On-board computer
SXC-MB-04

Features:
- Flat and flexible architecture: all devices have CAN bus interconnect
- Raspberry Compute Module CM3/CM3+ slot
- Sensors on CAN bus: magnetometer, angular velocity, temperature, voltages and currents.
- EM torquer driver
- On board ADCS controller
- Low-power board managing MCU with B-DOT and flight plan
- Bootloaders with in-flight flash ability
- Rich centralized satellite debug system

Configuration:
- CAN bus data rate
- Removable WiFi module
- Raspberry CM3 or CM3+ (default)
- ADCS controller presence
- RTC presence
The SPUTNIX computer board SXC-MB-04 represents a Raspberry-Pi Compute Module carrier which contains a set of devices, among them there are:

- standalone ADCS controller (option);
- gyroscope and magnetometer;
- electromagnetic coils driver unit;
- temperature sensor;
- real-time clock with backup power source;
- power system;
- central programming and debug system;
- main computer slot with appropriate power supply system and periphery.

All the onboard devices are accessible on redundant CANx2 buses as well as Raspberry, which is connected via onboard SPI-CAN converters. The main computer slot supports both Raspberry Pi CM3 and CM3+ modules, the last one is basic option, but CM1 can be used to reduce power consumption at the expense of compute facilities. Should be noticed that the usage of CM3L module is not possible due it has no onboard ROM. In addition to main CAN bus there are number of Raspberry interfaces available on PC/104 connector:

- SPI with double chip select;
- Ethernet;
- High-Speed USB 2.0 port;
- I2C bus;
- UART.

Native Raspberry-Pi's camera connector is placed on carrier board for faster remote photo sensing satellite development.

System programming and debug hub provides up to 6 two-wire interfaces to the on-board devices and to external PC/104 boards using multiplexer. As the result, all the MCUs inside the assembled satellite are available for debug and flash. For Raspberry module there is removable WiFi module, USB and video interfaces for easy access.

The board with installed daughter boards weights 55 g and operates normally in between -40..+85 degrees, but Raspberry-Pi has slightly reduced temperature range due to memory chip limitations but actual tests have shown that the whole system can operate normally in between -40..+85 degrees as well. Simple payloads, such as Arduino-based devices, can be easily powered by internal stable 5 V rail till it's supply current exceeds 200 mA.

When 3-axis ADCS is used, up to six sun sensors can be connected directly to the carrier board and on-board ADCS MCU can run the appropriate tasks autonomously using CAN interface for simple commands and telemetry.

Another low-power MCU provides CAN interfaces for sensors and manages on-board systems, additionally it runs a flight schedule to reduce power consumption of main computer module. It also can autonomously run the B-DOT stabilization algorithm using on-board electromagnetic torquers driver.

Flat and flexible hierarchy of the OBC provides satellite operational with appropriate consumption for every mode: low-power MCU only for energy harvesting, ADCS controller for idle mode and powerful Raspberry Pi compute facilities for payload operations.

Every programmable device on the OBC has a bootloader with in-flight reprogramming feature.
### Properties

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dimensions (w/o PC104 connector)</td>
<td>86.2 x 93.6 x 14 mm</td>
</tr>
<tr>
<td>Mass</td>
<td>55 g</td>
</tr>
<tr>
<td>Supply voltage</td>
<td>5..14V</td>
</tr>
</tbody>
</table>
| Power consumption, max                | 0.1 W – sensors only (ARS, Magnetometer, MCU)  
                                          1.4 W – sensors and loaded RPi (w/o WiFi) |
| Available power supply                | 5V output up to 200 mA for simple payloads  
                                          Up to 650 mA for external CAN sensors |
| Data interfaces                       | CAN2B x 2  
                                          Raspberry: Camera I/F, UART, I2C, SPI (2 CS), USB, Ethernet |
| Debug                                 | Two-wire debug channels: on board MCU, ADCS MCU, 4 external channels on PC/104  
                                          Raspberry: removable WiFi, USB, video output |

### Raspberry CM3+

**Hardware:**
- CPU up to 1.2 GHz quad-core ARMv8
- 4 GB Flash memory
- 1 GB SDRAM

**Software:**
- API for CAN bus, code samples, program loader

### Low-power MCU

**Hardware:**
- CPU Cortex-M4 16 MHz
- 256 KB Flash
- 64 KB SRAM
- 15 mW power consumption

**Software:**
- Sensor drivers, EM-torquer driver, B-DOT, Flight plan, bootloader

### ADCS MCU

**Hardware:**
- 80 MHz CPU
- 2 MB flash
- 128 KB SRAM

**Software:**
- ADCS, B-DOT, Flight plan, bootloader

### Performance

- **Power switch**
  - 3 channels up to 600mA each
- **EM torquer driver**
  - 3 channels up to 500mA each
- **Self telemetry**
  - Power voltages and currents, coils voltages and currents, magnetometer, angular velocity, temperature

### Operating conditions

<table>
<thead>
<tr>
<th>Condition</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating temperature range</td>
<td>-40...+85°C (0...+60°C recommended for Raspberry)</td>
</tr>
<tr>
<td>Storage temperature</td>
<td>-50...+105°C</td>
</tr>
<tr>
<td>Mechanical vibration</td>
<td>12 g (request full test report)</td>
</tr>
<tr>
<td>Mechanical shock</td>
<td>50g (request full test report)</td>
</tr>
</tbody>
</table>

### Testing*

<table>
<thead>
<tr>
<th>Test</th>
<th>Options</th>
</tr>
</thead>
<tbody>
<tr>
<td>Functional</td>
<td>QT, AT</td>
</tr>
<tr>
<td>Vibration</td>
<td>QT, AT (on demand)</td>
</tr>
<tr>
<td>Mechanical shock</td>
<td>QT</td>
</tr>
<tr>
<td>Thermal cycling</td>
<td>QT, AT (on demand)</td>
</tr>
<tr>
<td>Thermal vacuum</td>
<td>QT, AT (on demand)</td>
</tr>
</tbody>
</table>

*QT – Qualifying tests  
AT – Acceptance tests  
"QT is performed on the design/qualification model  
AT is performed on the unit to be shipped"
SPUTNIX LLC is a Russian private company manufacturing high-tech small satellite components and platforms, as well as ground equipment for smallsat testing, ground-based satellite stations, and equipment for aerospace education. The company is a resident of the Skolkovo Innovation Center.