

VARIOBOT[®]

DISCOVER MECHATRONICS

for
soldering

varikabo

A Variable Robot Kit with
12 Astounding Functions

- > for beginners and experts
- > no programming needed
- > patented sensor system

Manual

v20180815

AGE

10+

ASSEMBLY

2h

PARTS

35



Safety Instructions for Parents and Children

Attention! Please keep away from children under 3 years. Danger of suffocation by swallowing small parts.



Risk of injury due to sharp tips and edges of individual components. We reserve the right to make technical changes.

Please note: Only suitable for children over 10 years. Use under the supervision of adults recommended. Please read the instructions before use, follow them and keep them at hand for reference. Please keep the packaging.

Battery: The kit requires a 9 V battery, which is not included in the package due to limited storability.

A short-circuit of the battery must be avoided, because it can cause overheating of the cables and an explosion of the battery. After use, the battery clip must be removed of the battery. Non-rechargeable batteries must not be charged. There is a risk of explosion.

Deformations of the batteries must be avoided. Used batteries must be disposed of according to environmental regulations.

Please note: The LEDs, sensors and transistors must be inserted with the correct polarity for the circuits to work. The two transistors have a different designation and must not be confused. The motors must be connected correctly.

General Information

All circuits presented in this manual have been developed, checked and tested with the utmost possible care. Nevertheless, mistakes cannot be completely excluded. The author is liable in cases of intent or gross negligence in accordance with the statutory provisions. For the rest, the author shall only be liable in accordance with the Product Liability Act for injury to life, body or health or for culpable breach of essential contractual obligations. The claim for damages for the violation of essential contractual obligations is limited to the contract-typical, foreseeable damage, unless there is a case of mandatory liability according to the Product Liability Act.

The product has been manufactured in accordance with the applicable European directives and therefore bears the CE mark.

The intended use is described in this manual. In the event of any other use or modification of the product, you are the only responsible for compliance with the applicable rules. Therefore, assemble the circuits exactly as described in the instructions.

The crossed-out dustbin symbol means that this product must be recycled separately from household waste as electrical and electronic waste. Your local authority will tell you where to find the nearest free collection point.



Introduction

We are pleased you have chosen this versatile robot assembly kit. varikabo offers you an exciting and playful approach to electronics. You will certainly have fun and variety with varikabo for a long time.

varikabo's "muscles" are two motors, his "brain cells" two transistors. The simple control circuit is built up with four small boards.

With the help of a clever combination of three brightness sensors varikabo notices the smallest contrasts in its environment and reacts to them in different ways. Thanks to a selector switch and by aligning and switching the sensors, you'll explore twelve different functions and amazing behaviors.

varikabo can do a lot:

- Overcome obstacle courses
- Follow dark or light lines
- Track or move objects
- Search, track or circle light
- Trace or circle shadows
- Circle on light or dark areas



Content

1) Construction

After a short introduction to soldering, the assembly instructions first show step by step and with numerous illustrations how the boards are equipped with the electronic components. Afterwards you will find the instructions for the mechanical components. This includes both the construction of the varikabo kit and the Fischertechnik version varikabo-FT.

- S. 11 Construction of the circuit board
- S. 19 varikabo
- S. 26 varikabo-FT

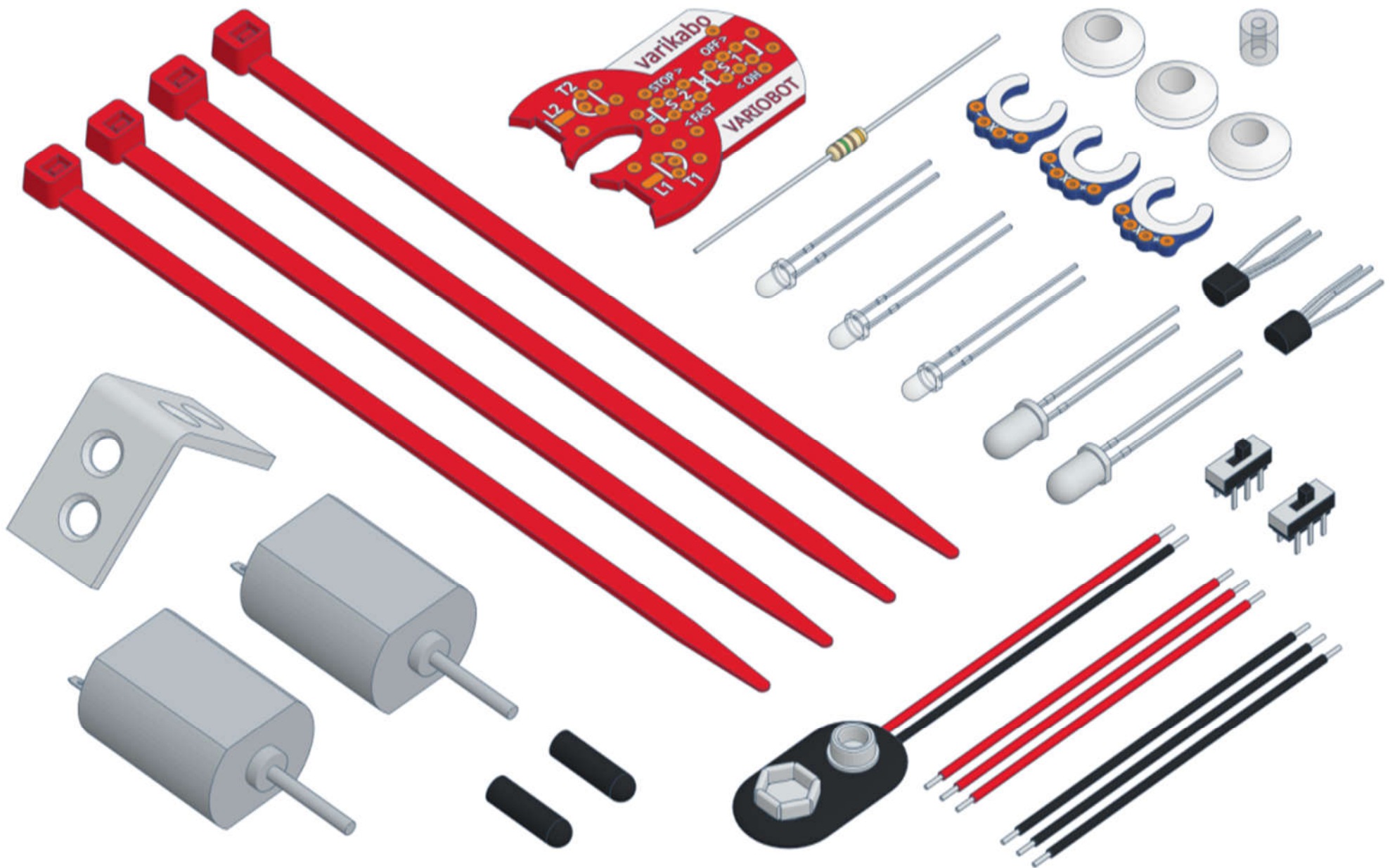
2) Functions

The experiment manual show and explain twelve functions of varikabo. It is shown how to set them using the selector switch and the three swivelling and interchangeable sensors. At the end you will find a fault diagnosis in case something does not work as expected.

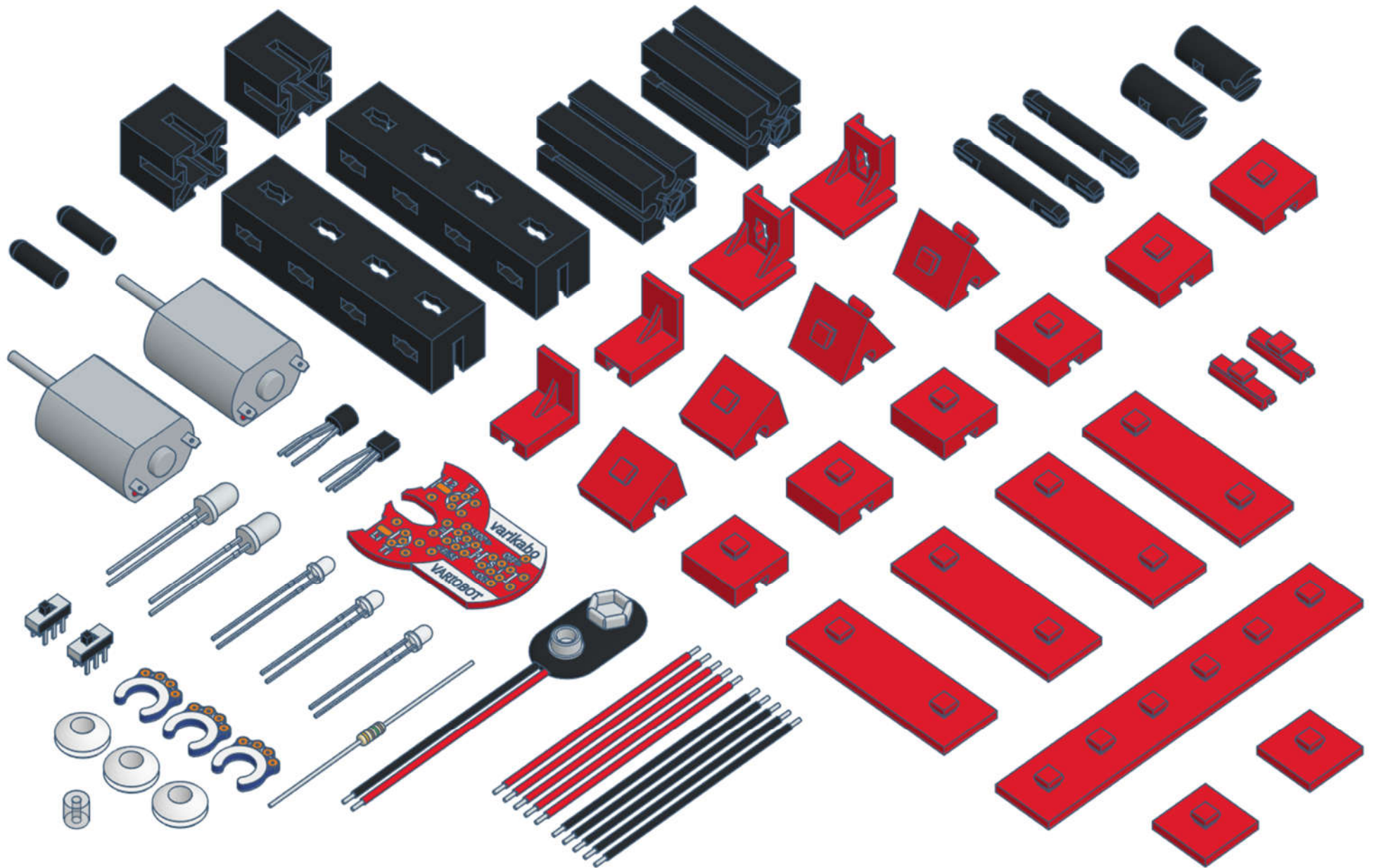
3) Operating Principle

Finally you will learn how varikabo's control circuitry is constructed and how the components of the kit work. You will learn to understand varikabo's versatile behaviours and how they are caused.

