to the base plate using six M3x12 screws (Fig. 35):

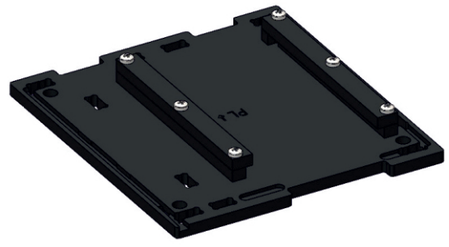


Fig. 35: Installing straight guide rails

3) Attach the Arduino MEGA2560 payload board to the bracket with six M2x6 screws. Mount the ArdShield card on top of it. Use connectors to secure the parts (Fig. 36):

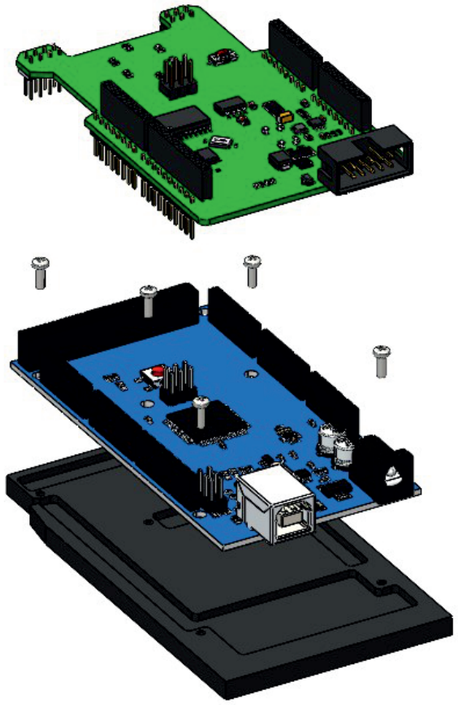


Fig. 36 Mounting the payload board and the ArdShield board

For the convenience of removing the board from the Payload module, loosen the screws on the straight guides.

4) Slide the bracket together with circuit boards onto the base plate using guide rails (Fig. 37):

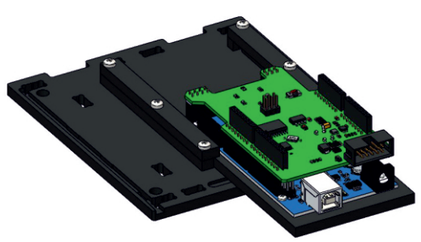


Fig. 37: Mounting boards on the base plate

5) Secure the Troyka Slot Shield board to the bracket using three M2x6 screws (Fig. 38):

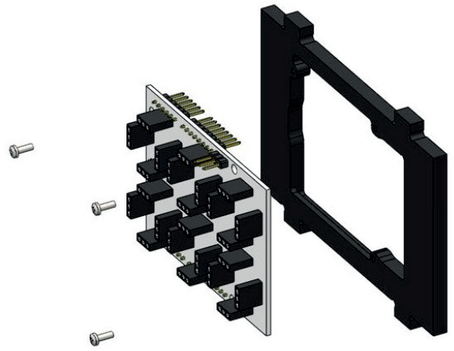


Fig. 38: Securing the Troyka board

6) Mount the bracket with the Troyka Slot Shield board secured to it on the bottom base plate. To do that, align bracket protrusions with holes in the base plate and latch them. Use ribbon cables to connect the Troyka Slot Shield board to the Arduino MEGA2560 board (Fig. 39):

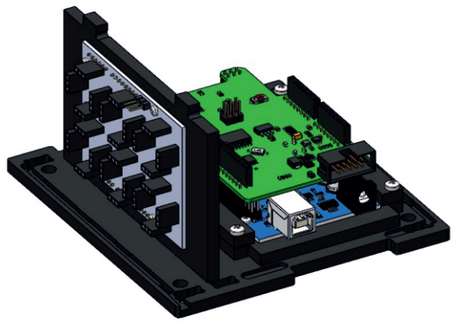


Fig. 39: Mounting the Troyka board on the base plate

7) Attach a detent to the side wall by means of two M3x8 screws (Fig. 40):

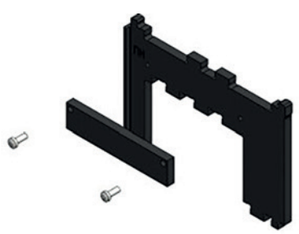


Fig. 40: Securing a detent to the side wall

8) Place the side wall together with the detent on the bottom base plate. To do that, align side wall protrusions with holes in the base plate and latch them (Fig. 41):

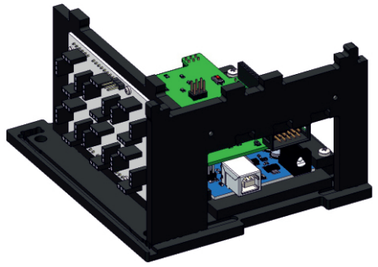


Fig. 41: Mounting a side wall with a detent on the base plate

9) Mount the second side wall on the base plate (Fig. 42):

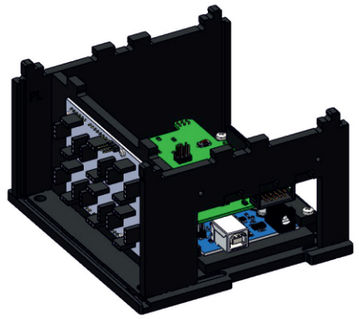


Fig. 42: Mounting the second side wall on the base plate

10) Mount the transparent panel on the bottom base plate. To do that, slide the panel along vertical guide rails in walls until it touches the base plate, then latch it (Fig. 43):

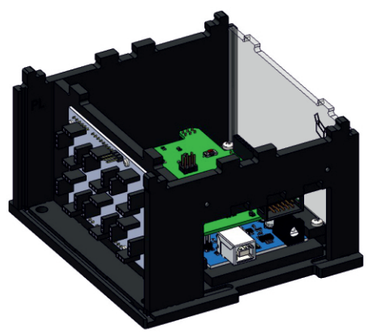


Fig. 43: Mounting a transparent panel

11) Place the top cover on the assembled housing. To do that, align holes in the top cover with protrusions of two side walls, transparent panel and the bracket and latch them by applying some force (Fig. 44):

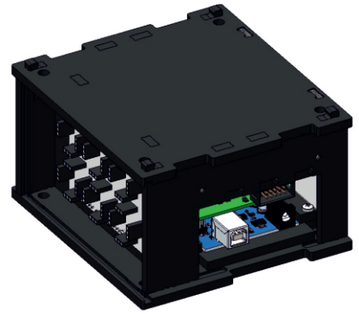


Fig. 44: Installing the top cover

12) Install the second transparent panel. To do that, drive it along horizontal guide rails in base plates.

