VARIOBOT

DISCOVER MECHATRONICS

variAnt

Realistic Robotic Ant as a
Programmable Construction Kit

AGE
14+

ASSEMBLY
4-8h

PARTS
345

solderless

Instructions

Version 230825

Safety instructions

Before building and using the robot, it is important to read the following precautions. Please follow them!

- Read through these instructions before you begin, and keep them on hand while building.

- This robot kit is not a toy! Keep it out of the reach of children! It is only for ages 14 and up.

- Do not use where small animals are loose.

- For safety reasons, never leave the robot unattended.

- Since variAnt doesn't have a cover, be extra careful to keep metal objects and tools from causing a short circuit.

- Caution: Do not touch inside the power unit!

- Caution: Due to variAnt's open structure, there are sharp edges and corners.

- variAnt may only be used indoors. Do not use this robot in traffic areas!

- Do not use variAnt on tables and other surfaces from which it could fall.

- Only use the robot in dry, clean spaces. Dirt, dust, foreign objects, and dampness destroy the mechanics and electronics.

- Caution: Do not hook up devices to the robot, especially not ones with mains voltage!

- If you hook up a device to the robot, we are not liable for lost data.

- The robot is designed exclusively for learners, teachers, and experimental purposes. Any and all liability is excluded in the case that it is used for any other purpose.

General Battery Information

- Rechargeable batteries (RBs) should be kept out of the reach of children!

- Do not charge conventional batteries. Doing so is both a fire and explosion hazard. Conventional batteries are not recommended for this kit.

- Avoid short circuiting the RB; it can result in the wires and/or the RB overheating.

- Do not disassemble, burn, or damage the RB.

- Charge the RB approximately every 3 months. Otherwise, it can come to an over-discharged or dead RB, which can make the battery unusable.

- Defect RBs are to be disposed of in accordance with the environmental rules and regulations of your state and/or country. Most typically they need to be entirely discharged, have non-conductive tape placed over the terminals or be placed separately into sealed plastic bags. Do not put them in the trash or municipal recycling bins!

Although the constructions and circuits introduced in this instruction manual were designed and tested with as much accuracy and detail as possible, errors cannot be entirely excluded.

The intended use of this kit is described in this instruction manual. If you deviate from the instructions, the guarantee and liability will be forfeited and the use of the robot is at your own risk!

This product was produced in accordance with the currently effective European Union directives and, therefore, has the CE symbol.

The symbol of the garbage can/rubbish bin with an X through it means that this product may not be put into household garbage bins; it should be brought to a recycling center and added to the electronic scrap. Please take the time to find where you can best recycle your electronic scrap!

Introduction

Thank you for buying our variAnt robot kit. We did our very best to make it as much like a real ant as possible.

Thanks to its innovative and compact running mechanism that's powered by two high quality micro-gear-motors, variAnt walks and acts almost exactly like its biological counterpart.

This autonomous robot ant explores its surroundings with up to 12 analog sensors. These allow it to be aware of obstacles, movement, floor markings or light with even the slightest difference in brightness.

The control unit with its Nano-control-board in the abdomen (rear part) and the breadboard, integrated in the head, make multiple options for connectivity and extensions possible.

Once the fun of putting variAnt together is over, the pre-made and expandable code modules ensure a quick and easy introduction to Arduino programming. Your first experiments with AI can begin!

Content

- Section A (Construction) of this manual uses numerous images to show you how to build your robotic ant step-by-step.

- Section B (Startup Procedure) uses a programming tutorial to explain how you can use the custom-made variAnt Library to help you write your first programs and then gradually expand upon them.

- Section C (Appendix) currently has an overview of the robot parts and circuit diagrams. We will be adding more soon.

We wish you lots of fun building, programming, and experimenting with variAnt!

You will also need:
- wire cutter & flat nose pliers
- utility knife & permanent marker
- PC or tablet with internet connection
- micro USB cable & USB-C cable

Table of Contents

We will continue to optimize and expand sections B) and C) as well as the variAnt library. We welcome your feedback so that we can incorporate it into future updates if necessary.

List of Abbreviations

Connections on the variAnt board (front)

DL0	Digital-I/O Left 0
DL1	Digital-I/O Left 1
DL2	Digital-I/O Left 2
DL3	Digital-I/O Left 3
DR0	Digital-I/O Right 0
DR1	Digital-I/O Right 1
DR2	Digital-I/O Right 2
DR3	Digital-I/O Right 3
RSL	Reed Switch Left
RSR	Reed Switch Right
MLA	Motor Left Ahead
MLB	Motor Left Back
MRA	Motor Right Ahead
MRB	Motor Right Back
PWR	Power

Connections on the variAnt board (rear)

AL0	Analog-Input Left 0
AL1	Analog-Input Left 1
AL2	Analog-Input Left 2
AL3	Analog-Input Left 3
AR0	Analog-Input Right 0
AR1	Analog-Input Right 1
AR2	Analog-Input Right 2
AR3	Analog-Input Right 3
GND	Ground (0 Volt)
REF	Analog Reference
RST	Reset
3V3	3,3 Volt output
5V	5 Volt output (Arduino)
6V	6 Volt output (motors)
9V	9 Volt output (battery)

Buttons

LEDs	LEDs on/off
PWR	Power (battery on/off)

A) Construction

Before you begin, remove the acrylic parts from their individual transparent plastic film.

Begin with the bottom body component.

Fragile! Handle with care!
When handling the acrylic parts, be careful not to bend them too much until they are connected to their counterpart.

1	bottom body component
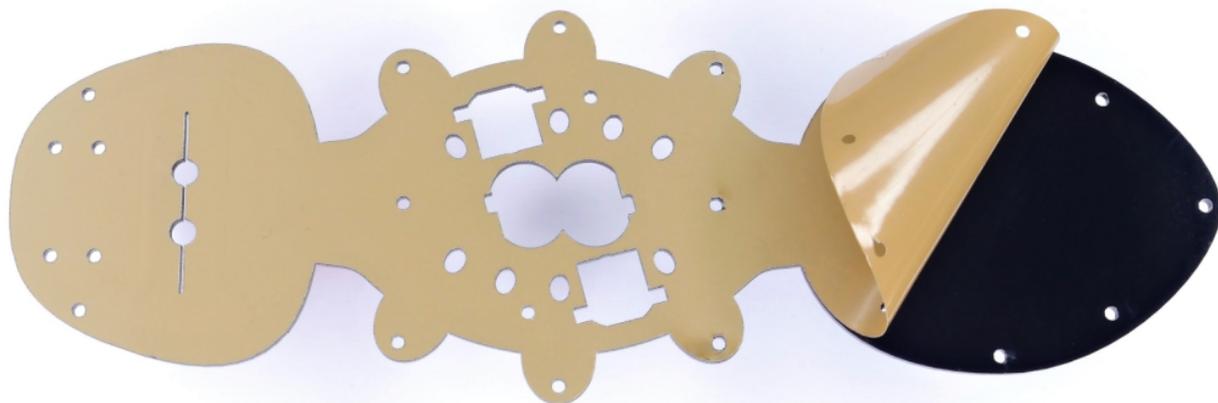
Overview of the most common combinations of small parts

short screw (4 mm)		medium screw (6 mm)	long screw (8 mm)
short spacer		brass ball (5 mm)	long spacer

1) Mounting the Spacers

Mount the 9 black hexagonal spacers with the 9 long screws (8 mm) and an Allen key at the indicated positions on the top side of the acrylic plate, which is smooth.

Then, on the same side of the plate, mount 4 of the short brass spacers with 4 of the 4 mm screws.

 9 long spacers (plastic)
15 long screws (8 mm)
10 short spacers (brass)
10 short screws (4 mm)

Now attach 6 brass spacers with 4 mm screws onto the bottom of the plate where variAnt's legs will be mounted.

Once you've done that, screw a long 8 mm screw into each of the spacers. Use the Allen Key to tighten them from the top and the bottom.

The temporary feet will make mounting the motors and gears easier.

2) Mounting the Motors

Bend the connectors of each of the black twin cables apart. Assure the indentations (1) are facing in the same direction.

Push them through the small square openings in the acrylic plate at the height of the indentations (2).

After that, bend the motor cables by 180° so that they lie flat against the side of the motor housing.

Press the motors' red cables right next to the black caps of the motor housings (3). This will prevent them from bumping into the gears while using variAnt.