The components of the varikabo kit



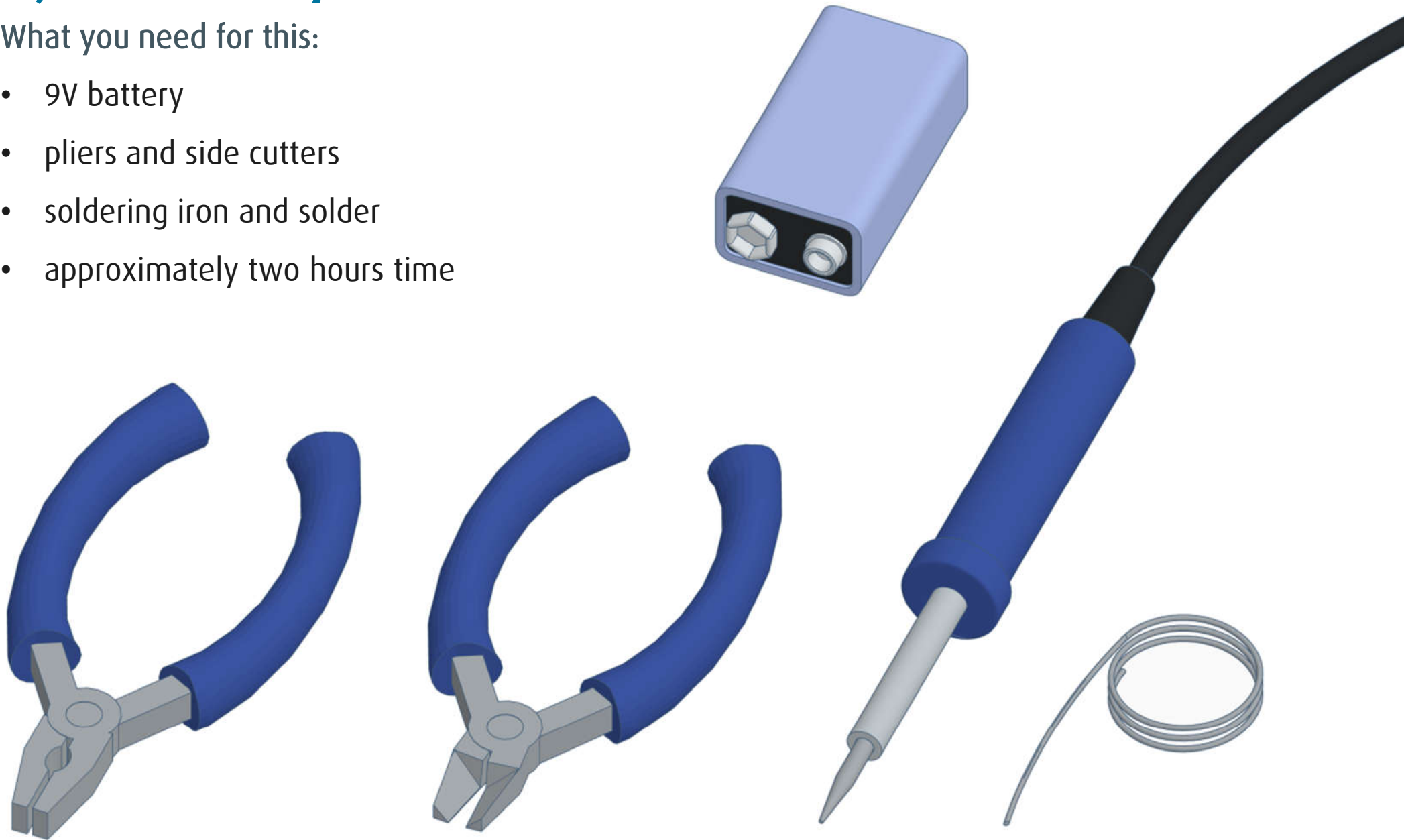
The components of the varikabo-FT kit



1) Assembly

What you need for this:

- 9V battery
- pliers and side cutters
- soldering iron and solder
- approximately two hours time



Introduction to Solder

If you don't have much experience with soldering, read these instructions carefully and practice with some old wires before you dare to use the varikabo kit.

Auxiliaries

- Soldering iron: 20 to 30 W / 300 to 350°C
- Solder: 0.5 to 0.7 mm in diameter
- Small side cutter
- Moist, heat-resistant sponge
- Possibly solder wick or suction pump for corrections

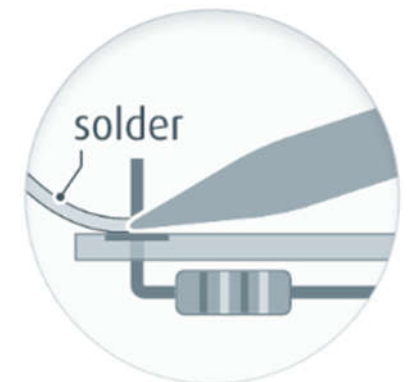
Way of Proceeding

1. Put the components in the marked position. Soldering is done on the other side of the board.
2. Clean the soldering tip lengthwise with a damp sponge.

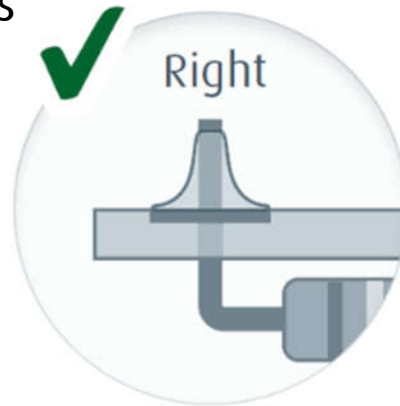
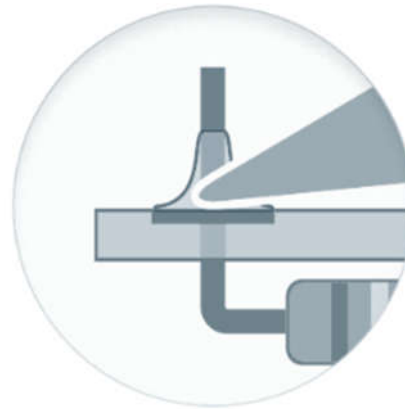
3. Press the soldering tip simultaneously against the solder pad and the lead of the component for about one second so that both are well heated.



4. Now add solder between the solder pad, the component wire and the soldering tip without removing the soldering tip. Use only enough solder to cover the entire solder pad.



5. Stay with the soldering tip at the soldering point for about one second until the used solder is well distributed, so that a shiny silver cone appears around the wire.
6. Then short too long wire pieces with a small side cutter.

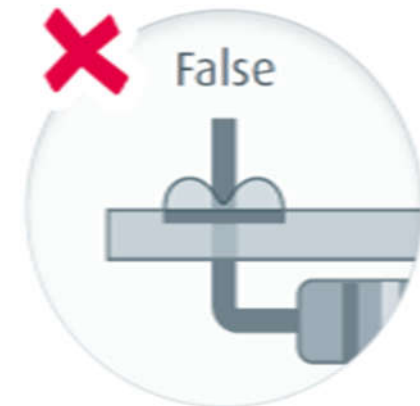
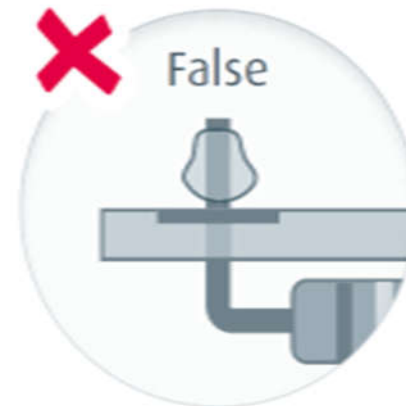


If it did not work out:

