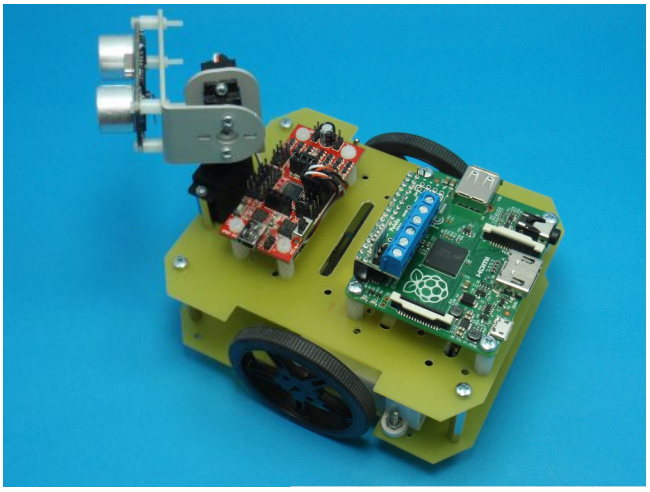
AMEX

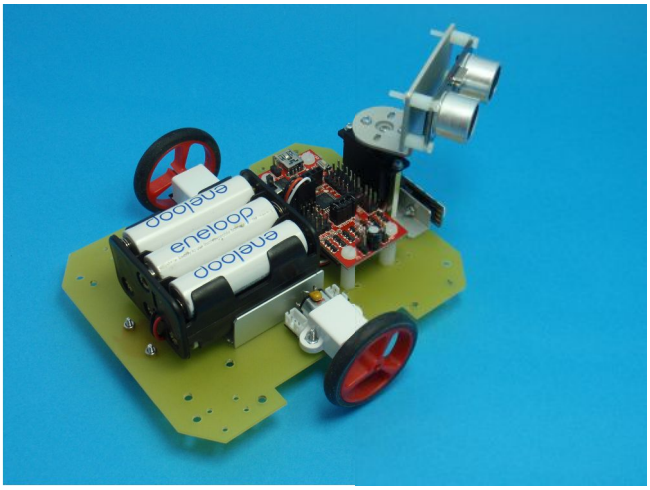
Research
Development of Electronics
Prototyping
Microcontroller education systems

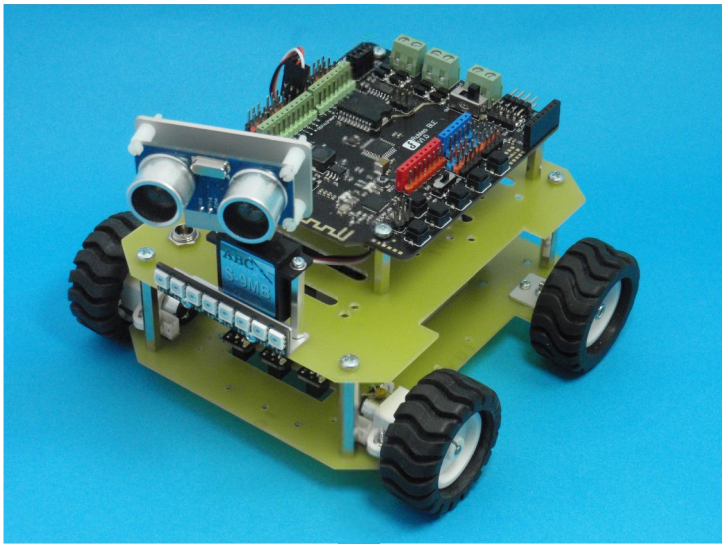
AMEX Mini Robot

The mini robot educational platform

(Rev. 1.0)







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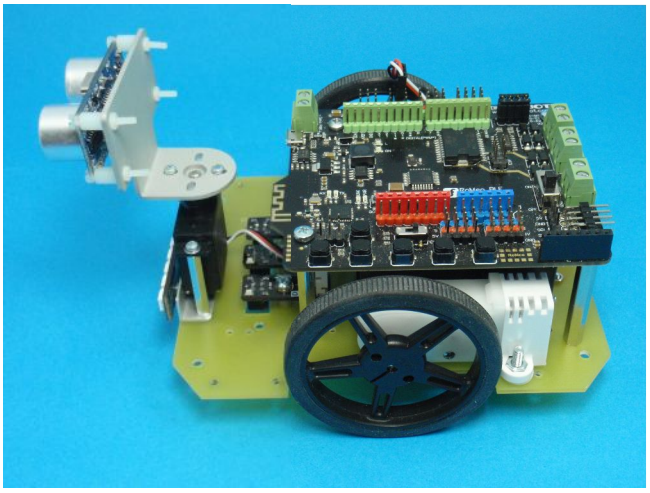

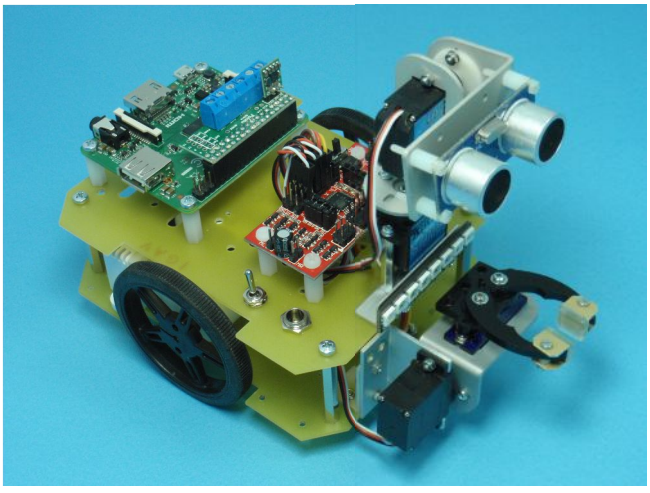

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AMEX Mini Robot

1. Introduction

AMEX Mini Robot is a new unique educational platform for building a mobile mini robot. The platform is designed in a way that provides a variety of configurations of mechanical and electronic part of the robot. It gives the possibility of creating as many as seven different versions of the chassis mounted on the same mounting board (please see versions 1a, 1b, 2a, 2b, 3, 4, 5). The change of the chassis is made by using different motors, wheels, tracks and changing their geometry and their placement on the mounting board. This solution has not been used so far by other manufacturers.

The AMEX Mini Robot platform is intended for those who want to learn programming of the mobile mini-robot without the need of personal designing and time consuming of making the whole mechanical construction of the mini robot from scratch. It is only necessary to join all the mechanical and electrical parts, according to the instructions, by the use of screws and nuts (delivered in the kit) and connect the sensors and power supply to the microcontroller board (robot controller/driver).

The platform is an ideal solution for individual users (beginners and more advanced hobbyists, pupils, students) and also for instance, for working with groups of pupils in secondary schools and innovative technical classes of electronics and robotics.

2. Platform construction

An additional and unique feature of the mini robot is the possibility to build mini robot with the use of only one or two mounting boards (bottom and top board). The mounting boards are offered in two versions:

- laser-cut, anodized and colored aluminium parts
- glass-reinforced epoxy laminate

Both versions ensure good rigidity, reliability and aesthetics. All mechanical parts are very well matched which simplifies their installation.

The mini robot platform itself (without additional enclosure) consists of one or two parts (mounting boards) joined together with four distance sleeves and M3 screws.
Small dimensions of the mini robot (130 mm x 116 mm), robust and reliable construction are a clear advantage in conducting technical classes in the range of robotics in schools and in many trainings that require mobility of educational equipment. This is especially important for persons conducting the classes.

Our solution enables the choice of mechanical configuration of the mini robot without the need of purchasing separate versions of robots. **It is only necessary to change the motors and wheels and mount them on the same mounting board.** The possibility of changing the chassis has great advantages because of possible modification of software used to control the motors. The type of the drive has influence on traction and movement dynamics of the robot.

The front part of the robot platform (top and bottom mounting boards) is equipped with mounting holes for scanning servo (0..180 degrees in vertical and horizontal direction) for example for ultrasonic distance meter, color mini camera or miniature robotic arm. The scanning mechanism is available in

two versions: horizontal scanning mode only (180 degrees) or two axis scanning mode (180 degrees in horizontal and vertical direction).

Besides mechanical parts as motors, wheels, line sensors, ultrasonic distance meter and scanning mechanisms driven by two miniature servos and power supply, the bottom board can also be equipped with robot controller (with built-in motor drivers) by *DFRobot* (type *RoMeo BLE Robot controller* (compatible with Arduino) with integrated function of wireless Bluetooth communication or *DAGU S4A EDU* controller or Pololu A-Star Robot Controller (compatible with Arduino)

The top board enables to install the same controller modules as are intented for the bottom board or to assemble other ones (Arduino and compatibles) or *Raspberry Pi* (model A+, B+) together with two DC driver motors. Such configuration enables to assemble NiMH battery charging module.

2.1. Chassis configurations

Particular robot versions differ in chassis configuration (2-wheel version, 4-wheel version and tracked drive system with two silicone tracks). Each configuration can be assembled on the same mounting board which is equipped with special spots and mounting holes to fasten the chosen motors and wheels.
The user can choose two types of motors and different wheels (see below, version 1, version 2 and version 3). These are assembled on the same bottom mounting board.

Configurations which use Pololu micro motors can be optionally used to assemble the encoders (it concerns 2-wheel versions: 1a, 1b, 2a, 2b, 4-wheel version (version 4) and track version (version 5). The drive motors can work with encoders placed under each motor. The use of encoders is recommended for more advanced users who - by the use PID controllers – can obtain optimal movement properties during turning of the robot, for instance depending on the current mini robot velocity and information gathered from line sensors and ultrasonic distance meters that measure distance from an obstacle.

The platform can be controlled by any microcontroller module with motors driver for example **ARDUINO, DAGU S4A EDU, DFRobot RoMeo BLE, Pololu A-Star 32U4 Robot Controller LV**, **RASPBERRY PI** (A+, B+, Pi2). The above drivers have special mounting holes on the mounting boards.

Version 1

Two-wheel platform (with Pololu 42 x 19 mm wheels)

With version 1 of the platform the user has the possibility to choose assembly place of Pololu micro motors and wheels on the bottom board of the platform. Version 1 exists in two options (1a and 1b). Both versions differ in the assembly place of motors and wheels.

Types of motors and wheels (versions 1a, 1b):

Both versions (1a, 1b) utilize two miniature Pololu HP micro motors (High Power) with metal gear (100:1, 150:1 or 210:1) and Pololu wheels (2 pieces); dimensions 42 x 19 mm with rubber tires which ensure high tractive adhesion.

Wheels and motors used in version 1

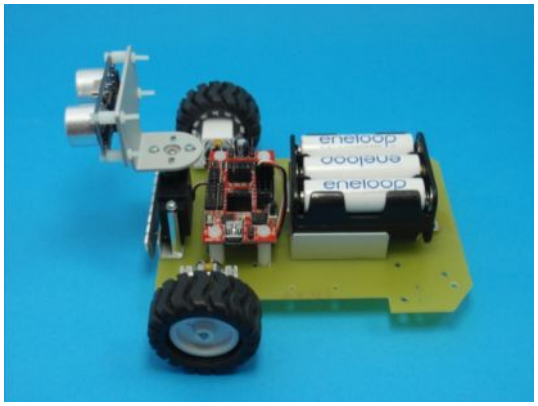
Pololu HP Motor

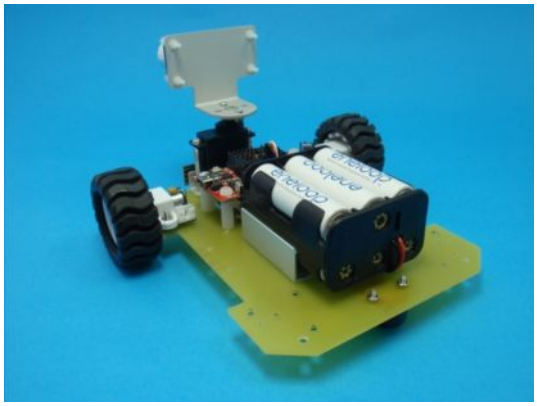
Fixing of the motor and driving wheel

In version 1, motors and wheels can be mounted on bottom mounting board in two places (version 1a and 1b).

Version 1 a:

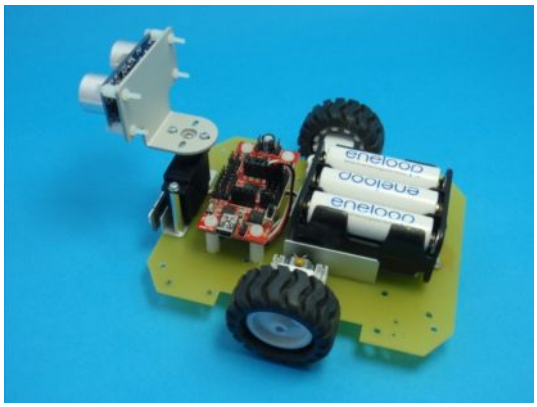
Motors and driving wheels are mounted at the front of the mounting board. To ensure the balance of the robot a supporting ball was used at the end of the mounting board.

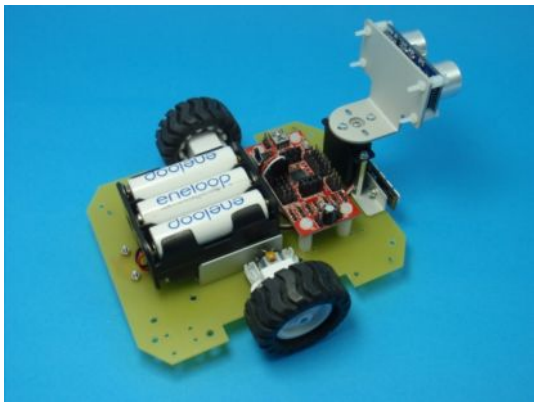




Version 1 b:

Motors and wheels are mounted in the middle of the bottom mounting board. To ensure balance of the robot one can use two supporting balls at both ends of the bottom mounting board.





Version 2

Two-wheel platform (with Pololu 40 x 7 mm wheels)

Version 2 is two-wheel platform with the possibility to choose assembly place of micro motors and Pololu wheels on the bottom board of the platform. The user can choose two versions of the platform (2a and 2b). The two versions differ in the fixing place of the motors and wheels.

Version 2 differs from version 1 only in wheels dimensions (40 x 7 mm). The motors and their location on the platform board is the same as in version 1.

Types of motors and wheel (version 2a, version 2b):

Both versions (2a and 2b) utilize 2 Pololu HP micro motors *(High Power)* with metal gear (100:1, 150:1 or 210:1) and Pololu wheels (2 pieces) with dimensions 40 x 7 mm with rubber tires which ensure high tractive adhesion.

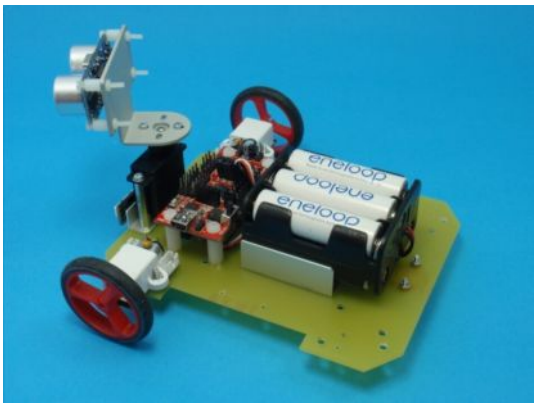
Wheels and motors used in version 2

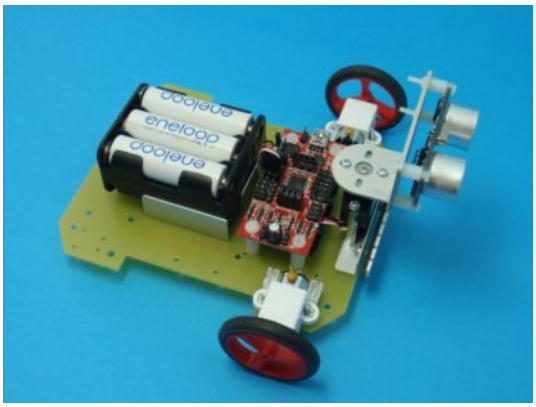
Driving wheels (40 x 7 mm)

Fixing of motor and driving wheel

Version 2a:

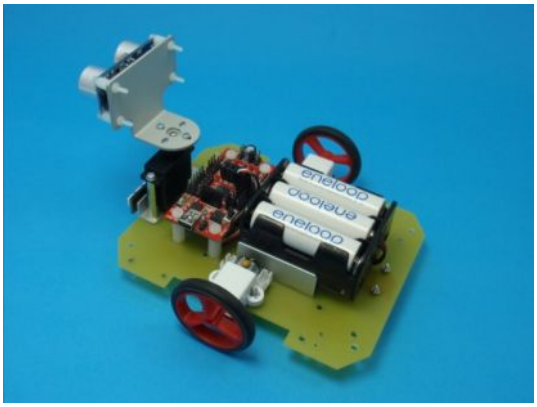
The motors and wheels are mounted at the front of the mounting board. To ensure robot balance a supporting ball is fixed at the end of the mounting board of the platform.

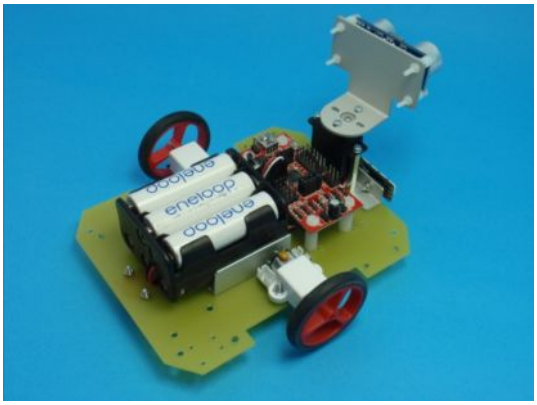




Version 2 b:

Motors and wheels are mounted in the middle of the bottom mounting board. To ensure balance of the robot two supporting balls can be fixed at both ends of the bottom mounting board.