Do not install it if additional payload shields are used (Fig. 45):

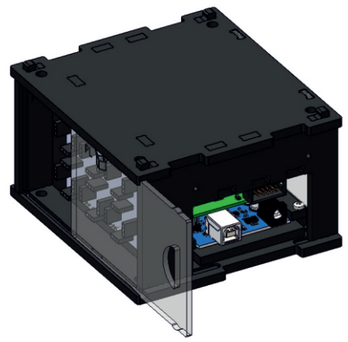


Fig. 45: Mounting the second transparent panel

13) Install the cover. To do that, tilt it slightly and insert it into grooves in the base plate, then turn it vertically and insert it into grooves in the side wall (Fig. 46):

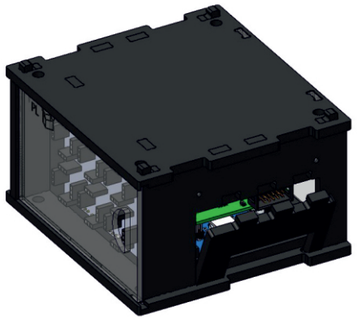


Fig. 46: Mounting the side cover

A fully assembled payload module will appear like this (Fig. 47):

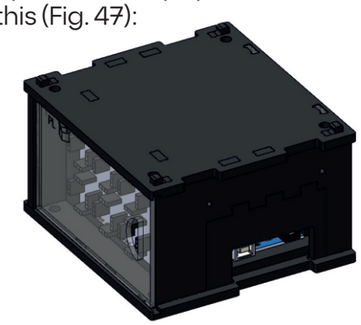


Fig. 47: A fully assembled module

3.7 Assembling the RW Module (Reaction Wheel)

The reaction wheel built into the RW module produces torque that will make the nanosatellite functional kit revolve around its axis in a direction opposite to wheel rotation (Fig.48):

Fig. 48 A suspended OrbiCraft 3D

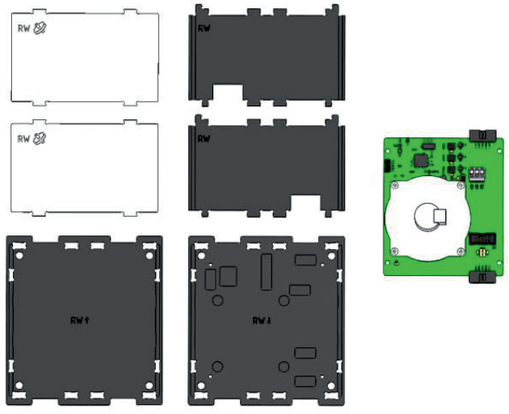


Fig. 49: Module assembly components

Components necessary for assembly (Fig. 49):

- All parts marked as “RW” (two base plates, two walls, two transparent panels)
- Circuit board with a reaction wheel
- Fixtures (M3x6 cylindrical-head screws – 4 pcs.)

Assembly Procedure

Use a reaction wheel with an address B when assembling the RW module from a three-axis configuration set

1) Place the RW board on the bottom base plate (marked as “Rw↓”), then secure the board with four M3x6 cylindrical-head screws (Fig. 50):

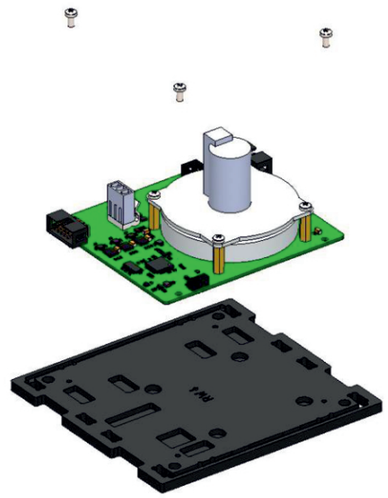


Fig. 50: Mounting the RW circuit board

2) Mount side walls on the base plate. To do that, align side wall protrusions with holes in thebase plate and latch them (Fig. 51):

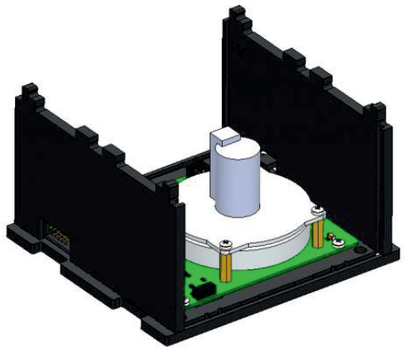


Fig. 51: Mounting side walls

3) Secure two transparent panels to the bottom base plate. To do that, slide each panel along guide rails in walls until it touches the bottom base plate, then latch it (Fig. 52):

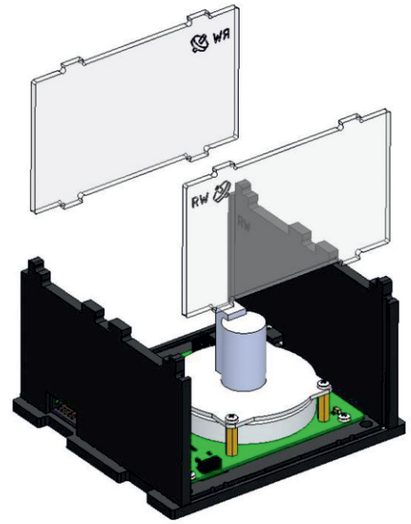


Fig. 52: Mounting two transparent panels

4) Attach the top cover to the assembled housing. To do that, align holes in the top cover with protrusions of two side walls and two panels and latch them by applying some force.

A fully assembled RW module appears like this (Fig. 53):

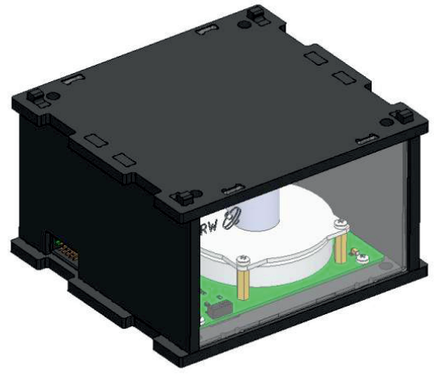


Fig. 53: A fully assembled RW module

3.8 Assembling the RW 3D Module (Reaction Wheel for a Three-Axis Configuration)

The RW 3D module includes three controlling reaction wheels aligned with magnetometer axes x, y and z. It enables the nanosatellite functional kit to rotate around its center of mass when the orientation and stabilization system is in control. The respective control problem is solved using a hardware-in-the-loop simulation setup comprising three closed loops (coils) directed along three planes together with a platform accommodating the orbiter functional kit.

Components necessary for assembly (Fig. 54):

- All parts marked as “RW 3D” (two base plates, three walls, two transparent walls)
- Reaction wheel unit with a circuit board – 3 pcs.
- Ribbon cable to connect reaction wheel circuit boards together – 1 pc.
- Fixtures (M3x6 cylindrical-head screws – 14 pcs.)

Fig. 54: Module assembly components

Assembly procedure:

Circuit boards of controlling reaction wheels are marked with addresses A, B and C. Observe their correct arrangement inside the module. Place reaction wheel A on the rear wall of the module, place wheel B on the bottom base plate and place wheel C on the side wall.

1) Place the reaction wheel board (marked as “RW3D↓”, with side connectors soldered on), then secure the board with four M3x6 cylindrical-head screws (Fig. 55):

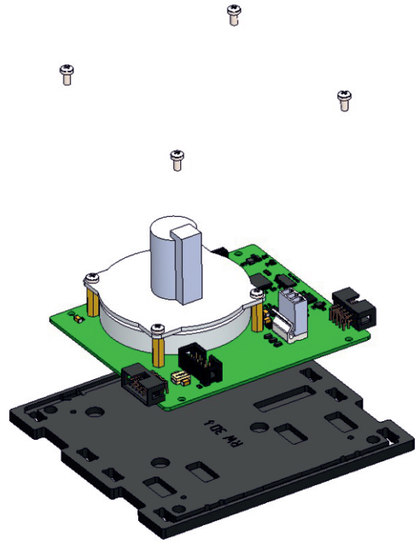


Fig. 55: Mounting the RW board on the base plate

2) Secure the second reaction wheel board on the side wall using four M3x6 cylindrical-head screws (Fig. 56):