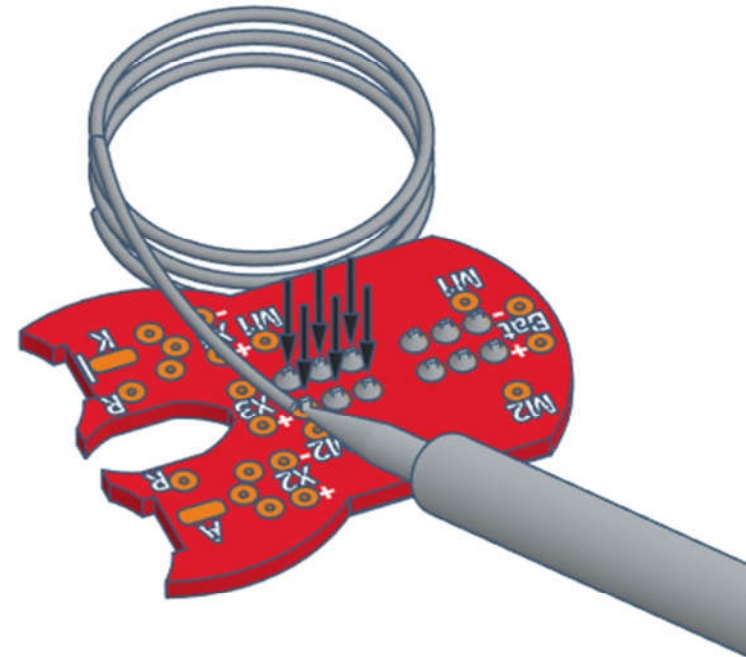
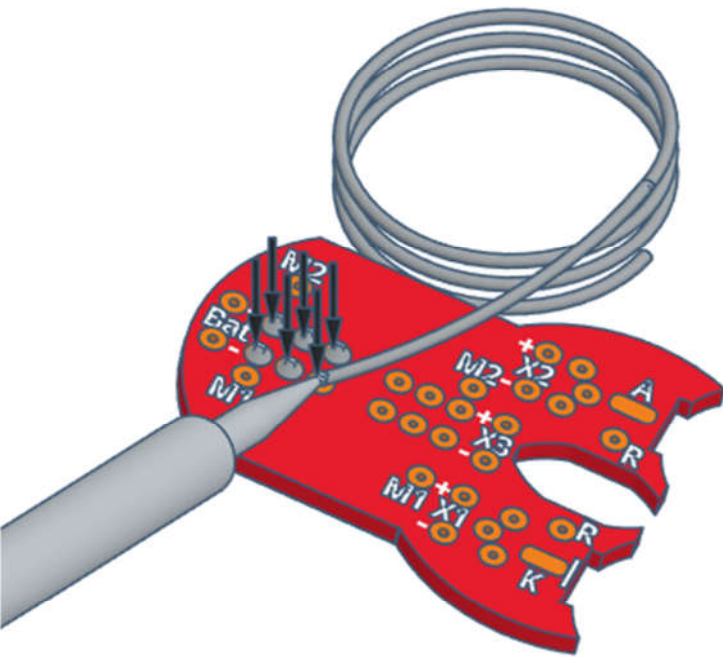
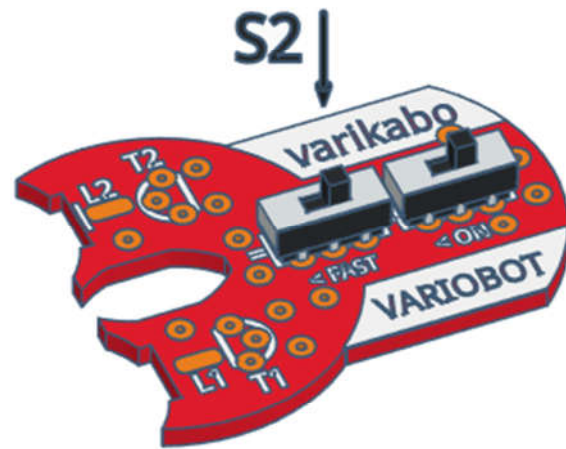
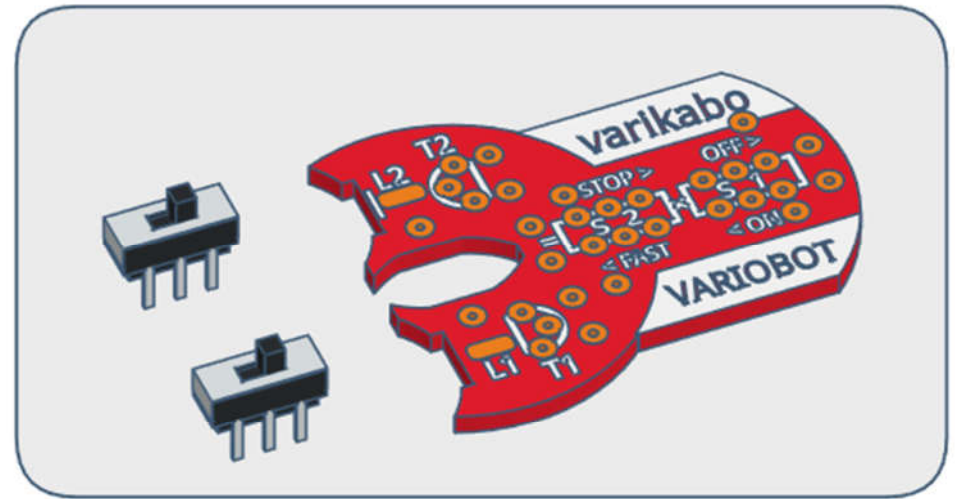
Remove solder with solder suction cup or with solder wick and start over. You'll do better the second time!

Tips

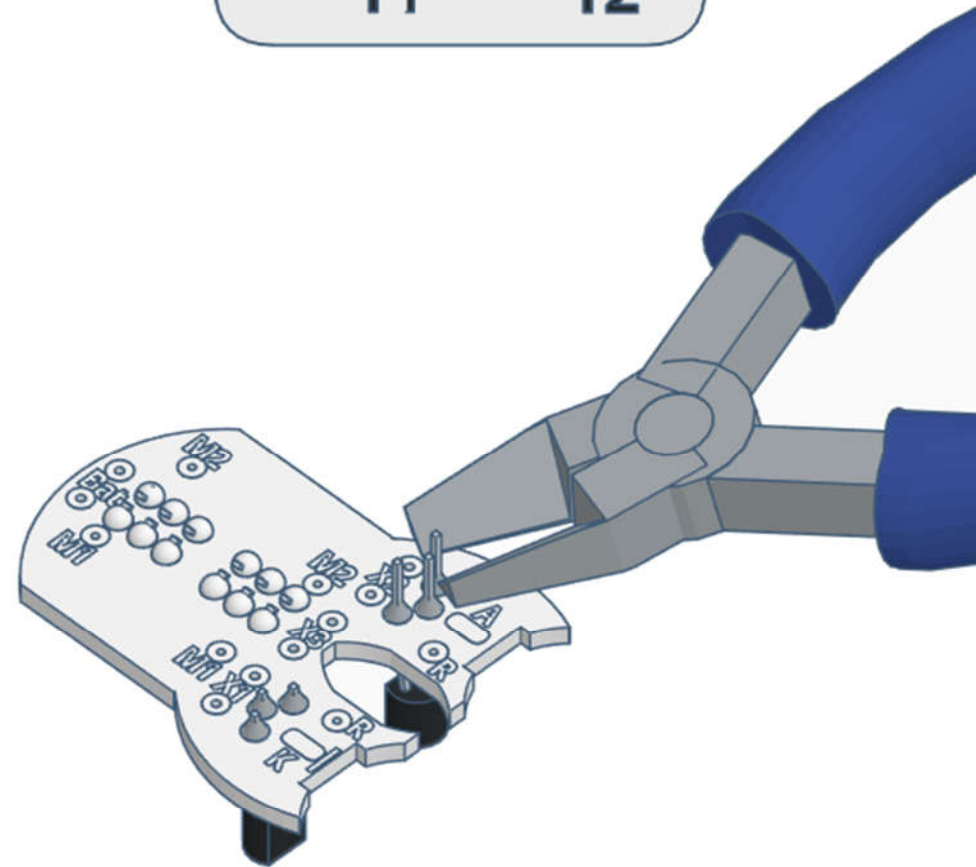
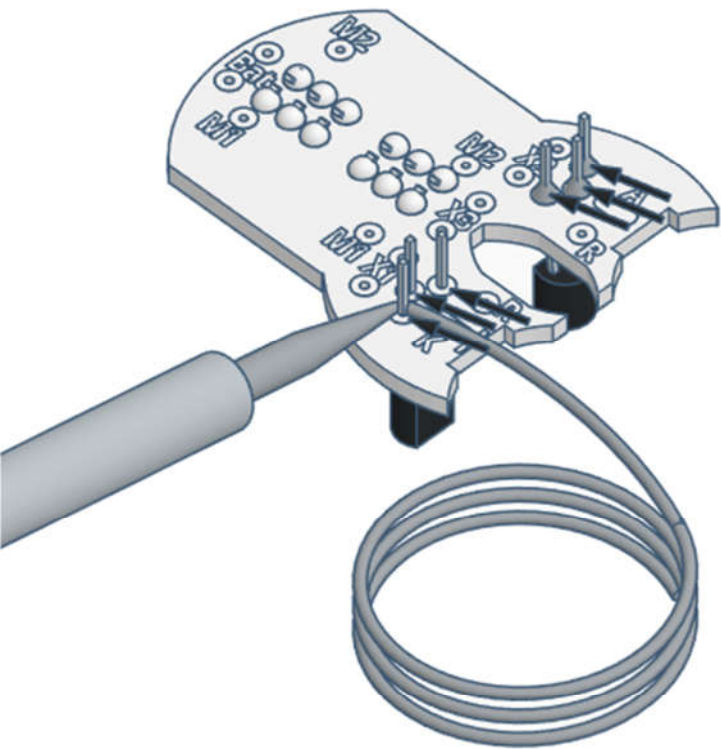
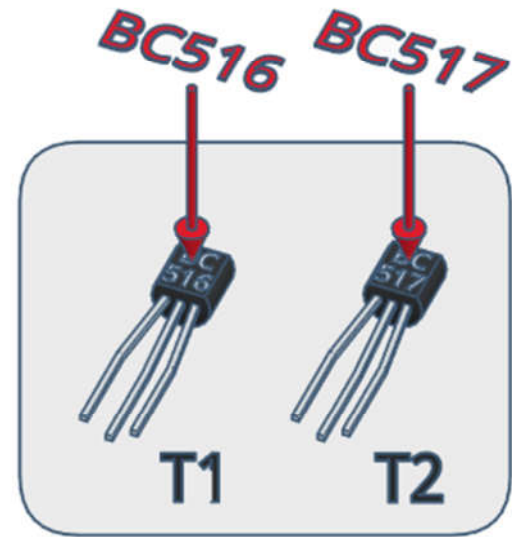
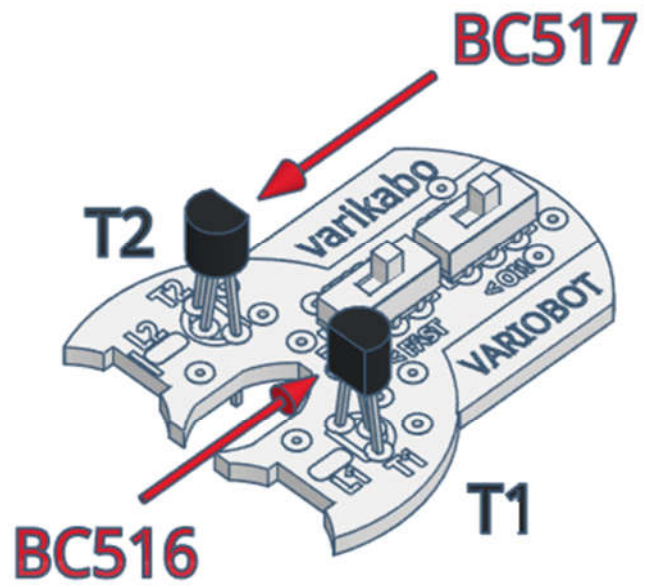
- Heat for a sufficiently long time and do not "dab" with the soldering iron
- Do not heat for too long - otherwise the solder will become "sticky"
- Not too much solder, otherwise there are thick "lumps"



