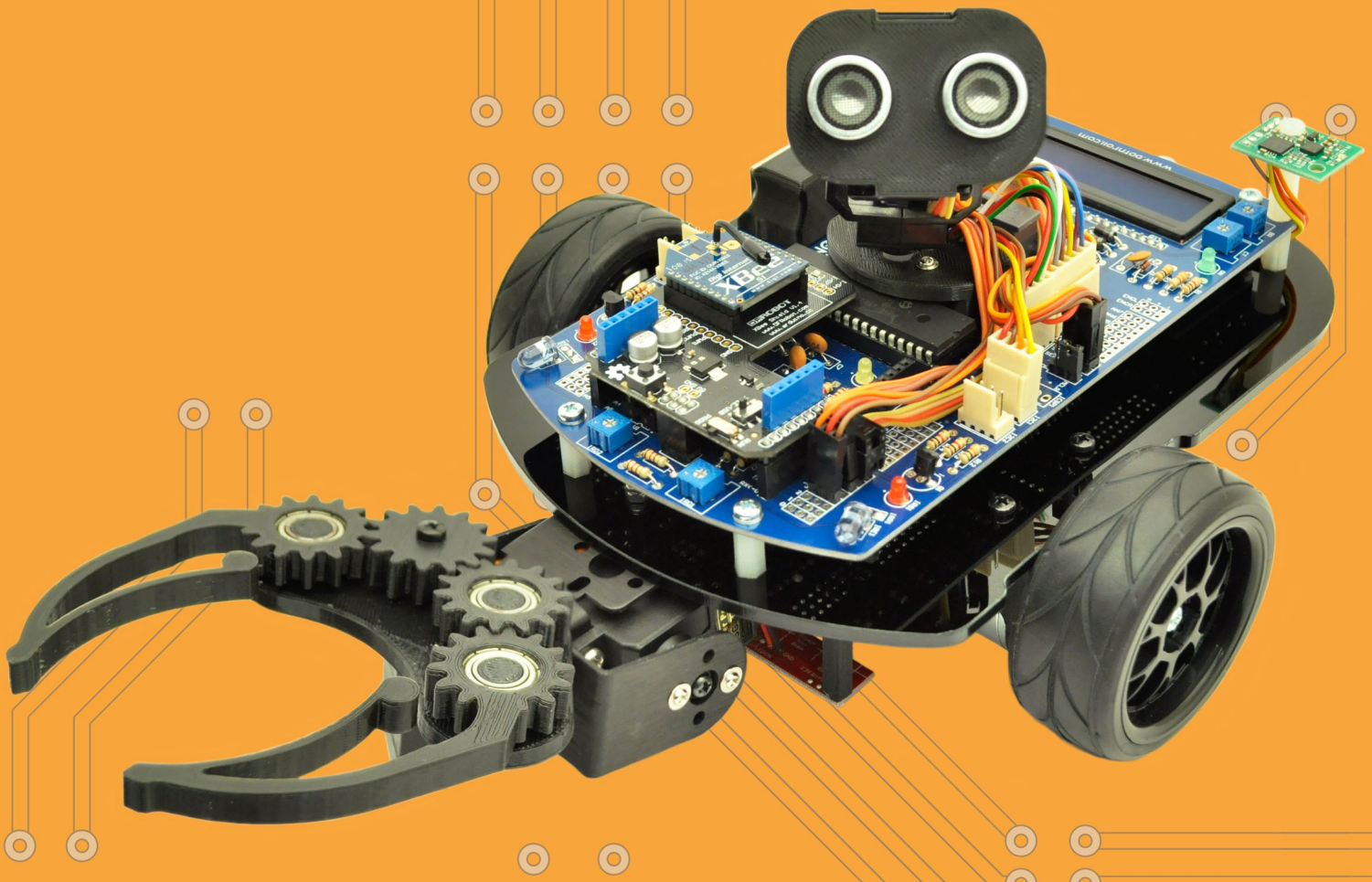
bot'n roll

ONE

build your own robot



extras assembling
user manual

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Document Revision: May 29th, 2023

1. LINE FOLLOWER

The Line Follower (Pololu© QTR-8A) has 8 analog infrared sensors which Bot'n Roll ONE A can use to follow a line.

Cables previously prepared and two KK connectors establish the link between the Line Follower and Bot'n Roll ONE A.

Together with the Line follower, the following parts are supplied:

- 2 x 35mm PLA stands
- 2 x M2x4mm screws
- 2 x M2x10mm screws
- 1 x 4 pins KK male connector
- 1 x 6 pins KK male connector

Fig. 1: Line Follower

1.1 PLACING THE LINE FOLLOWER

Remove the battery and remove the printed circuit board from the robot unscrewing the six M3x6mm screws to gain access to the holes of the acrylic base.

The acrylic base has three sets of 2mm holes that allow you to place the line follower in three different configurations: **forward**, **central** and **backward**.

Fig. 2: Three different configuration options

The **forward** position of the line follower is far away from the wheels and this allows a better control of the robot movement when following the line, however, it may limit the robot mobility on steep ramps.

The **backward** configuration allows Bot'n Roll ONE A to easily overcome steep ramps because the line follower is placed beside the wheels. However, it is more difficult to control the robot, in terms of software, to follow the line.

In the **central** position, you have a balance between the two extreme configurations, i.e., better movement control than the **backward** configuration and better mobility than the **forward** configuration.

Fix the line follower supports to the acrylic base using the longer screws.

Fix the line follower to the supports using the shorter screws.

IMPORTANT NOTE: The PLA is a plastic material, therefore do not tighten too much the screw, because you might grind the screw thread!

Use the central hole of the acrylic base to guide the line follower cables from bottom to top.

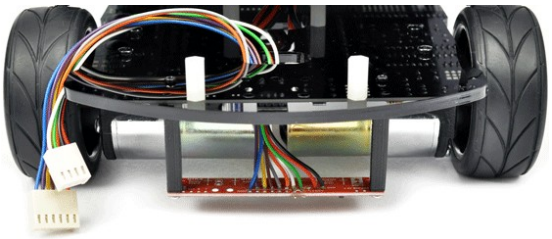

Fig. 3: Line follower on the acrylic base

1.2 ELECTRICAL WIRING OF LINE FOLLOWER

To electrically connect the Line Follower to the Printed Circuit Board, two KK male connectors are supplied which must be soldered to the **Bot´n Roll ONE A**.