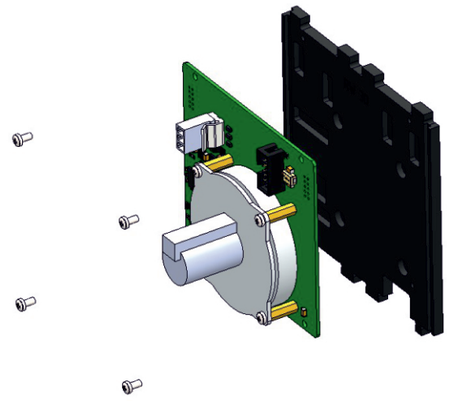


Fig. 56: Mounting the reaction wheel board on the side wall

3) Mount the side wall on the base plate. To do that, align side wall protrusions with holes in the base plate and latch them (Fig. 57):

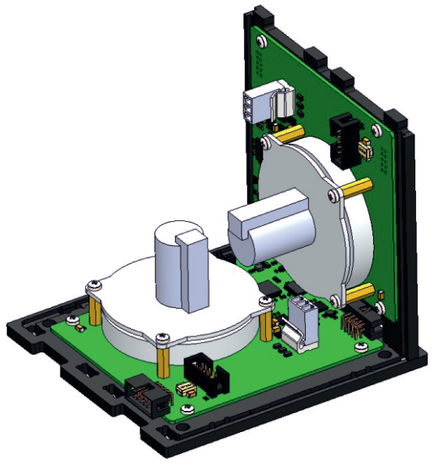


Fig. 57: Mounting the side wall on the base plate

4) Secure a transparent panel to the side wall using two M3x6 cylindrical-head screws (Fig. 58):

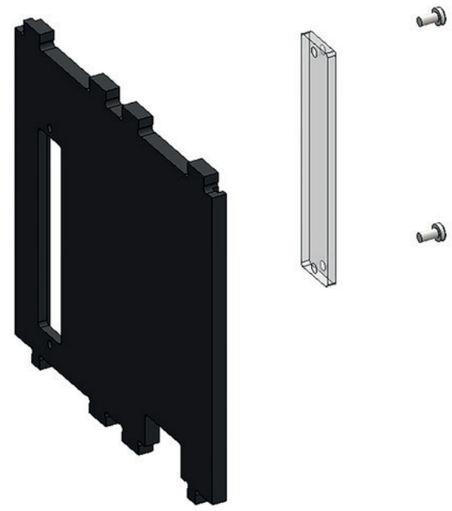


Fig. 58: Securing a transparent panel to the side wall

5) Mount the side wall on the base plate. To do that, align side wall protrusions with holes in the base plate and latch them (Fig. 59):

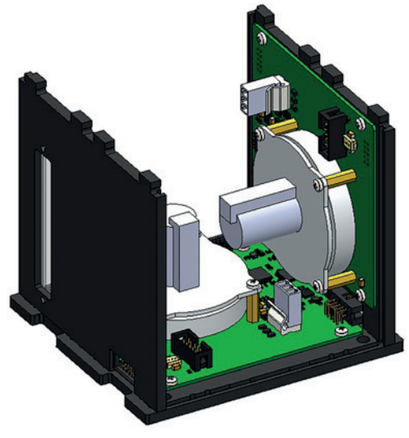


Fig. 59: Mounting the side wall on the base plate

6) Secure the third reaction wheel board on the side wall using four M3x6 cylindrical-head screws (Fig. 60):

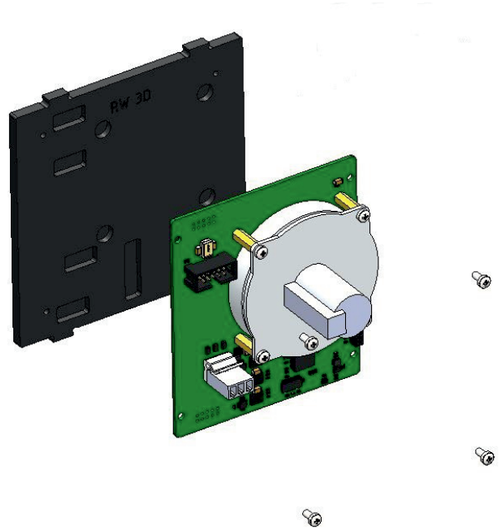


Fig. 60: Securing the reaction wheel board to the side wall

7) Mount the side wall on the base plate. To do that, align side wall protrusions with holes in the base plate and latch them. Connect the three boards with reaction wheels using a ribbon cable (Fig. 61):

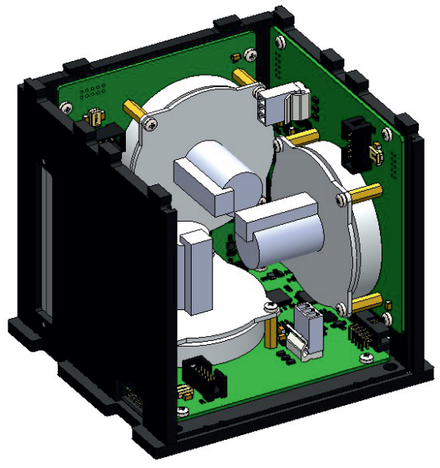


Fig. 61: Mounting the side wall on the base plate

8) Secure the transparent panel on the bottom base plate. To do that, slide the panel along guide rails in walls until it touches the bottom base plate, then latch it. Observe the position and axial alignment of the transparent panel as indicated below (Fig. 62):

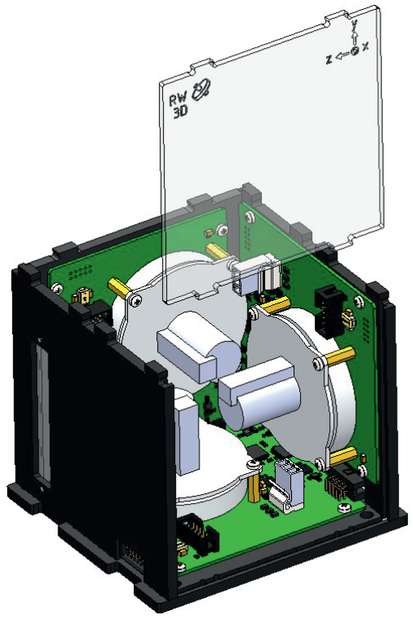


Fig. 62: Mounting a transparent panel

9) Attach the top plate (marked as “RW 3D↑”) to the assembled housing. To do that, align holes in the top plate with protrusions of two side walls and two transparent panels and latch them by applying some force.

A fully assembled RW module appears like this (Fig. 63):

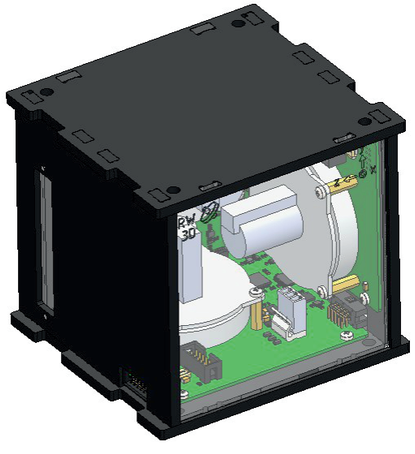


Fig. 63: A fully assembled module

3.9 Assembling the HF (High-Frequency) Ground Module

The HF ground module is a transceiver device that makes it possible to accept data (pictures or information) by means of an IR receiver. The HF terrestrial module simulates directional data transmission at a rate of 115,200 bps. As a prerequisite for transfer, the receiver and the transmitter must be located opposite each other at distance no more than 1 m.