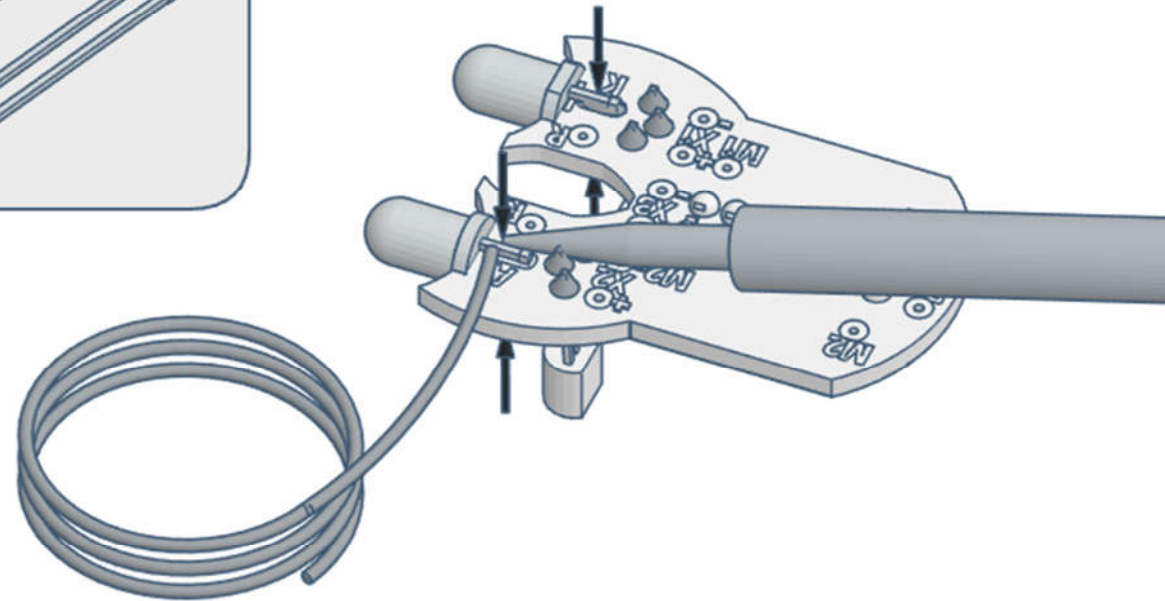
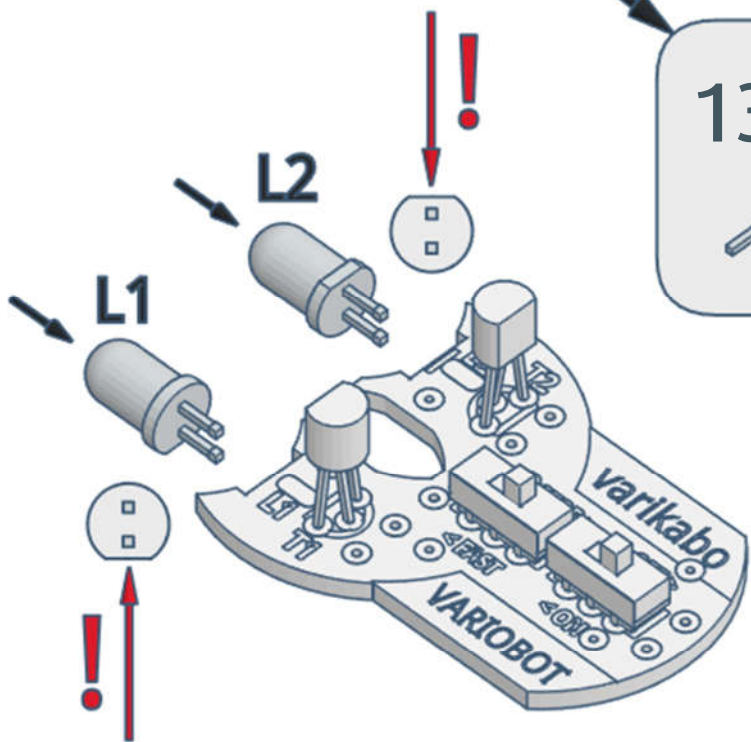
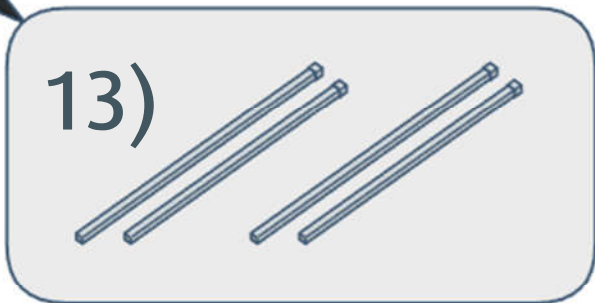
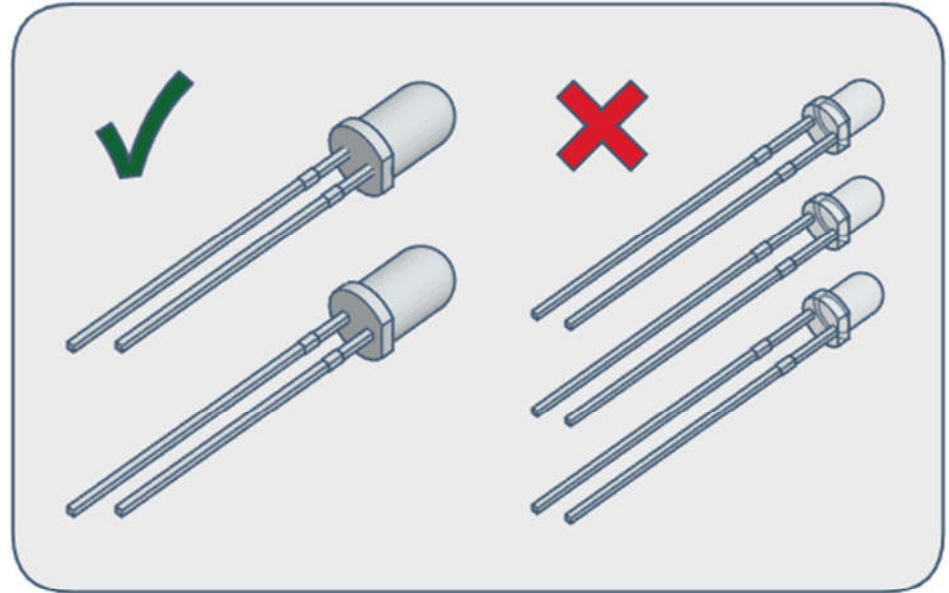
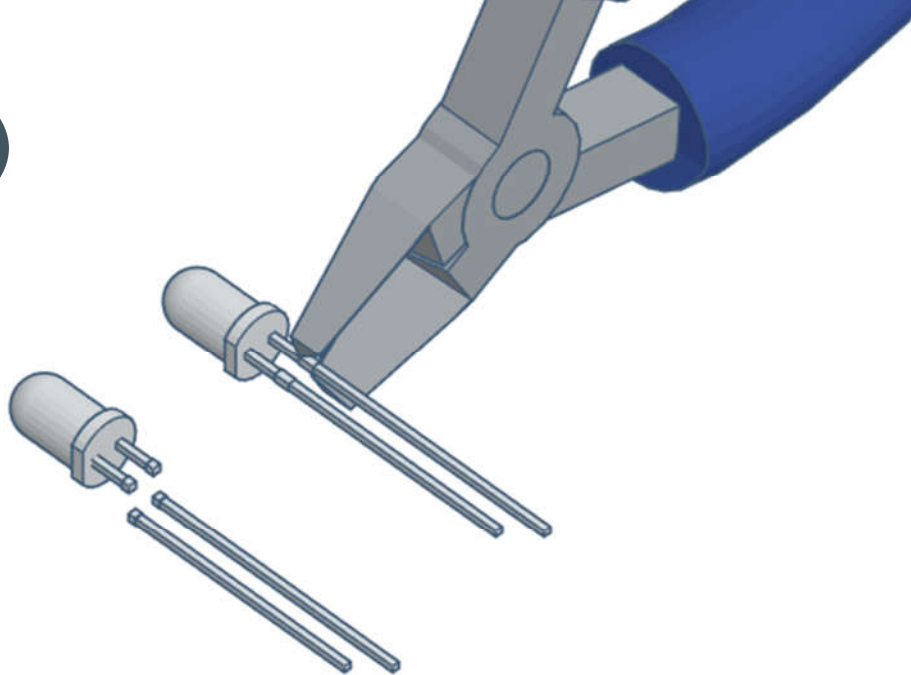
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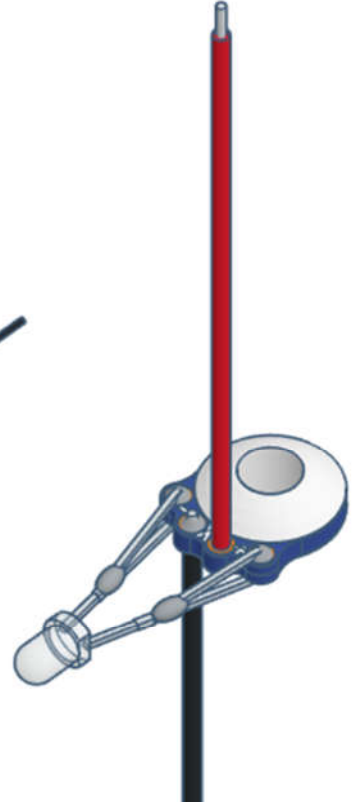
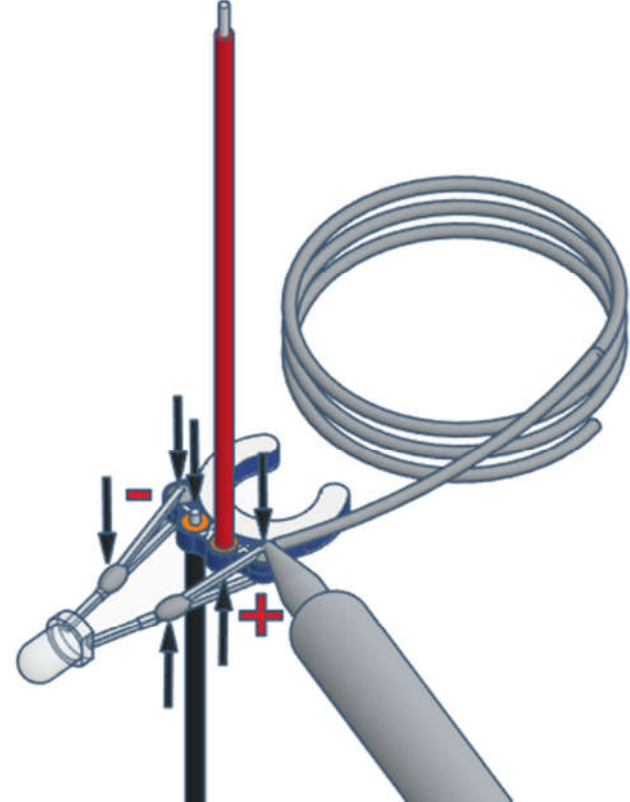