Solder the 4-pin KK male connector on "**LF1**".

ATENTION: Respect the orientation indicated on the serigraphy, otherwise, you will permanently damage the Line Follower!

Solder the 6-pin KK male connector on "**LF2**".

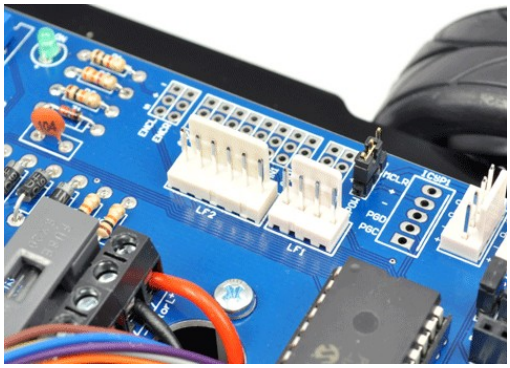

Fig. 4: Line follower connectors

The Line Follower cables must be guided through the central hole on the Printed Circuit Board up to the connectors.

The 4 wires cable is plugged on the "**LF1**" and the 6 wires cable on the "**LF2**".

ATENTION: Always perform the electrical wiring with the robot powered OFF!

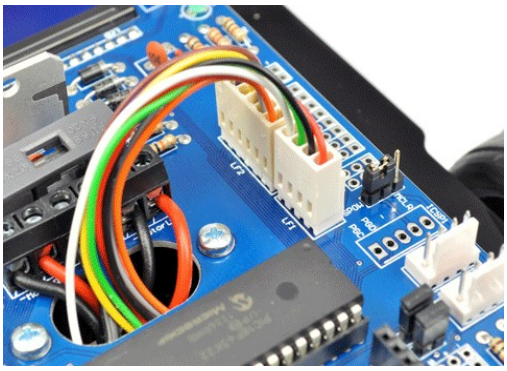

Fig. 5: Line follower electrical connection

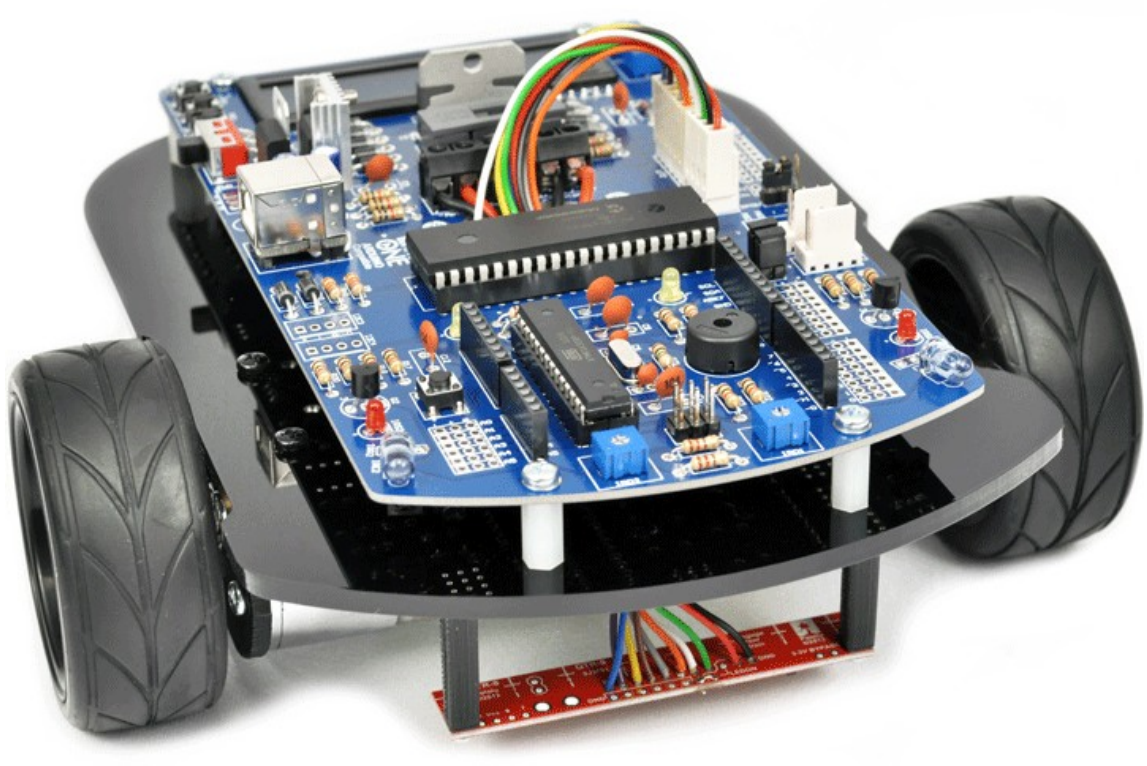

Fig. 6: Line follower assembled on Bot'n Roll ONE A

1.3 SOURCE CODE EXAMPLE AND TESTING

Load the sample program "***_01_SensorRead***" located on "***File -> Examples -> BnrOneA-> LineSensor -> _01_SensorRead***" to your Bot'n Roll ONE A. When the program starts you will be able to see the analog to digital conversion values of each of the **8** sensors, on the LCD. The values vary between 0 and 1023. Lighter colors have values near 0 and the dark colors have values near the 1023.

Lift the robot and check that the values are all near 1023, and afterwards put the robot on top of a white paper and check that the values are near 0.

If any of the 8 sensors do not change, check that the Line Follower cables are correctly placed and if there are short-circuits or bad solders on:

- **LF1** connector;
- **LF2** connector;
- PIC18F45K22 **integrated circuit socket**.

On ***"File -> Examples -> BnrOneA-> LineSensor ->..."*** there are some programs to explain the usage of the Line Follower to make the robot to follow a line. Study and improve these sample programs because line following is one of the more interesting challenges that **Bot'n Roll ONE A** provides you!