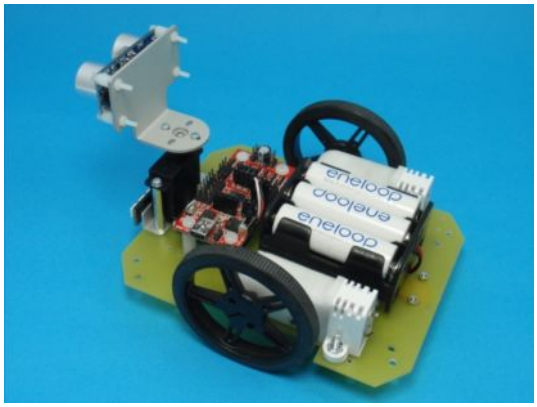
Version 3

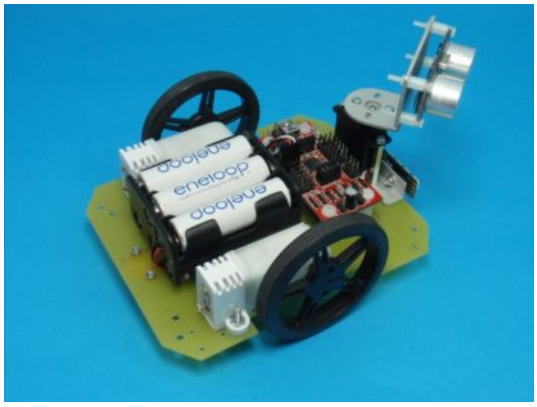
Two-wheel platform (with wheels 60 x 8 mm)

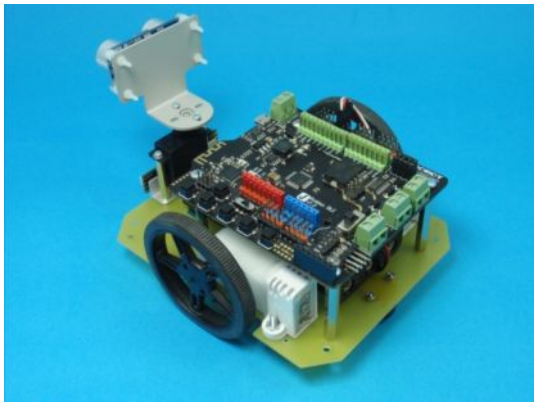
Types of motors and wheels:

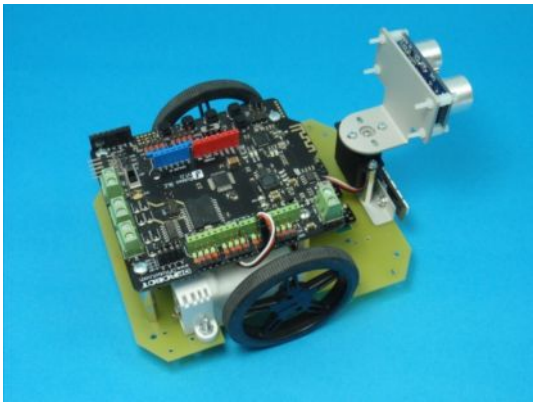
Two angled Pololu motors with plastic gear (120:1) and Pololu wheel 60 x 8 mm with rubber tires ensuring high tractive adhesion.

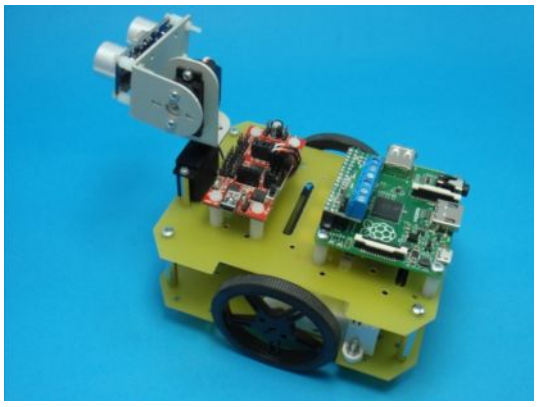
The motors and wheels are mounted in the middle of the bottom mounting board of the platform. To support robot balance two supporting balls are used at both ends of the bottom mounting board.











Wheels and motors used in version 3

Driving wheels (60 x 8 mm)

Fixing of the motor and driving wheel

Pololu angled motor

Motor fasteners

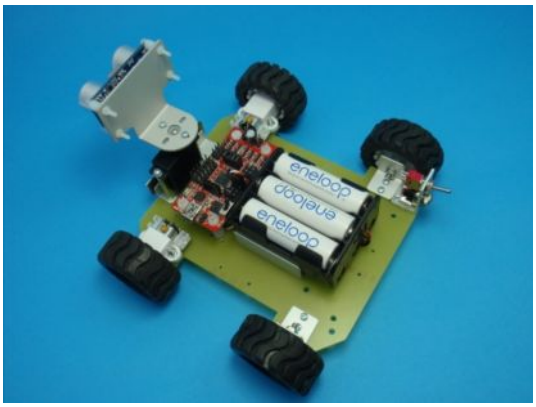
Supporting ball

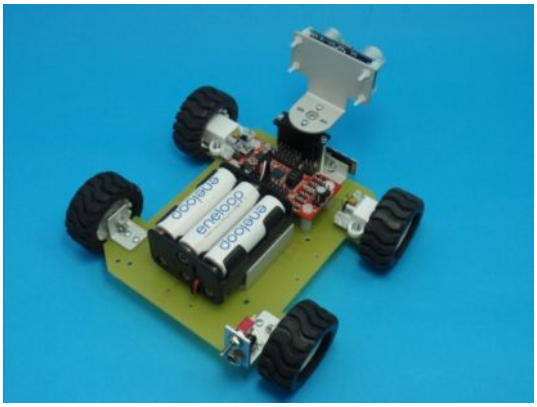
Version 4

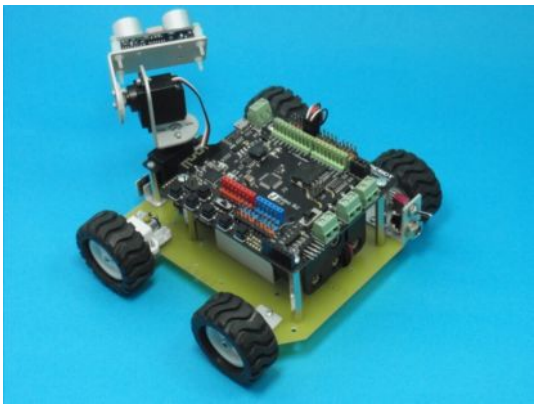
Four-wheel platform

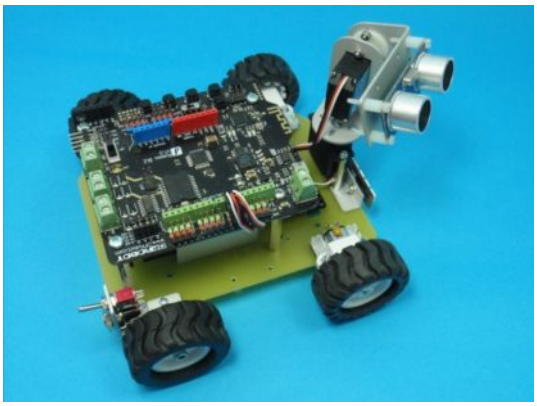
Types of motors and wheels:

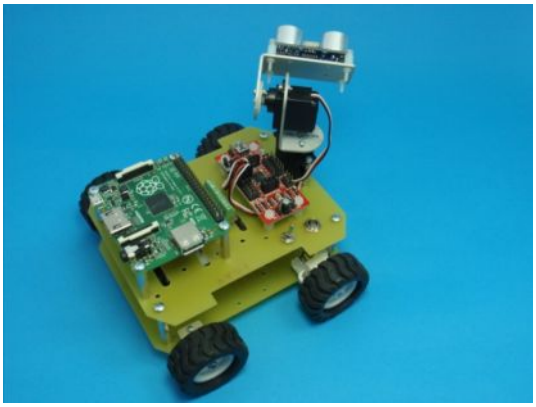
The four-wheel platform (two driving wheels at the front of the platform and two passive wheels at the back). Driving wheels are powered by two Pololu HP micro motors (*High Power*) with metal gear 100: 1 or 150:1 or 210:1.











Wheels and motors used in version 4

Motor mounted on the board

Driving wheels (42 x 19 mm)

Passive wheels mounting components

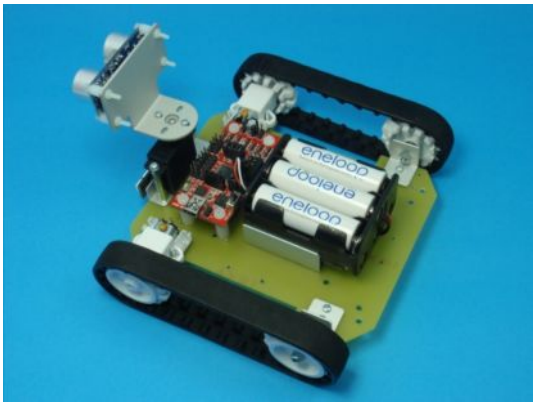
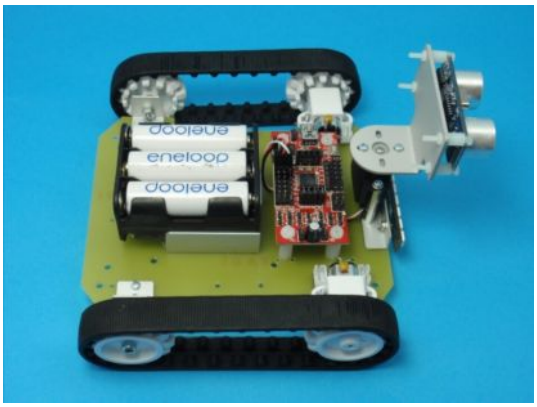
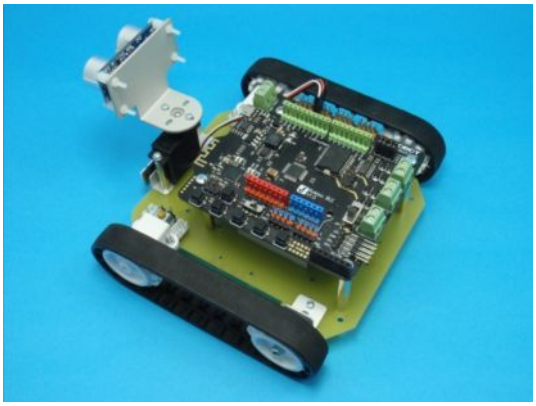
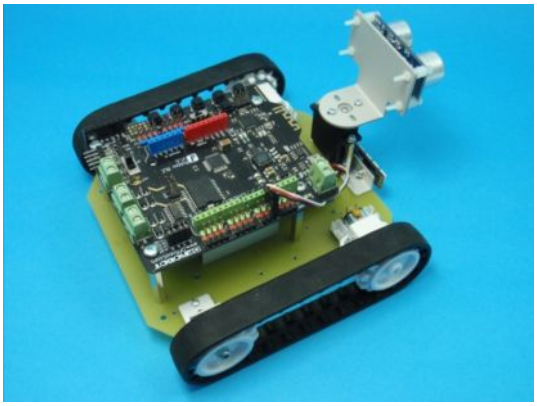
Passive wheels with tires

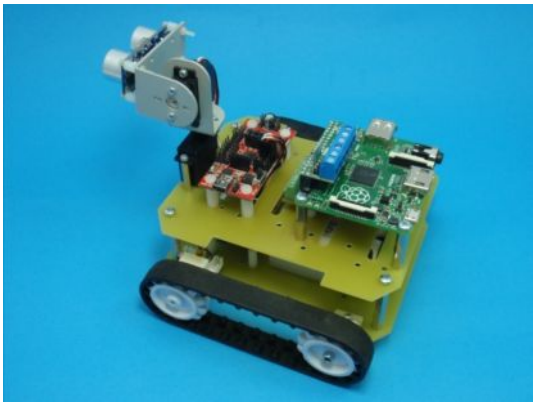
Pololu HP motors mounting components

Version 5

Platform with tracked drive system

The platform with tracked drive system contains 2 driving wheels (at the front) powered with two Pololu HP motors (High Power) with meal gear (100:1 or 150:1 or 210:1) and 2 passive wheels placed at the rear. The chassis is composed of two silicone tracks with 30 teeth each, two driving wheels and two passive wheels with their mounting components.

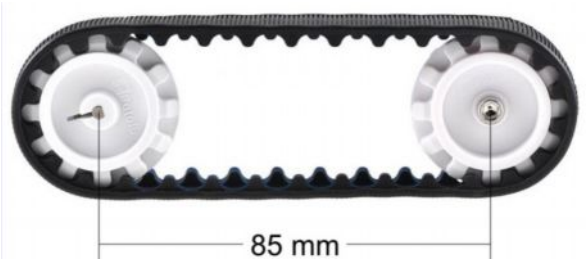







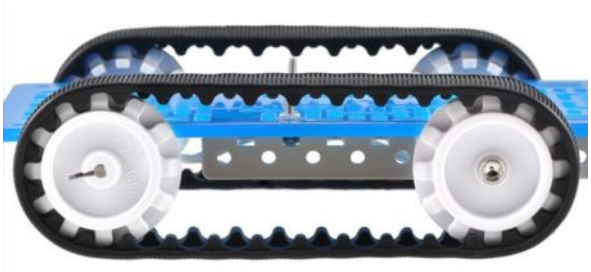
Wheels and motors in version 5

Track set

Mounting of the track set unit



Track set mounted on a chassis

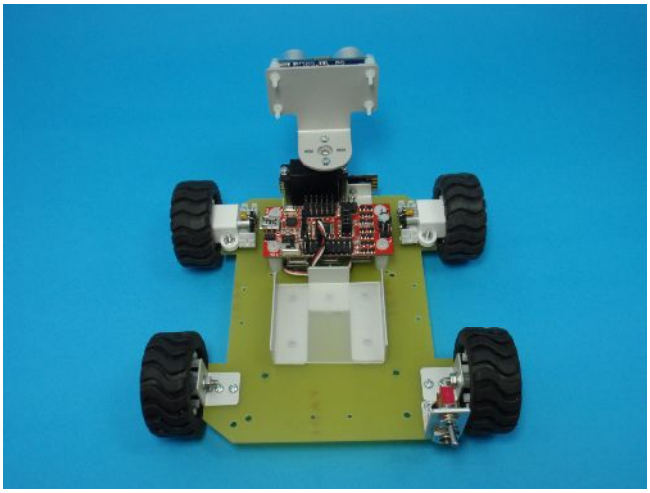


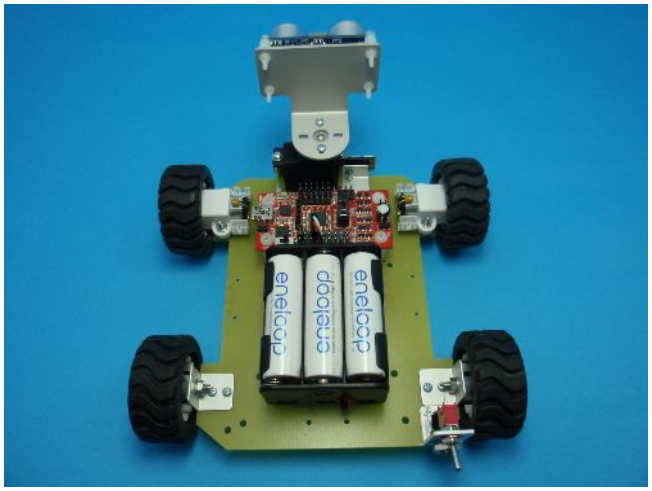
2.2. Powering of the Mini Robot

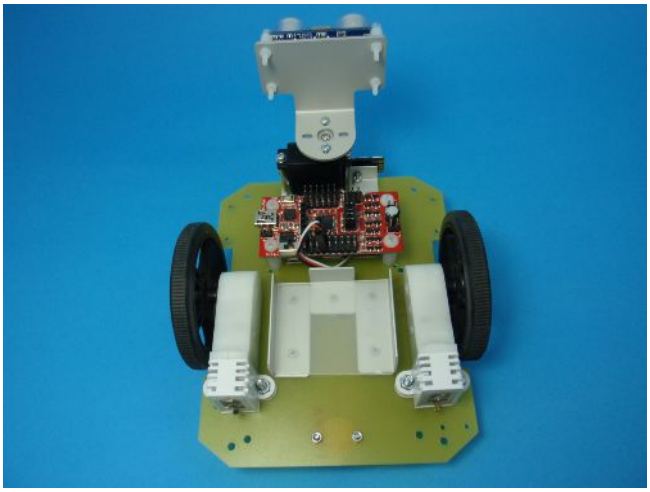
All mini robot versions are powered from 7.2V battery pack (6 x NiMH AA, 2000 – 2800 mAh). The pack is placed in a holder on the bottom board. Charging of the battery is performed by external charger connected through a plug at the rear of the platform. There is no need to remove the battery from the robot to charge it. The access to the battery holder is simple and is done by ejecting it.

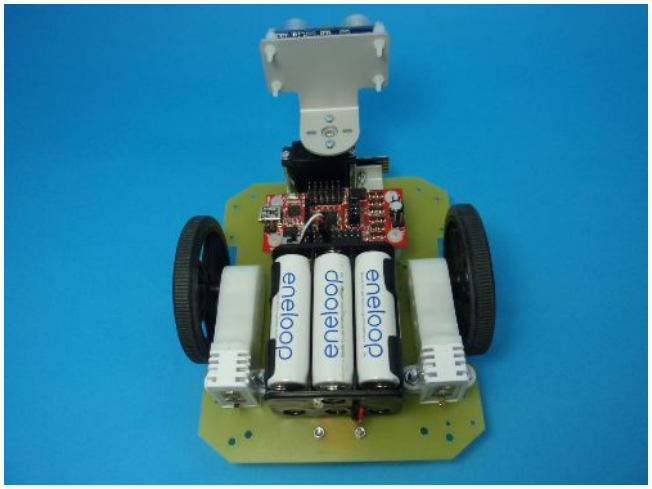
Optionally, the platform with top mounting board the battery pack can be charged from built-in charger (type NHC-01 by AMEX) placed on the bottom mounting board. Therefore, the battery pack need not to be removed from the holder to charge it. It is needed only to connect external stabilized AC/DC adapter (230VAC/12VDC; 1.5A) to charging connector placed at the robot power supply switch.

The photos below show the battery holder for version 4 and 3 of the Mini Robot.









3. Specification

AMEX Mini Robot platform is offered in 7 mechanical versions which differ in chassis type. The electronic part (robot controller module, sensors etc.) is offered separately in order to customize the mini robot by the user.
Each version has the possibility to mount microcontroller module such as Arduino or Raspberry PI (model A+, B+, Pi2) and motor drivers or compatible *DFRobot* driver type *RoMeo BLE Controller* or *DAGU S4A controller* (compatible with Arduino) or Pololu A-Star Robot Controller together with integrated motors driver.

Pololu HP micro motors specification

Small, light but robust and reliable Pololu motors with metal gear (100:1 or 150:1 or 210:1) as chassis driving units. These motors can be powered with voltage up to 9V, the power output is obtained above 3V. The optimal voltage that ensures the most favorable power to efficiency relationship is 6V. The maximum power voltage in AMEX mini robot fed from battery pack is 7.2V (6 x 1.2V).

Pololu HP 100:1 motor
Power supply voltage: 3V - 9V
Gear ratio: 100:1
Idle rotational speed without load: (6V): 320 RPM
Idle supply current: (6V): 80 mA
Supply current with locked shaft: (6V): 1600 mA (Note: Dagu and Romeo BLE drivers have automatic overcurrent protection in case of motor locked shaft)
Torque: 2,2 kG cm (0,215 Nm)
Motor body dimensions: 24 x 10 x 12 mm

Pololu HP 150:1 motor
Power Supply voltage: 3V - 9V
Gear ratio: 150:1
Idle rotational speed (6V): 200 RPM
Idle supply current (6V): 70 mA
Supply current with locked shaft (6V): 1600 mA mA (Note: Dagu and Romeo BLE drivers have automatic overcurrent protection in case of motor locked shaft)
Torque: 2,9 kG cm (0,284 Nm)
Motor body dimensions: 24 x 10 x 12 mm

Pololu HP 210:1 motor
Power supply voltage: 3V - 9V
Gear ratio: 210:1
Idle rotational speed (6V): 140 obr/min.
Idle supply current (6V): 70 mA
Supply current with locked shaft (6V): 1600 mA mA (Note: Dagu and Romeo BLE drivers have automatic overcurrent protection in case of motor locked shaft)
Torque: 3,6 kG cm (0,353 Nm)
Motor body dimensions: 24 x 10 x 12 mm

Pololu angled motors specification

Small motor with plastic gear 120:1, 120 RPM, torque 1,4 kg*cm (0,137 Nm)
This motor can be an alternative for Pololu micro motors.