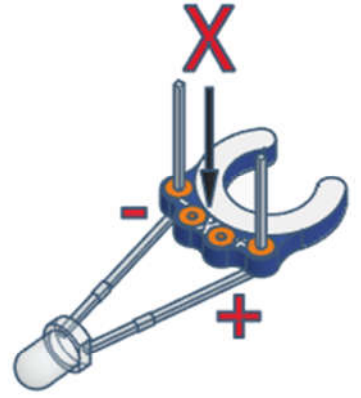
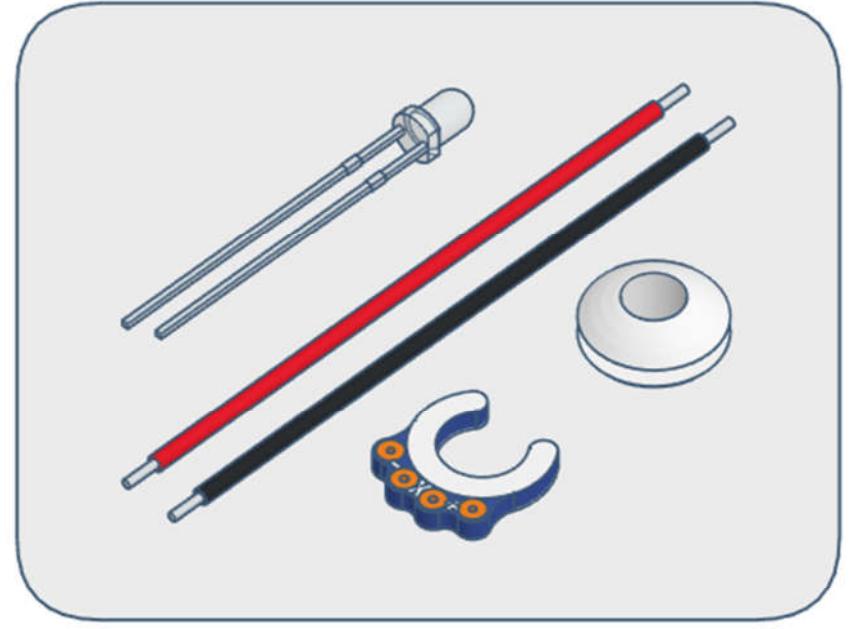
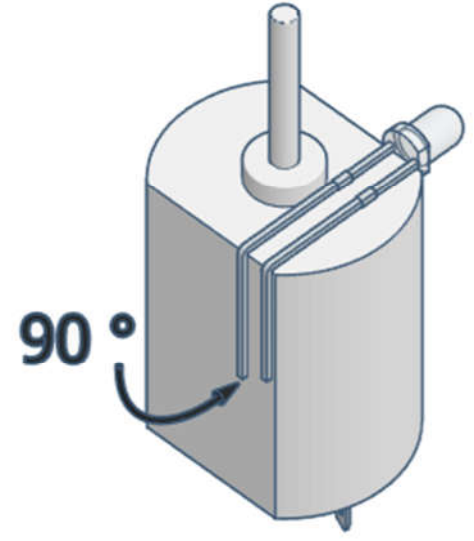
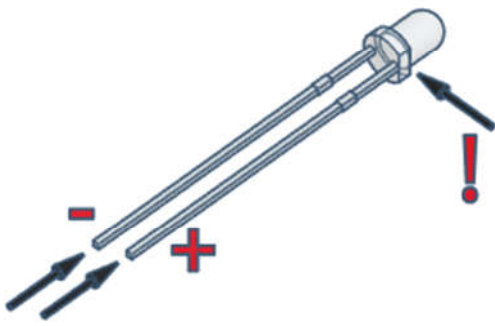
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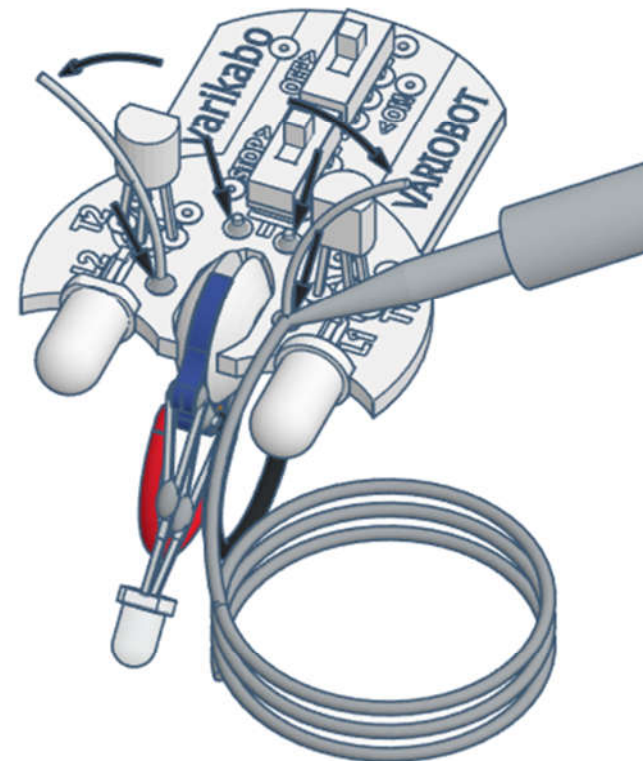
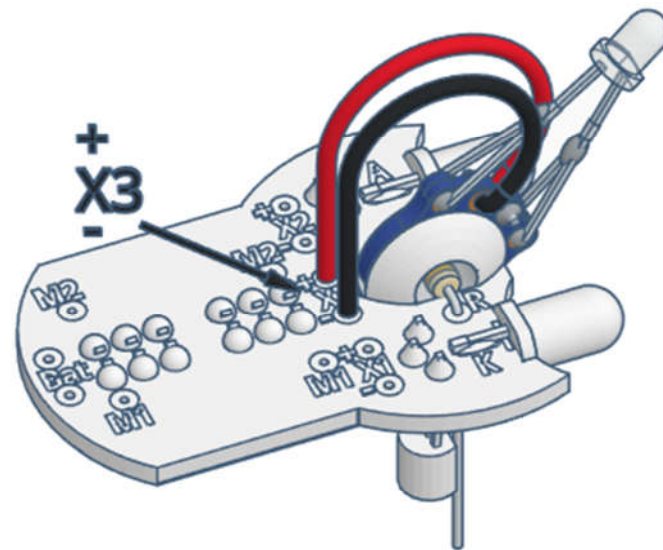