Now, ensuring you use little pressure, slant the motors and set them into the corresponding openings. The motors' cables should run through the small openings (4) next to the motors and the black cable connectors should now be stabilized.

2 black twin cables
2 gear motors with cables
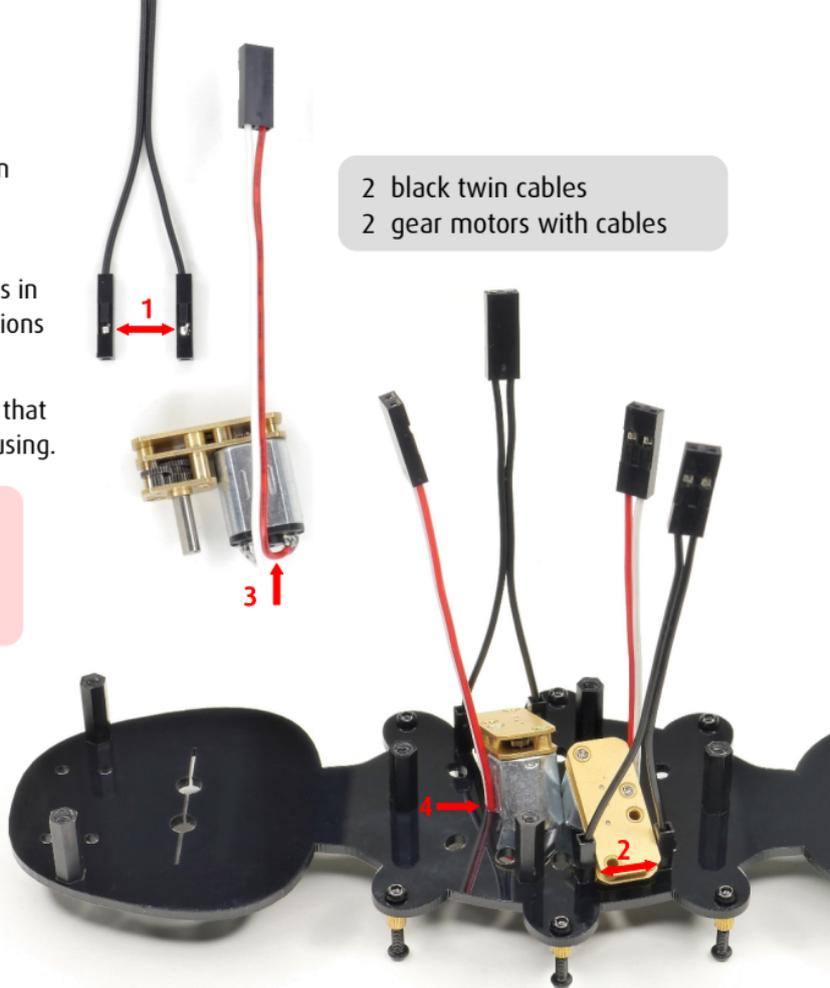
3) Prepping the Cables

Carefully use a utility knife (held almost horizontally) to split the 10 cm long flat ribbon cable into 4 two-colored twin cables.

Keep the leftover cable in case you decide to do some additional wiring.

From one of the 20 cm long flat ribbon cables, separate the outer four pole strands. Now split the three long cables according to the specified dimensions.
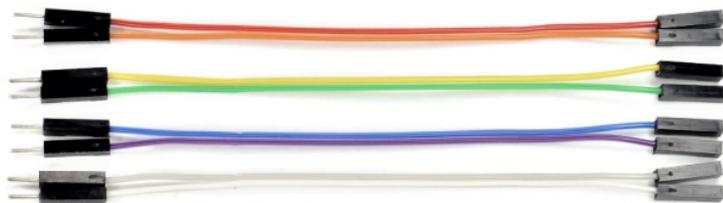
1 rainbow flat ribbon cable, 10 cm (10 pin)
2 rainbow flat ribbon cables, 20 cm (10 pin)

4 cm

4 cm   9 cm   7 cm
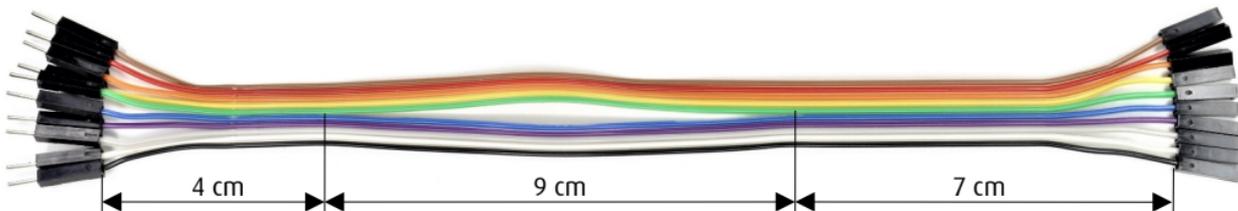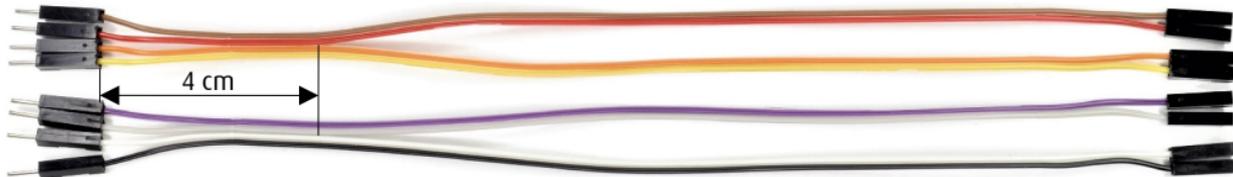
4) Mounting the Boards

Plug the connectors of the split 10-pin flat ribbon cable onto the back pin header of the control board (brown » +5 V, . . . , black » GND).

Bend the cable 180°, so that it runs under the control board. Then use the 4 short screws to mount the board onto the brass spacers.

1 breadboard
1 control board
4 short screws

Now place the breadboard into the 2 large openings on variAnt's head, just far enough that it sits firmly.

Push the cable's 10 pins into the 4th row of the breadboard. Leave position number 5 vacant.

To finish the job, bend down the cable on the left and on the right of the 2 spacers in the middle (1), pressing them close to the breadboard (2).

5) Installing the Long Cables

Tie a knot in the 4-pin cable (brown, ..., yellow) as shown, and then thread the 2-pin branches from the center through the 5-pin cable strand (brown, ..., green).

Insert the 4 connectors directly in front of the cables of the same color into the breadboard. Place the brown-red cable between the motors and slide the knot onto the middle spacer.