Pololu Motor DC 210:1 – angled type
Gear ratio: 120:1
Power supply voltage: 4.5V
Idle rotational speed: 120 RPM
Average current consumption: 80 mA
Peak current: 800 mA
Torque : 1.4 kg cm (0.137 Nm)

3.1. Electronic part

Robot Controller modules

NOTE
Both platform boards (bottom and top) include mounting holes adapted to install the following motor drivers:

bottom board:
- **DAGU S4A EDU**
- **DFRobot ROMEO BLE**

Top board:
- **ARDUINO** (in UNO vesrion, Leonardo itp.) with compatible versions
- **DAGU S4A EDU**
- **DFRobot ROMEO BLE**
- **Pololu A-Star 32U4 Robot Controller LV**
- **Raspberry Pi** (Model A+, B+ and Pi2)

One can use microcontroller module in the platform such as *Arduino Uno, Arduino Leonardo* with the extension of Adafruit motor driver or Dagu microcontroller (name ***DAGU S4A EDU controller***) which is excellent combination (on one small board) of fully compatible microcontroller module (compatible with *Arduino*) and motors driver.

As an alternative solution one can use other DFRobot controller (name ***Romeo BLE*** with Bluetooth communication) which is ideal solution for beginners and also more advanced users.
The AMEX Mini Robot Platform is also suited for ***Raspberry Pi*** installation (model A+, B+ and Pi2).

The further description depicts three models of robot controllers with integrated motors drivers: *DAGU S4A EDU*, *Romeo BLE* by DFRobot and *Pololu A-Star 32U4 LV Robot Controller*.

It should be mentioned that the **AMEX Mini Robot** platform is capable of using other, virtually any of available microcontroller modules and motors drivers which mounting will require to drill mounting holes on top mounting board of the platform. The mounting holes on the top board are suited for *Arduino* and mentioned earlier ***DAGU S4A EDU, Romeo BLE, Pololu A-Star Robot Controller*** and ***Raspberry Pi*** modules.

Apart from typical *Arduino* module it is also possibile to use a contact board working with appropriate microcontroller modules and motors drivers with terminals (pins) plugged into the contact board (for example, *Pololu* microcontroller module, type *A-Start Micro* based on *Leonardo* module and a module with two-channel DC current motor driver, type *TB6612FNG* by *Toshiba*.

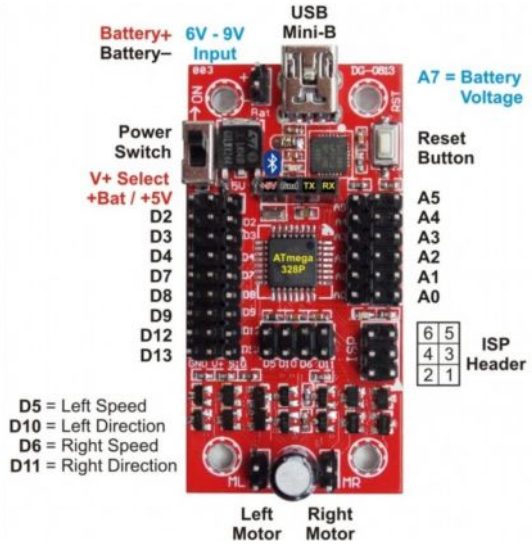
The following short descriptions and pictures show some of the robot controller modules recommended for using in AMEX Mini Robot Platform.

Robot controller module with DAGU S4A EDU motor driver

(PCB dimensions: 60 mm x 30 mm)

Description

Dagu robot controller compatible with Arduino. As in Uno version, it is based on ATmega 328 microcontroller run at 16 MHz clock. The board is also equipped with motor drivers capable of supplying currents up to 2,5A at 9V. The device can be programmed through miniUSB connector with Arduino IDE programming environment. All the signals are fed to traditional goldpin type connector (2,54 mm) which are already soldered into the board.



Specification

Power supply voltage: 6 V to 9 V
Built-in voltage regulator
Microcontroller: Atmega 328
Clock: 16 MHz
Flash memory: 32 kB
RAM memory: 2 kB
EEPROM memory: 1 kB
Built-in 2.5A motors driver

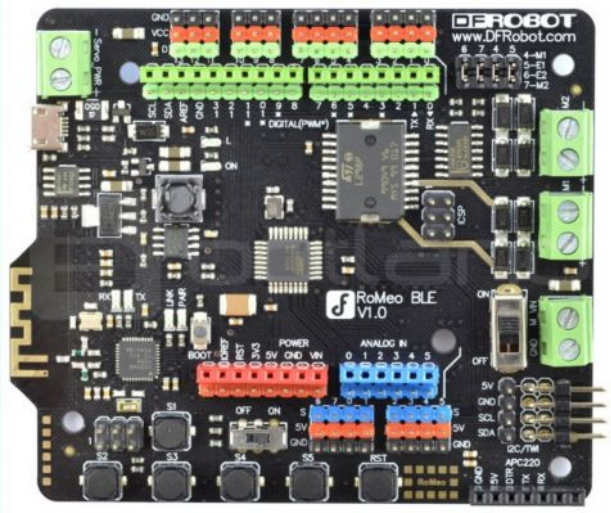
Signals are connected to soldered goldpin connector (2.54 mm raster). The connector can be used to connect model servos. The board include four mounting holes.

Romeo BLE controller – Bluetooth

(PCB dimensions: 94 mm x 30 mm)

Description

DFRobot module compatible with Arduino Uno. Apart from typical features of such boards it also includes Bluetooth module, two-channel 32V/2A motor driver, power supply switch and also many additional connectors and terminals.



Romeo BLE is fully compatible with popular Arduino Uno. It means that it can be programmed in Arduino IDE environment with available libraries. The add-ons so called Arduino Shield will also work with DFRobot module. Apart from typical features of Arduino boards it also includes BLE CC2540 chip which provides communication of Bluetooth 4.0, two-channel 32V/2A motors driver, power supply switch and many additional connectors and terminals.

The board includes ATmega328 microcontroller equipped with 14 digital I/O of which 6 can be used as PWM outputs (for example to drive motors) and 8 as analog inputs. The chip is clocked at 16 MHz. The module also includes: micro USB connector, power supply connector with screws, RESET button and terminals prepared for AVR programmer connection.

The device has many additional features which are absent in typical Arduino modules:

power supply switch – an ON/OFF type switch which enables simple disconnection of power supply at any time,
moduł BLE CC2540 by Texas Instruments – communication module; programmed through Bluetooth (range up to 70 meters in open area)
5 tact-switch type buttons – available to the user
voltage regulator – 5V/2A
twho-channel motors driver based on L298 – enables speed control and rotation direction control of DC motors with current consumption up to 2A.

The module includes colored connectors that facilitate the identification of terminals:
red – power supply terminals,
blue – analog terminals,
green – digital terminals

Power supply
The module can be Powered via USB cable and external devices such as AC/DC adapter, a battery or an accumulator. To connect through the power supply source is done automatically. The power supply is connected to the screw connector. The battery (or other power supply source) is connected to POWER terminals.

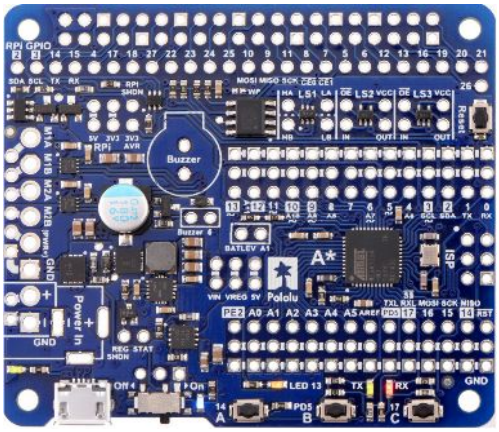
Programming
Creating and installing the software can be performed in free Arduino IDE environment. An implemented bootloader enables sending the software directly through microUSB cable. ISCP connector enables to connect external AVR programmer.

Specification
Power supply voltage: 5 V do 23 V
Programmed through microUSB connector
Fully compatible with Arduino Uno
Microcontroller: ATmega328
Maximum clock frequency: 16 MHz
SRAM memory: 2 kB
Flash memory: 32 kB (5kB zarezerwowane dla bootloadera)
EEPROM memory: 1 kB
I/O Ports: 20
PWM outputs: 6- pins: 3, 5, 6, 9, 10, 11
Analog inputs: 8 (A/D converter inputs)
Serial interfaces: UART, SPI, I2C
External interrupts
Connector: microUSB socket (microUSB cable purchased separately)
ISP connector soldered into the PCB
User buttons: 5
Built-in BLE CC2540 chip with antenna:
- enables Bluetooth 4.0 communication
- enables wireless Arduino programming
- supports Bluetooth HiD and IBeacons
- supports AT commands

Motors driver: two-channel L298 2A
Voltage regulator with 5 V and 3,3 V outputs
PCB dimensions: 94 x 80 mm
In order to run the module it os to connect the device with PC through microUSB cable and select Arduino IDE in Arduino IDE. Detailed description of the product can be found in user's guide at http://www.dfrobot.com/wiki/index.php/RoMeo_BLE_(SKU:DFR0305)

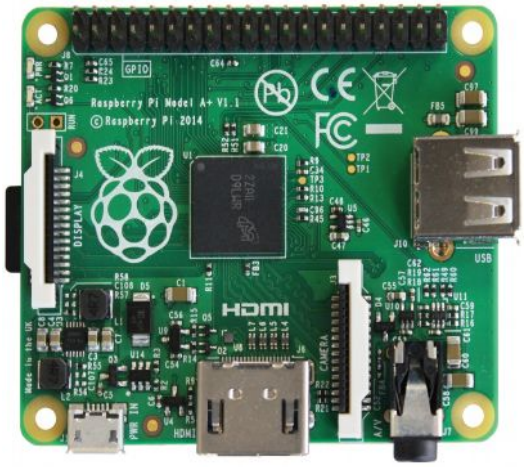
POLOLU A-Star 32U4 Robot Controller LV with Raspberry Pi Bridge

Description

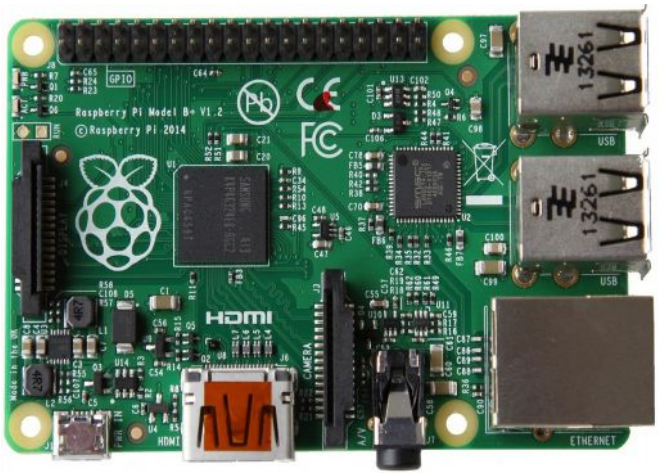


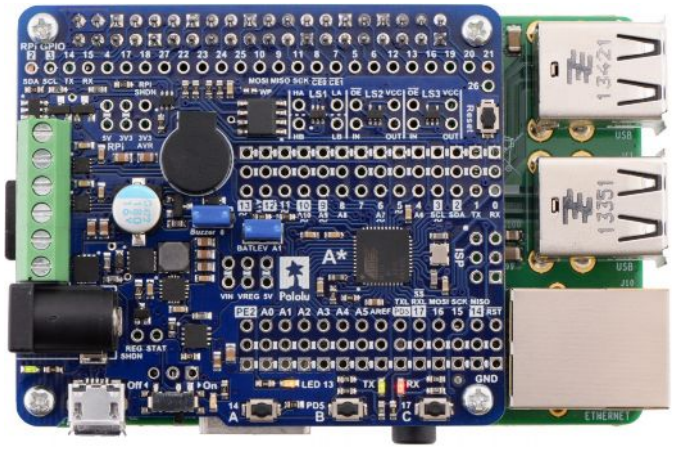
The A-Star 32U4 Robot Controller LV with Raspberry Pi Bridge is a programmable module well-suited for robotics applications, designed to work either as an auxiliary controller mounted to a Raspberry Pi or as a standalone control solution for a small robot. This A-Star is based on Atmel's ATmega32U4 AVR microcontroller, which has built-in USB functionality, and it ships with a preloaded Arduino-compatible bootloader. Its complement of peripheral hardware includes dual motor drivers capable of delivering a continuous 1.8 A per channel, along with pushbuttons, LEDs, and an optional buzzer for building a user interface. An efficient switching voltage regulator allows the controller to work over a wide range of input voltages (2.7 V to 11 V).

Raspberry Pi (Model A+)



Raspberry Pi (Model B+)



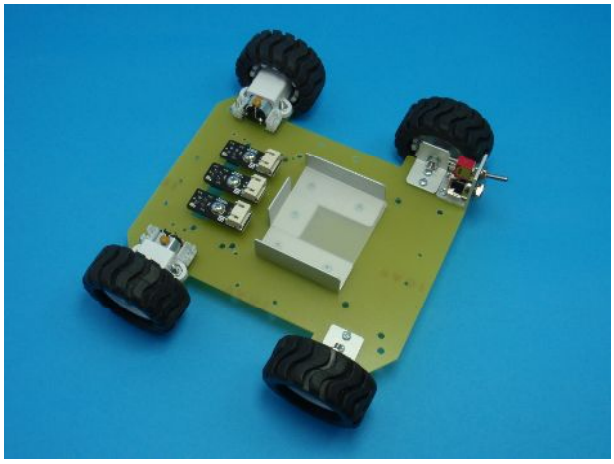
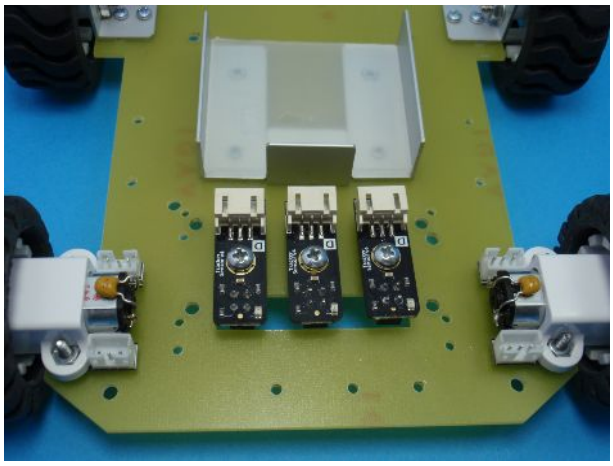


The robot controller board conforms to the Raspberry Pi HAT specification, allowing it to be used as an add-on for a Raspberry Pi with a 40-pin GPIO header (Model B+, Model A+, and Pi 2 Model B). On-board level shifters make it easy to set up I²C communication and interface other signals between the two controllers, and the A-Star automatically supplies 5 V power to an attached Raspberry Pi. In this setup, the Raspberry Pi can handle the high-level robot control while relying on the A-Star for low-level tasks like reading analog sensors and controlling timing-sensitive devices (e.g. servos).

Detailed description of this product can be found in user's guide at https://www.pololu.com/docs/pdf/0J66/a-star_32u4_robot_controller.pdf

3.2. Line tracking sensors

The Line sensor can detect black or white line. Detection of the line is signaled with digital signal (TTL standard). AMEX Mini Robot platform contains 3 line detectors placed on the bottom mounting board (see picture below).

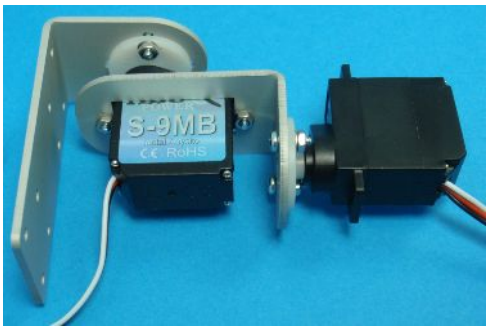
3.3. Encoders

Driving motors can optionally work with encoders placed under each motor (it concerns platform version with Pololu HP micro motors, that is, versions 1, 2, 4, 5). The use of encoders is recommended for more advanced users who, with the help of PID control, can attain optimal moving parameters during turning depending for example on current speed of the robot and information gathered from line sensors or ultrasonic distance sensors.

Encoder view with connection cables:

3.4. Scanning unit with ultrasonic sensor

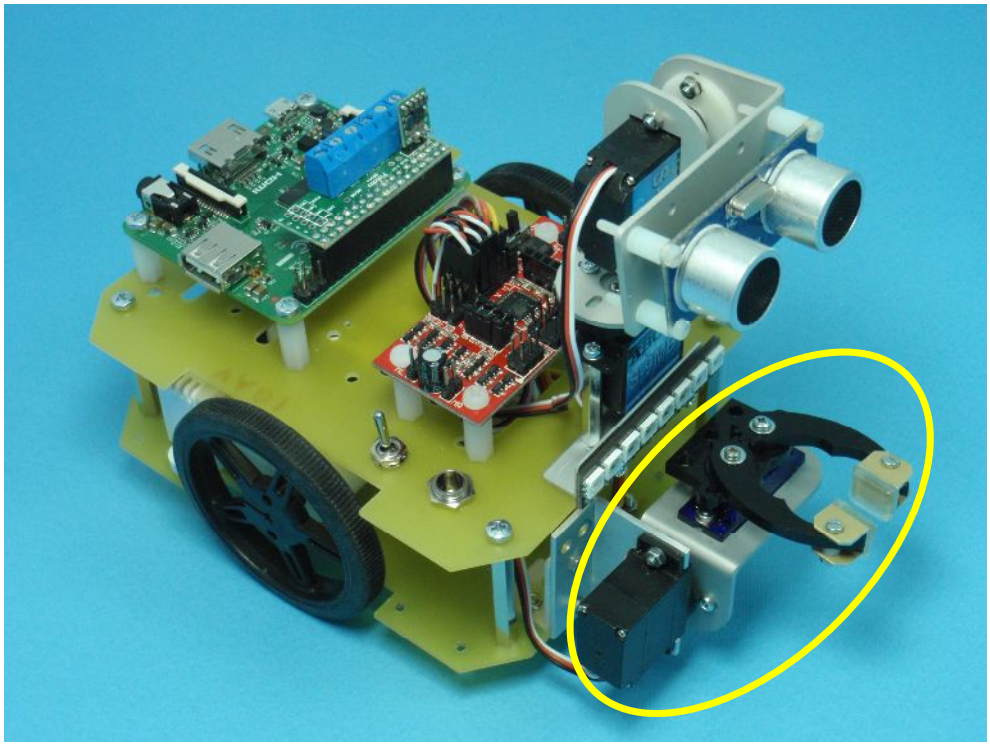
The front part of the platform has mounting holes intended for scanning unit servomechanism (in the range of 180 degrees, horizontally and vertically) for example, for ultrasonic distance meter, color mini-camera or miniature robotic arm.
The scanning unit is available in two versions: horizontal scanning mode only (180 degrees) or two-axis scanning (180 degrees in horizontal and vertical direction).
Both scanning unit versions with ultrasonic sensor and servos are shown below. The included photo gallery shows also scanning unit mounted on AMEX Mini Robot platform.