Note: For more information about the Pololu© QTR-8A Line Follower check the document "QTR-8x.pdf" present on your Bot'n Roll ONE A documentation.

2. CMPS12 COMPASS

The **CMPS12** compass is an I2C device to help navigating. The electronic compass indicates the robot heading direction relative to the Earth's magnetic pole.

The compass returns the heading **direction** (bearing) value in two bytes, a 16 bits Word. The value varies between 0 and 3599, corresponding to degrees within a range of 0º to 359.9º.

The CMPS12 compass perform tilt compensation. Integrates a three axes (x, y, z) magnetometer and accelerometer and uses both sensors to calculate the orientation accurately.

Fig. 7: CMPS12 compass and accessories

The compass also measure the robot inclination in two axes, returning the "**Pitch**" and "**Roll**" angles.

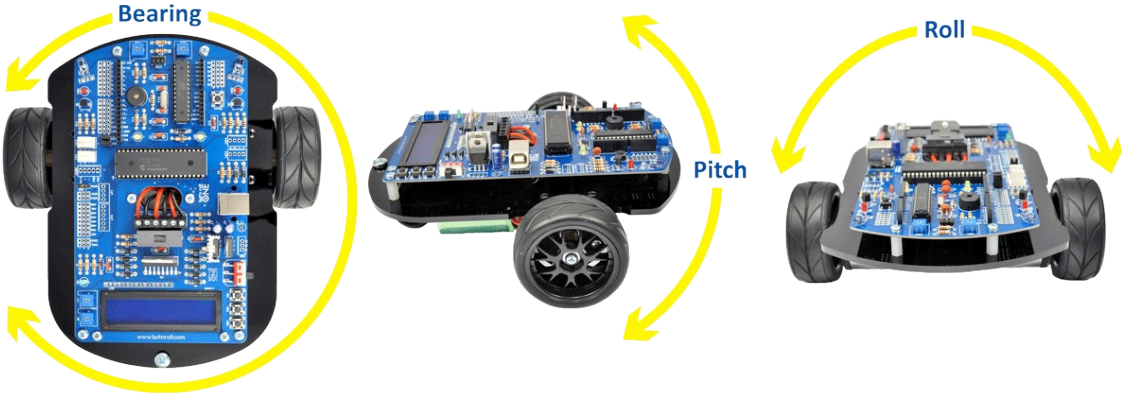

Fig. 8: Bearing, Pitch and Roll

The compass orientation "***Bearing***" corresponds to the rotation over the perpendicular axis of the robot.

The "***Pitch***" corresponds to a rotation over the wheels axis.

The "***Roll***" corresponds to a rotation over the previous perpendicular axis but on the acrylic base plane.

2.1 PLACING THE COMPASS ON BOT'N ROLL ONE A

To place the **CMPS12** Compass on **Bot'n Roll ONE A** both 18mm nylon spacer and screws are supplied.

The compass is placed lifted and outside the robot's printed circuit board, not to suffer interference from the metal present in the robot components.

Remove the metallic screw that holds the PCB and tighten the 18mm nylon spacer instead.

Hold the compass to the nylon spacer using the supplied nylon screw, inserting it on one of the existing holes on the compass as described on the image.

Fig. 9: Placing the CMPS12 compass

2.2 ELECTRICAL WIRING OF CMPS12 COMPASS

The **CMPS12** compass can be connected to any of the I2C connectors available on **Bot'n Roll ONE A**: **I2C1**, **I2C2**, **I2C3** or **I2C4**.

Guide the compass cable through the central hole of the board and plug it to one of the I2C bus connectors available.

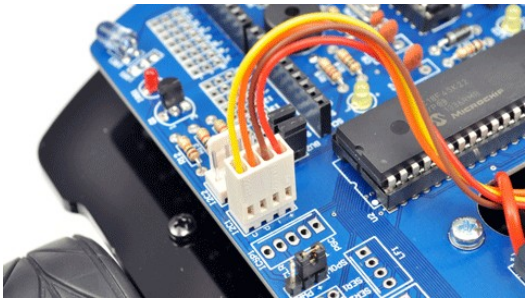

Fig. 10: Compass electrical connection

Together with the **CMPS12** compass, it is also supplied a 4-pin KK male connector which you can solder in any **I2C** connection available on the Printed Circuit Board. If you already have an I2C bus connector available for the compass you do not need to solder it now, you can do it later on!

Note: When soldering the connector, please check that you respect the orientation shown in the Bot'n Roll ONE A PCB board, otherwise you will not be able to communicate with the compass.

2.3 COMMUNICATING WITH CMPS12 COMPASS

Communication with the **CMPS12** compass is carried out through the **I2C** bus. The compass has the address 192 (C0 hexadecimal) by default.

In order to obtain the direction value (16 bits Word) you have to read from the compass two 1-byte registers. The direction most significate byte corresponds to **register 3** and the least significate byte corresponds to **register 2**.

It is possible to carry out a direction reading in one byte only (**register 1**), but on this case it varies between 0 and 255.

The reading of **register 4** returns the "***Pitch***" value in 1 byte (varies between -90 and +90).

The reading of **register 5** returns the "**Roll**" value in 1 byte (varies between -90 and +90).

It is possible to obtain the magnetometer and the accelerometer values, from each of the three axis. It is also possible to change the I2C compass address. You can check all this information on the **CMPS12** product page at **www.botnroll.com**.

2.4 SOURCE CODE EXAMPLE AND TESTING

Load the "***CompassRead***" sample program located on "***File -> Examples -> BnrOneA -> Extra -> CompassRead***" to your robot. When ready, it should show up on the LCD the direction, pitch and roll values updated every 100ms.

Change the orientation and inclination of your robot and check that the values also adjust accordingly.

If the values do not change check that the compass cable is properly placed, the **I2C connector** has been properly soldered with the **correct orientation** and that there are no short-circuits or bad solders on:

- **I2C1**, **I2C2**, **I2C3** and **I2C4** connectors;
- **R9** and **R10** resistors;
- ATmega328 **integrated circuit socket**.

Important Note: In order to use the I2C bus you cannot have any device using the **A4** and **A5** pins of the Arduino **A0-A5** connector!