Proceed in the same manner with the cable (violet, ..., black) on the left side.
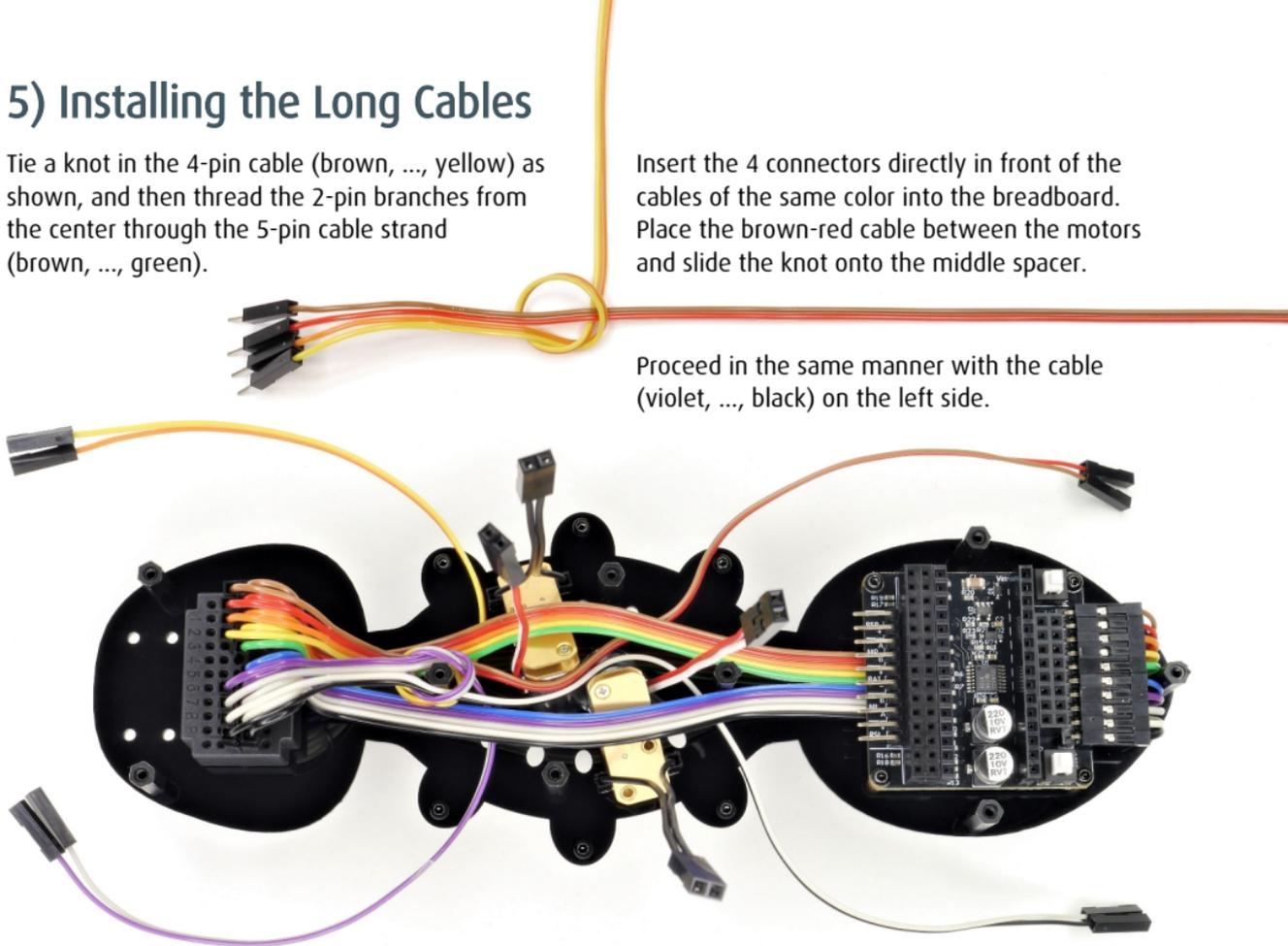
6) Connecting the Short Cables

Insert the orange-red and white-gray cables (each 10 cm long) directly in front of the cables of the same color on the breadboard. Then, bend them backward and guide them to the front between the breadboard and the spacers.

Now, plug the two black twin cables into the outer contacts RSR and RSL on the front pin header of the control board.

Knot the left motor cable. Then, connect both motor cables to the contacts MR and ML on the control board, ensuring that the red cable is positioned on the right side for each connection.

Make sure the cables located near the motors do not go too far above the black spacers.
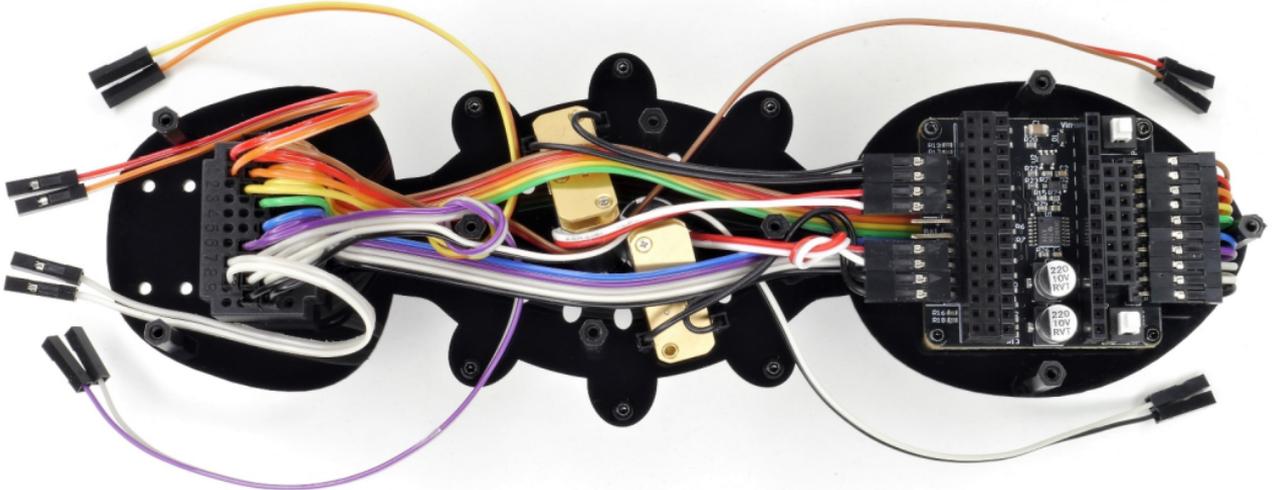
7) Prepping the Top Body Component

Attach 6 short spacers to the top body component using short screws.

Then slide the clip cable for the battery through the small rectangular opening (1) and connect it to the available contacts in the middle of the control board (BAT, red » +, black » –).

Using the included sandpaper, roughen up both sides of the two spacers on the head before attaching them. Then, be sure to screw them on tightly.

1 top body component
6 short screws (4 mm)
6 short spacers
1 battery clip cable
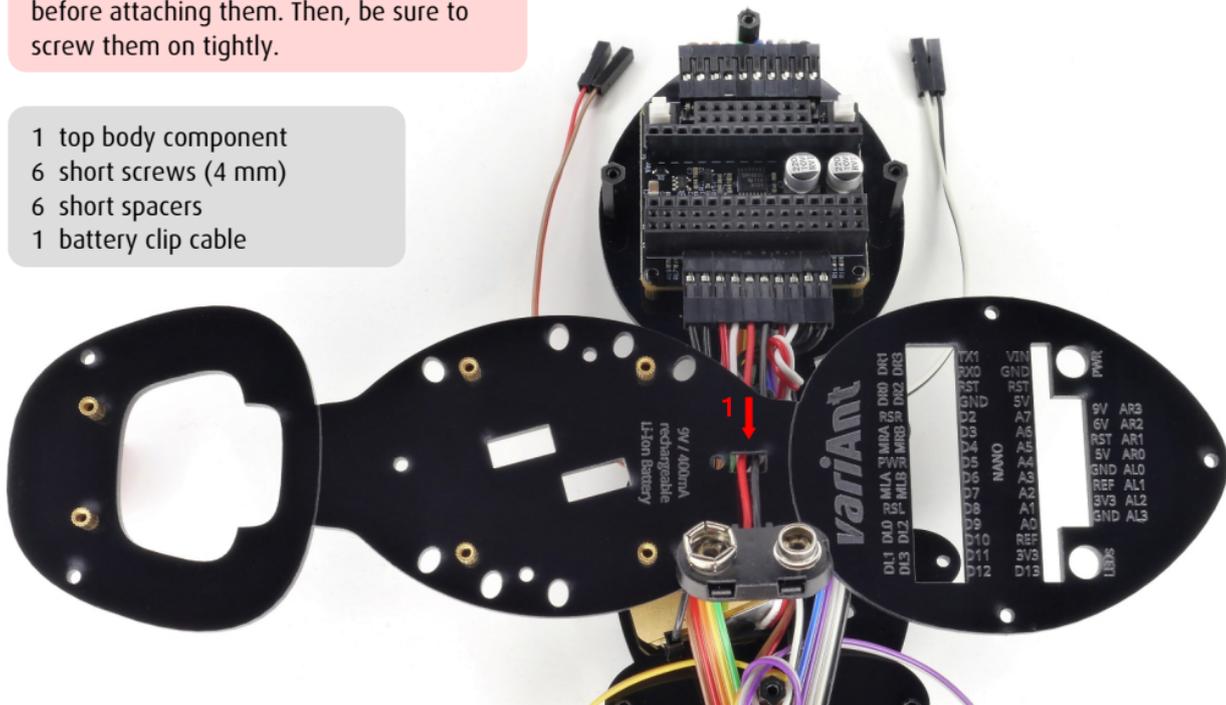
8) Connecting the Body Components

Now, press the diagonally positioned motors apart at the top, and push the cables that are in between downwards. Then, position the top acrylic component in a way that all the components (cables etc.) protrude through their respective openings.

Check if the top acrylic component can be easily pressed against the black spacers without pinching any cables.

Also ensure the push buttons of the control board do not stick on the acrylic when pushed.