NOTE:

AMEX Mini Robot kit requires manual assembly. We can deliver (on request, for an extra charge) fully assembled and configured by the user the version of the platform including mechanical and electronic part.
The AMEX company is planning to develop and publish on its website demo software.

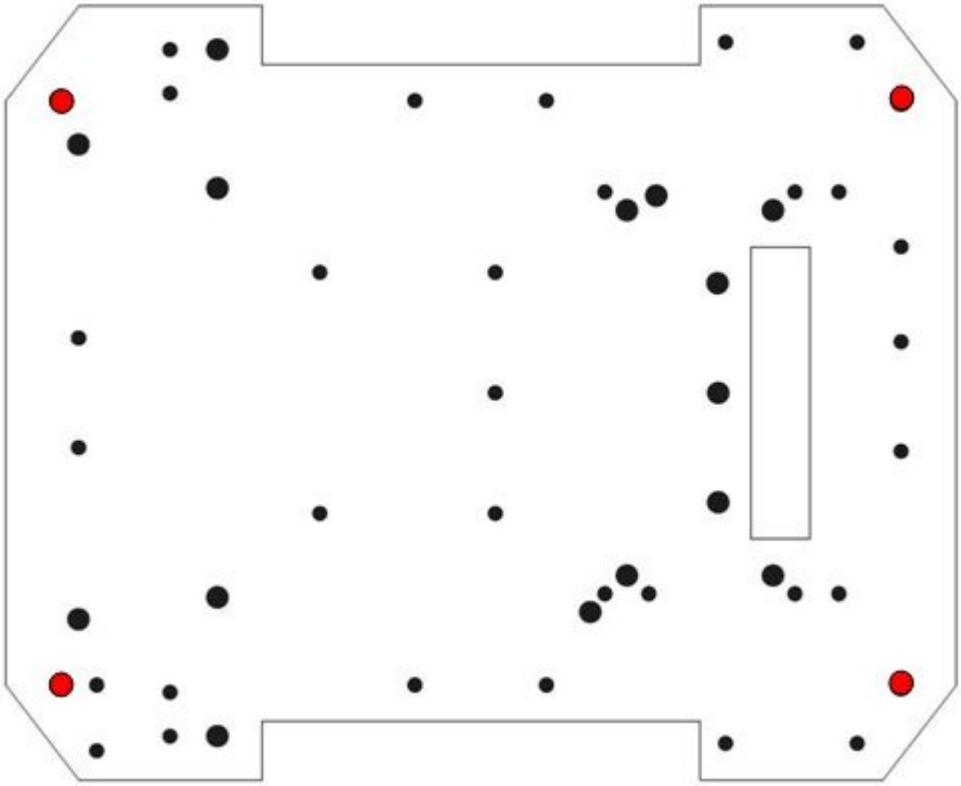
3.5. AMEX Mini Gripper



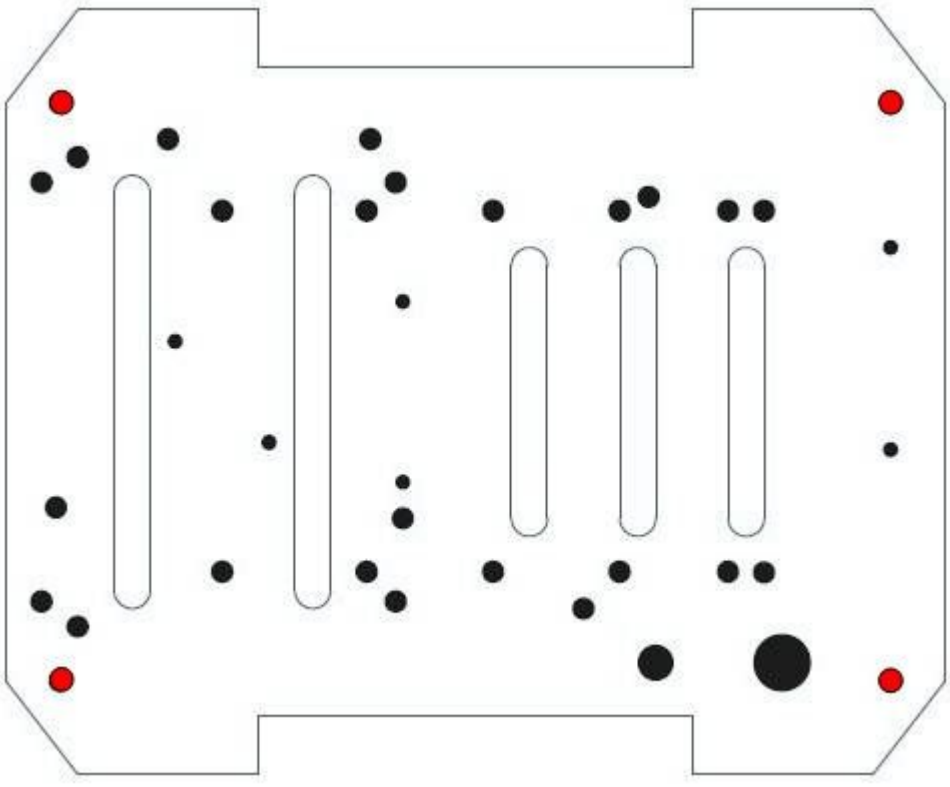
APPENDIX

Note: *Holes selected on the figures below with* ***red*** *are intended to join two boards with four distance sleeves and four M3 screws. The driving components (motors with wheels), line sensors and (optionally) – battery charger are mounted on the bottom board. The Mini Robot can also be made with only bottom board. Top board gives greater capabilities to mount other modules.*

Bottom board



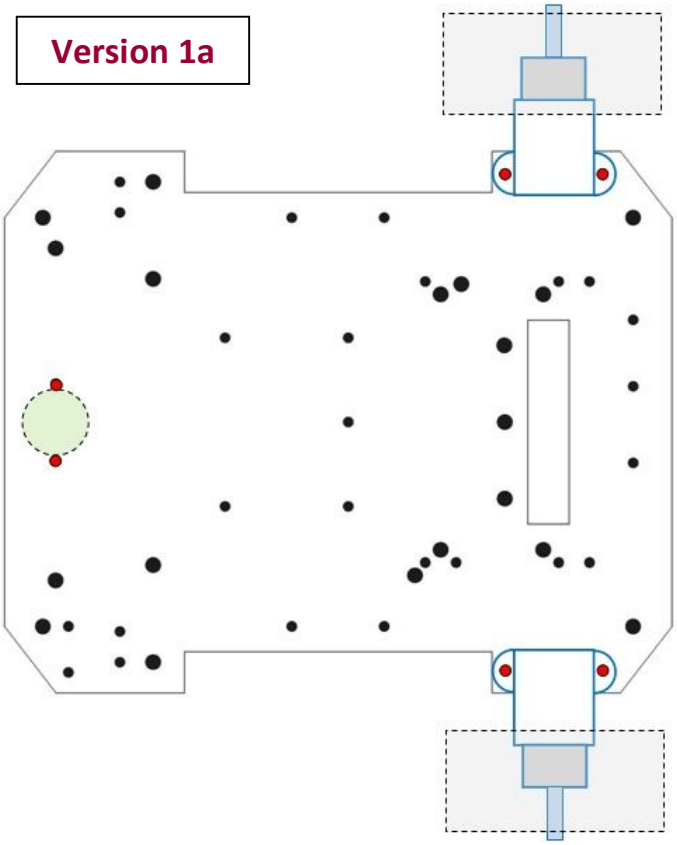
Top board



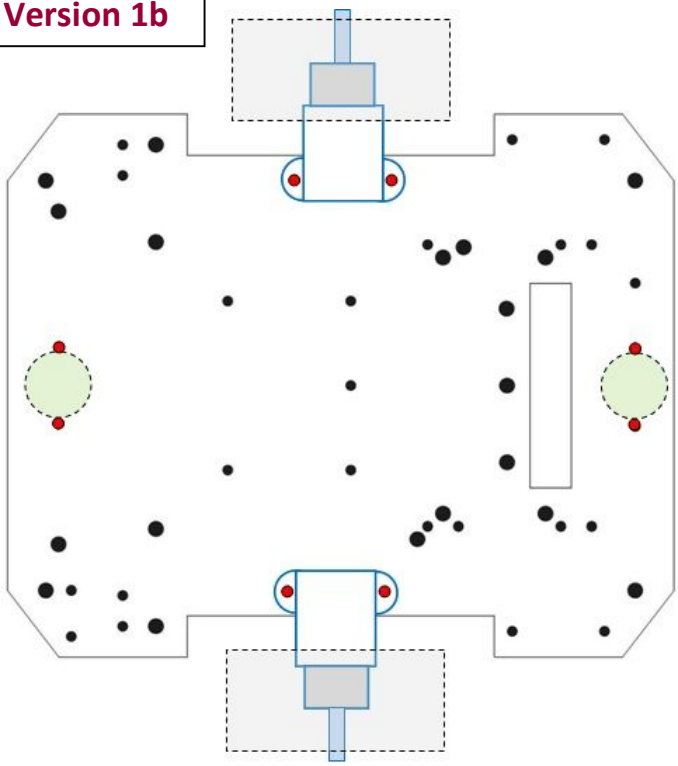
Chassis configurations – the placement of assembly components and holes on bottom board of the mini robot

NOTE: The holes selected with red color concern only the components intended for a given chassis