3. PAN & TILT KIT

The ***Pan & Tilt*** kit allows horizontal and vertical rotational movements and is ideal to apply sensors and scan areas without moving the robot wheels.

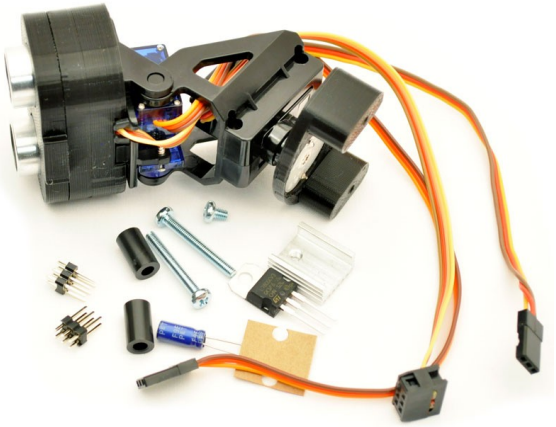

Fig. 11: Pan & Tilt kit

It is supplied pre-assembled with a PLA stand and two servomotors mounted on a metallic structure. To place it on the robot, the following parts are also provided:

- 2 M3x25mm screws
- 2 plastic spacers (without thread)
- 2 header connectors (3x2-pin)
- 1 LM7805 voltage regulator
- 1 heat sink and M3x4 screw for the LM7805
- 1 electrolytic capacitor (100µF)

The kit also contains one HC-SR04 sonar and its respective PLA case already part of the *Pan & Tilt* system.

The *Pan & Tilt* movements are achieved with two servomotors that move the system in two axis.

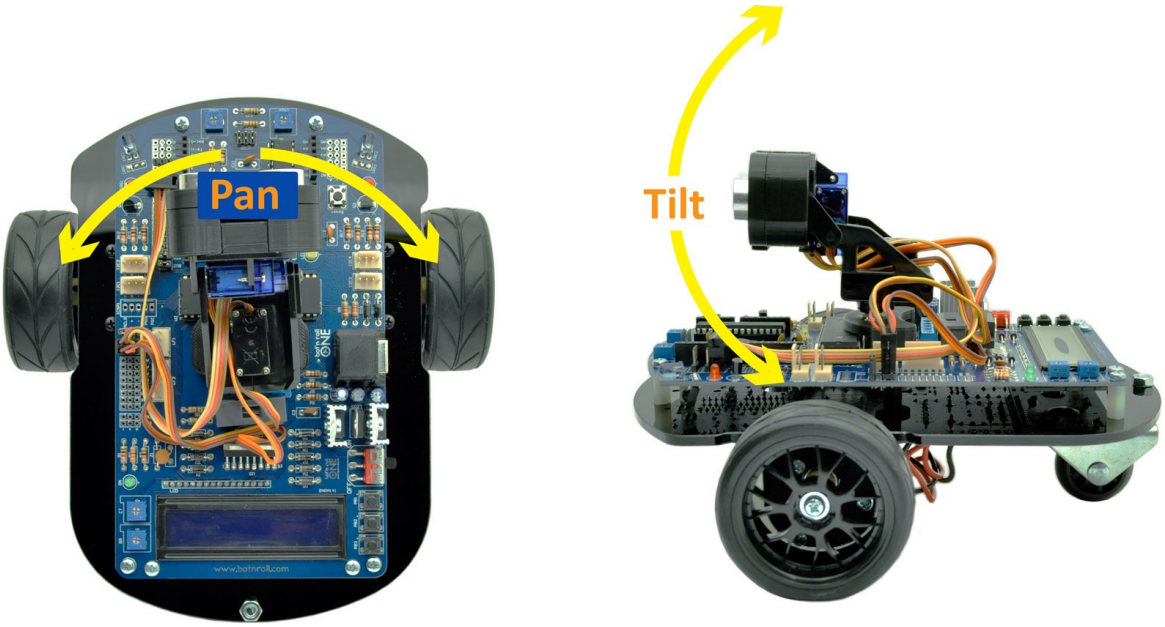

Fig. 12: Pan and Tilt

The "***Pan***" corresponds to the rotation over the robot perpendicular axis.

The "***Tilt***" corresponds to the rotation over the wheel's axis.

3.1 SONAR HC-SR04

A sonar is a device that measures how far away objects are by emitting sound waves and listening to the echo.

Fig. 13: Sonar HC-SR04

A sonar comprises a speaker and a microphone. The speaker emits an acoustic signal that travels through the air at approximately 340 meters per second. If the sound hits an object, it will be reflected to the sonar and detected by the microphone. The reflected sound is the **echo**, and the time that passes since the sound is emitted until the echo is received, tells the distance at which the object is from the sonar.

Fig. 14: Sonar on its support

The HC-SR04 sonar emits ultrasound, high frequency sound like that emitted by bats and it is not audible to the human ear. The HC-SR04 can accurately measure distances between 2 cm and 4 meters with accuracy of 3 mm.

The HC-SR04 sonar is controlled by the Bot'n Roll ONE A through a digital input and a digital output on pins **6** and **7** respectively, which connect to **Echo** and **Trig** pin of the sonar.

The sonar starts a reading when the robot places 5V on **Trig** pin during 10us. After starting reading, the sonar puts 5V on the **Echo** pin, sends ultrasonic waves through the air and when it receives the echo it puts 0V on the **Echo** pin. To find out how far away an object is, the robot must measure the time that the **Echo** pin has 5V and apply the formula:

Distance = **Echo time** x **Sound speed** / **2**

3.2 SOLDERING THE COMPONENTS ON THE BOARD

The LM7805 voltage regulator and the 100µF capacitor may already be in the circuit if you have previously assembled the **Bot'n Roll ONE A Gripper**. However, you must solder the 3-pin header connectors for servos and sonar.

According to the serigraphy, place the LM7805 where indicated "**PWR**". You must respect the component orientation, i.e., the double line on the serigraphy corresponds to the LM7805 metallic dissipater.

The 100µF capacitor has polarized terminals, place it on "**C6**". You must respect the electrolytic capacitor polarity or the component will be permanently damaged!