For now, secure the upper component only to the head and the abdomen using 5 long screws.

Then, attach 2 balls with 6 mm screws to the short spacers in the head area.

Ensure that these screws are firmly tightened.

5 long screws (8 mm)
2 medium screws (6 mm)
2 perforated brass balls (5 mm)

9) Prepping the Drive Shafts

Ideally, the bending angles of the 6 drive shafts should be exactly 10°. However, they may have some manufacturing tolerances.

> The bending angles of the shafts determine the range of motion for the legs. If a shaft is bent too much, the legs may collide with each other while walking.

To check the bending angles, use the angle references below. If a shaft is bent slightly more than 10°, gently press it together at the bending point using flat pliers.

If it is less than 9°, hold the shaft with the pliers precisely at the side of the bend and carefully adjust it.
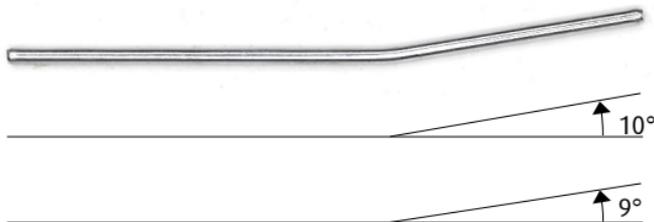
> When variAnt runs into an obstacle, the impact upon the gears is very high. To prevent the gears from slipping on the shafts during such situations, it's necessary to roughen those areas beforehand.

Slide a shaft collar onto each of the long sides of the 6 shafts; they'll be 5 mm away from the end of the shaft (the width of a small gear).

Now, using the sandpaper, roughen the ends in a **longitudinal direction** (1) all the way around. When finished, remove the shaft collars.

10°

9°

5 mm

1
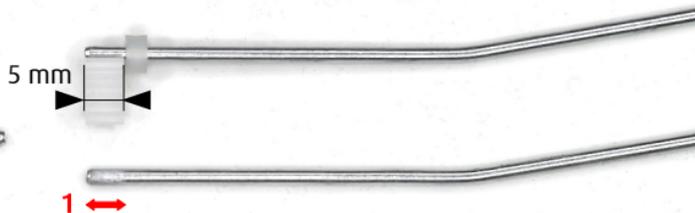
6 bent shafts (80 mm)
6 small shaft collars

10) Putting on the Gears

Start by sliding one brass bushing over the roughened ends of each of the 6 bent shafts.

Hold the shafts upright on a surface and press one small gear onto each of these ends.

Now, place the shafts on a smooth surface as shown below, with 4 of the bent ends pointing upward as much as possible and 2 pointing downward.

If the alignment of the bending angles doesn't match precisely for some of the shafts, the corresponding gears need to be adjusted as follows.

Use pliers to hold the shaft near the bend and a piece of cloth to slide the gear off the shaft. Then, press the gear back on again.

> Keep in mind that the 15 teeth of the gear correspond to one step cycle (360°).
> So, if a gear is, for example, half a tooth misaligned when attached, it results in a deviation of 360°/30 = 12°.

Now, mark the 6 upward-facing teeth of each gear with a marker, and using the provided lubricant, lubricate the shafts between the gears and the bushings (1).

Lastly, for the two 35 mm long shafts, press a small gear onto each one, lubricate them, and slide a brass bushing onto each of them as well.
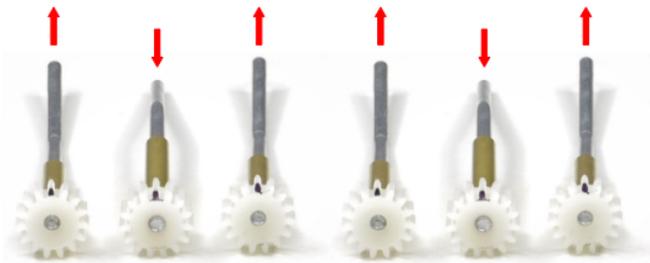
> 8 brass bushings (26 mm)
> 8 small gears (2 mm hole)
> 2 medium shafts (35 mm)

11) Installing the Drive Shafts

Start by rotating the D-shaped motor shafts so that the flattened sides are facing directly outward (1). Then, place the two small cube-shaped magnets approximately in the middle of each shaft (2).

Carefully slide the two shafts, whose gears you marked in the opposite direction of their bending, through the middle oval holes (3).

If the brass bushing gets stuck in the second hole, gently push the end of the shaft towards the center while inserting it. Ensure the gears protrude the same distance as the motor shafts.

Next, insert the 2 shorter shafts into the openings opposite the motors (4).
Lastly, slide the remaining 4 long shafts through the outer oval openings.
The alignment of the gears to each other does not need to be considered at this stage.

> 2 cube magnets (2 mm)
> 8 little shaft collars

Please note that the red-brown cable should run between two shafts, while the other three cables should run either in front of or behind the shafts.

Now, secure each of the 8 shafts with a shaft collar.

Place variAnt on its feet, and adjust the height of the brass bushings so that the gears just barely rotate without touching the ground.

By adjusting the height of the gears, you can also adjust their distance from each other.
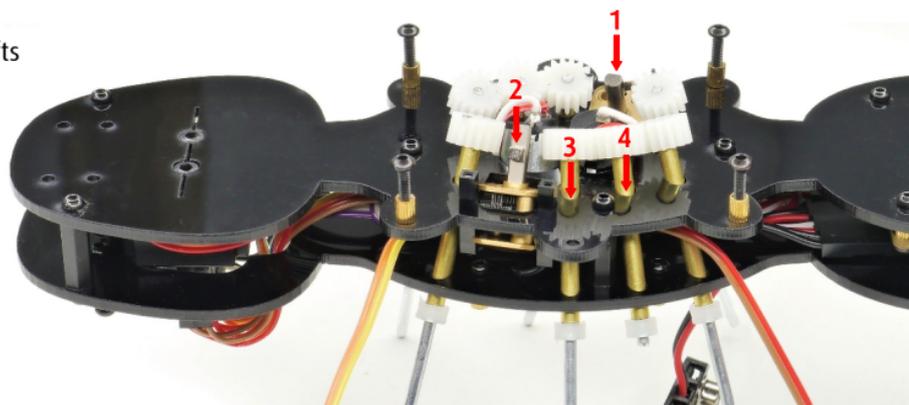
12) Securing the Bushings and Attaching the Ball Joints

Begin by disassembling the six temporary feet and placing the whole thing on its gears.

While applying slight pressure to the center of the body (to keep the brass bushings from slipping out of place), carefully tighten the acrylic pieces at the remaining positions using 4 long 8 mm screws.

At this point, ensure all the gears are still at the correct height.

Then temporarily remove the two short shafts.

Now, attach 6 short brass spacers to the 6 leg mounts using short 4 mm screws.

Lastly, mount 6 brass balls on top of them using medium-length screws.

Ensure the 6 mm screws are positioned exactly at the center of the balls.

6 medium-length screws (6 mm)
6 brass balls with holes (5 mm)
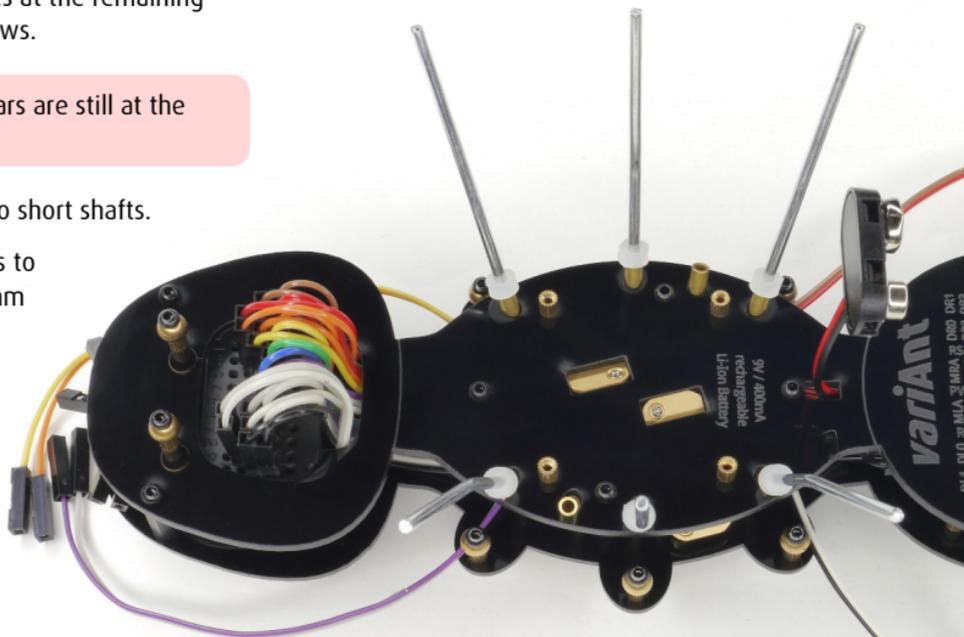
13) Assembling the Legs

Attach 4 short spacers using 4 short screws to each of the unengraved sides of the right leg elements.