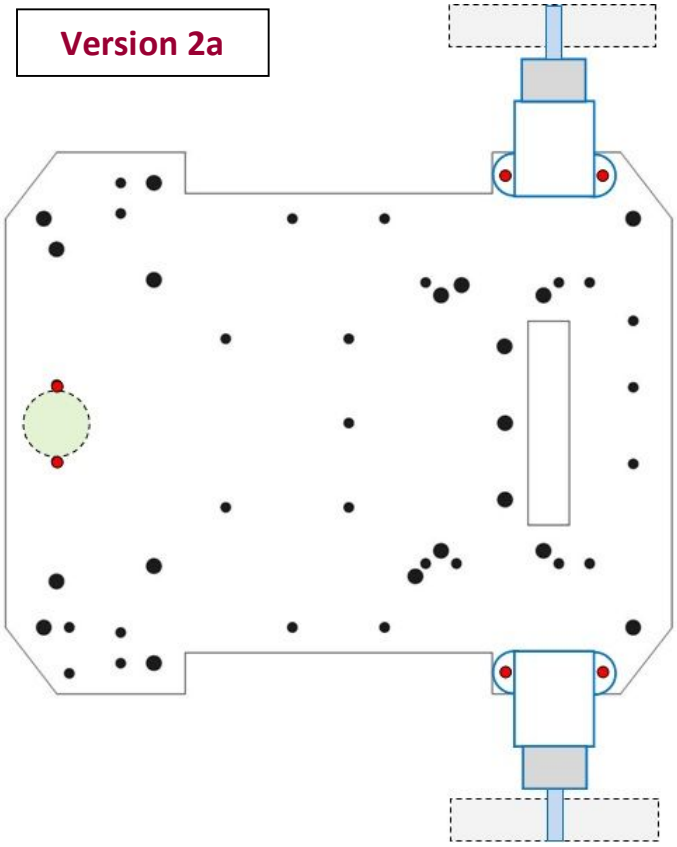
Version 1a



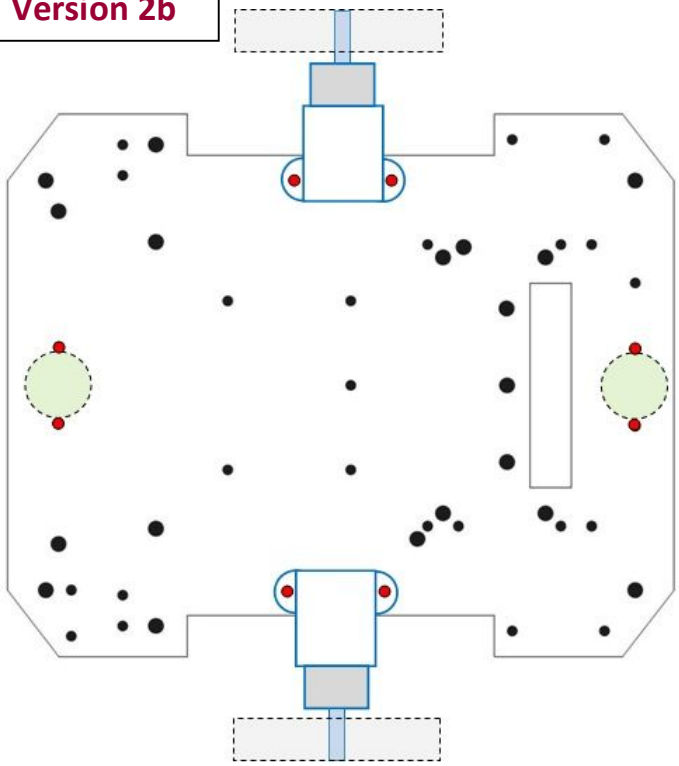
Version 1b



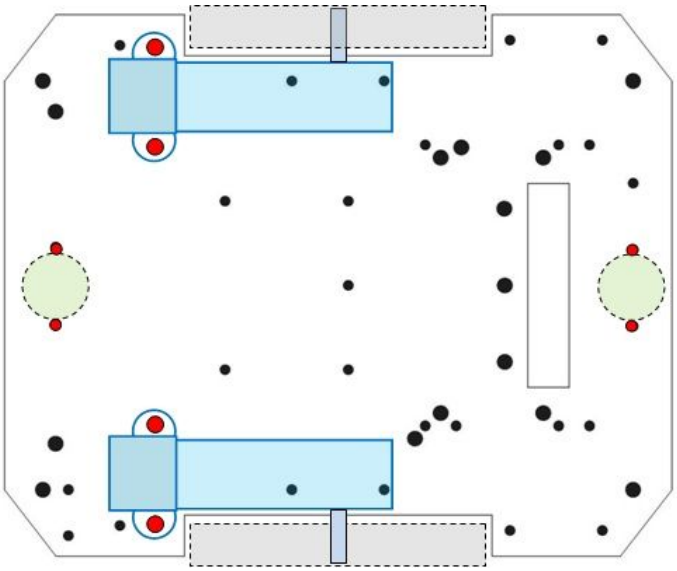
Version 2a



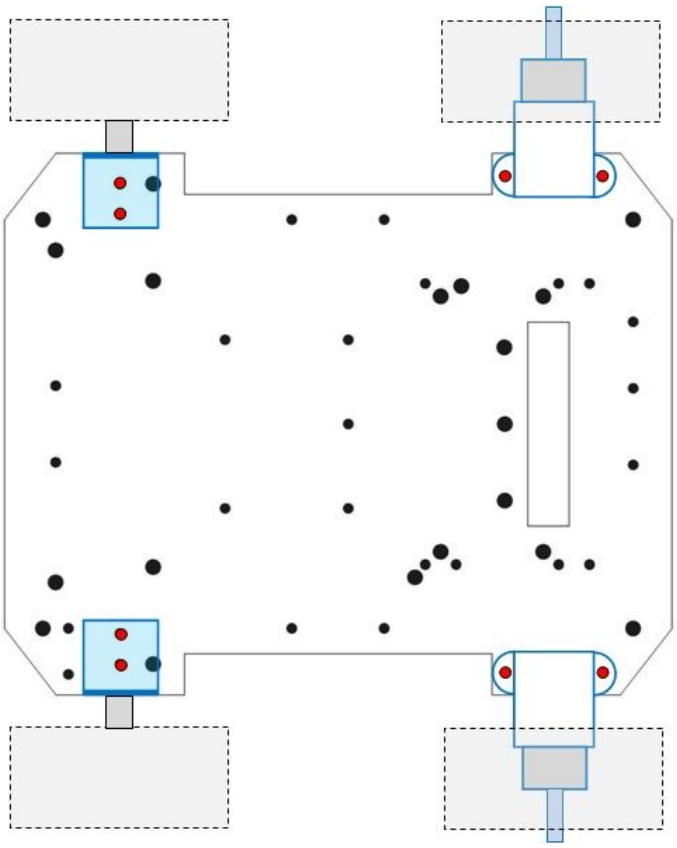
Version 2b



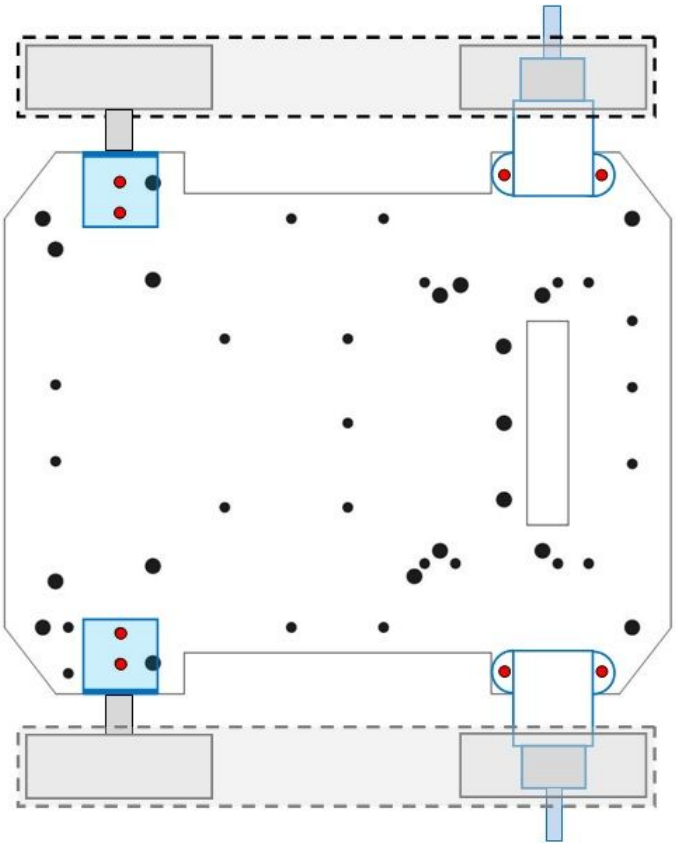
Version 3



Version 4

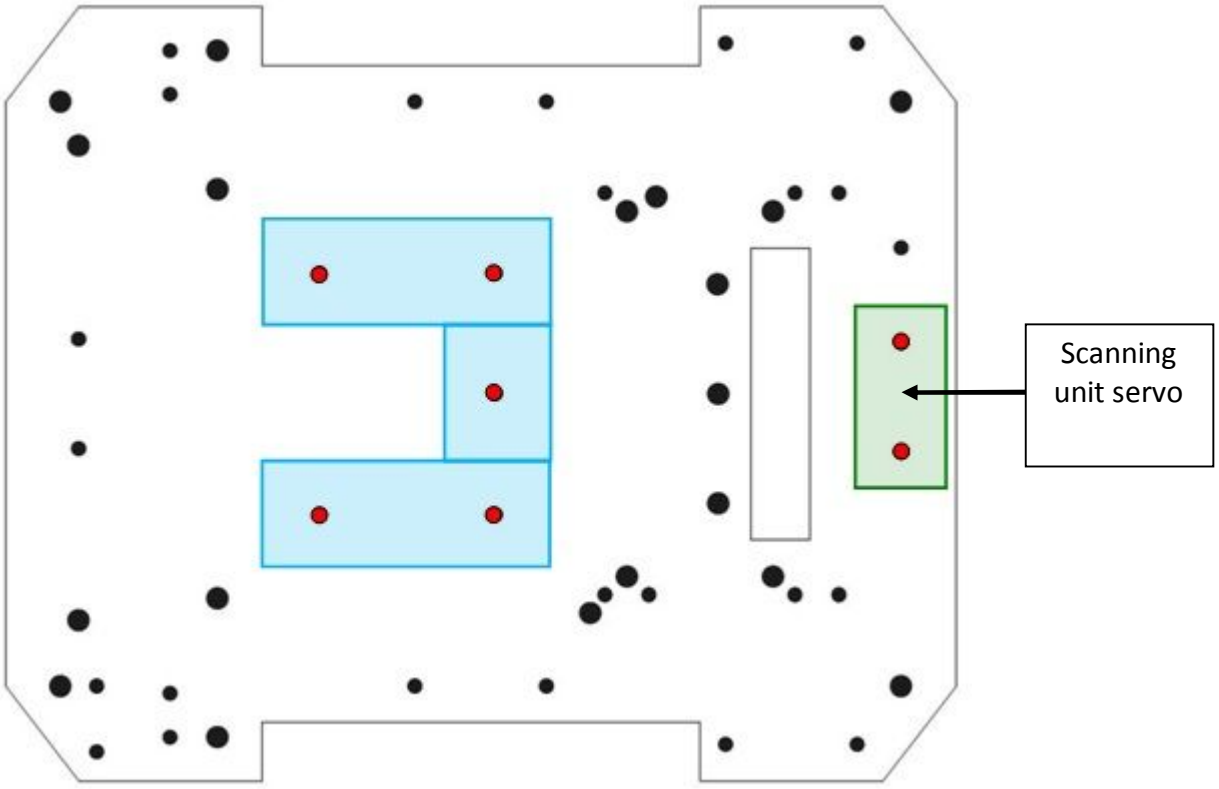


Version 5

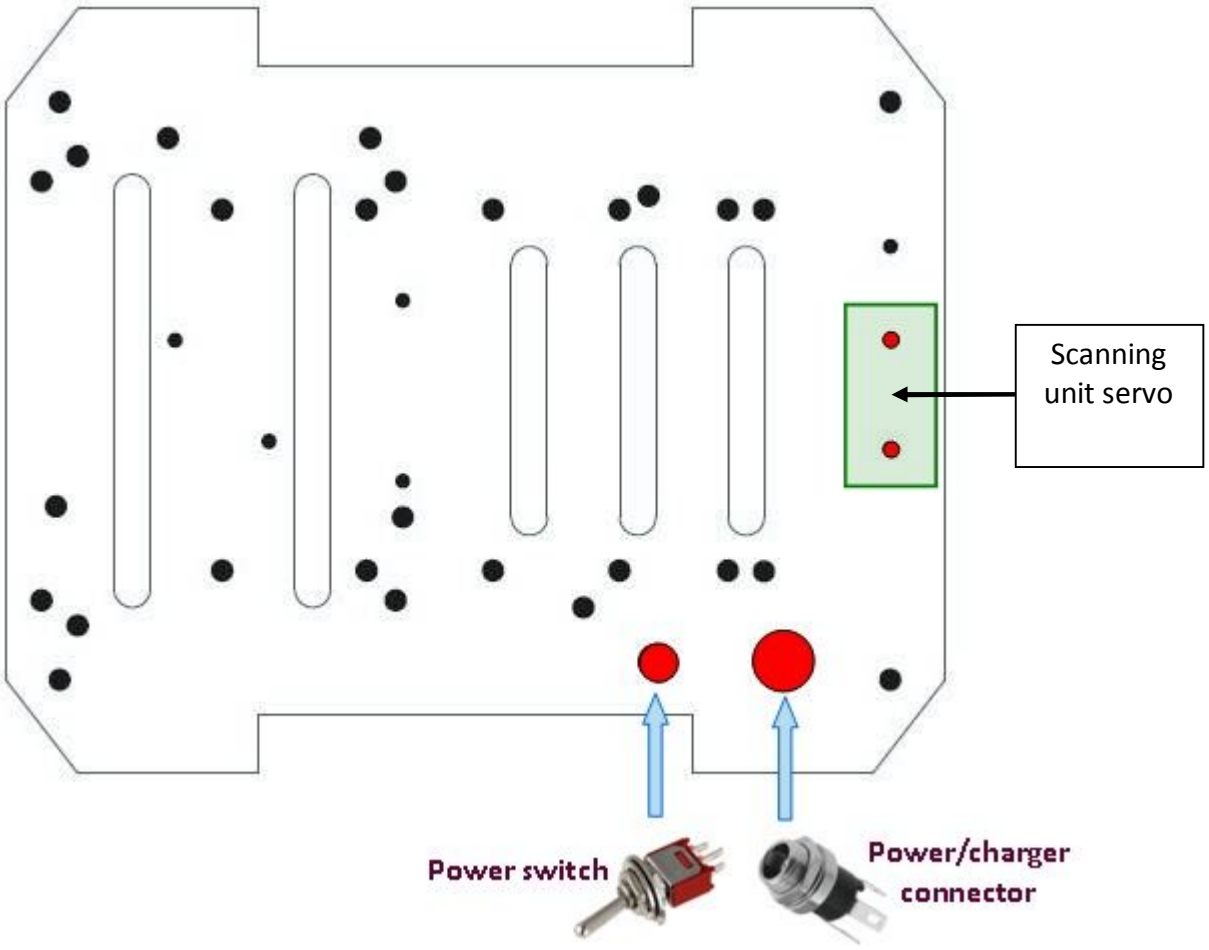


The placement of other mechanical and electronic components and modules

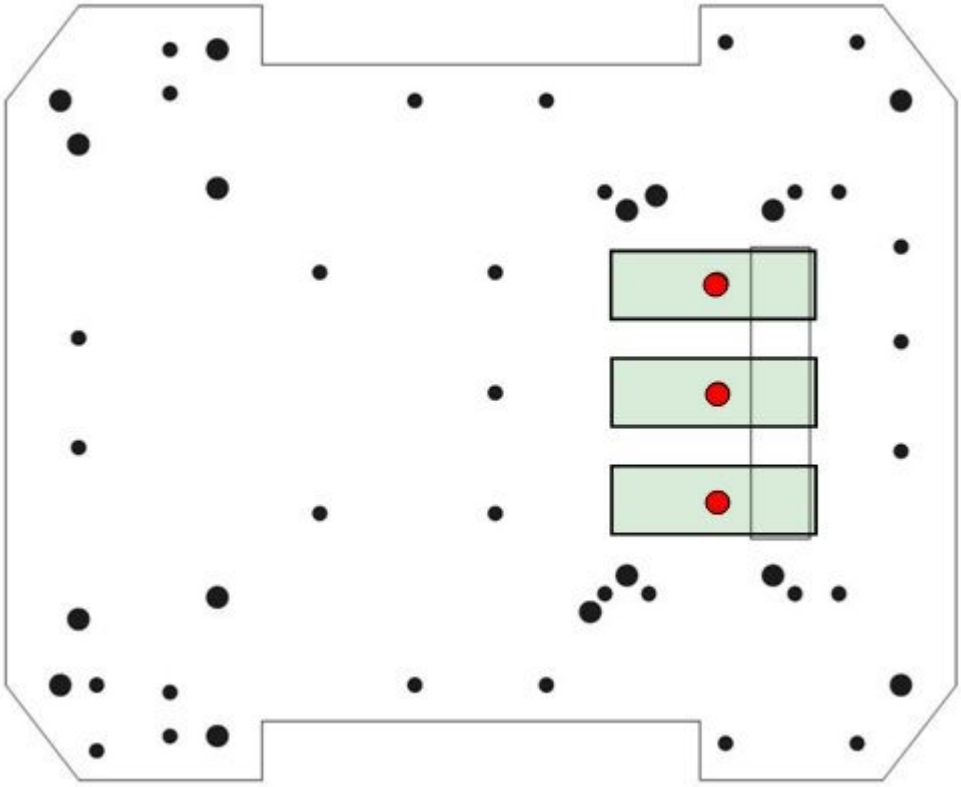
Bottom board: fixing components for a battery holder and servo of scanning unit



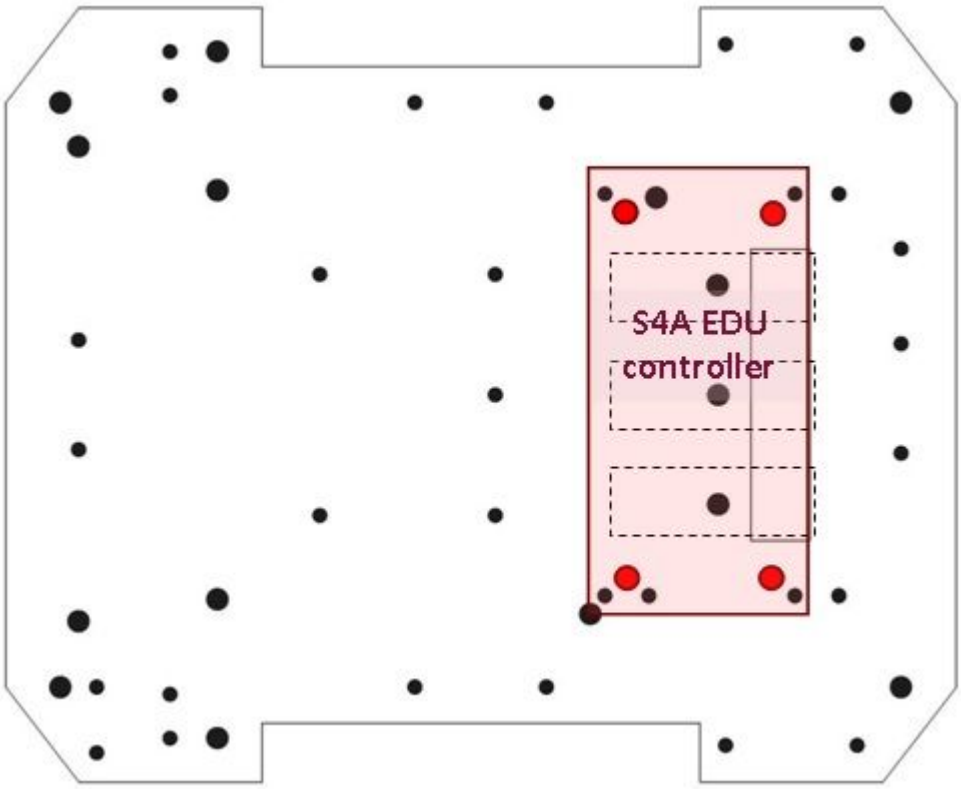
Top board: Power switch and battery charger socket



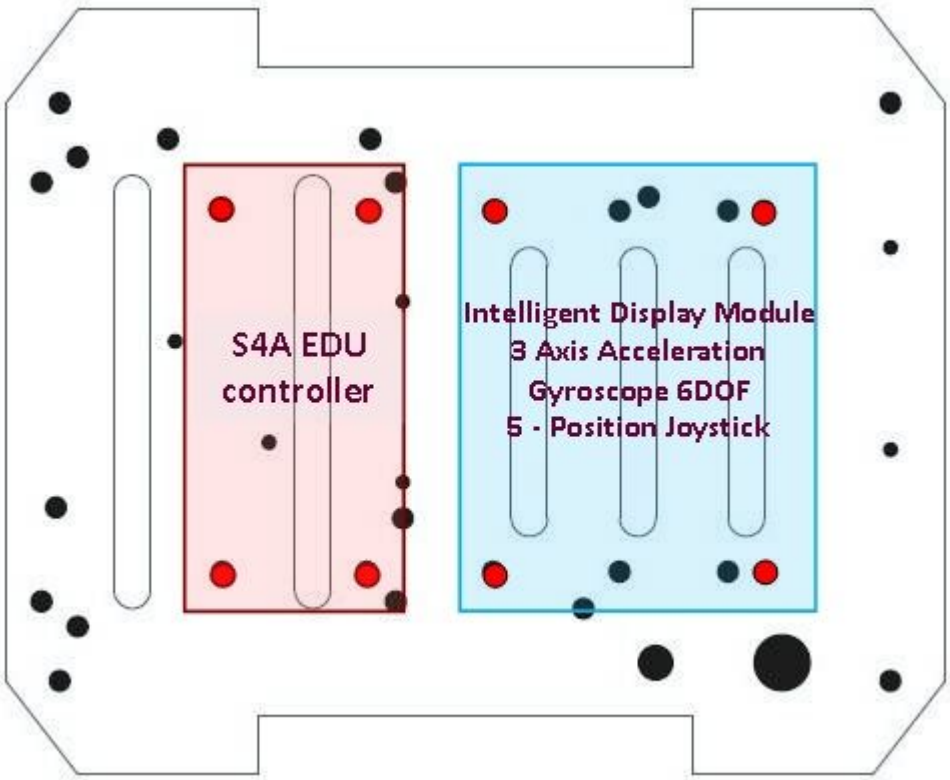
Bottom board: Line sensors



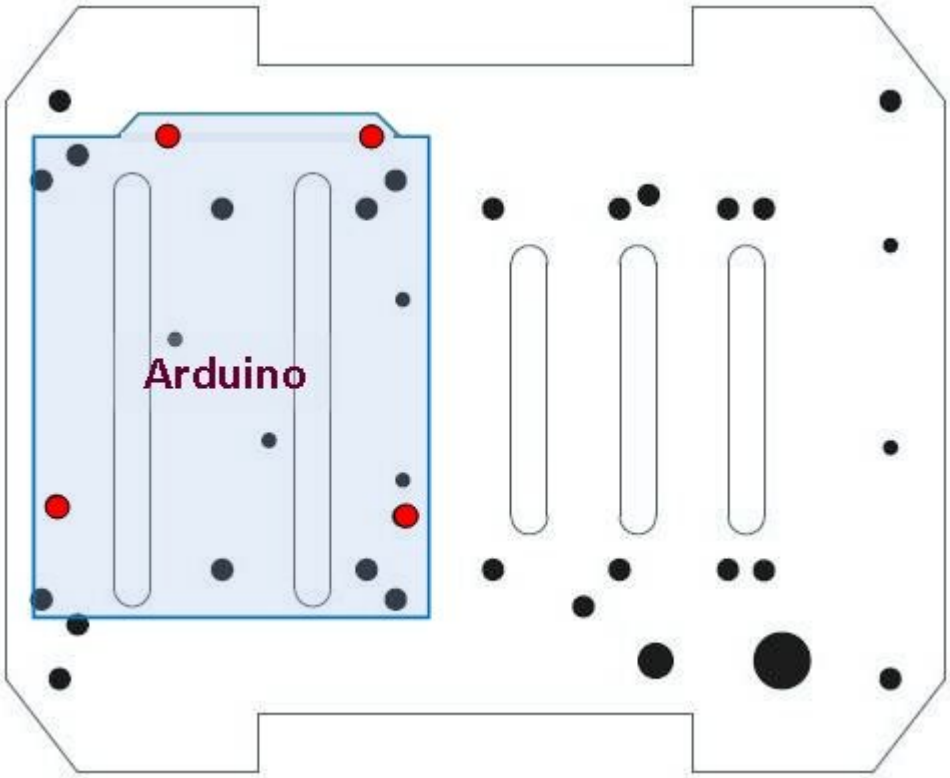
Bottom board: DAGU S4A EDU robot controller module (placed under lines ensors)



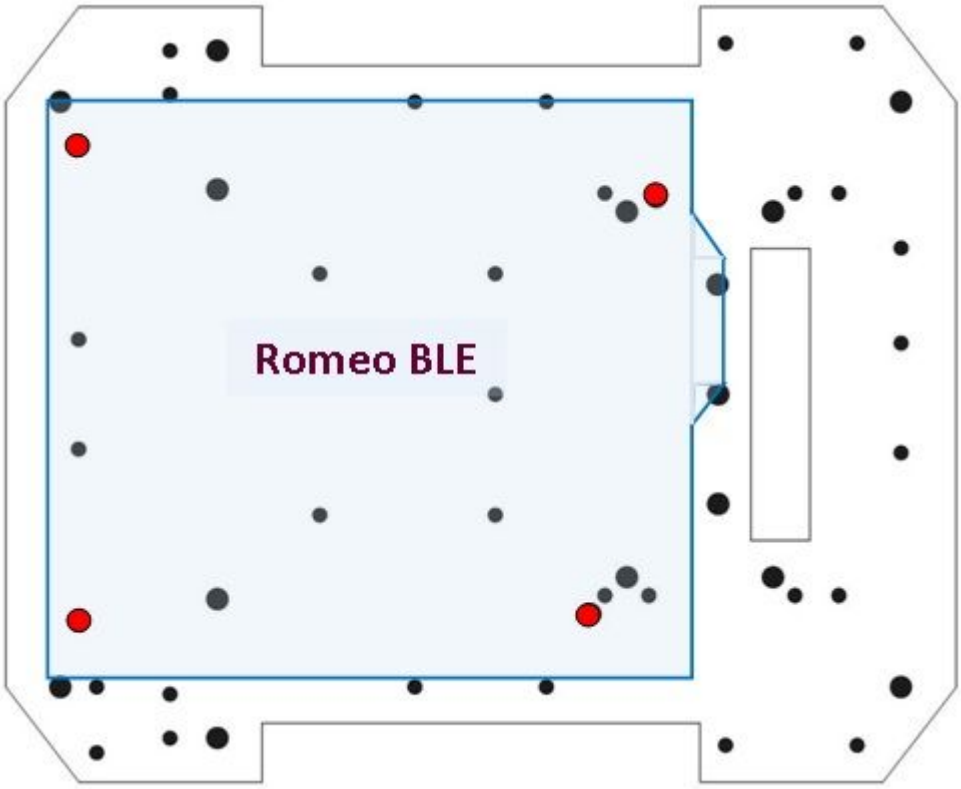
Top board: DAGU S4A EDU robot controller module and (oprionally) display module, accelerometer, gyroscope and joystick