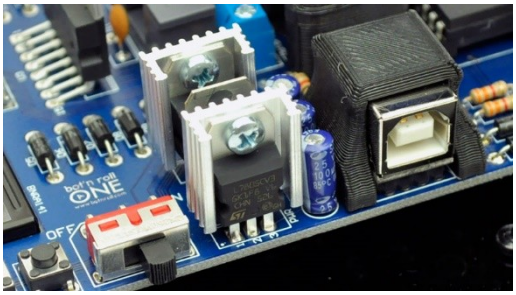

Fig. 15: Voltage regulator on "PWR" and "C6" capacitor

Solder the 3x2-pin header connector on "**SER1**", "**SER2**" and "**6**" and "**7**" pins of the connectors of the digital Arduino 0-7.

Configure the "**SPOW**" jumper, servo power, so that the central pin is linked to the **PWR** pin. This way, the servos are fed by the voltage regulator "POW" dedicated to the servos and not by the "**7805**" which powers the 5V electronics of the **Bot'n Roll ONE A**.

This jumper connection is important because if you have several servos working at the same time they will consume a lot of current, and the voltage will surely become unstable. The microcontrollers will block and restart if the voltage becomes unstable, so it is not good practice to have the servos and microcontrollers connected to the same circuit.

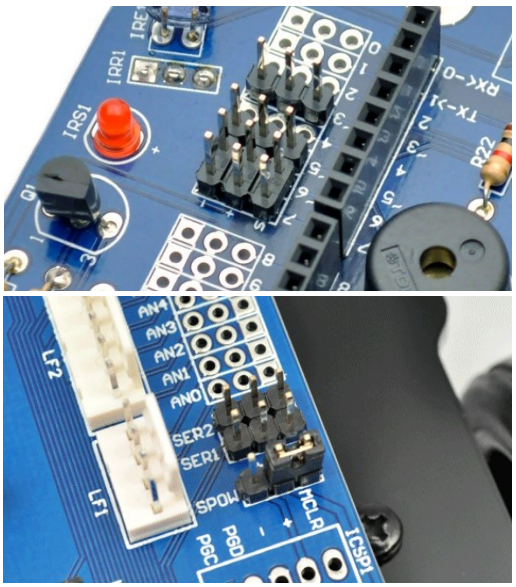

Fig. 16: Pan & Tilt kit connectors and "SPOW" jumper configuration

3.3 PLACING THE PAN & TILT KIT ON BOT'N ROLL ONE A

Remove the central nylon spacers and replace them by the spacers without thread.

Insert the M3x25mm screws on the acrylic base from bottom to top passing by the spacers.

Alternatively, you can use the existing nylon spacers, if you prefer. Replace the nylon spacer's central screws of the acrylic base by the M3x25mm. The bolts pass through the spacers and are inserted in the PLA stand. Do not tighten hard the spacers against the acrylic base since they should rotate freely.

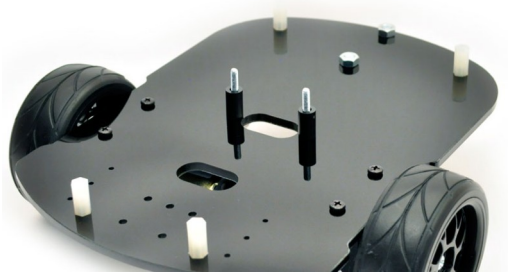

Fig. 17: M3x25mm screws and central spacers

Place the electronic board on the robot so that the two M3x25mm screws pass by the board central fixing holes.

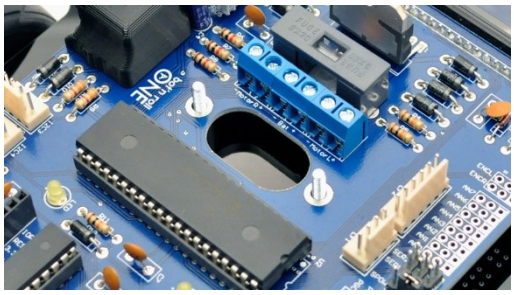

Fig. 18: M3x25mm screws and electronic board

Position the Pan & Tilt kit so that the sonar is facing forward.

Place the Pan & Tilt on Bot'n Roll ONE A tightening the M3x25mm screws on the PLA stand with a Philips screwdriver.

Very Important! Hold the PLA stand against the robot electronic board, using your fingers, while tightening the M3x25mm screws!.

Do not force the Pan & Tilt system while tightening it because it might break!

Fig. 19: Pan & Tilt positioned

Place the remaining screws, which hold the robot's electronic board.

3.4 ELECTRICAL WIRING OF PAN & TILT KIT

The Pan & Tilt kit has 3 cables. Tidy and position the cables so that they do not hinder the movement of the Pan & Tilt Kit.

Servo connections:

- The bottom servo, ***Pan*** movement, connects to **SER1**.
- The top servo, ***Tilt*** movement, connects to **SER2**.

Insert the cables into their respective header connectors such that the brown wire goes on "**-**" **0V**, and the orange wire connects to the "**s**" **sign** terminal. The central terminal has the 5V power connection.

Fig. 20: Servos electrical connection

Sonar connection:

- The sonar cable connects to digital inputs **6** and **7** as in image 21. With this double connection, you connect sonar **VCC** to 5V, **Trig** to digital output 6, **Echo** to digital input 7 and **GND** to 0V.