Components necessary for assembly (Fig. 64):

- All parts marked as “HF” (two side covers, a bracket, a back cover, a front ring, top and bottom base plates)
- Extra parts (rings – 3 pcs.)
- HF board, USB-UART converter
- A ribbon cable for connecting the HF board with the board adapter
- Two beam guides
- Fixture (PCHSS brass studs M3x12 – 4 pcs., PCHSN brass studs M3x18 – 4 pcs., M3x10 sunk screws – 8 pcs., M3x20 – 2 pcs., M3x12 cylindrical-head screws – 4

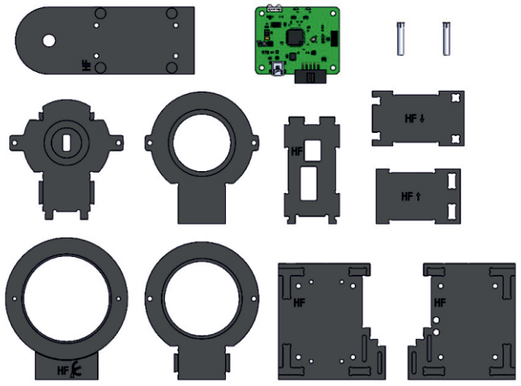


Fig. 64: Module assembly components

Assembly Procedure

1) Arrange four rings in the order of increasing diameter and join them together using two M3x20 screws. (The largest ring is marked “HF + logo) (Fig. 65):

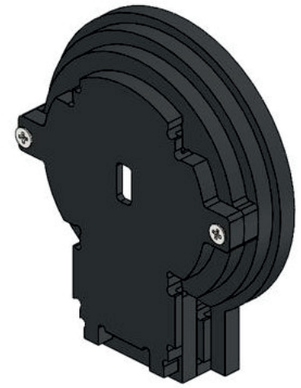


Fig. 65: Ring assembly

2) Align the circuit board with the rear wall (marked “HF”) (Fig. 66):

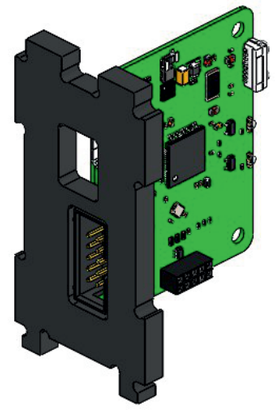


Fig. 66: Mounting the board with a rear wall

3) Attach the rear wall to the bottom plate (marked “HF↓”) and the top plate (marked “Hf↑”). To do that, align rear wall protrusions with holes in the bottom and top plates and latch them (Fig. 67):

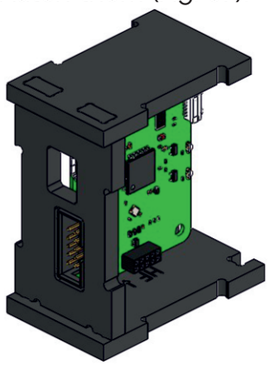


Fig. 67: Mounting plates

4) Join the structure with four rings. To do that, align protrusions of the smallest ring with holes in the base plate and latch them. There are no special mating components for joining the smallest ring with the top plate (Fig. 68):

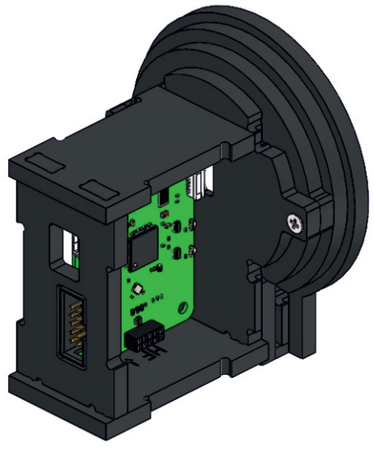


Fig. 68 Joining the structure with rings

5) Attach M3x10 sunk screws (4 pcs.) and female-threaded PCHSS M3x12 studs (4 pcs.) to the side wall (marked “HF”) (Fig. 69):

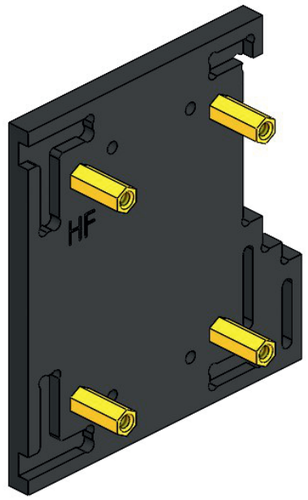


Fig. 69: Securing to the side wall

6) Join the side wall with the rest of the structure. To do that, align holes in side walls with protrusions of top and bottom plates, rear wall and rings and make them latch. Then secure the circuit board by means of PCHSN M3x18 female-threaded brass studs (4 pcs.)(Fig. 70)

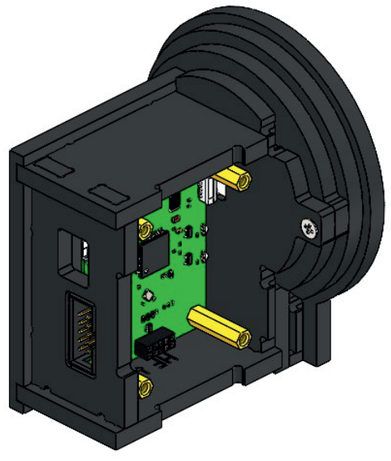


Fig. 70: Joining with the side wall

7) Join the other side wall with the rest of the structure. Align holes in side walls with protrusions of top and bottom plates, rear wall and rings and then make them latch. Secure the side wall using M3x10 screws (4 pcs.) Use M3x12 screws (4 pcs.) to attach the bracket to the assembled housing (when the module is to be secured to a structural section) (Fig. 71):

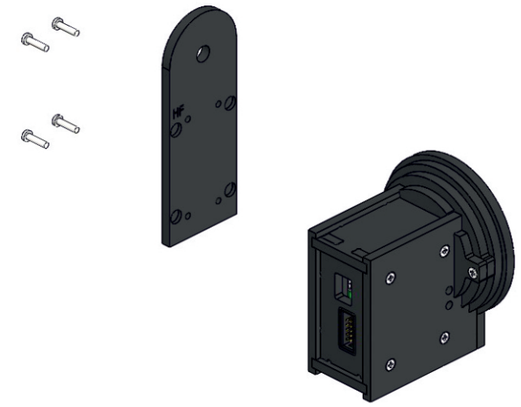


Fig. 71: Mounting the second side wall and the bracket

8) Join two beam guides with the side cover (Fig. 72)

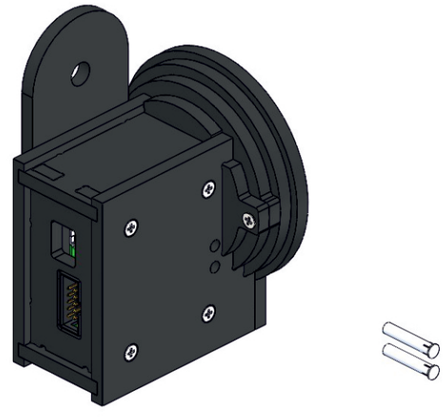


Fig. 72: Mounting beam guides

A fully assembled device will appear as follows (Fig. 73):

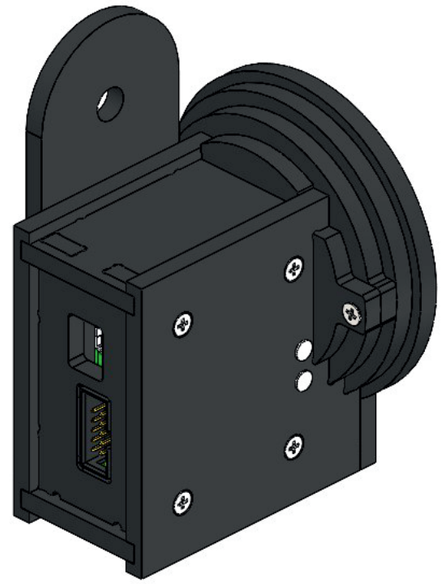


Fig. 73: A fully assembled module

3.10 Assembling the UHF (Ultrahigh Frequency) Ground Module

The UHF ground module is a device that provides a communication link between the MCC and the orbiter UHF unit using the Houston Application. The UHF terrestrial module operates in the 435..437 MHz range to simulate directional data transfers at a rate of 9600 bps. The line-of-sight distance between terrestrial and orbiter UHF modules can be up to 100 meters.