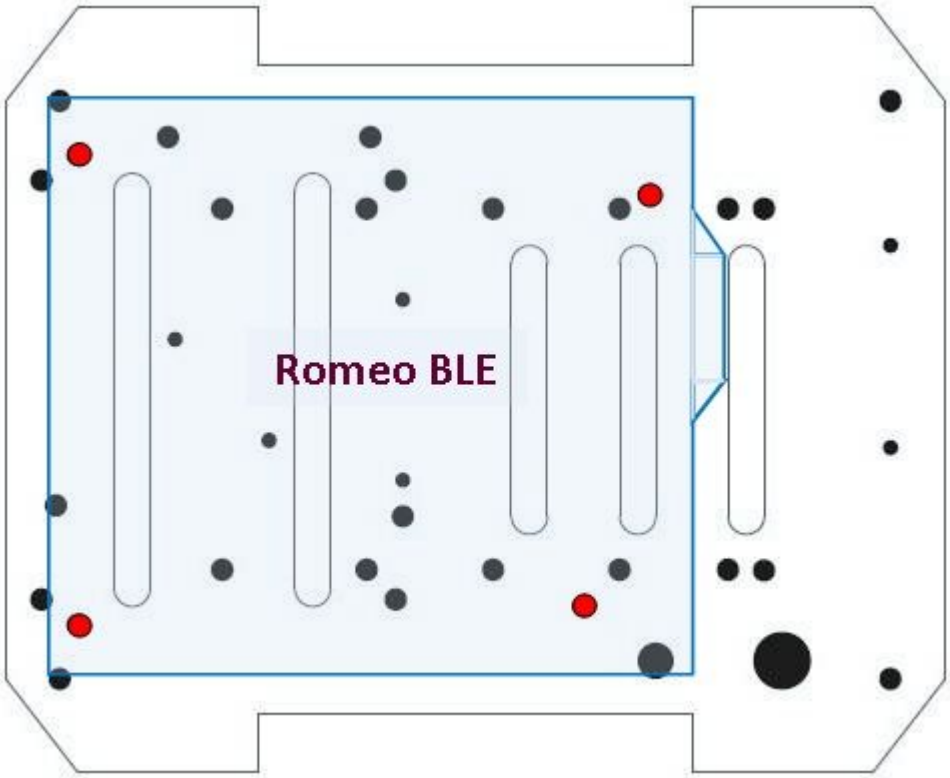
Top board: ARDUINO module



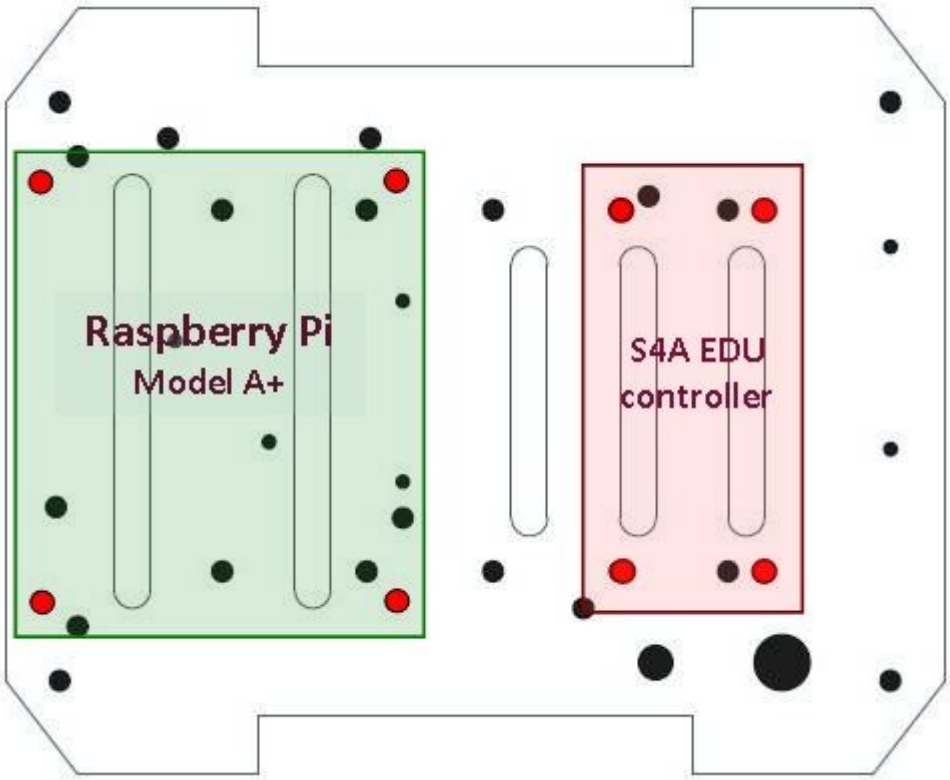
Bottom board: ROMEO BLE robot controller module



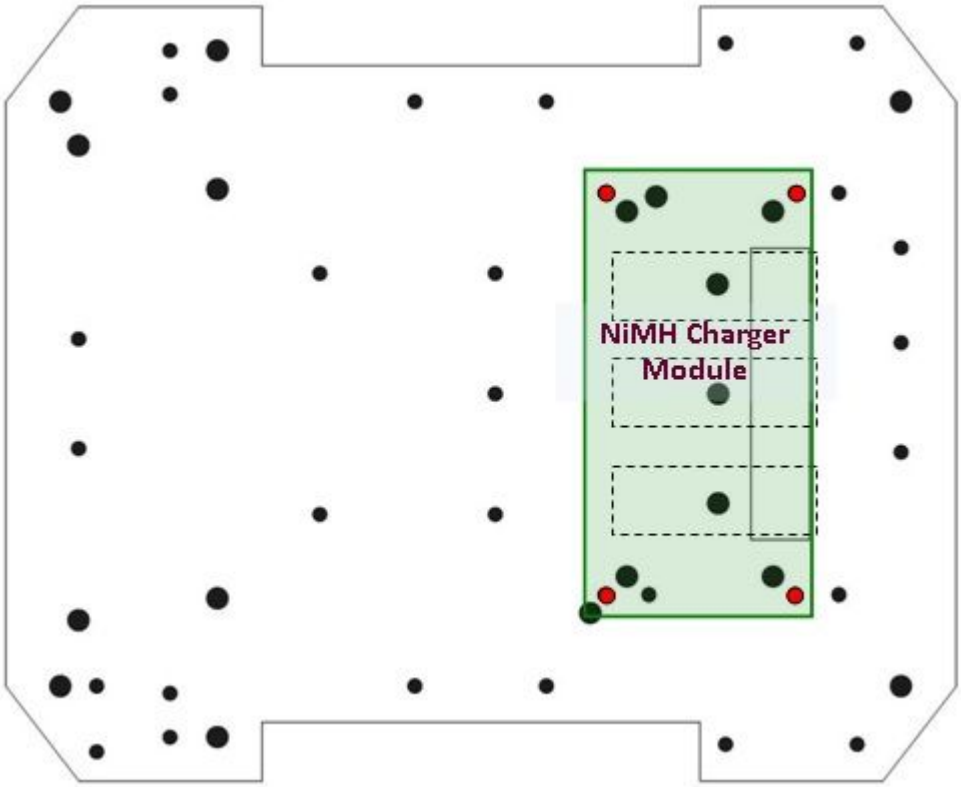
Top board: ROMEO BLE robot controller module



Top board: RASPBERRY PI (A+ model) module and DAGU S4A EDU microcontroller module

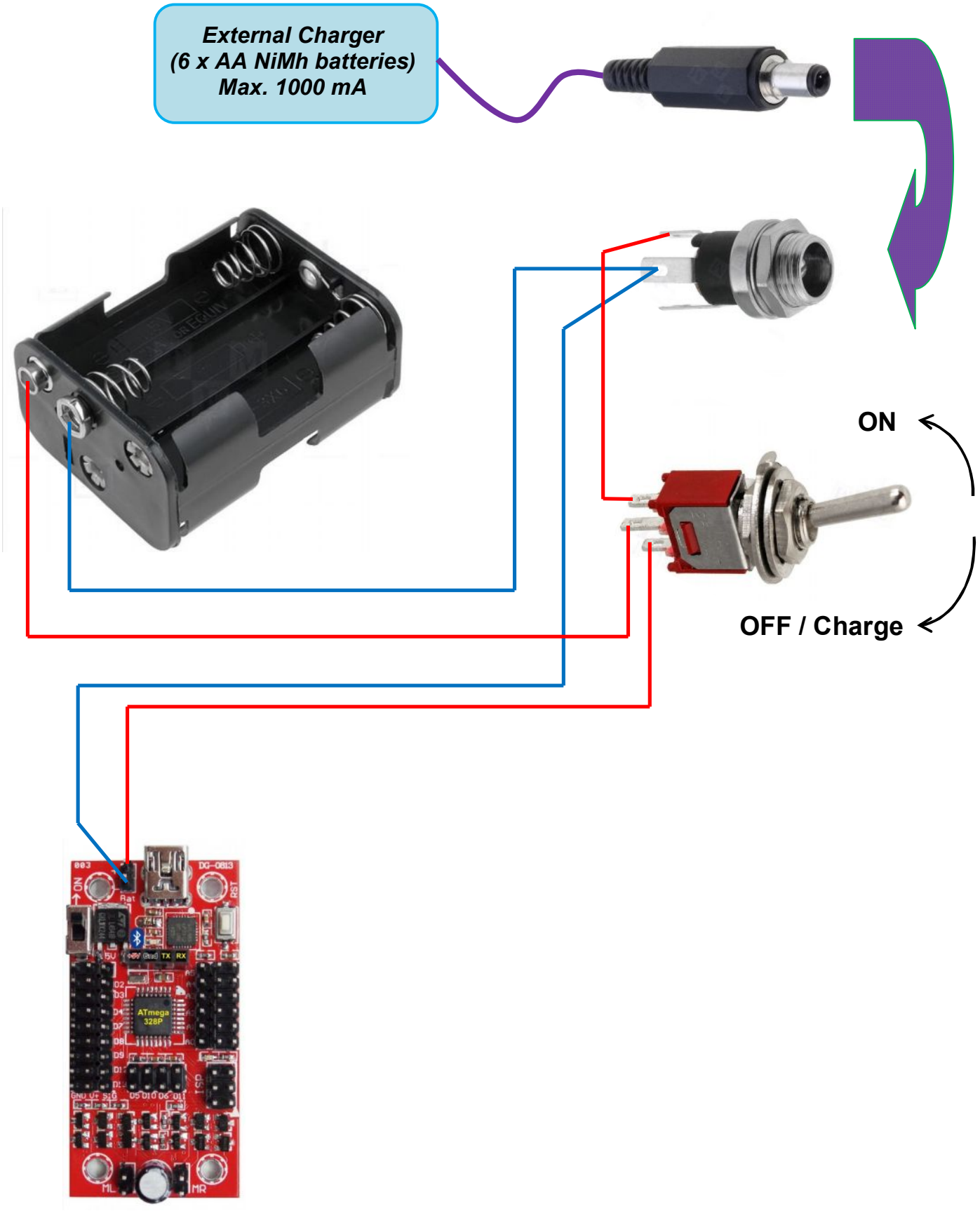


Bottom board: NiMH battery charger unit (placed over line sensors)



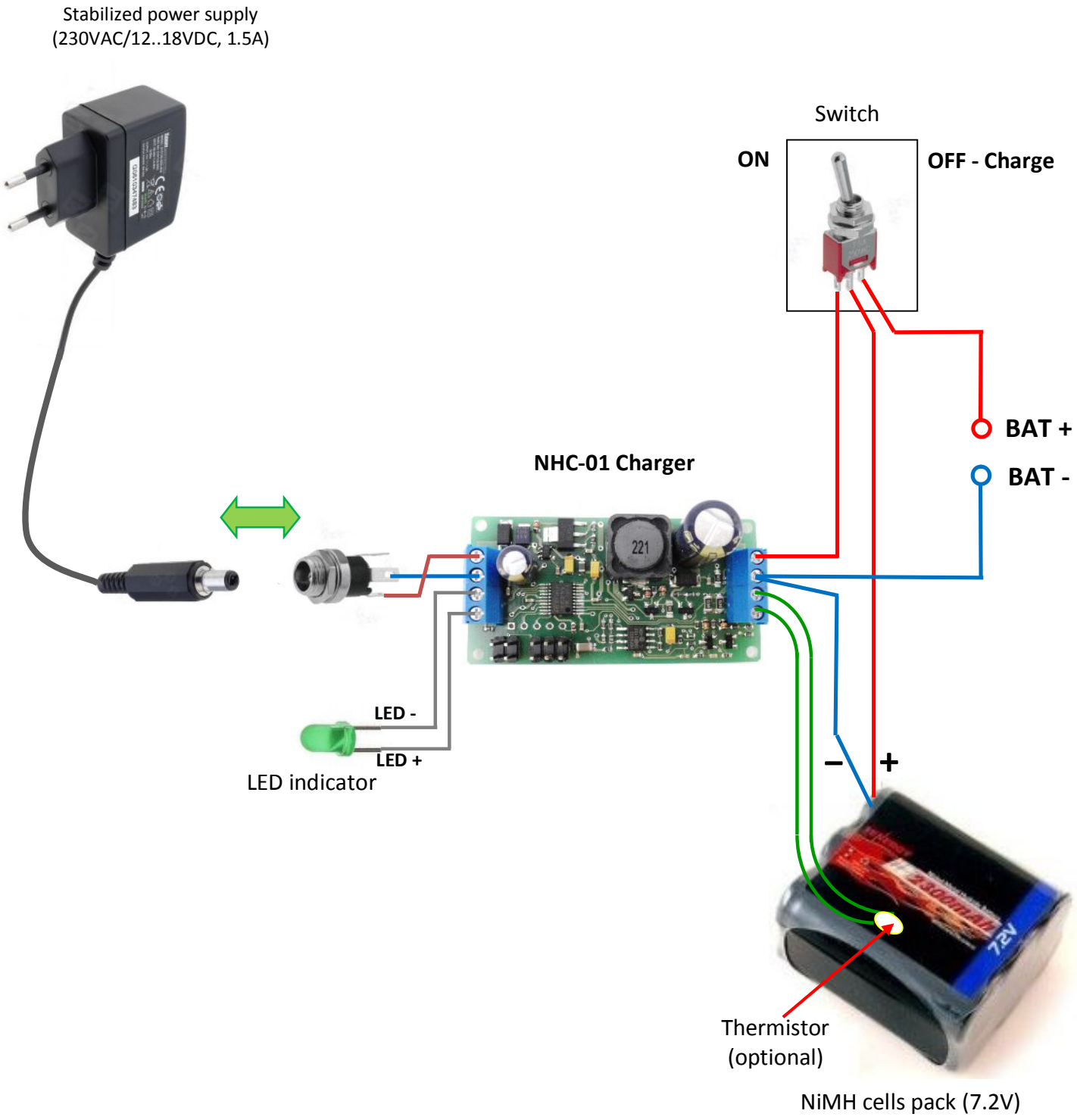
AMEX Mini Robot

Schematic diagram of DAGU S4A EDU controller and external Charger

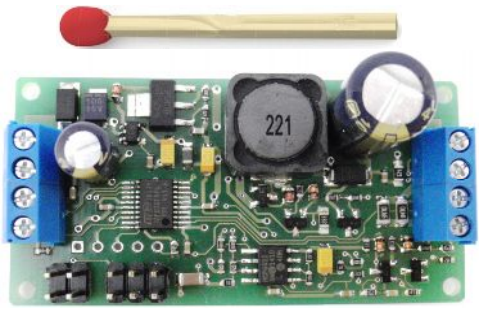


AMEX Mini Robot

Schematic diagram of the charger (embedded to AMRobot), external power supply, power supply connector, NiMH battery pack, thermistor, LED diode and a switch



Smart Charger Module for NiMH Battery Packs
Model No.: NHC-01



DESCRIPTION

The NHC-01 is a professional, processor-controlled charger module for NiMH battery pack for AA and AAA cells (1000…2800 mAh) intended to build into mobile devices, mobile educational robots and other apparatus. It has the possibility to set different charge currents and number of cells. This charger module can charge 2..8 pcs series NiMH battery.

Because of small dimensions of the NHC-01 (60 mm x 30 mm x 17 mm) it is ideally suited to build into many devices (for OEM and DIY) which normally require inconvenient and frequent removing of battery cells from battery holder and moving them to an external charger. The possibility of building the NHC-01 charger module into different devices is very unique, practical and economical solution for many users and designers in the field of electronics and robotics.

The NHC-01 charger module requires only external power supply (AC/DC adapter or other power supply source; (230VAC/9..18VDC, 1.5A). The charger module employs several algorithms to detect the end of the charge. They ensure high reliability and make the battery to be fully charged without the risk of overheating and overcharging. Configuring the charger is very simple and boils down to proper setting of jumpers build into the charger.

Indication of current work mode is signaled by a LED diode. It is also possible to connect an optional NTC thermistor to measure temperature of the battery cells. The thermistor ensures the most accurate detection of the end of charge at higher charge currents.

FEATURES: Smart DC Charger Module for OEM and DIY

Basic NHC-01 parameters:

- Charging current: 125 mA, 250 mA, 500 mA, 1000 mA
- Cell capacity: 1000..2800 mAh (cells are connected in series)
- Number of cells: 2, 3, 4, 5, 6, 7, 8 (2.4V – 9.6V)
- Power supply voltage: 9..18 VDC (from external power supply : 230V AC/9..18 VDC, 1.5A)
- Small dimension (LxWxH): 60 mm x 30 mm x 17 mm
- Ambient operation temperature: 0°C to +40°C
- Ambient operation relative humidity: 20% to 85%
- Applications: excellent for building in battery charging function inside your device or build your own battery pack charger

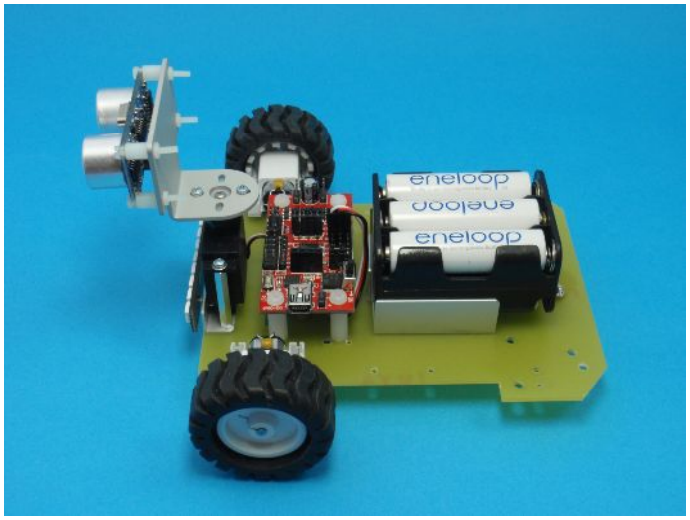
Examples of use:

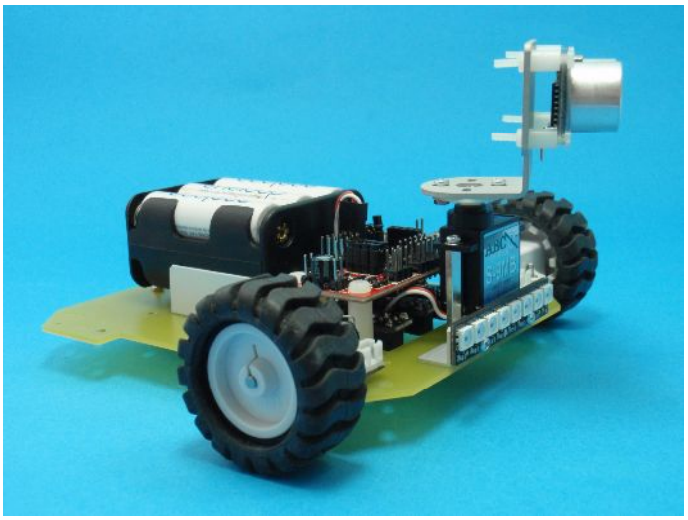
- mobile robots
- measurement instruments
- mobile devices

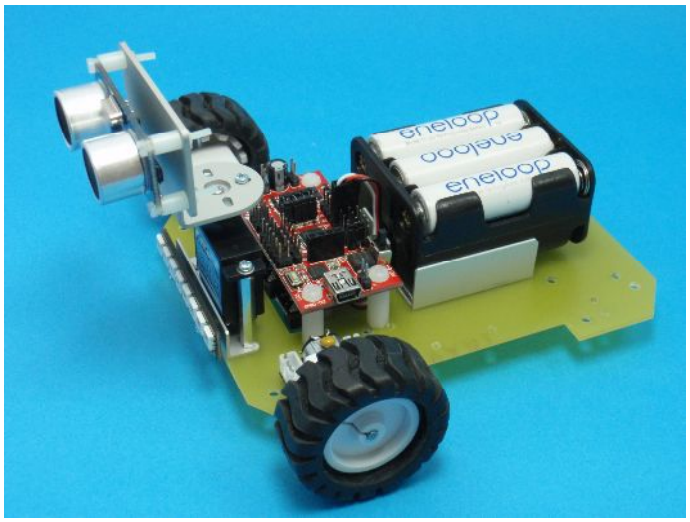
Producer:
AMEX Research Corporation Technologies
Address: PL 15-692 Bialystok,
Elektronowa Str. 6, POLAND
Tel.: +48 602723295, Fax: +48 856530703
website: www.amex.pl
e-mail: amexinfo@amex.pl