Slide one shaft collar up to the middle of each of the 6 short shafts (8 mm) and insert one of these into the hole at the end of each right leg element.

Place a left leg element on top of each right leg element, and secure each with 2 short screws at positions 1 and 2.

So that the legs can be easily attached to the body in the next step, the two screws at positions 3 and 4 should not be tightened yet.

Screw the other two screws loosely into the spacers at positions 3 and 4 (about halfway in).

On a smooth surface, check if the shaft collars at the end of the legs roll smoothly.
They compensate for lateral leg movements and even increase variAnt's speed.

Carefully remove any rough edges on these shaft collars using a utility knife.

6 right leg elements
6 left leg elements
48 short screws
24 short spacers
6 short shafts (8 mm)
6 small shaft collars

14) Attaching the Legs

Begin by applying some lubricant to the outside of the 6 brass balls mounted earlier, distributing it evenly. Also apply some lubricant to the holes of 12 additional brass balls.

> Start either at the back right or front left and proceed counterclockwise.

First, attach the leg joint to the corresponding ball on the body (1), and then tighten the screw directly above it (2).

Now, place the cable (if available) inside the leg, above the spacers (2 and 4).

> The cable must be close to the ball joint to prevent the acrylic parts from rubbing against it.

Now, slide a ball onto the drive shaft and raise the leg until the ball snaps into place between the holes (3). Be careful not to lose the balls in the process.

> 12 brass balls (5 mm)

Insert another ball onto the shaft until it reaches the elongated hole (5), and then tighten the screw below it (4) so that the leg can still move smoothly when the gear rotates.

Lastly, slide the end of the cable under the spacer (6) in the middle of the leg.
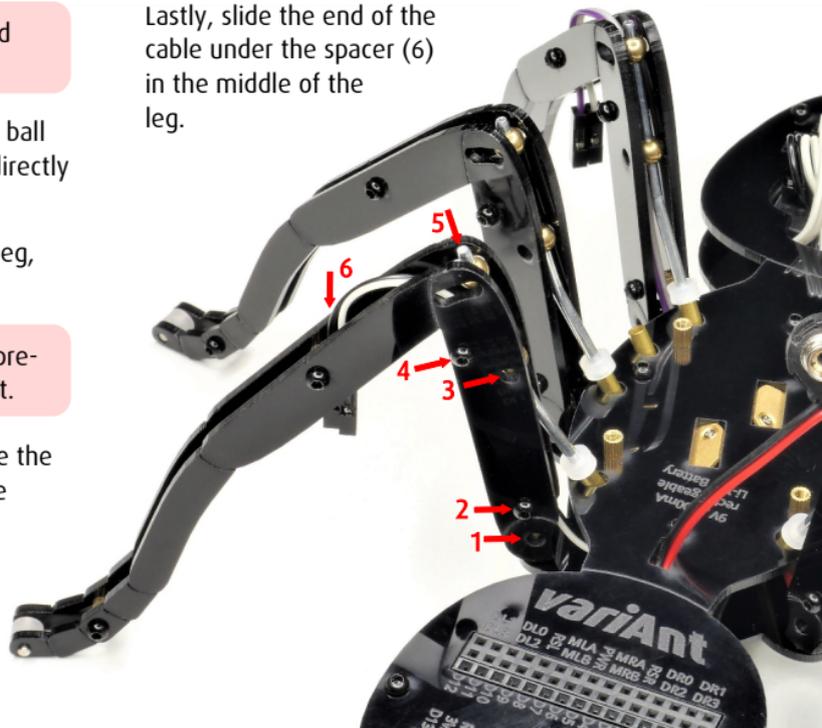
15) Defining the Step Sequence

Now align the gears so that the teeth you marked face outward toward the corresponding brass bushings (1).

Now, reinstall the 35 mm long shafts.

Make sure that none of the gears touch a red motor cable.

Place the 2 gears for the motors on their teeth and in such a way that their D-shaped openings are aligned as mirror-symmetrically as possible to each other. If necessary, turn one of the gears around.

Now, attach the gears to the motors, being careful to keep the marked gears correctly aligned or slightly deviating in the same direction.

Lastly, check if the magnets are positioned directly under the gears.

2 gears with D-shaped holes
2 reed switches

Bend the leads of the reed switches by 90° and trim them to a length of 8 mm using a wire cutter.
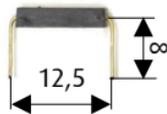
Lastly, insert the switches into the connectors next to the motors.

12,5

8
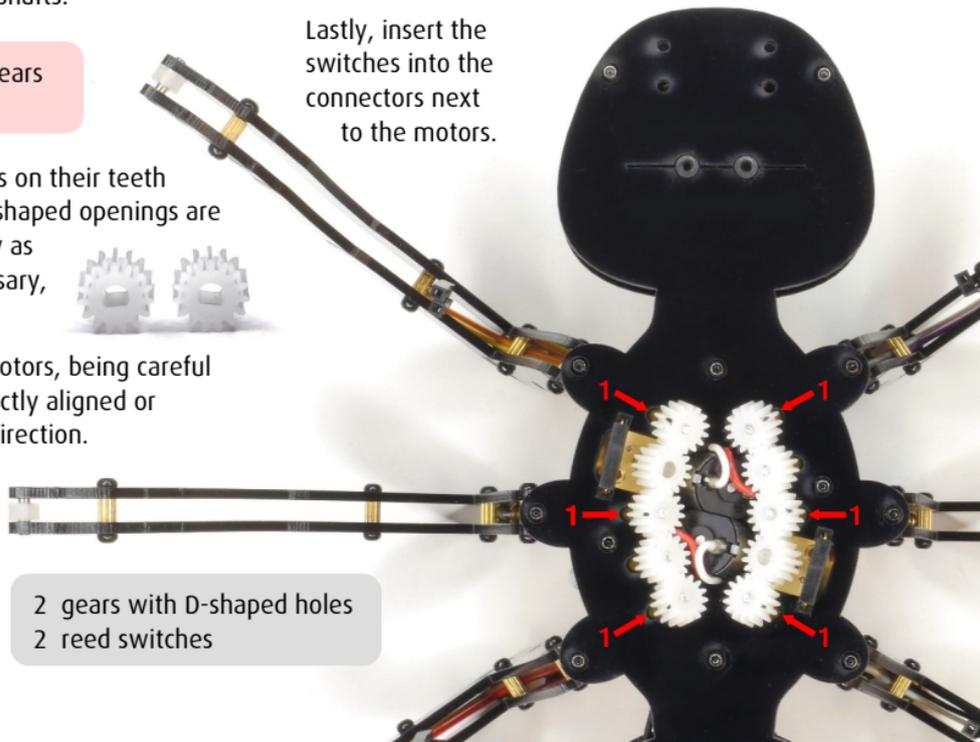
16) Attaching the sensors

Using a wire cutter, trim the leads of 8 of the phototransistors to exactly 8 mm. Then, correctly polarize 4 of them and connect them to the cable terminals of the legs.

The positive terminal (collector) of the phototransistors is located on the short pin or the side of the housing that is flat (K). For the collector, always choose the wire color that is plugged into the breadboard closest to brown (+5V).

The sensors sit more firmly if the notches (1) on the connectors are facing outward.

Now, cut off 12 pieces of heat shrink tubing, each 5 mm long. Slide 4 pieces over the housing of the sensors on the legs. Position the sensors near the leg bend between the acrylic parts.

Slide one piece of tubing over the housing of each of the 4 untrimmed sensors. Then, correctly polarize one of them and insert it into the green/blue rows in the middle of the board.