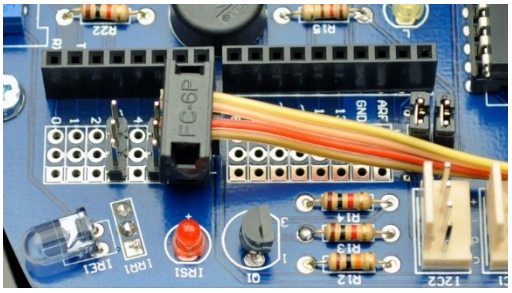

Fig. 21: Sonar electrical connection

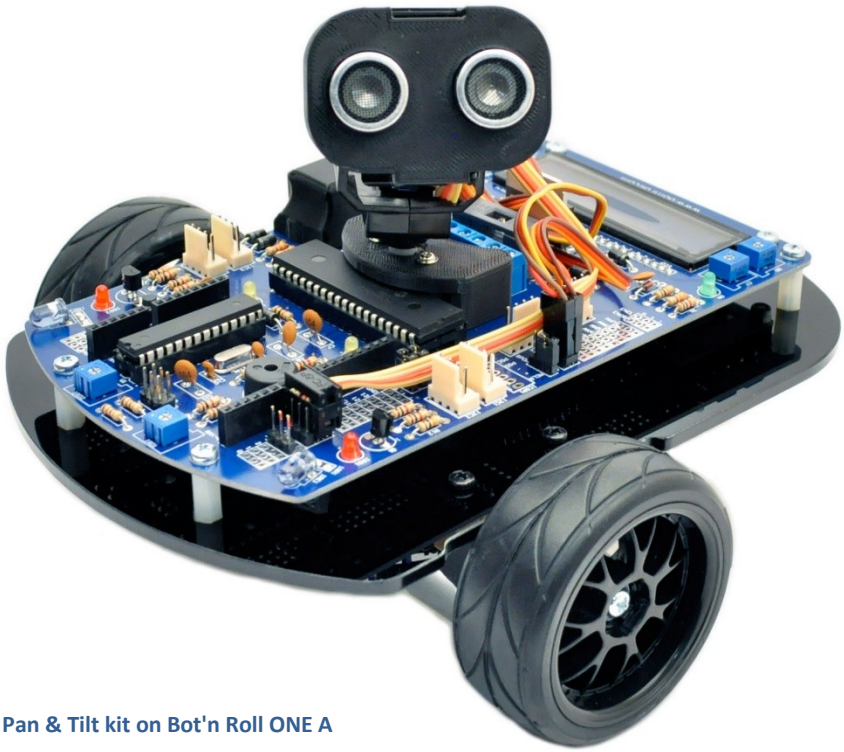

Fig. 22: Pan & Tilt kit on Bot'n Roll ONE A

3.5 SOURCE CODE EXAMPLE AND PAN & TILT TESTING

Load the sample program "***Pan&Tilt***" located on "***File -> Examples -> BnrOneA-> Extra -> Pan&Tilt***" to your robot. When the upload is completed, you will see the angle of each servo on the LCD.

Use the **PB1** and **PB2** push buttons to change the angle.
Use the **PB3** push button to alternate between both servos.

Register the necessary angles for your program to work as you wish and use them later on your program!

Very Important! Each servo has two mechanical limits and a different behavior for the control signal. Some servos may reach the mechanical limit positions before 0º or 180º on your program. When a limit position is achieved, the servo controller will try to move to the desired position but the mechanical gear will not allow it. Whenever this happens, **the servo vibrates**, **makes noise**, **increases the current consumption** to its maximum and **starts heating!** This is **not desirable** and in a few seconds, the servo can be **permanently damaged**! Verify and register your software values for the mechanical limit angles of each servo before programming!

If one servomotor do not move, check that:

- The servo cable is properly plugged to Bot'n Roll ONE A;
- The **SPOW** jumper is correctly configured;
- The servo is not blocked mechanically, i.e., with the robot powered off, you can easily move the servo using your hands;
- When you try to move the servo outside the limits, the symptoms are vibration, noise and heating on the servo.

If the problem persists, check if there are short-circuits or bad solders on:

- LM7805 placed on "**POW**";
- **C6** capacitor;
- **SPOW** jumper;
- 3-pin header connector placed on **SER1** and/or **SER2**;
- PIC18F45K22 **Integrated circuit socket**.

3.6 SOURCE CODE EXAMPLE AND SONAR TESTING

Load the sample program "***Sonar***" located on "***File -> Examples -> BnrOneA-> Extra -> Sonar***" to your robot. When the upload is completed, you will see the distance in centimeters, measured by the sonar, on the LCD.

Place your hand in front of the sonar, move it closer and further and check that the distance is changing.

If the distance is not changing, please check that:

- The sonar cables are correctly connected to Bot'n Roll ONE A;

If the problem persists, check if there are short-circuits or bad solders on:

- 3x3-pin header connector soldered to Arduino digital **6** and **7** connection;
- jumper **SPOW**;
- ATmega328 **integrated circuit socket**.

4. BOT'N ROLL GRIPPER

Bot'n Roll Gripper is built from PLA plastic material. Is very light robust and has an opening greater than 180º with two 69mm long calipers that allow embracing objects with diameters from 47mm to 110mm. Fully opens or closes in less than a second!

The gripper incorporates a metal gear servo MOT03009 already fitted in position that provides the opening and closing movements of the gripper.

A standard servo, a metallic servo stand and assembling accessories were also added to this kit to allow lifting the gripper. The **gripper** allows you to **lift objects** and **transport** then with your **Bot'n Roll ONE A**.

Fig. 23: Bot'n Roll Gripper and accessories

A LM7805 voltage regulator, a thermal dissipater, a **100µF** capacitor and two 3-pin headers (to be soldered on the robot´s board) are also provided to power and connect the servomotors.

The gripper is connected to the digital pins **~3** and **~5** from the **0-7** connector and is directly controlled by the ATmega3128 using the **Servo.h** Arduino library.

You will not need all the provided components to assemble the gripper on your **Bot'n Roll ONE A**.

4.1 SOLDERING THE COMPONENTS ON THE BOARD

The LM7805 voltage regulator and the 100µF capacitor may already be soldered on the circuit if you previously assembled the **Pan & Tilt** kit. However, you must solder the 3-pin headers for the servos.

Solder the LM7805 on the board in "**PWR**". You must respect the orientation of the component, matching the metallic dissipater to the double dashed indication on the board.

The 100µF capacitor has polarized terminals, place it on "**C6**". You must respect the electrolytic capacitor polarity or the component will be permanently damaged!