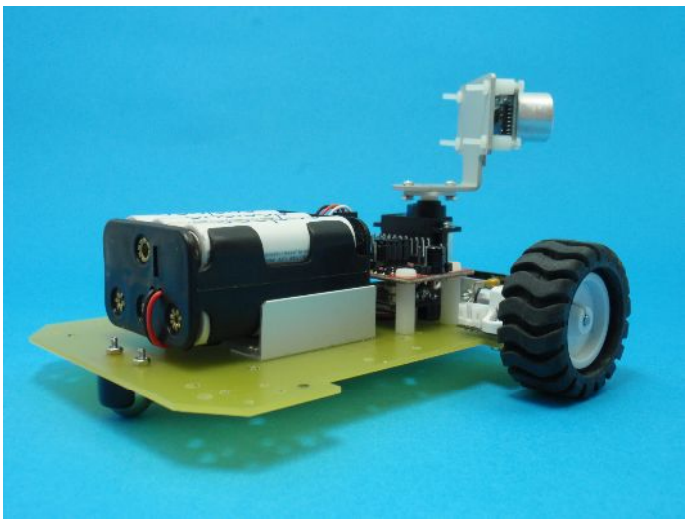
PHOTO GALLERY

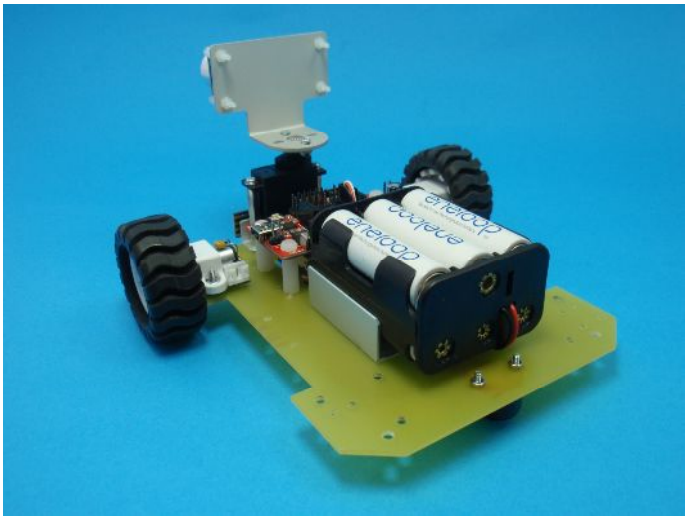
Version 1a

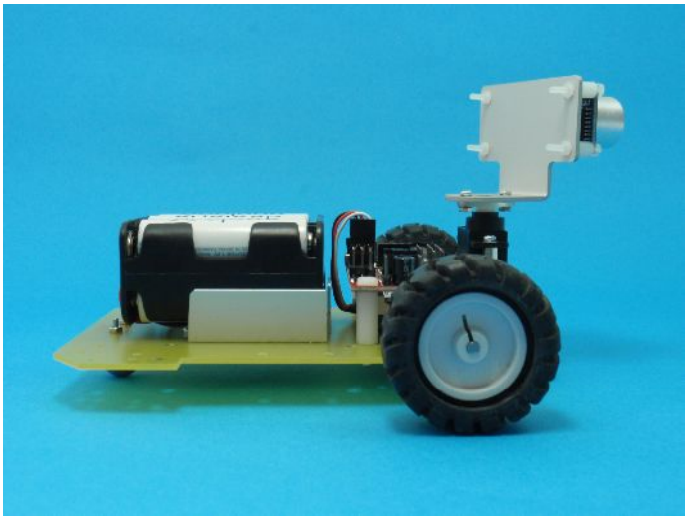












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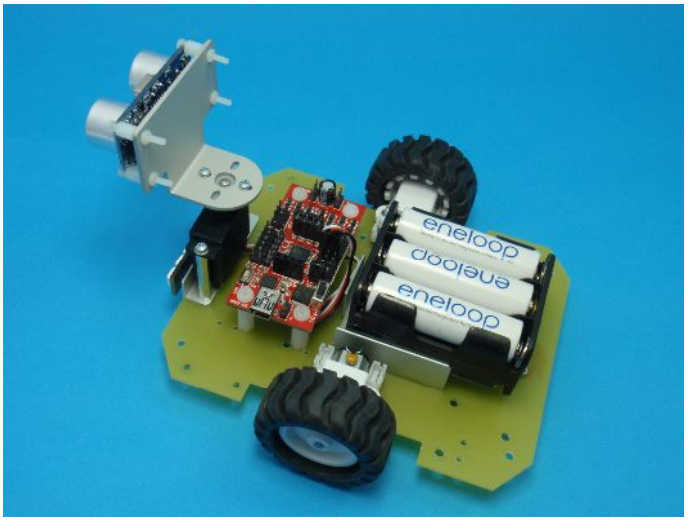
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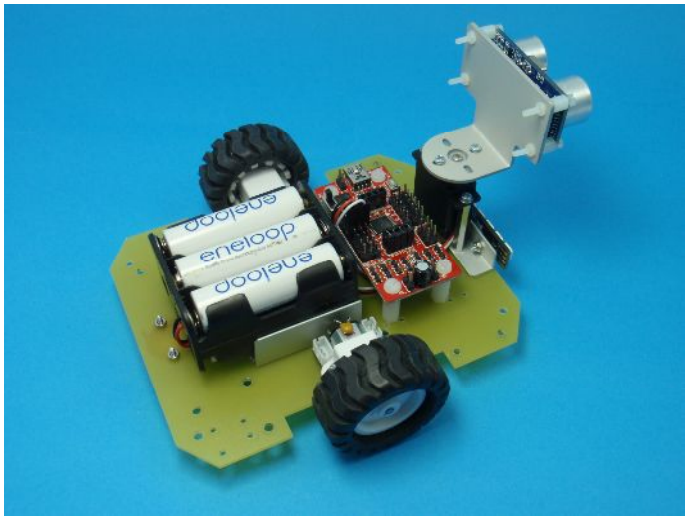
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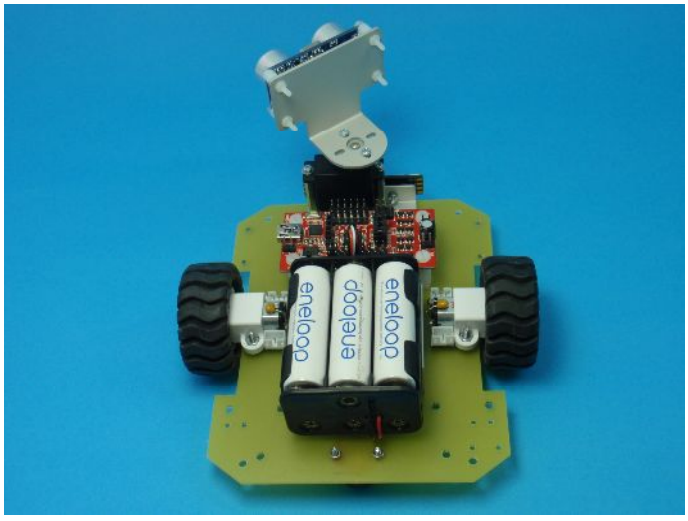
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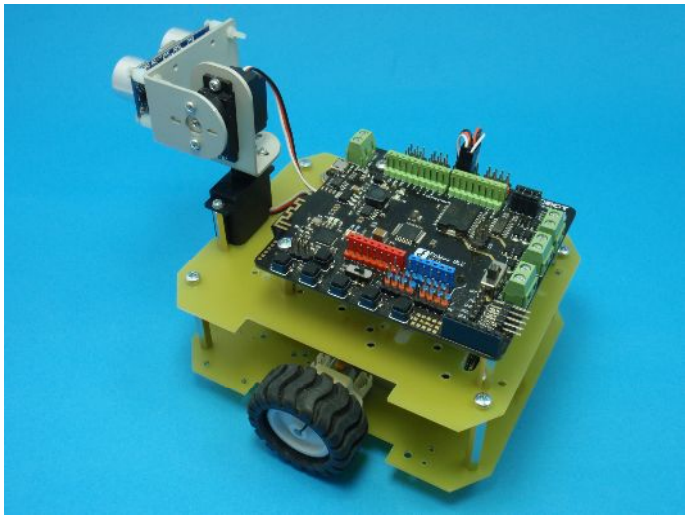

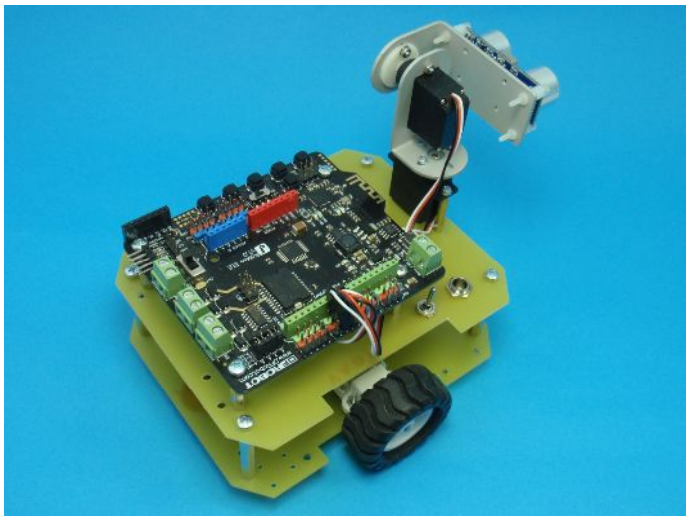

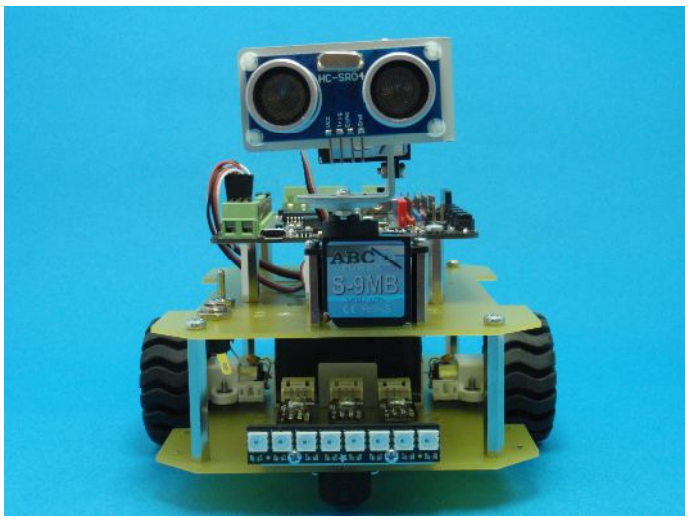
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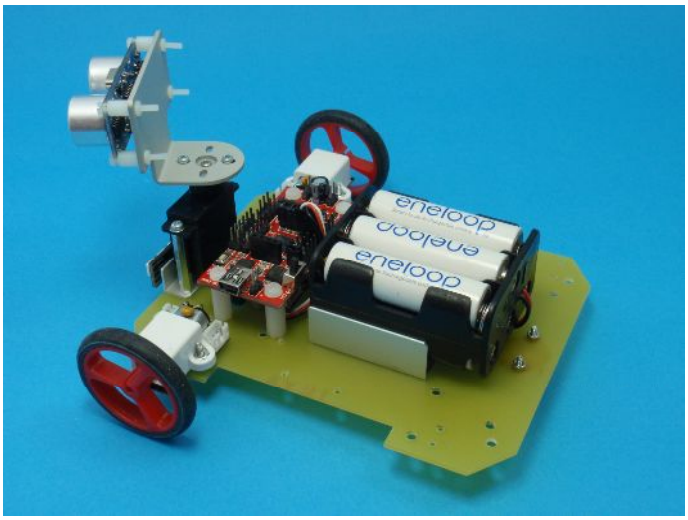
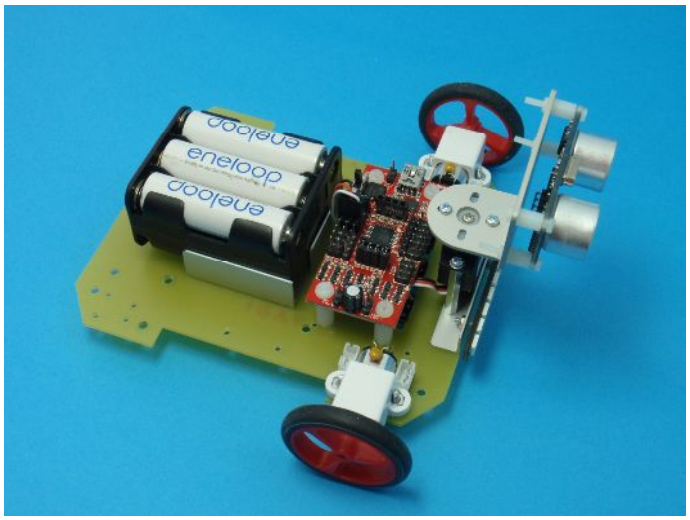
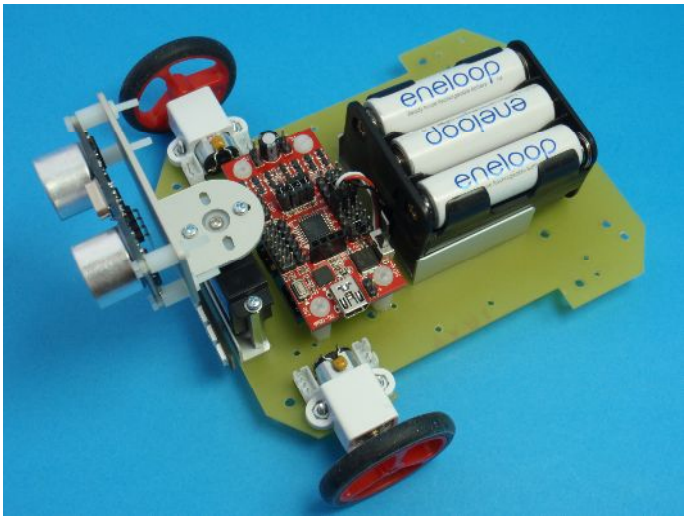
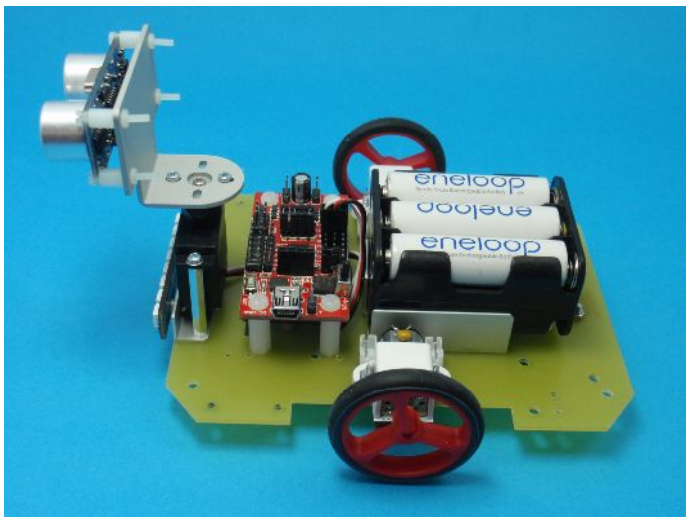
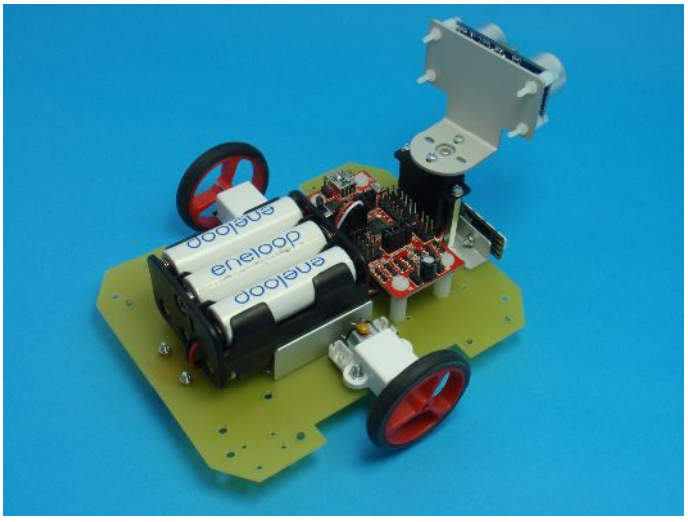
Version 2a, 2b

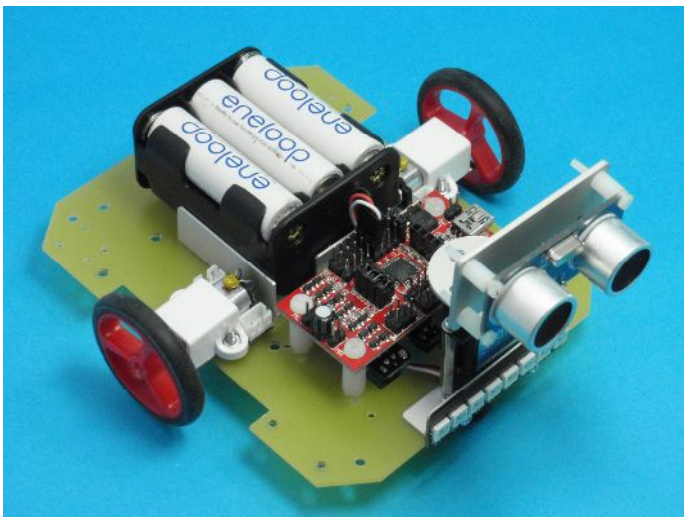












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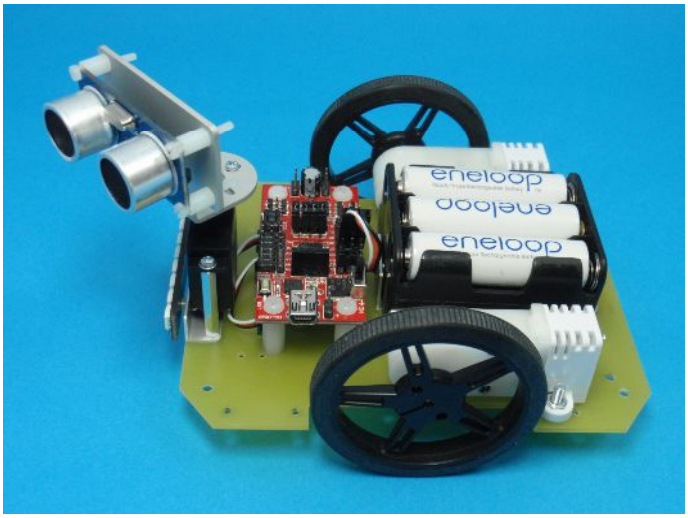