Bend the pins of 2 other sensors 10 mm apart and slide a silicone sleeve over their heat shrink tubing. Then, insert them into the very front and very back of the brown/red and white/black rows, bent approximately 45° to the side.
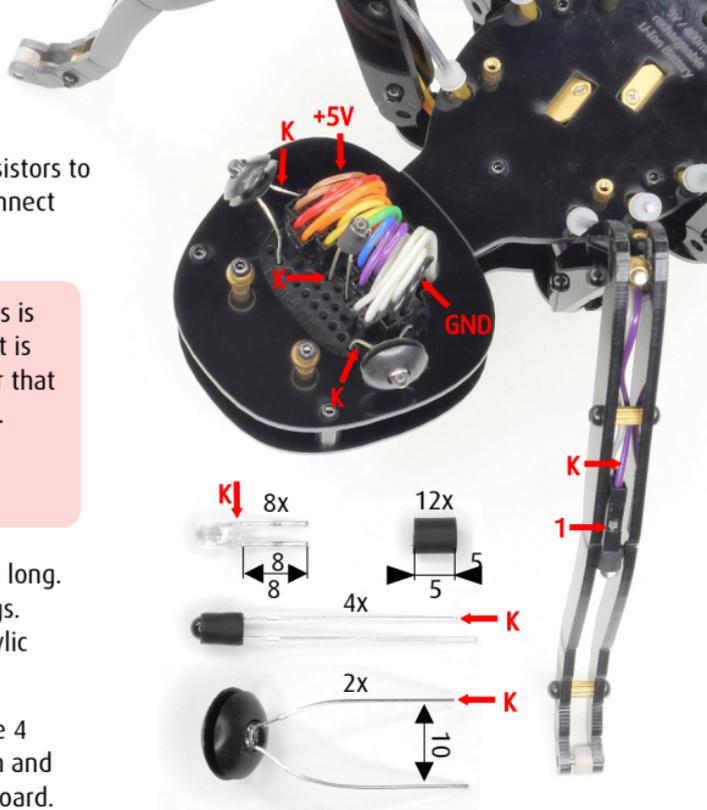
12 phototransistors (Ø 3 mm)
1 heat shrink tube (Ø 3 mm)
2 black silicone sleeves

17) Attaching the Mandibles

Attach 2 short spacers to both a left and a right mandible element using short 4 mm screws.

> The left and right mandible elements differ only in how they are serrated.

Now, mount the 2 counterparts onto the spacers, but use only one screw for each, namely at the tip of the mandible.

Next, thread the orange-red and white-gray cables between the spacers, from the outside and through the mandible elements (1).

Attach the mandibles symmetrically to the head from below using 6 mm screws, ensuring that they can still move.

Then, insert two of the trimmed sensors, correctly polarized, into the cable connectors, and slide a piece of heat shrink tubing over each one. Bend the sensors slightly downward, so they are slanted toward the ground.

Then, loosen one of the front screws on each side and slide the sensors between the acrylic parts, making sure they protrude about 3 mm at the front. Now, carefully tighten the screws again.
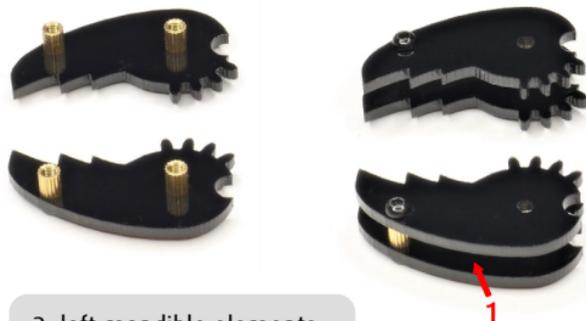
2 left mandible elements
2 right mandible elements
6 short screws
4 short spacers
2 medium screws

18) Attaching the Antennae

Attach 4 short spacers to each of the unengraved sides of the two right antenna elements using 4 short screws. Slide a shaft collar onto each of the 2 short shafts and insert them into the opening at position 5.

Now, place the left antenna elements on top and secure them with 2 short screws (1 and 2).

Screw the remaining screws only halfway into the spacers (3 and 4) at the most.

Insert the violet-blue and green-yellow cables into the front row of the breadboard, matching their respective colors. Slide the cables between the spacers (4) and the rollers (5), and then guide them out over the top spacers (2).

Now, place the antennae onto the balls on the head and tighten the screws (3 and 4) evenly so that the antennae can still move.

Position the cable ends above and below the front spacers (1) with the antennae in the furthest most upward position. Plug 2 correctly polarized sensors onto the cable connectors. Slide a piece of heat shrink tubing over each one and slide them between the acrylic plates.

2 right antenna elements
2 left antenna elements
8 short spacers
16 short screws
2 short shafts
2 shaft collars
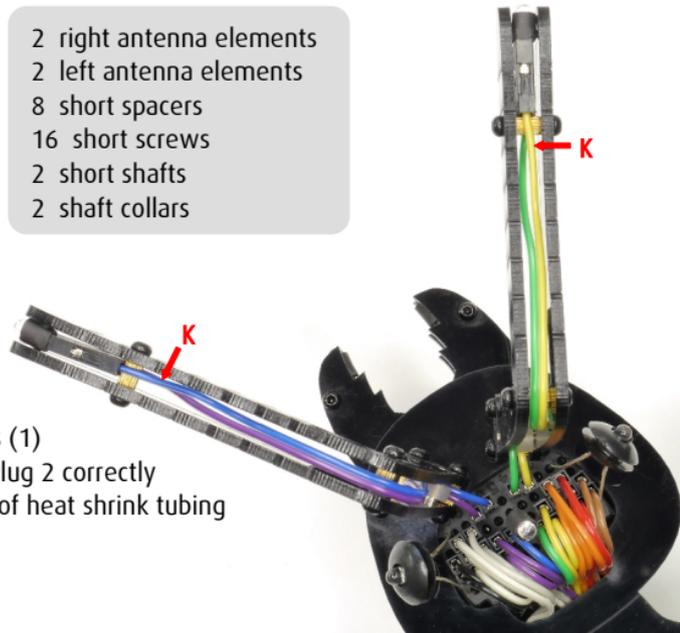
19) Installing the Battery

Mount the 2 battery holders on the small spacers in the center of the body using 4 short screws.

Begin by placing the elastic band around the two protruding tips of the acrylic parts at the back. Then, pull the lower part of the elastic band towards the center and stretch it from below over the protruding tips at the front.

Now, place the battery between the holders with the USB port facing upwards, and secure it with the two elastic loops.

Lastly, bend the red-black clip cable 180° towards the back and connect the clip connector to the contacts of the battery.

- 2 battery holders
- 4 short screws (4 mm)
- 1 elastic band (Ø 40 mm)
- 1 Li-ion battery (9 V)

If your kit does not include a battery, make sure to use a rechargeable 9 V lithium-ion battery or, a 9 V lithium battery.

Standard 9 V alkaline block batteries are not suitable as they do not provide enough power.

20) Mounting the Electronics

Trim the leads of the blue and red LEDs as well as the 2 push buttons to a length of 6 mm.

For the LEDs, you can identify the negative terminal (cathode) by the shorter leg and the larger "flag" (K) inside.

To ensure the contact for the 3 red LEDs in the sockets is good, you'll need to twist the ends of the legs 90° using a small pair of pliers.

Now, insert the 12 blue LEDs into the sockets shown in the picture, making sure the cathode is always on the inside. The red LEDs need to have the cathode facing toward the writing on the acrylic plate.

Plug the push-buttons into the sockets AL1/AL3 and AR1/AR3.

Now insert the final sensor, plugging the shorter pin (collector) into socket AR0, and the longer one into AL0. Then, bend the sensor 90° backwards.

Place the two red switch caps, with their slots facing sideways, onto the push-buttons (LEDs and PWR).

Lastly, insert the Nano board, with the USB connector on the left side, into the corresponding socket terminal strips.

3 red LEDs (2 x 3 x 4 mm)
12 blue LEDs (2 x 3 x 4 mm)
1 Nano-Board (Arduino comp.)
2 round pushbuttons (Ø 6,2 mm)
2 switch caps (Ø 4,5 mm)

B) Startup Procedure
1) Charging the Battery

The rechargeable 9 V block battery included in the VARIOBOT kit, unlike conventional 9 V alkaline batteries or NiMH batteries, can deliver a current of up to 600 mA. It provides power to variAnt for a minimum of 3 hours.