Components necessary for assembly (Fig. 74):

- All parts marked as “UHF” (two base plates, two walls, two transparent panels)
- The UHF board
- Antenna
- Fixtures (PCHSS M3x15 brass racks – 4 pcs., M3x10 sunk screws – 8 pcs.)

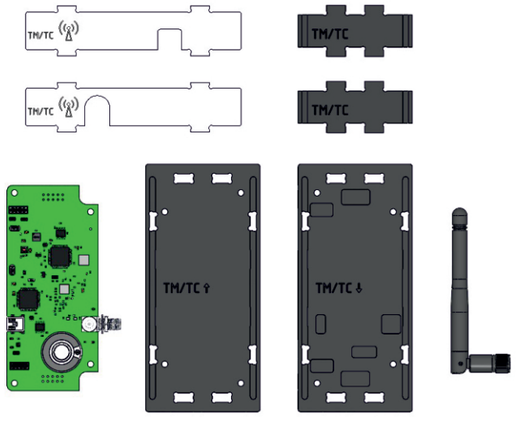


Fig. 74: Module assembly components

Assembly Procedure

1)Place the UHF circuit board on the bottom base plate (marked “UHF↓”). Secure the board using four PCHSS M3x15 brass studs and four M3x10 sunk screws (Fig. 75):

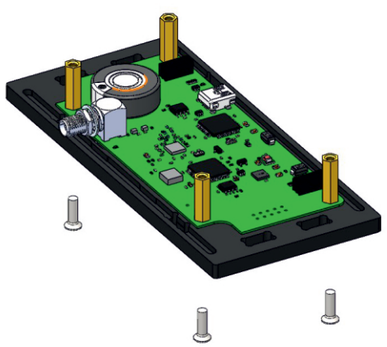


Fig. 75: Installing the circuit board

2) Mount side walls on the base plate. To do that, align side wall protrusions with holes in the base plate and latch them (Fig. 76):

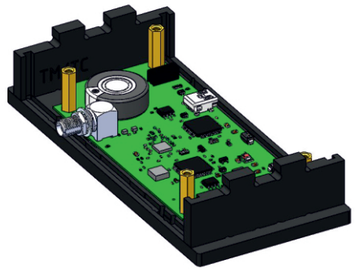


Fig. 76: Mounting side walls

3) Mount two transparent panels on the bottom base plate. To do that, slide each panel along guide rails in walls until it touches the bottom base plate, then latch it (Fig. 77):

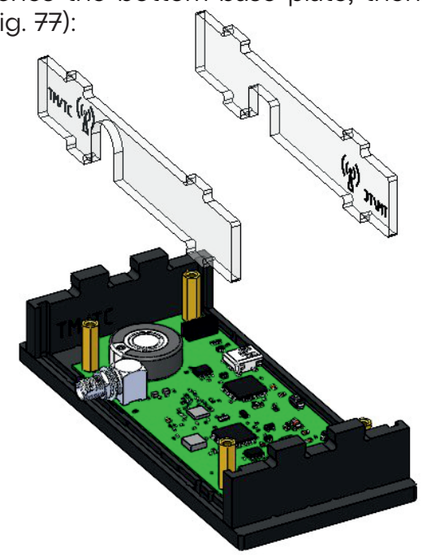


Fig. 77: Mounting transparent panels

4) Attach the top cover (marked as “UHF↑”) to the assembled housing. To do that, align holes in the top cover with protrusions of two side walls and two transparent panels and latch them by applying some force (Fig. 78):

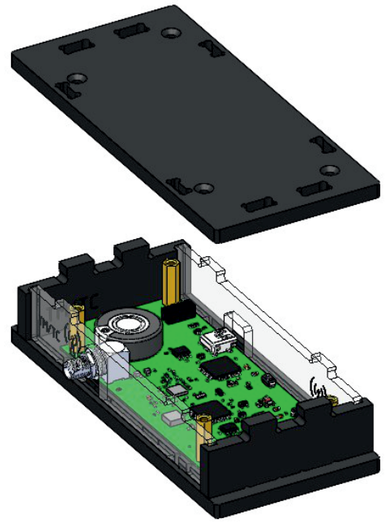


Fig. 78: Installing the top cover

5) Fix a cover by four M3x10 countersunk head screws (Fig. 79):

Fig. 79: Securing the cover with screws

6) Connect the antenna to the UHF board. A fully assembled UHF module will appear like this (Fig. 80):

Fig. 80: A fully assembled module with an antenna installed

3.11. Assembling the Ribbon Cable Tester

The ribbon cable tester module can be used to verify if a crimped cable works correctly. When a cable is crimped correctly, a green LED on the module will light up, otherwise a red LED will be lit.

Components necessary for assembly (Fig. 81):

- All parts marked as “Tester” (two base plates, two walls, two transparent panels)
- Extra parts (a transparent panel with holes)
- A ribbon cable tester circuit board
- Fixtures (M3x10 PCHSS brass studs – 4 pcs., M3x10 sunk screws – 4 pcs., M3x6 cylindrical-head screws – 4 pcs.)

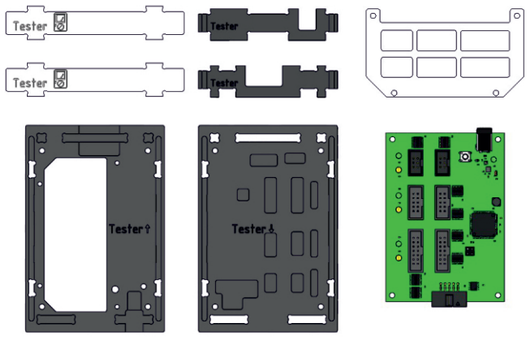


Fig. 81: Module assembly components

Assembly Procedure

1) Mount two side walls on the bottom base plate (marked as “Tester ↓”). To do that, align side wall protrusions with holes in the base plate and latch them (Fig. 82):

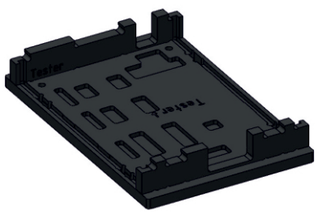


Fig. 82: Mounting side walls

2) Install the tester circuit board (Fig. 83):

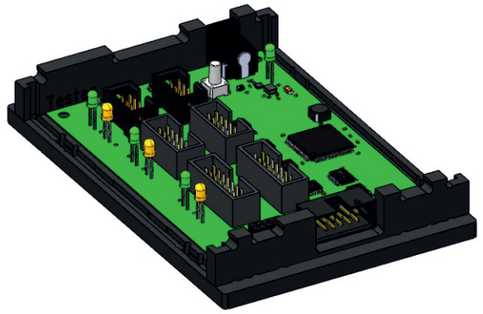


Fig. 83: Installing the tester circuit board

3) Attach the circuit board to the bottom base plate using four PCHSS M3x10 brass studs and four M3x10 sunk screws (Fig. 84):