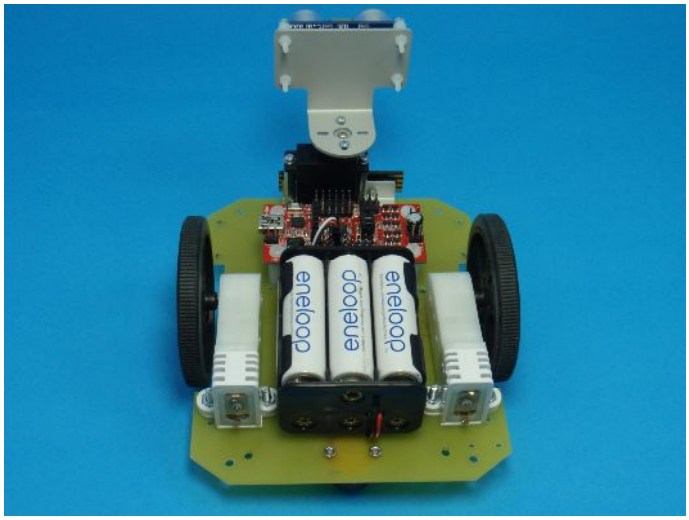

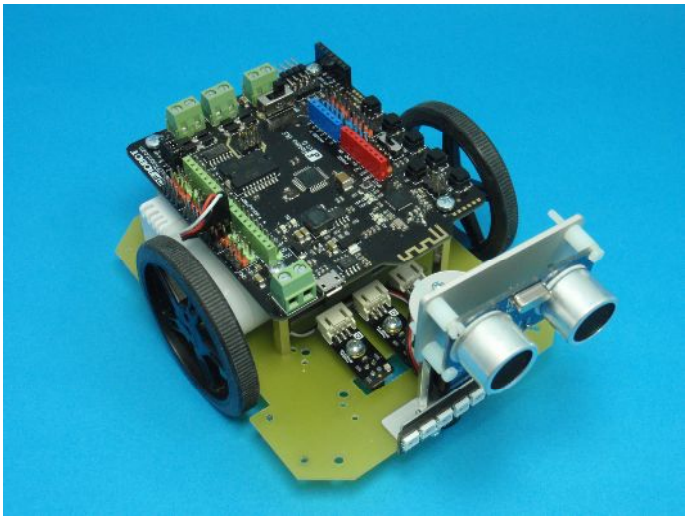

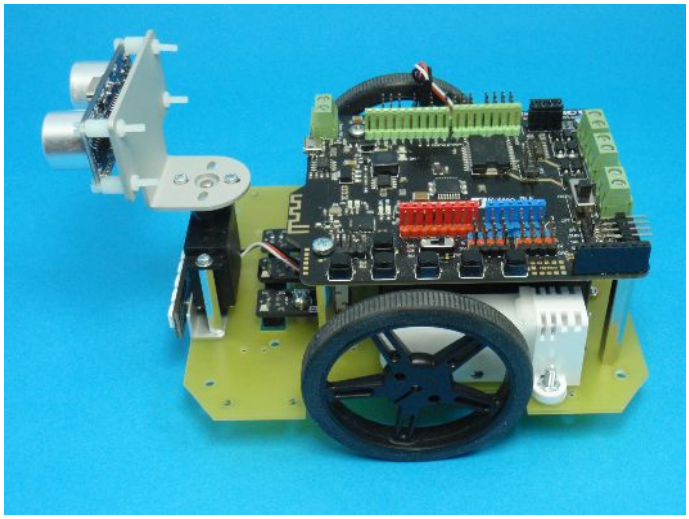

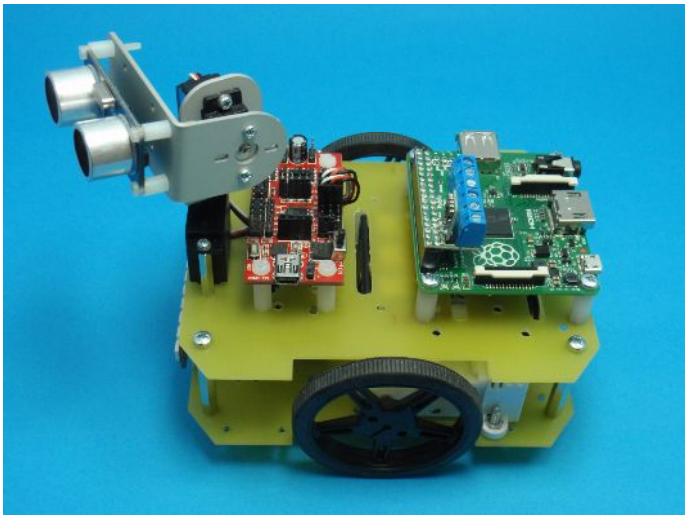

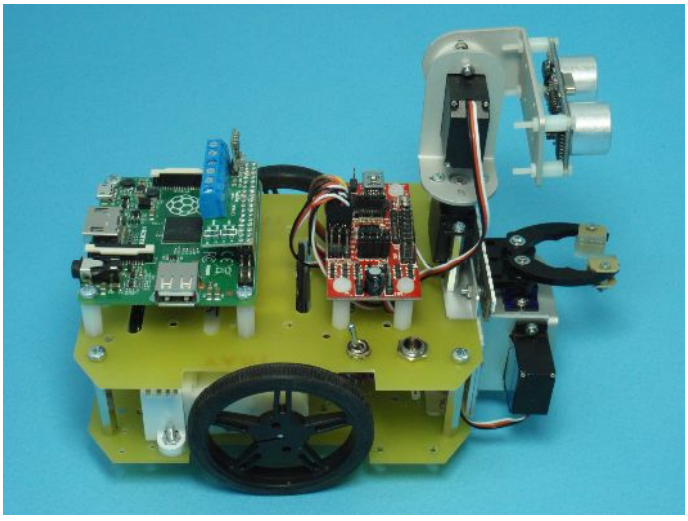

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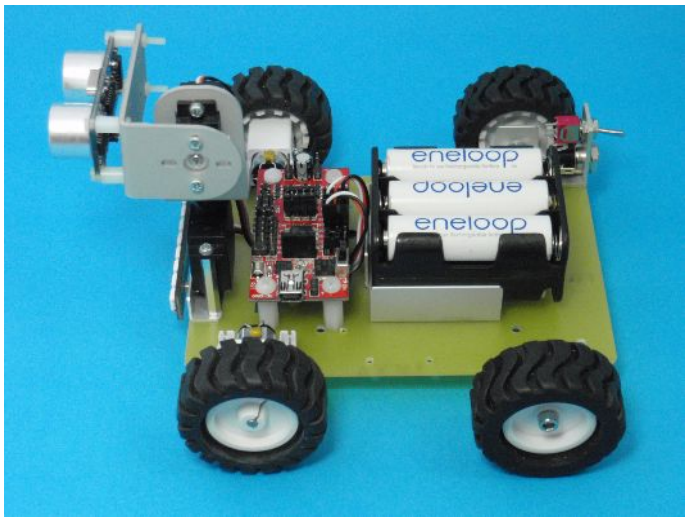
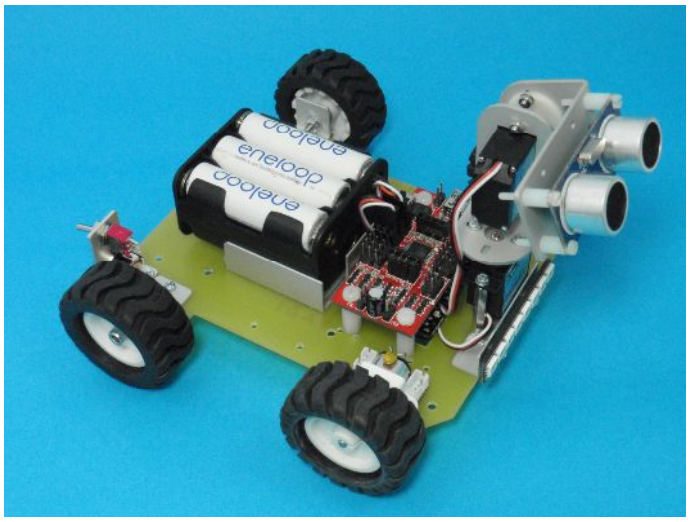
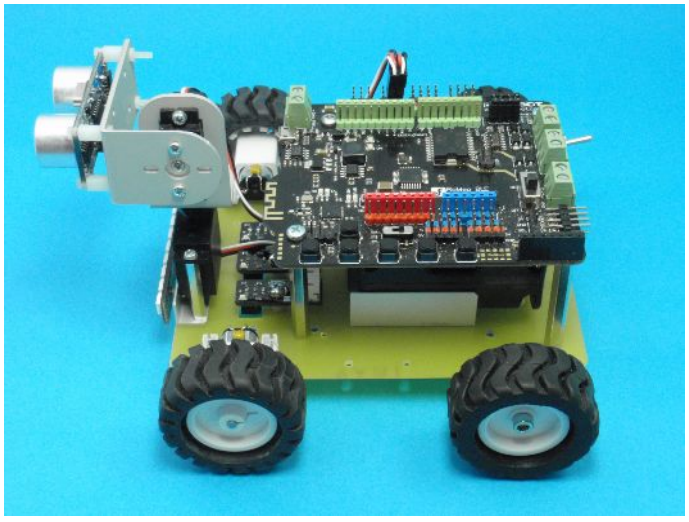
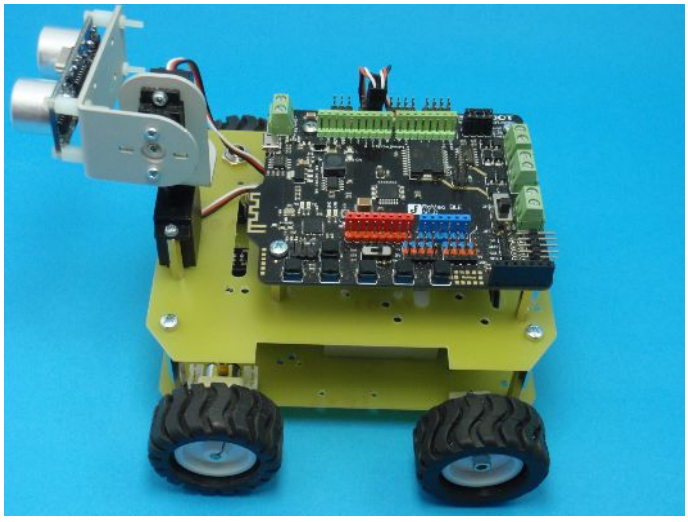
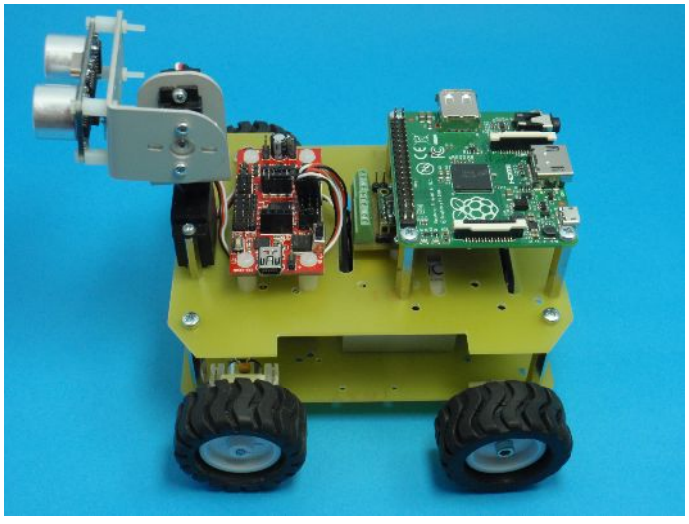
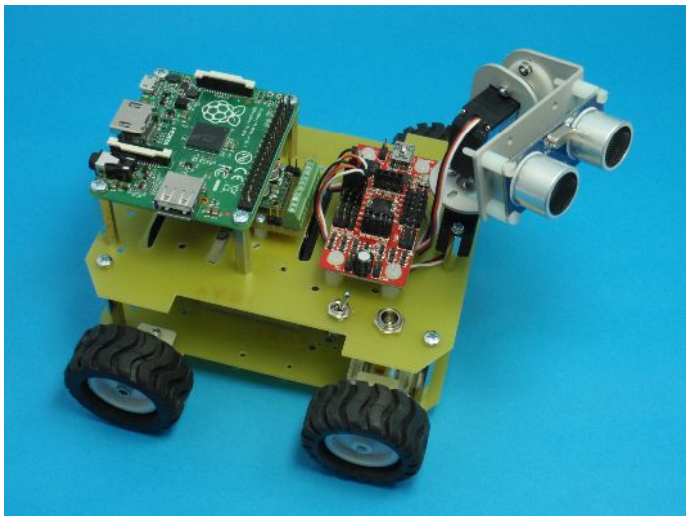




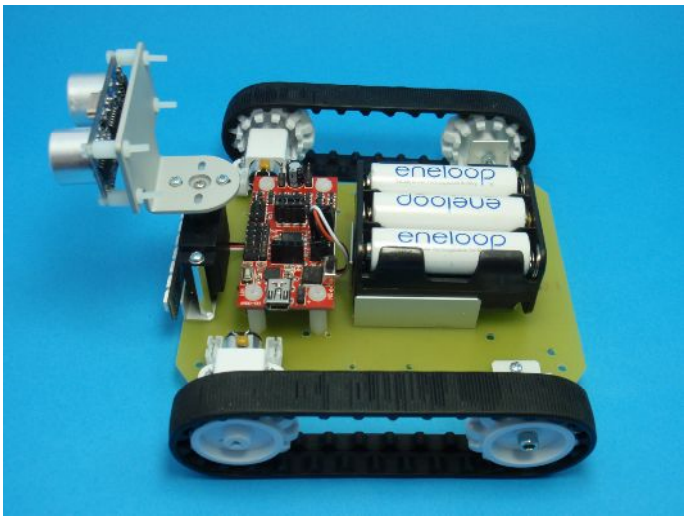


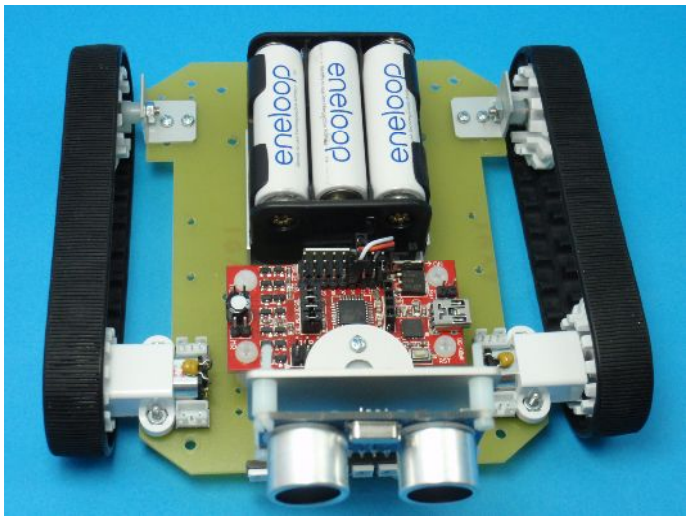


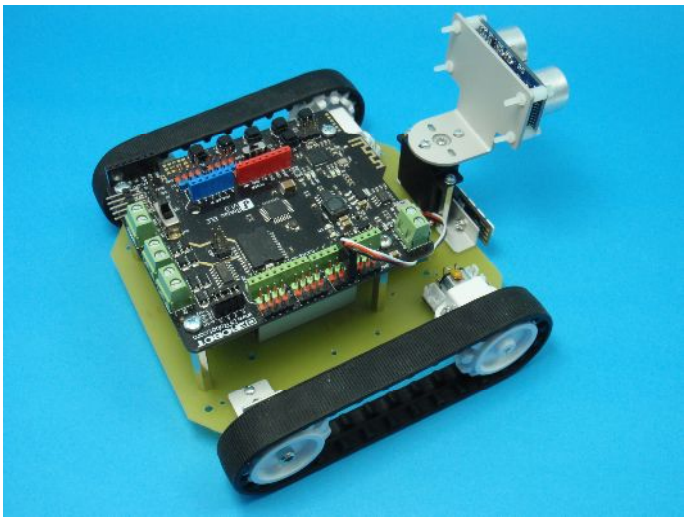


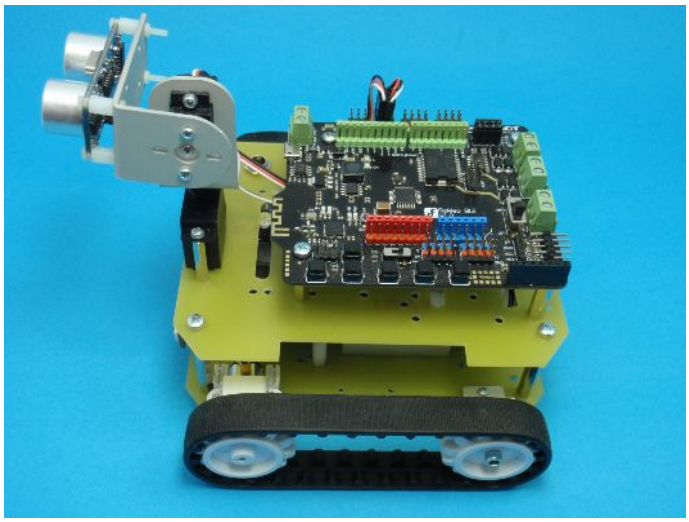


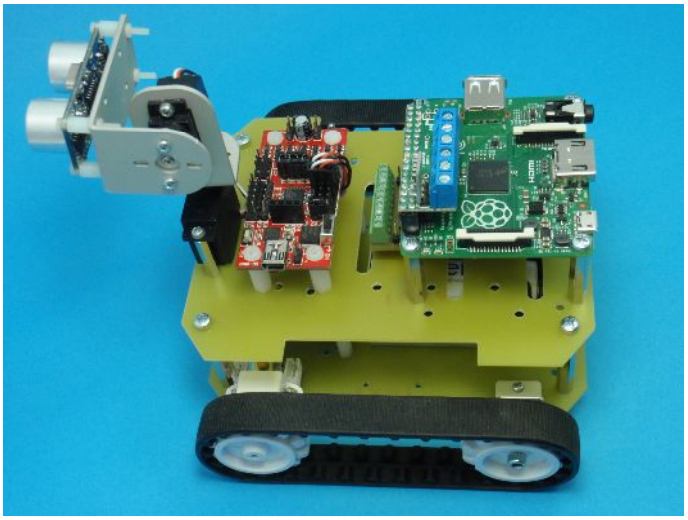
Version 5

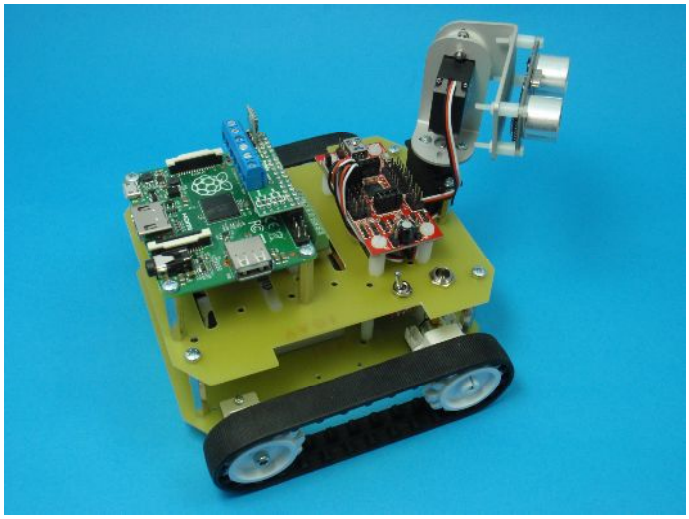












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