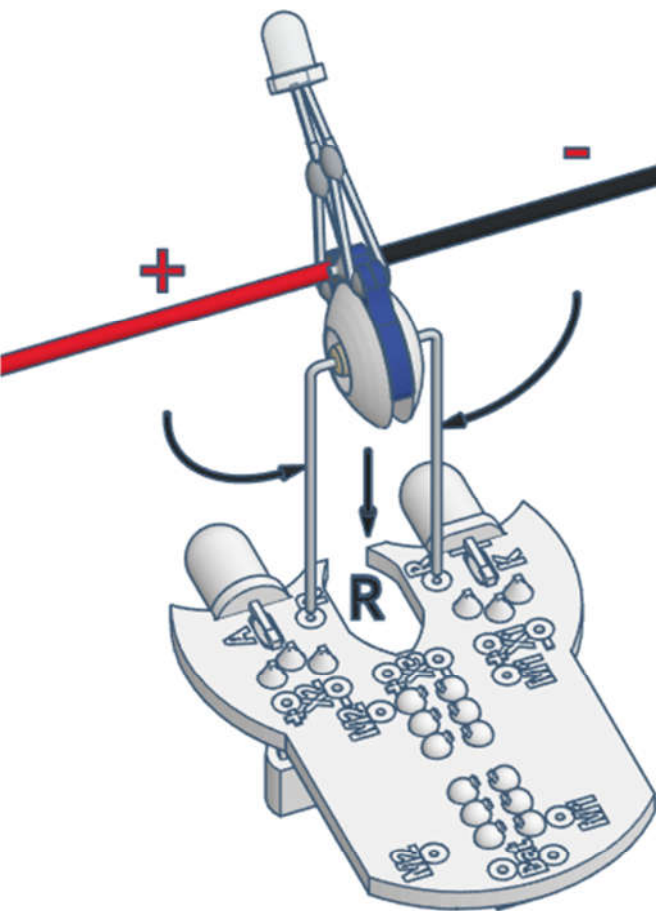
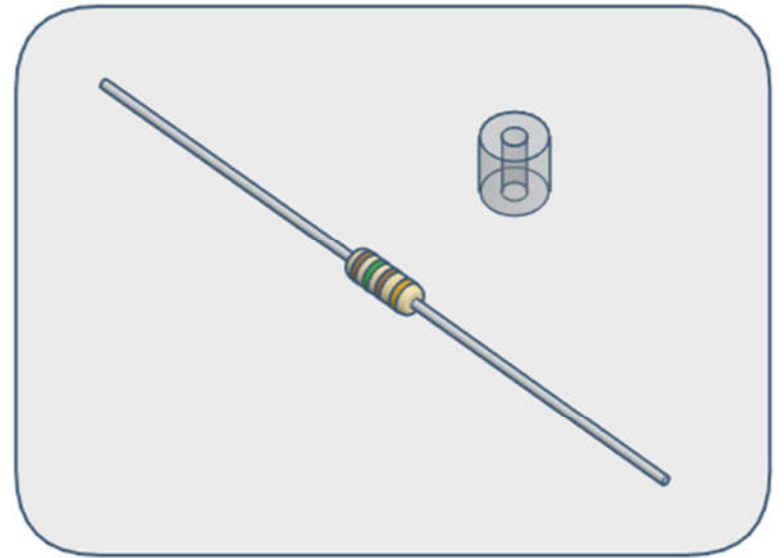
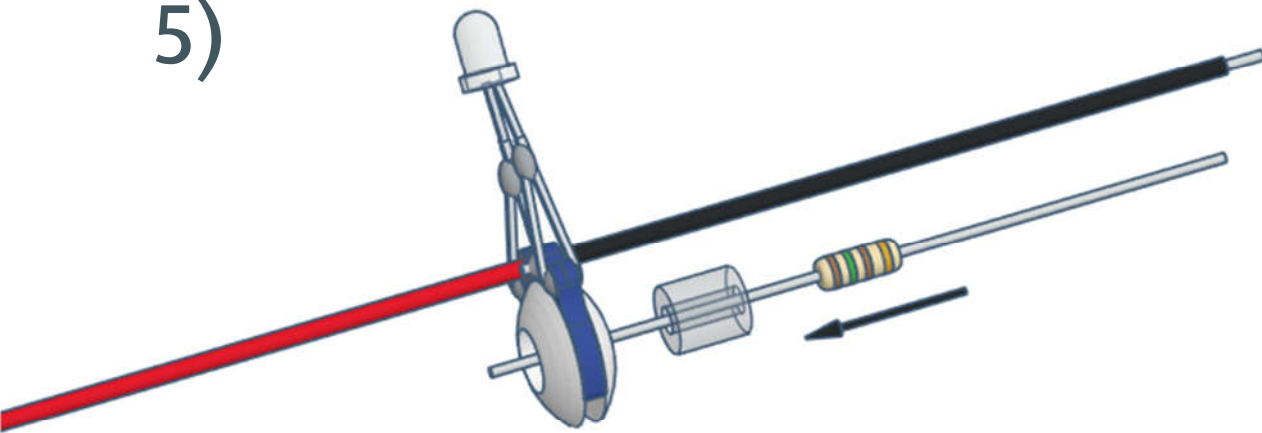
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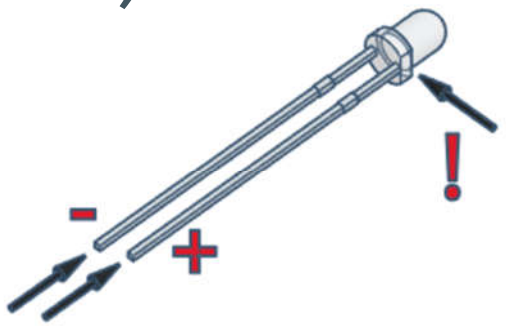
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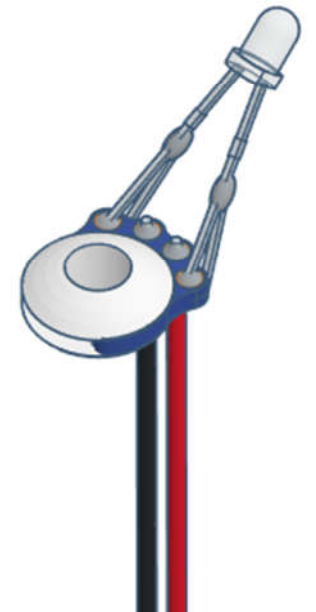