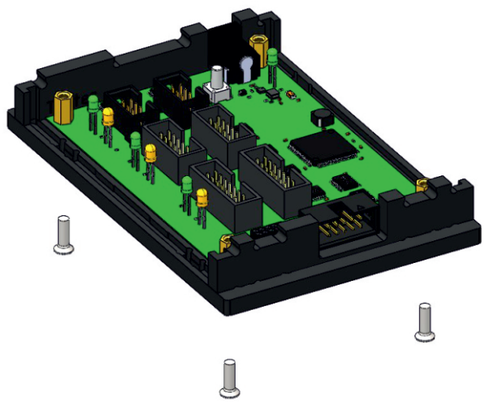


Fig. 84: Securing the bottom base plate

4) Secure two transparent panels to the bottom base plate. To do that, slide each panel along guide rails in walls until it touches the bottom base plate, then latch it (Fig. 85):

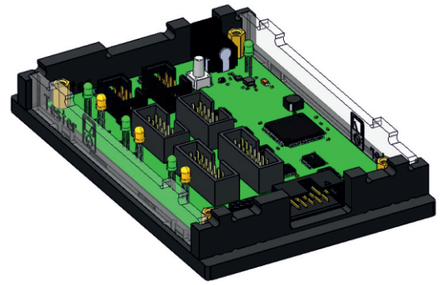


Fig. 85: Securing two panels

5) Assemble the top plate (marked “Tester ↑”) together with a transparent panel with holes using M3x6 cylindrical-head screws (Fig. 86):

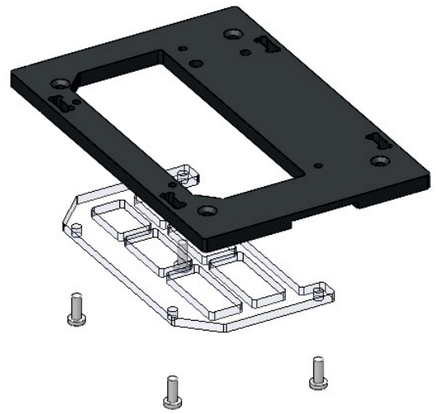


Fig. 86: Assembling the top plate

Viewed from below, an assembled top plate will appear as follows (Fig. 87):

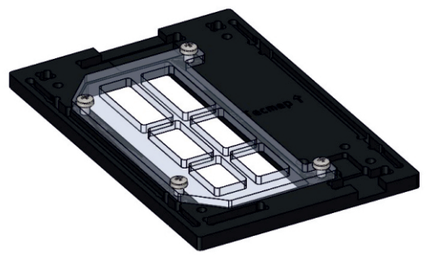


Fig. 87: An assembled top plate

6) Place the top cover on the assembled housing. To do that, align holes in the top cover with protrusions of two side walls and two transparent panels and latch them by applying some force (Fig. 88):

Fig. 88: Installing the top cover

7) Secure the top cover using upper four M3x10 sunk screws. A fully assembled ribbon cable tester module will appear like this (Fig. 89):

Fig. 89: A fully assembled module

3.12 Assembling the Cable Network

About the Cable Network

The satellite relies on its cable network for information exchange between subsystems and the central computer as well as powering its subsystems.

Satellite subsystems are provided with several redundant connectors for the satellite network. In that manner, a device connected to the onboard network will not only be itself accessible for communication but will also enable pass-through connections to subsequent components in the circuit.

The data network is based on the UniCAN protocol. A single ribbon cable combines power and data lines to facilitate wiring. Subsystems are connected using an IDC-10F (Ds1016-10) connector on the wire harness side and a IDC-10M (DS1013-10) connector on the device side. Considering that components of the functional kit can be arranged in different ways, sizing and making individual ribbon cables of necessary lengths and configurations will be left to the user.

An IDC-10F connector is shown below (Fig. 90):

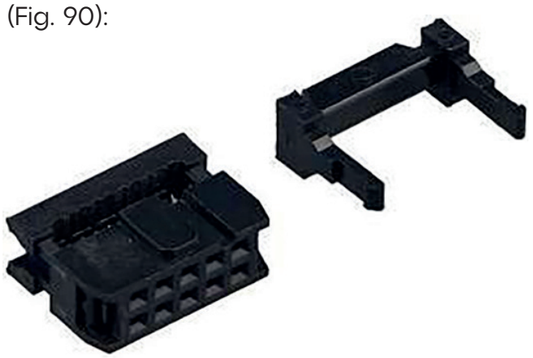


Fig. 90: An IDC-10F connector

The OBCU module is connected to the camera adapter using a wide ribbon cable with IDC-14F (DS1016-14) connectors.

An IDC-14F connector is shown below (Fig. 91):

Fig. 91: An IDC-14F connector

OBCU is connected to the HF module by means of a narrow ribbon cable with IDC-6F (DS1016-06) connectors.

An IDC-6F connector is shown below (Fig. 92):

Fig. 92: An IDC-6F connector

A 10-pin ribbon cable is shown below (Fig. 93):

Fig. 93: A 10-pin ribbon cable

Preparation

- Take the following items out of the OrbiCraft 3D kit: crimper, wire-cutters, ribbon cable reel, two IDC-10F connectors, ribbon cable tester and 12VDC power adapter
- Cut a ribbon cable of the required length from the 10-channel cable reel.

Ribbon Cable Assembly

- Insert a yellow fixture from the kit into the crimper.
- Place the connector into the yellow fixture below the clamping bar of the crimper.
- Holding the crimper with the connector with one hand, insert cable end into the crimper with your other hand.
- Compress the connector with cable end inserted until the crimper makes a distinct click.
- Perform a visual check to make sure that the connector has clicked into place.
- Take care to ensure that the ribbon cable has fully entered the connector but does not protrude too far from its back side.

Before applying force to the crimper to click, press the latch gently to make sure that cable wires fit evenly between contact pins and only then finally click the connector into place.

- Repeat the same operations with the opposite end of the ribbon cable having the second 1DC-10F connector.
- When crimping the cable, remember that all connectors must be facing the same side, as shown in pictures below.

A correct assembly layout is shown below (Fig. 94):

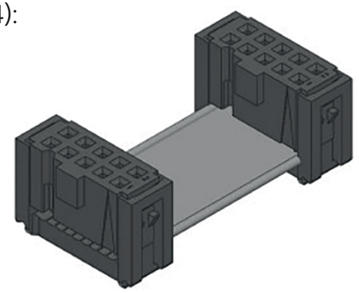


Fig. 94: Correct assembly

A wrong assembly layout is shown below (Fig. 95):

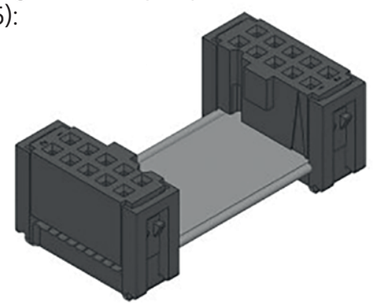


Fig. 95: Incorrect assembly

The current connector pinout (designations of individual pins) minimizes the likelihood of damage of the equipment if the user fails to terminate the ribbon cable correctly. Nevertheless it provides no guarantee that the device cannot be damaged at all. It should also be noted that ribbon cables can be made and tailored by the user without any need for special knowledge and tools.

Joining Functional Kit Modules Together (Fig. 96):

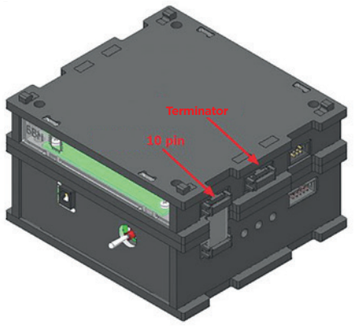


Fig. 96: Functional kit modules joined together

Be sure to insert a matching resistor (terminator) into one of the empty slots when assembling cabling.