> Average power consumption: approx. 160 mA
>
> Peak current for both motors: 400 mA

The battery has two 3.7 V lithium-ion cells. However, its electronics simulate a typical 9 V battery at the output. During operation, the voltage drops to around 5 V, at which point the battery shuts off to prevent deep discharge.

Before using it, fully charge the battery by connecting it to the Micro-USB port.

> While the battery is charging, the LED indicator will be red. Once the battery is fully charged, the LED indicator will turn blue.

Charging time may vary depending on the current battery level and can take up to 2 hours.

> **Key specifications for the VARIOBOT battery:**
>
> Output voltage: 9.5 V - 5 V
>
> Maximum output current: 600 mA
>
> Capacity at the output: 4500 mWh
>
> USB charging voltage: 5 V
>
> USB charging current: 0.5 A
>
> Voltage of the internal Li-Ion cells: 3.7 V
>
> Capacity of the internal Li-Ion cells: 1200 mAh
>
> Weight: approximately 28 g

> If your kit does not include a Lithium-Ion 9 V block battery that can deliver 400 mA of current (which is necessary), we recommend ordering one from www.variobot.com.

2) Configuring the Arduino IDE

A convenient way to program with Arduino is through the Arduino-IDE. To install the Arduino IDE environment, download the latest file, for example, *"Arduino IDE 2.1.1"*, for your operating system from here:
https://www.arduino.cc/en/software

Here's how to install it on Windows:
Double-click on the downloaded file e.g. *arduino-ide_2.1.1_Windows_64bit.exe* and install Arduino on your computer. You'll need to confirm the licensing agreement, the suggested components and the storage location.

> Your kit includes a Nano variant with a powerful LGT8F328 processor that can be clocked up to 32 MHz.
>
> As an alternative, the control board can also be equipped with a standard Arduino Nano (ATmega328, 16 MHz).

Before using the LGT8F328 Nano board, the appropriate software needs to be installed.

- Start the Arduino IDE.
- Go to *File/Preferences...*
- Change the language if necessary.
- In the *"Additional boards manager URLs"* field, add the complete URL shown in the gray box below and click *"OK"*.
- Go to *Tools/Board:/Boards Manager...* and search for and install *"LGT8fx Boards"*.

Now the board will appear in the *"Tools"* menu:

- Select the board: *"LGT8fx Boards/LGT8F328"*
- Select the clock source: *"Internal"*
- Select the clock: *"16 MHz"* or *"32 MHz"*
- Select the variant: *"328P-LQFP32 (Mini EVB)"*

You can find more information about it here:
https://github.com/dbuezas/lgt8fx

https://raw.githubusercontent.com/dbuezas/lgt8fx/master/package_lgt8fx_index.json

3) Installing variAnt's Library

We prepared an Arduino library that will make controlling your ant easy.

Start by downloading the current file, *VariAnt.zip*, at https://www.variobot.com/variant

This is how you can install the library in the Arduino-IDE:

1) In the menu, click *Sketch/Include Library/Add .ZIP Library...*

2) Open the *VariAnt.zip* file you downloaded.

The Arduino IDE automatically installs the library in the correct "libraries" folder. Before using it, you may need to restart the Arduino IDE.

To access the variAnt functions in your program (Sketch), the library has to be included in your Sketch. To do that, you can either go to the menu and use *Sketch/Include Library/VariAnt* or write the following at the beginning of the program:

```
#include <VariAnt.h>
```

The variAnt library manages the movements of your robot ant as well as the sensor polling and LED indicators.

It includes two subordinate objects of the class AntMotor, which handle the control of the left and right motors using the reed switches.

The VariAnt Library has 2 data files for each of the classes, VariAnt and AntMotor.

VariAnt.h	AntMotor.h
VariAnt.cpp	AntMotor.cpp

The so-called header files (.h) only have the declarations of the variables and functions.

The C++ (.cpp) files contain the actual implementation of those specific functions.

Since the class AntMotor cannot be accessed directly through your Sketch, its functions are rather irrelevant for you.

4) Creating a Test Program

Start by testing the movement of your ant using this simple test program. Save your initial sketch, for example, under the name "variAnt_test.ino".

First create an object of the VariAnt class in the program and give it a name like "ant", for example.

Within the setup function, the "ant" object needs to be initialized using its own setup function.

Use "setSpeed(160)" to set the starting speed to 160, for example. The highest possible value is 255.

For controlling the motors and polling the sensors, the "ant.update()" function must always be called within the loop function.

The if statement uses the "buttonPressed(LEFT, SHORT)" to check if the left button was pushed for a short amount of time (< 500 ms). In this case, the speed is reduced by 32 using "changeSpeed(-32)".

"buttonPressed(LEFT, LONG)": If the button is pressed for a long time, "stepBack(15, 3)" is used to have the ant move backward 15 steps on the left and 3 steps on the right. This will result in a rotation of 12 steps to the left.

```
#include <VariAnt.h>

VariAnt ant;

void setup( )
{
  ant.setup( );
  ant.setSpeed(160);
}

void loop( )
{
  ant.update( );

  if(ant.buttonPressed(LEFT, SHORT))
    ant.changeSpeed(-32);

  if(ant.buttonPressed(RIGHT, SHORT))
    ant.changeSpeed(32);

  if(ant.buttonPressed(LEFT, LONG))
    ant.stepBack(15, 3);

  if(ant.buttonPressed(RIGHT, LONG))
    ant.stepBack(3, 15);
}
```

5) Testing the Walking Movement

Start by uploading your program to the Nano board. Connect it to the computer using a suitable USB cable.

In the Arduino IDE, select the corresponding *"COM"* port under *Tools/Port*, and then click on the round button with the right-facing arrow to upload the program.

In the output below that, you will be shown whether the compilation and uploading of the program were successful or not.

> At the beginning of the upload, the blue LED (L) on both the Nano board and the VariAnt board (DL3) will blink if the left red switch (LEDs) is pressed. The LEDs DR1 and DR3 will then indicate the upload process.

Once the upload is complete, you can disconnect the USB cable and turn on the ant by pressing the right red button (PWR). The motors should start running, and the LEDs MLA, MRA, and PWR will be illuminated.

Check if two of the legs are touching while walking. If this is the case, try to correct the position of the legs as follows:

- Loosen the 4 mm screws that attach the ball joints to the body from below.

- Push the affected joints away from each other and tighten the screws while doing so.

- If that is insufficient, repeat the process with the upper 6 mm screws.

Next, check if the left and right opposing legs are moving offset by 180°.

> The red LEDs (RSL and RSR) indicate the activation of the reed switches. While the middle leg is in the air, the corresponding LED should flash twice.

Lastly, test the buttons. If they are not working, there may be an issue with the sensors (refer to Chapter 7 for troubleshooting).

6) Implementing Outputs

The USB connection can also be used to run input and output operations via the PC, which is particularly useful for testing or troubleshooting purposes.

Initialize the serial connection with "Serial.begin()". Use the transmission speed (baud rate) as the argument.

While the program is running, you need to start the output via *Tools/Serial Monitor* and set the desired baud rate (e.g. 57600).

The function "printSensors(500)" will then output the 9 values for the sensors at the selected interval, e.g, every 500 ms.

> At the beginning of the program, the usage of the serial interface is defined by using "#define TEST".
>
> If you no longer want to use serial output, you can comment out the definition as follows: "//#define TEST."
>
> Instead, in this example, the output is done using LEDs via the "#else" operator, for instance.

By using "showShadows(500)", you can display on the 8 outer blue LEDs whether the corresponding sensor values exceed the threshold value of, for example, 500. In this case, the maximum value of 1023 corresponds to a voltage of 5 V.

```
#include <VariAnt.h>

#define TEST

VariAnt ant;

void setup()
{
  #ifdef TEST
    Serial.begin(57600);
  #endif

  ant.setup();
}

void loop()
{
  ant.update( );

  #ifdef TEST
    ant.printSensors(500);
  #else
    ant.showShadows(500);
  #endif
}
```

7) Checking the Sensors

Place your ant in a well lit area and check the values outputted using "printSensors()".

Antennae:	L0	R0
Mandibles:	L2	R2
front legs:	L1	R1
back legs (eyes):	L3	R3
rear part (head):		M

variAnt's phototransistors are connected in series between GND and 5 V, and they provide eight analog voltages or values ranging between 0 and 1023 (5 V) at the connections AL0 - AL3 and AR0 - AR3 on the board.