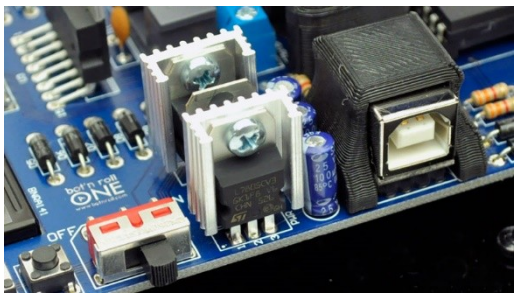

Fig. 24: LM7805 and heat sink

The 3-pin header connectors must be soldered on "**~3**" and "**~5**" connections from the Arduino digital I/O connector **0-7**.

Configure the "**SPOW**" jumper, servo power, so that the central pin is linked to the **PWR** pin. This way, the servos are fed by the voltage regulator "POW" dedicated to the servos and not by the "**7805**" which powers the 5V electronics of the **Bot'n Roll ONE A**.

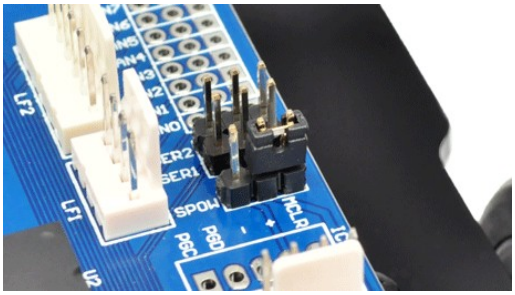

Fig. 25: "SPOW" jumper configuration

This jumper connection is important because if you have several servos working at the same time they will consume a lot of current, and the voltage will surely become unstable. The microcontrollers will block and restart if the voltage becomes unstable, so it is not good practice to have the servos and microcontrollers connected to the same circuit.

4.2 PLACING THE GRIPPER ON BOT'N ROLL ONE A

After assembled, the gripper fits on the robot like in the immage on the right.

The **servomotor stand**, the **U-Shaped stand**, the **gripper** and the **servomotor** must be properly assembled together following the instructions below.

Fig. 26: Gripper on the robot

Place the **servomotor stand** on the acrylic base inserting the 3 **M3x10mm bolts** from bottom to top as indicated in the image.

Screw the 3 nuts on the bolts from the top verifying that the metallic stand is perfectly aligned with the acrylic base.

Note that all M3 nuts are on the top side of the robot and the bolts entered from the bottom!

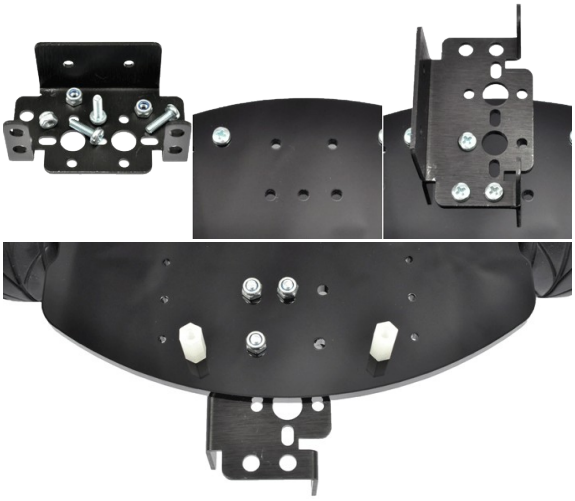

Fig. 27: Servomotor stand

Place the **smaller circular hub** in the **U-shaped stand** using **two self-tapping screws**. Note that the plane surface of the hub must be in contact with the inner part of the stand. Insert the screws from the outside to the inside of the U-Shaped stand and use a plier to cut the tip of the screws.

Fig. 28: Circular hub placed on the U-Shaped Stand

Attach the **gripper** to the **U-shaped stand** using the four **M3x8mm bolts**. The bolts must tight in the enclosed lock nuts of the gripper.

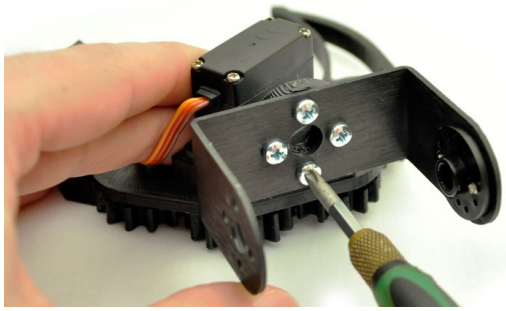

Fig. 29: Gripper on the U-Shape stand

Attach the **U-shaped stand** and **gripper** to the **servomotor stand** using the **spacer with bearing**. Insert the bearing in the U-Shaped stand from the outside. Insert the M3x12mm bolt, from the inside, thru the servomotor stand and bearing. Place the split lock washer and the blind nut on the bolt from the outside of the U-shaped stand and tighten.

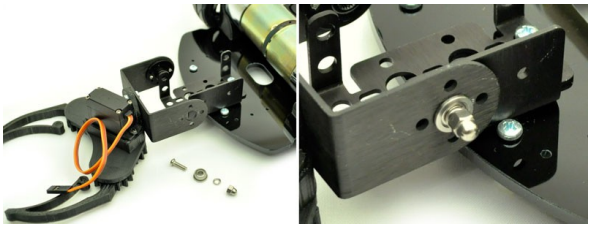

Fig. 30: U-shaped stand on the servo stand

Note that the servomotor **rotates 180°** and has **internal mechanical limits** for 0° and 180° positions.

Before placing the servomotor, test its **mechanical limits** using a temporary hub. Rotate the servo gently and find a **central position** so the gripper can be fully lifted when assembled.

Attach the **servomotor** to the **servo stand** using four **M4x12mm bolts** and four **M4 nuts**.

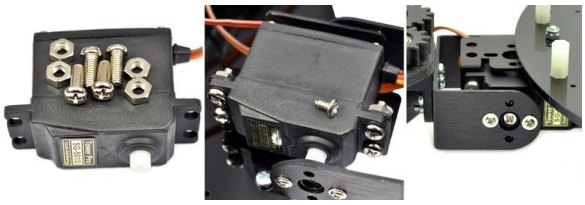

Fig. 31: Servomotor in position

Insert the servomotor in the hub of the U-shaped stand and verify that you can fully move the gripper up and down. Attach the hub to the servo using a self-tapping screw.