The Matching Resistor (Terminator)

A terminator is an energy sink (typically, a resistor) connected to the end of a long line, the resistance of the terminator being equal to the wave resistance of the line. In computer electronics, the word “terminator”

is a slang synonym for “matched load”. The CAN bus uses a terminator with a resistance of 120 Ohm (Fig. 97):

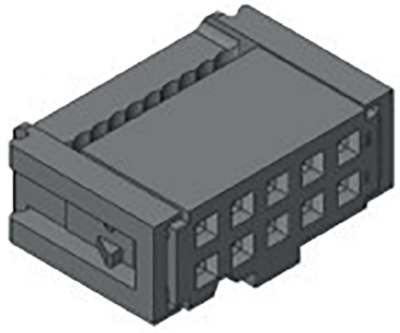


Fig. 97: The matching resistor (terminator)

Ribbon Cable Test

- Connect the ribbon cable tester to the 220VAC mains using a 12VDC adapter from the kit.
- Insert the assembled ribbon cable into the respective receptacles of the ribbon cable tester. The “OK” green LED will light up.
- If the “Short Circuit” red LED lights up, this may be caused either by punctured insulation of two adjacent channels during cable crimping or by improper orientation of two connectors against each other. Try to crimp the cable again following instructions above.

4. Assembly Instructions for OrbiCraft 3D in a Uniaxial Configuration

Components necessary for assembly (Fig. 98):

- Modules (RW, Payload, PSS, OBCU, SS, ERS)
- Bottom base plate, instrument support feet – 4 pcs., M3x5 cylindrical-head screws – 4 pcs. (preassembled)
- Top plate, M4 ring screw – 1 pc., M4 nut – 1 pc. (preassembled)

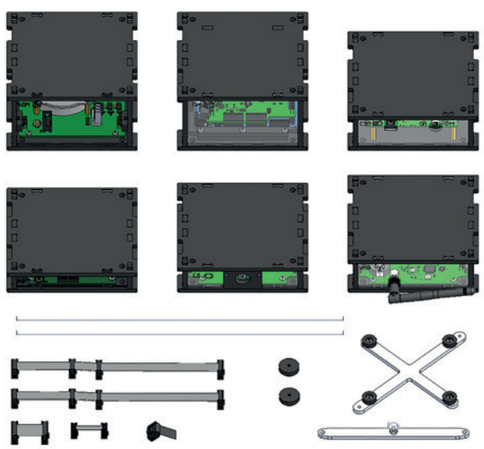


Fig. 98: Modules used in the assembly of the functional kit

- Fixtures (M4 pin – 2 pcs., M4 knurled nuts – 2 pcs.)
- Ribbon cables (6-pin – 1 pc., 14-pin – 1 pc., 10-pin – multiple pieces).
- Terminator.

Assembly Procedure

1)Take the bottom base plate preassembled with instrument support feet (4 pcs.) and M3x5 cylindrical-head screws (4 pcs.) and place the first module on top of it so that four threaded holes in the base plate would match four holes in the module. The picture below (Fig. 99) shows the PSS module:

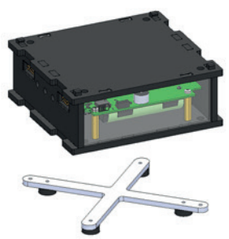


Fig. 99: Mounting the base plate

2) Place the next module on top, having aligned four protrusions of the lower module with four holes on the upper module (Fig. 100):

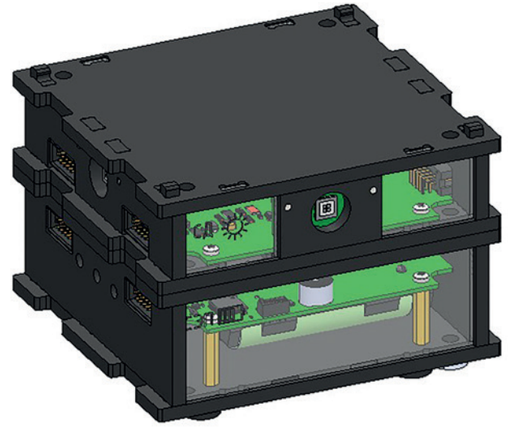


Fig. 100: Mounting the next module

3) Install all six modules (RW, Payload, PSS, OBCU, SS, ERS) by aligning four protrusions of the lower module with four holes on the upper module (Fig. 101):

To ensure that magnetometer readings are accurate, avoid installing the **PSS** and **OBCU** modules next to each other or placing the RW module near the OBCU module.

Insert two M4 pins into module holes (any diagonally located pair) and crew them into threaded holes of the bottom base plate.

Take the top plate preassembled with an M4 screw (1 pc.) and an M4 nut (1 pc.) and place it ontop of the last module having aligned it with two M4 pins.

Secure the top plate by screwing two M4 knurled nuts on M4 pins. Also tighten two M4 nuts from below.

Fig. 101: Assembling an OrbiCraft 3D in a uniaxial configuration

Connect modules to each other using ribbon cables. Connect a terminator (Fig. 102):

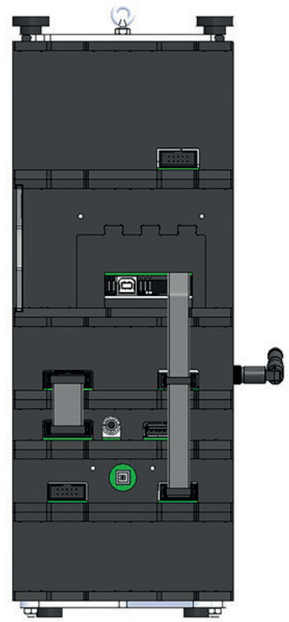


Fig. 102: Ribbon cable connection

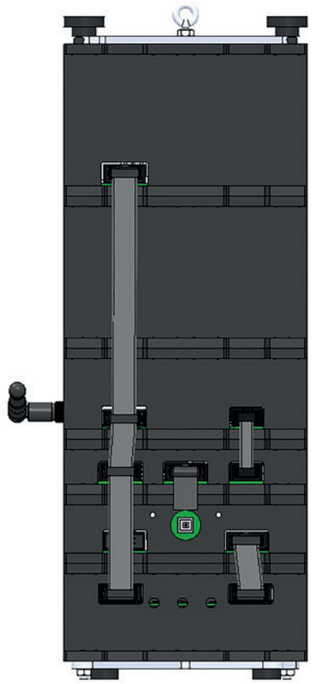


Fig. 102: Ribbon cable connection (2)

4) An assembled device will appear as follows (Fig. 103):

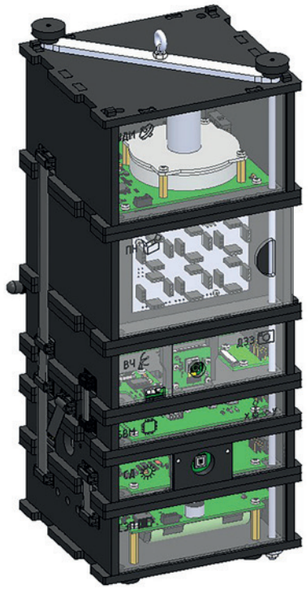


Fig. 103: A completely assembled nanosatellite functional kit (uniaxial configuration)

5. Assembly Instructions for OrbiCraft 3D in a Three-Axis Configuration

Components necessary for assembly (Fig. 107):

- Modules (RW 3D, SS, PSS, OBCU, ERS, Payload)
- Bottom base plate, instrument support feet – 4 pcs., M3x5 cylindrical-head screws – 4 pcs. (preassembled)
- Top plate, M4 ring screw – 1 pc., M4 nut – 1 pc. (preassembled)
- Fixtures (M4 pin – 2 pcs., M4 knurled nuts – 2 pcs., M4 nuts – 2 pcs.)
- Ribbon cables (6-pin – 1 pc., 14-pin – 1 pc., 10-pin – multiple pieces).
- Terminator.