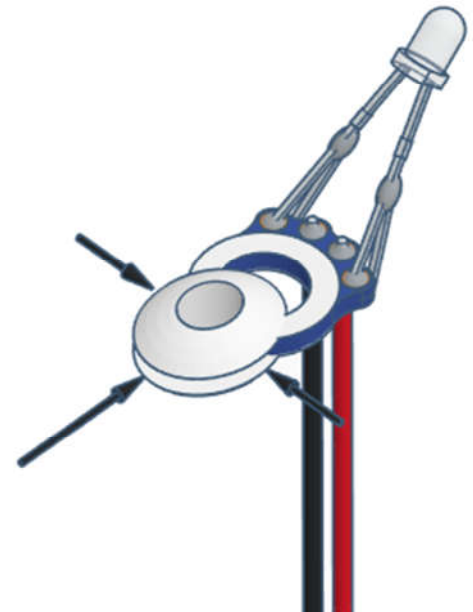
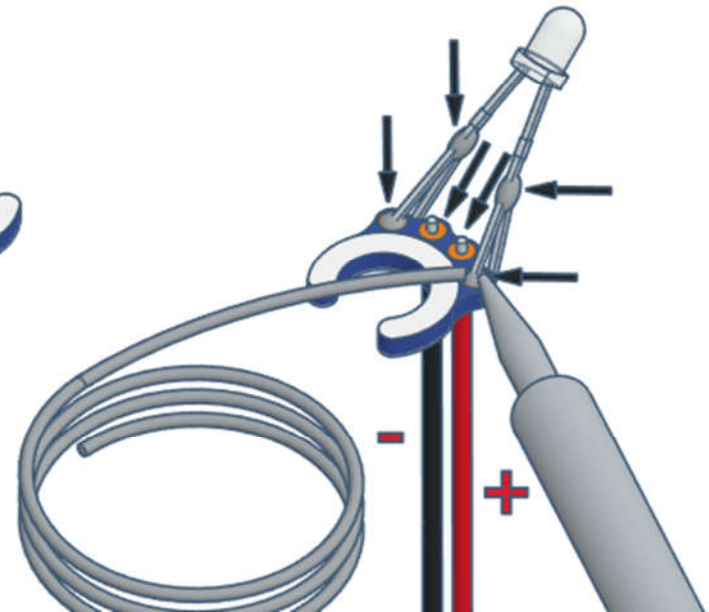
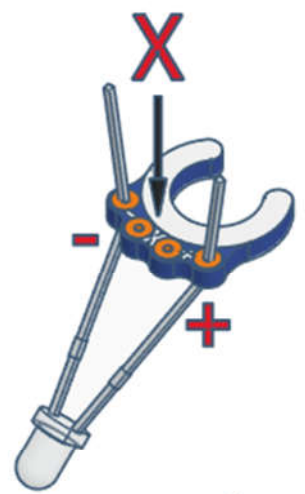
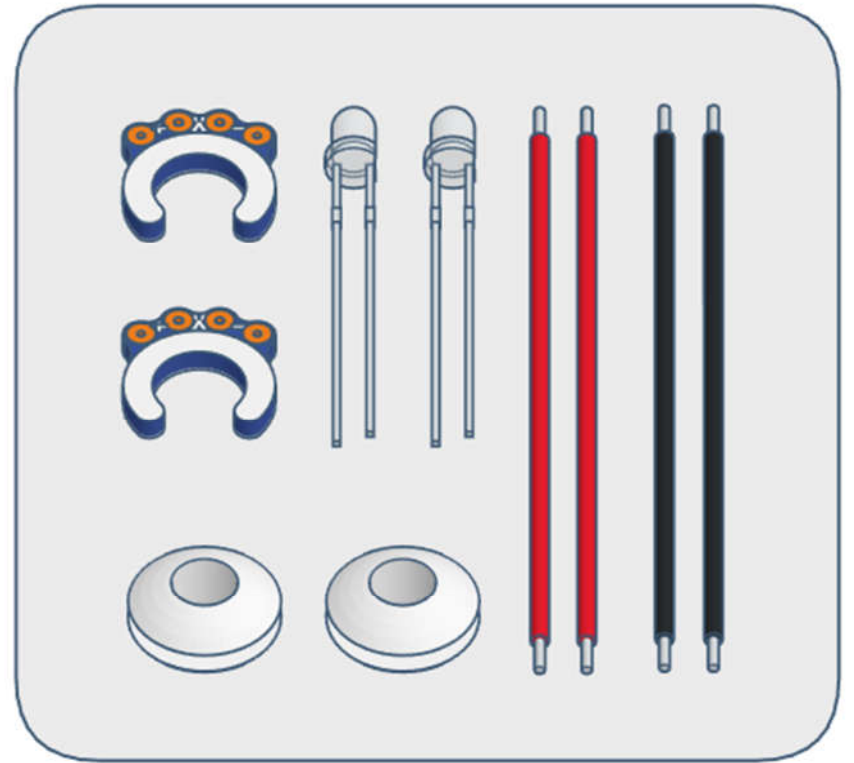
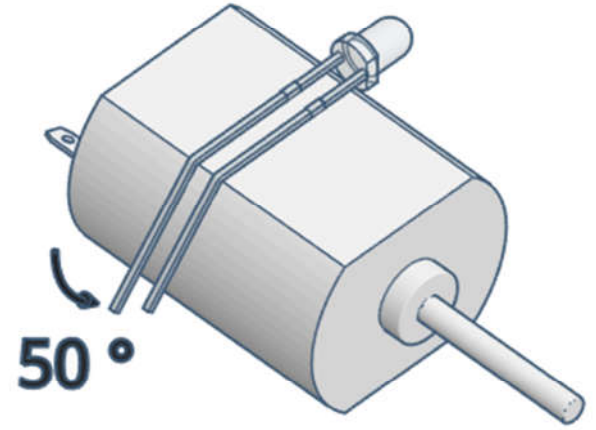
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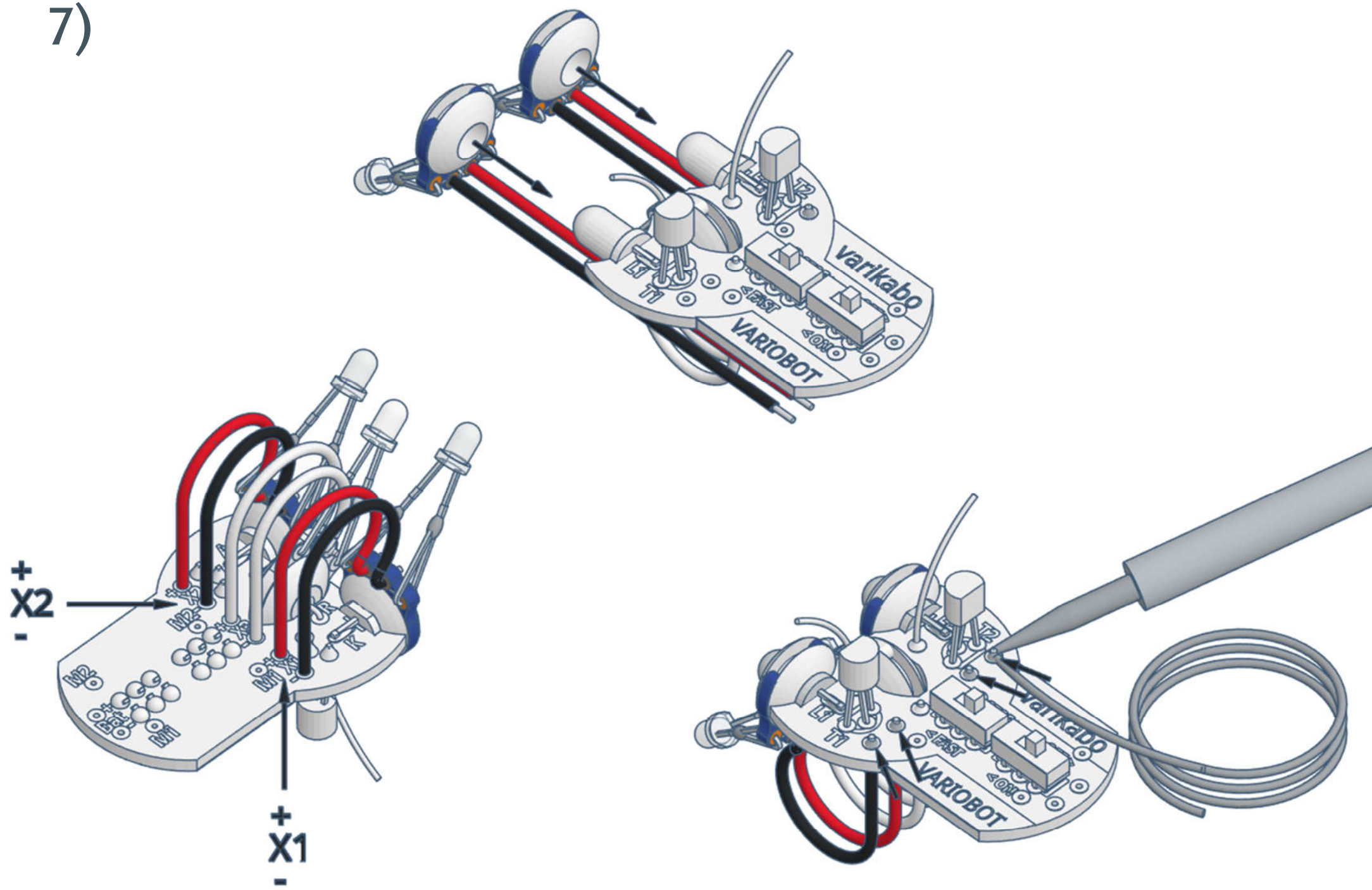