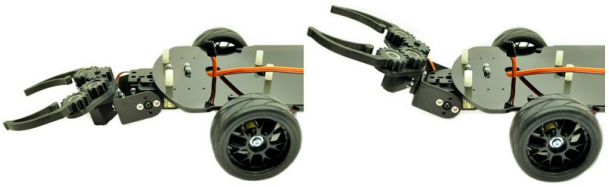

Fig. 32: Moving the gripper

4.3 ELECTRICAL WIRING OF BOT'N ROLL GRIPPER

Guide the servomotor cables thru the central holes of the acrylic base and board. Check that the cables don´t touch the floor and not limit gripper movement.

The servomotor cable to **open and closing** the gripper connects to the 3-pin header connector on digital **~3.**

The servomotor cable to **lift** the gripper connects to the 3-pin header connector on digital **~5.**

Insert the cables into their respective header connectors such that the brown wire goes on "**-**" **0V**, and the orange wire connects to the "**s**" **sign** terminal. The central terminal has the 5V power connection.

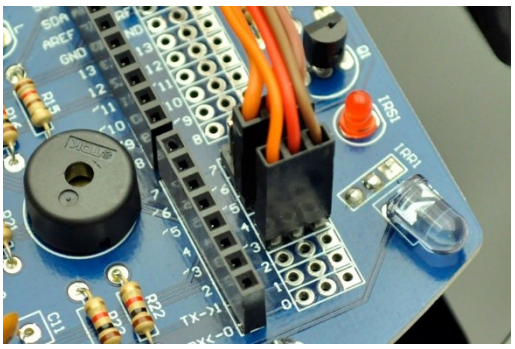

Fig. 33: Electrical connection of the gripper

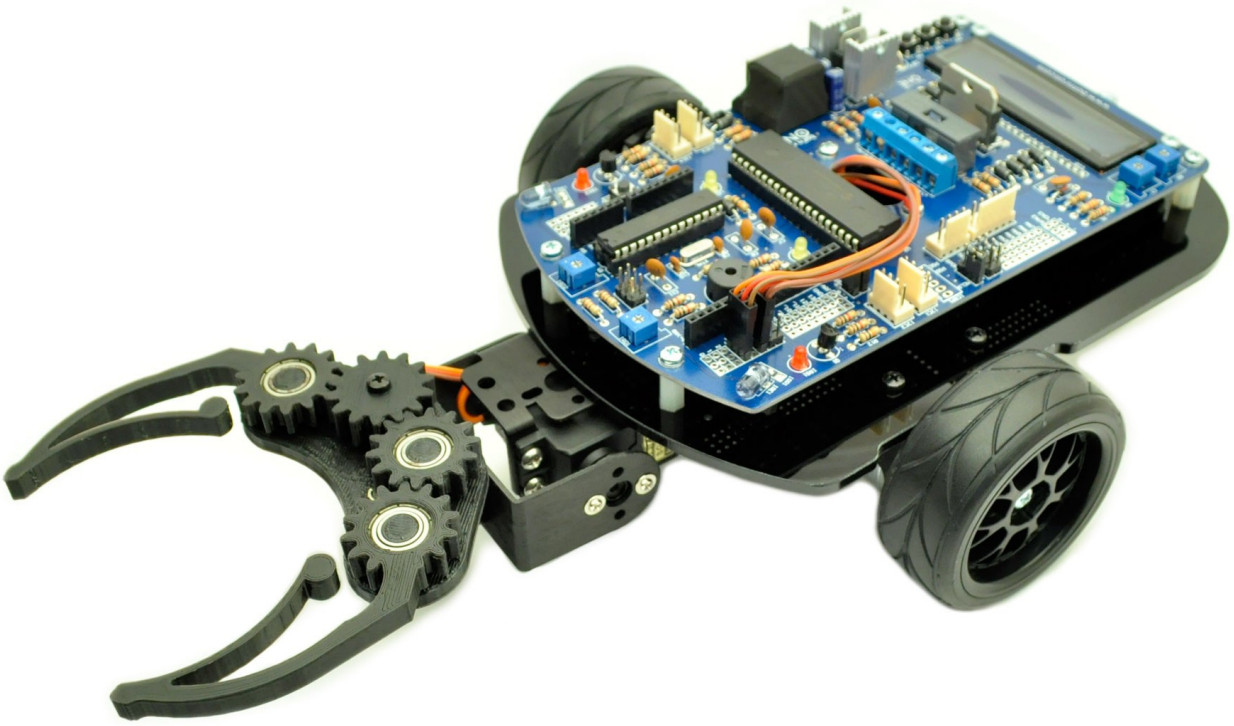

Fig. 34: Gripper on Bot'n Roll ONE A

4.4 SOURCE CODE EXAMPLE AND TESTING

Load the sample program "***Gripper*** " located on "***File -> Examples -> BnrOneA-> Extra -> Gripper*** " to your robot. When the upload is completed, you will see the angle of each servo on the LCD.

Use the **PB1** and **PB2** push buttons to change the angle.
Use the **PB3** push button to alternate between both servos.

Register the necessary angles for your program to work as you wish and use them later on your program!

Very Important! Each servo has two mechanical limits and a different behavior for the control signal. Some servos may reach the mechanical limit positions before 0º or 180º on your program. When a limit position is achieved, the servo controller will try to move to the desired position but the mechanical gear will not allow it. Whenever this happens, **the servo vibrates**, **makes noise**, **increases the current consumption** to its maximum and **starts heating!** This is **not desirable** and in a few seconds the servo can be **permanently damaged**! Verify and register your software values for the mechanical limit angles of each servo before programming!

If one servomotor do not move, check that:

- The servo cable is properly plugged to Bot'n Roll ONE A;
- The **SPOW** jumper is correctly configured;
- The servo is not blocked mechanically, i.e., with the robot powered off, you can easily move the servo using your hands;
- When you try to move the servo outside the limits, the symptoms are vibration, noise and heating on the servo.

If the problem persists, check if there are short-circuits or bad solders on:

- LM7805 placed on "**POW**";
- **C6** capacitor;
- **SPOW** jumper;
- 3-pin header connector placed on "**~3**" and/or "**~5**";
- ATmega328 **Integrated circuit socket**.