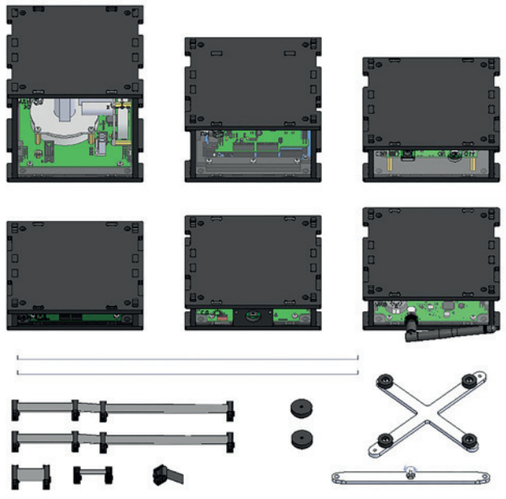


Fig. 104: Modules used in the assembly of the nanosatellite functional kit

Assembly procedure:

1)Take the bottom base plate preassembled with instrument support feet (4 pcs.) and M3x5 cylindrical-head screws (4 pcs.) and place the first module on top of it so that four threaded holes in the base plate would match four holes in the module. It is recommended that the PSS module be mounted first (Fig. 105):

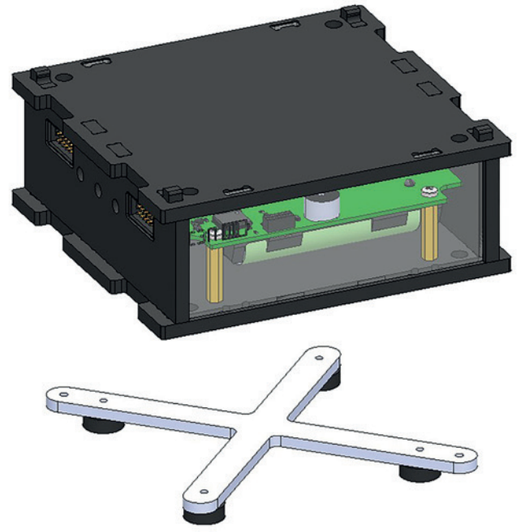


Fig. 105: Mounting the base plate

2) Place the next module on top, having aligned four protrusions on the lower module with four holes in the upper module (Fig. 106):

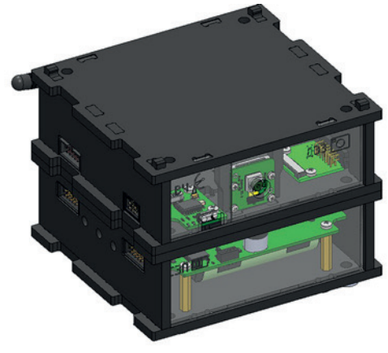


Fig. 106: Mounting the next module

3) Install all six modules (PSS, ERS, OBCU, SS, Payload, RW 3D) by aligning four protrusions of the lower module with four holes in the upper module. All modules should be positioned as shown in the picture (walls of RW 3D, SS, OBCU modules with engraved axes should all be facing the same side). It is recommended to observed module installation sequence shown in the picture (Fig. 107).

To ensure that magnetometer readings are accurate, avoid installing the PSS and OBCU modules next to each other or placing the RW module near the OBCU module.

Insert two M4 pins into module holes (any diagonally located pair) and crew them into threaded holes of the bottom base plate.

Take the top plate preassembled with an M4 screw (1 pc.) and an M4 nut (1 pc.) and place it on top of the last module having aligned it with two M4 pins.

Secure the top plate by screwing two M4 knurled nuts on M4 pins. Also tighten two M4 nuts from below.

Fig. 107: Assembling an OrbiCraft 3D in a three-axis configuration

4) Connect modules to each other with ribbon cables and connect a terminator (Fig. 108):

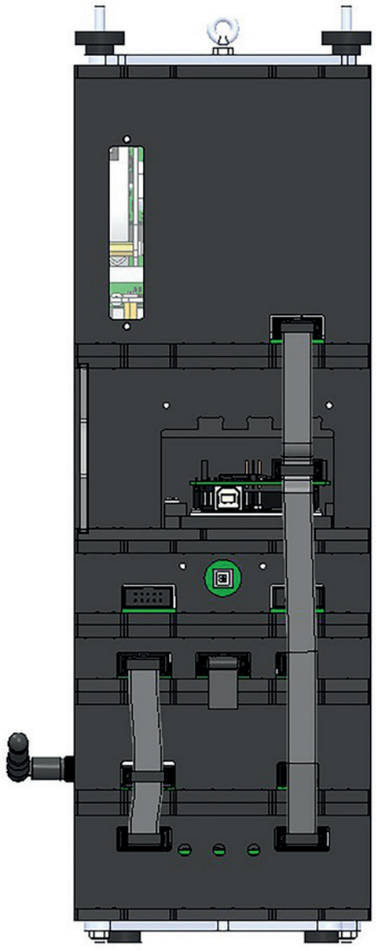


Fig. 108: Ribbon cable connection

5) An assembled device will appear as follows (Fig. 109):

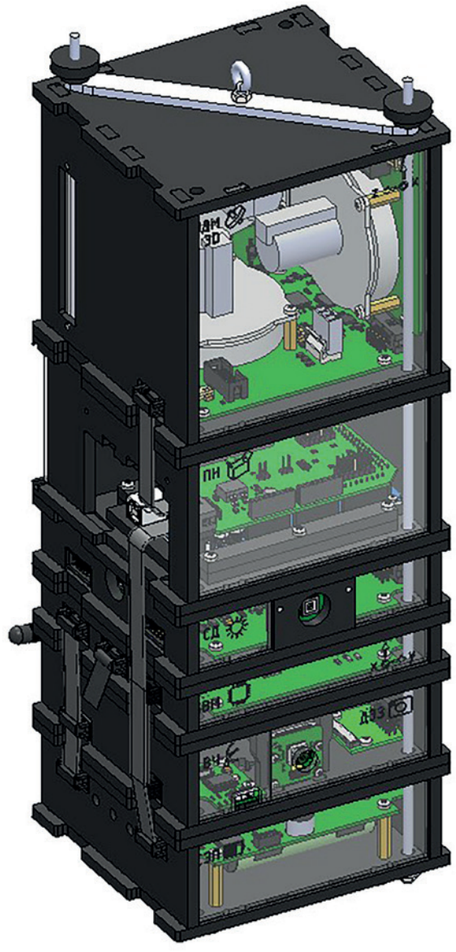


Fig. 109: A completely assembled orbiter functional kit (three-axis configuration)

6. Lessons on Working with the OrbiCraft 3D Nanosatellite Functional Kit

To view lessons on programming the orbiter functional kit and operating the orbiter to perform various tasks, open the orbicraft3d.sputnix.ru website and navigate to sections titled “Work through the WEB interface” and “Work with earth-based UHF”.

Wi-Fi network access password: **ORBICRAFT3D**

The chosen Wi-Fi network will be marked as “Restricted connection” or “No Internet access”. This is normal indeed as the network set up by the OrbiCraft 3D functional kitdoes not provide Internet access but rather serves to let the user control the orbiter functional kit.

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