From these 8 values and the maximum value of 1023, 9 difference values are then calculated. These difference values correspond to the respective relative shadowing of the sensors and add up to 1023 in total.

The sensor values should change depending on the ant's orientation.

If a sensor consistently has a high value, it is either incorrectly polarized or not properly connected.

Shade one of the sensors with your hand and test if the corresponding value increases significantly (to 700 - 1000).

The sensors on the hind legs should be shaded simultaneously with the eye sensors on the same side, just as the sensor on the rear part and the central sensor on the head should be.

The 3 additional sensors, which are directly inserted into the breadboard, are aligned parallel to the sensors on the hind legs and rear part.

The sensitivity of the sensors can be adjusted, if needed, by appropriately shifting the respective heat shrink tubing.

8) Avoiding Obstacles

The walking speed should now be automatically regulated. As the ant gets closer to an obstacle, it will gradually slow down.

> By using "getSensor(L2)", for example, the sensor value of the left mandible "L2" is retrieved.

The measured value is divided by 8 and subtracted from the maximum speed of 255.

> By using "senseShadow(820, L1)", the sensor value defined by "L1" is compared to a threshold value (e.g., 820). If the threshold is reached, the corresponding LED will light up.
>
> You can specify 1 to 4 parameters for the sensors. In this case, the sum of these sensor values is compared to the threshold value.

This causes the "variAnt" to rotate one step to the right when the left front leg "L1" is shaded, using "stepBack(0,1)".

"senseShadow(900, L0, L2, R2)": However, if the two mandibles (pincers) "L2, R2" or the left antenna "L0" are shaded, the ant should take one step back with "stepBack(1,4)" and then turn 3 steps (approximately 90°) to the right. Adjust the parameters according to your needs.

```
void loop()
{
  ant.update( );

  ant.setSpeed(255 – ant.getSensor(L2)/8);

  if(ant.senseShadow(820, L1))
    ant.stepBack(0,1);

  if(ant.senseShadow(820, R1))
    ant.stepBack(1,0);

  if(ant.senseShadow(900, L0, L2, R2))
    ant.stepBack(1,4);

  if(ant.senseShadow(900, R0, R2, L2))
    ant.stepBack(4,1);
}
```

9) Notes on the Testing Environment

Surface

Please test your programs preferably on the floor to prevent variAnt from accidentally falling off the table. However, in a dark environment with direct lighting on a bright table, it can generally avoid the edges of the table as well.

Always use a smooth surface to enable lateral compensation movements that use the rollers on variAnt's legs.

Since the surface serves as a brightness reference, it's best if it is uniformly bright.

> In general, the obstacles should neither be brighter than the surface nor too small.

Lighting

For the best results, use the robotic ant under a ceiling light or near a window.

> Avoid any lateral light sources that could cause a glare on the photosensors.

Brightness

Since variAnt can detect relative brightness values due to the combination of the photosensors, its sensor system works in both very bright and almost dark environments.

In addition, unlike other robots, variAnt does not need to emit infrared light to detect lines or objects. This simplifies the circuitry and reduces power consumption at the same time.

Sensor alignment

To prevent large, distant objects or shadows from being mistaken as obstacles, the sensors on the legs and antennae are tilted approximately 45° downwards. For this reason, the sensors in the mandibles and at the rear part should also be slightly inclined towards the ground.

On the other hand, the three optional sensors on the breadboard are primarily used to detect the direction of light sources, which is why these should be directed upwards.

10) Additional Functions of the variAnt Class

```
run(bool direction);
```

```
turn(bool s);
```

"run(FORWARD)" allows variAnt to move in the selected direction, either "FORWARD" or "BACKWARD".

"turn(LEFT)" enables variAnt to rotate in the desired direction, either "LEFT" or "RIGHT".

```
slowDown(bool s);
```

By using "slowDown(LEFT)", the speed of the left motor is reduced until the next left step is taken.

```
bool getButton(bool s);
```

```
bool buttonPressed(bool s);
```

The function "getButton(LEFT)" indicates whether the left button is currently pressed or not. "buttonPressed(LEFT)" without a second parameter indicates whether the button has just been pressed, regardless of the duration of the press.

```
setLed(pos i, bool value=HIGH);
```

Using "setLed(R1)" turns on the corresponding LED at the digital output "DR1", while "setLed(R1, LOW)" turns it off.

> The LEDs may need to be set again in each iteration of the loop function, since they are automatically reset to "LOW" in the update function.

```
setLeds(byte valueL, byte valueR);
```

Using "setLeds(100, 200)" assigns a brightness value between 0 and 255 to the first LEDs connected to the digital outputs "DL0" and "DR0".

```
showSensors(pos s1=L0, pos s2=R0);
```

This function utilizes the first digital outputs "DL0" and "DR0" to represent the chosen sensor values as brightness levels.

C) Appendix

1) Overview of the Components

2) Schematic Diagram of the variAnt Board

variAnt's Features

› 24 high-quality acrylic components

› 12 variable environmental sensors

› 2 reed switches for counting the steps

› 2 programmable buttons

› 8 flexible Digital I/Os

› 15 plug-in status LEDs

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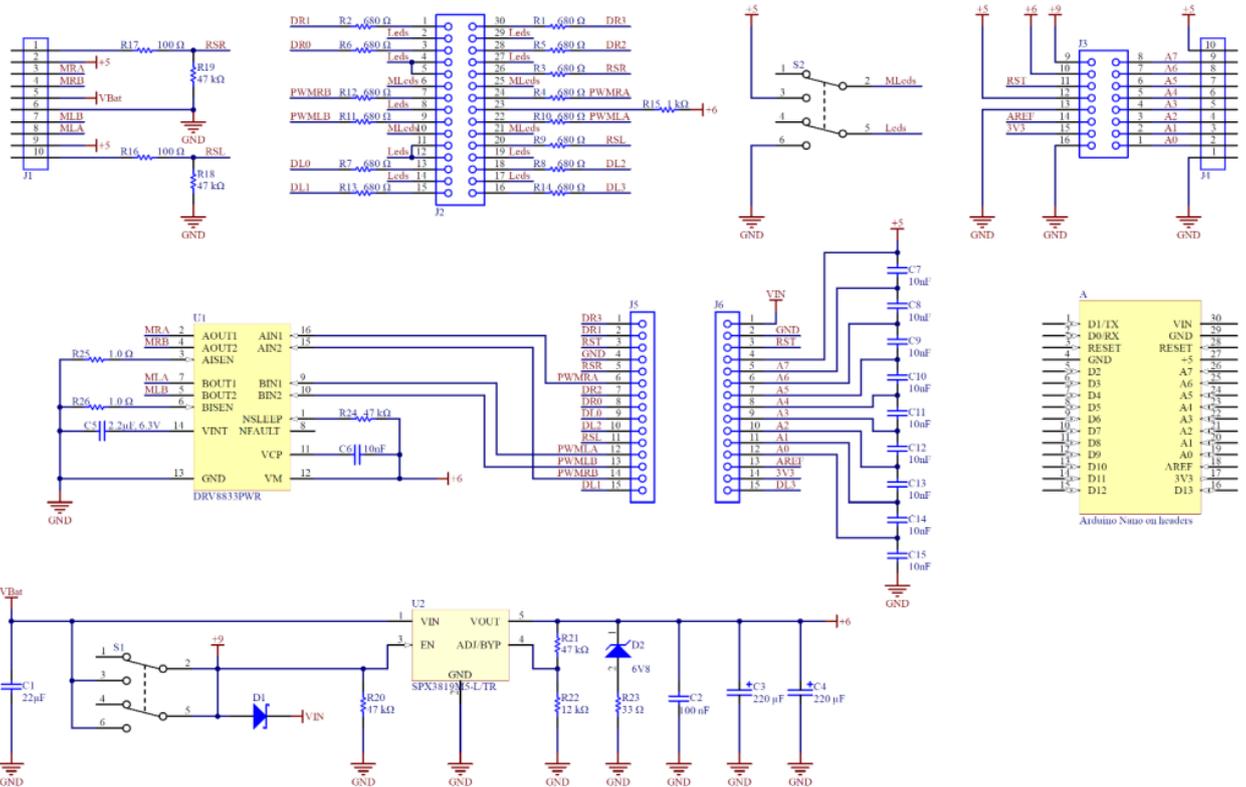
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