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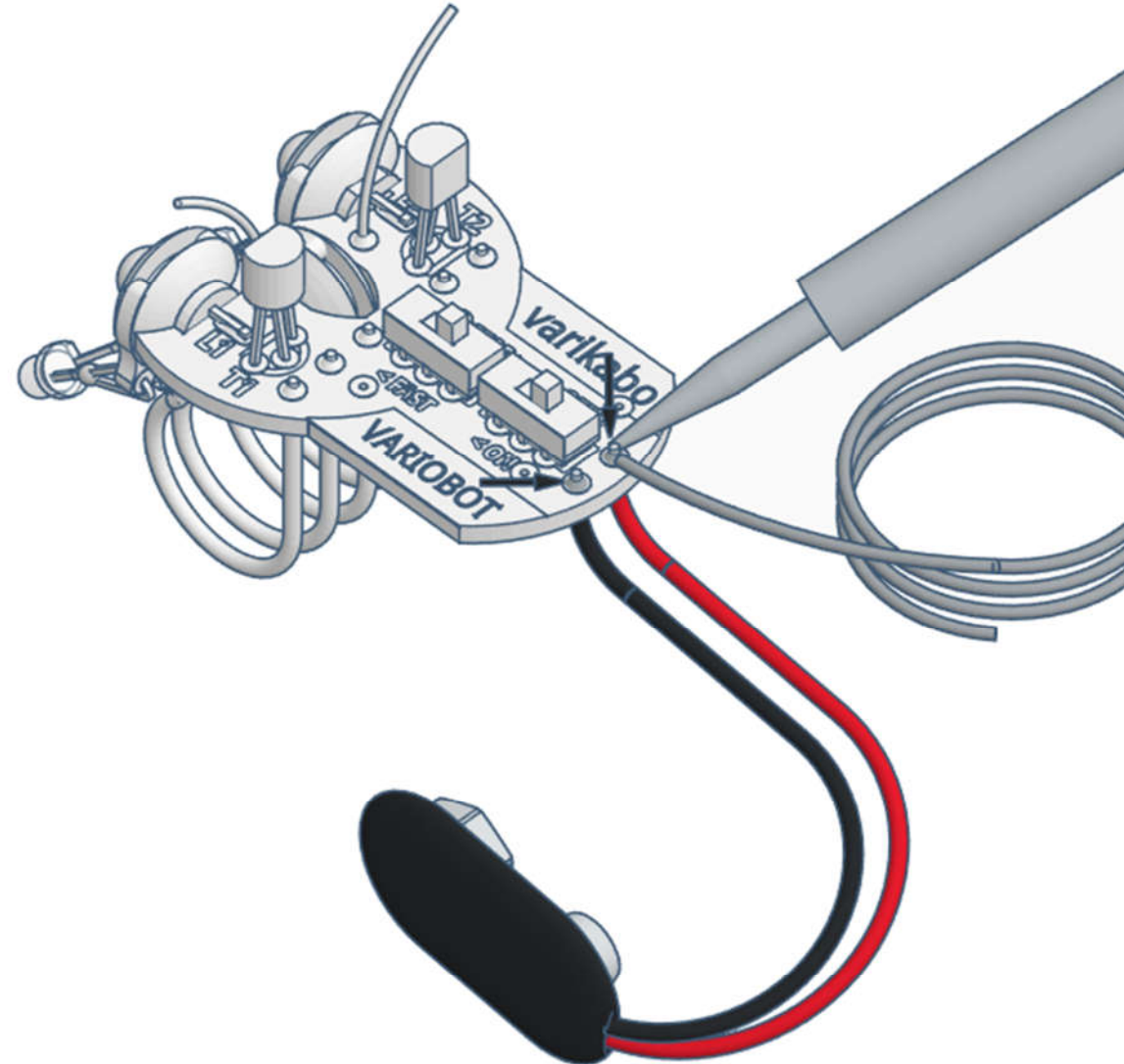
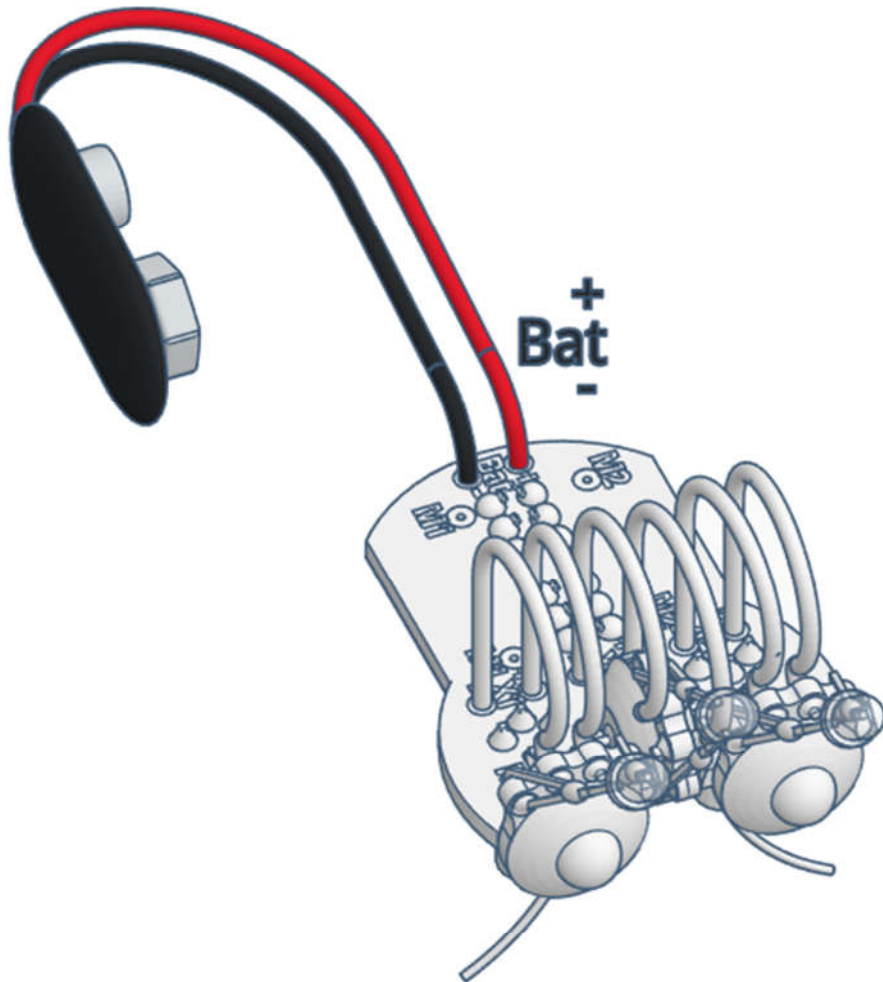
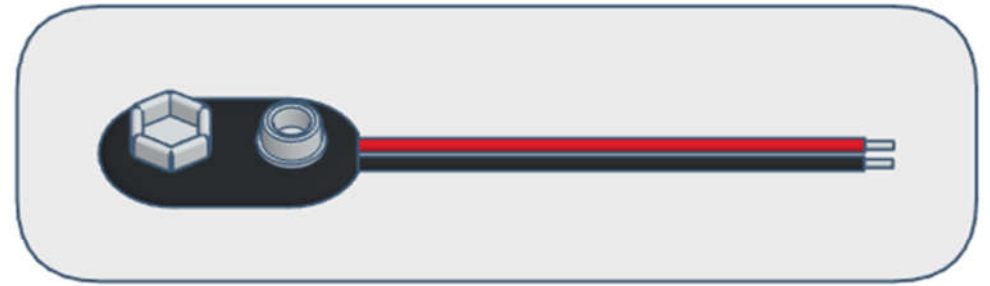
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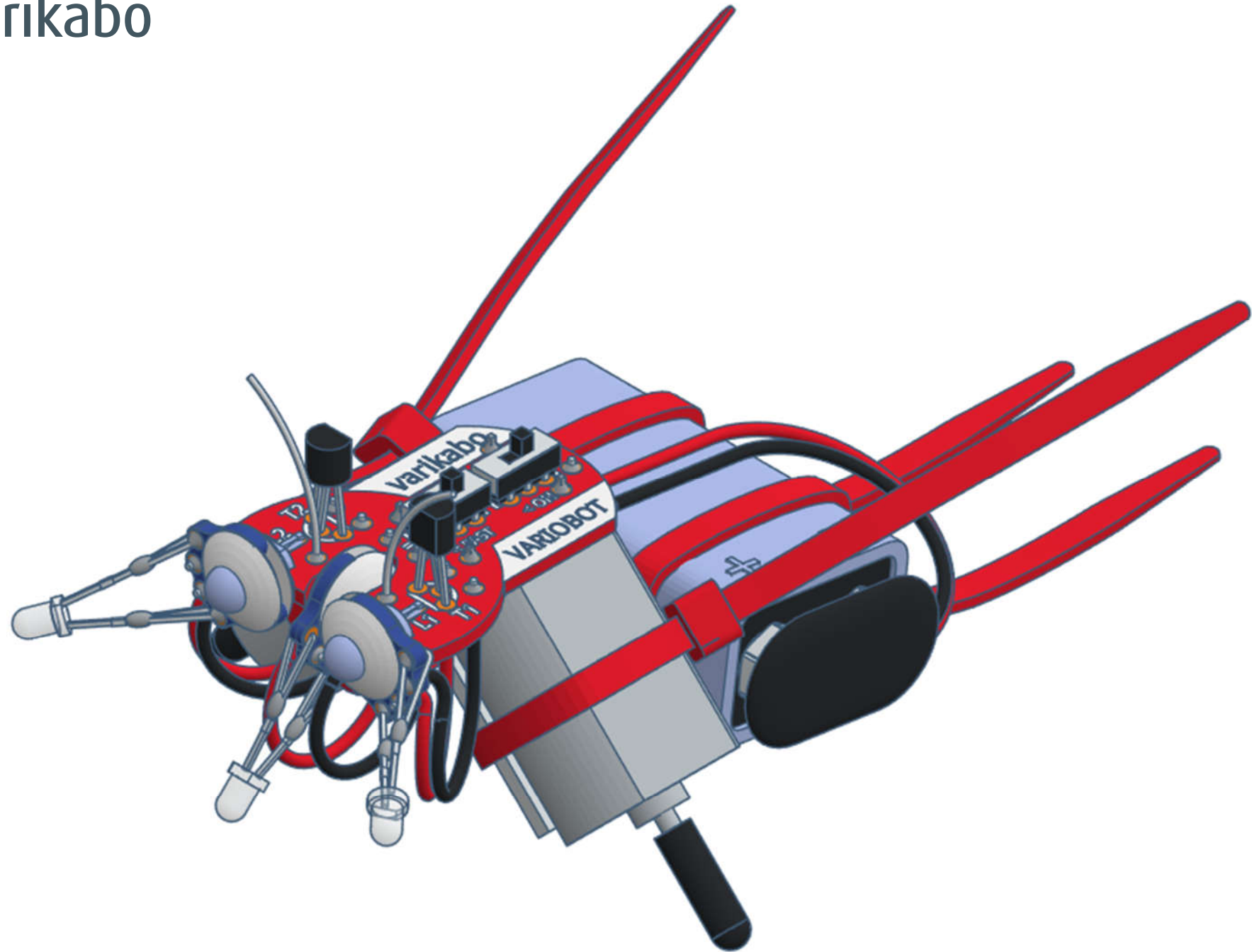
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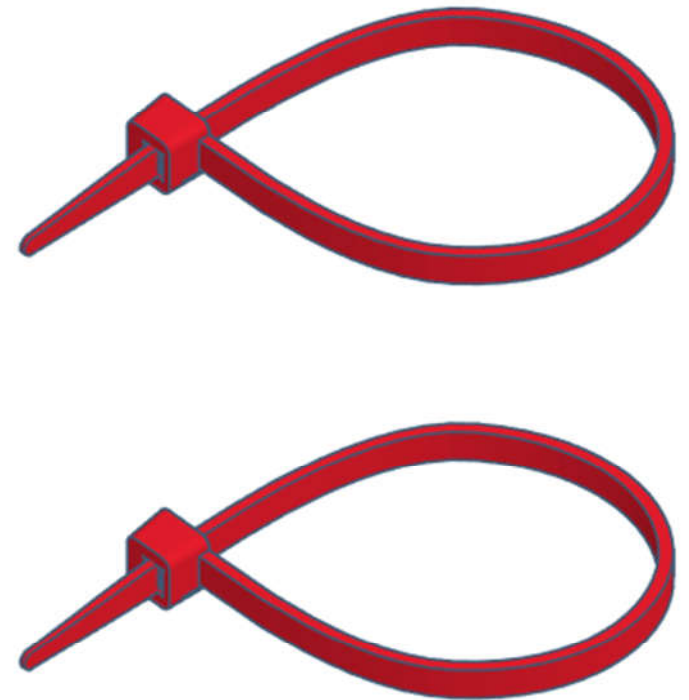
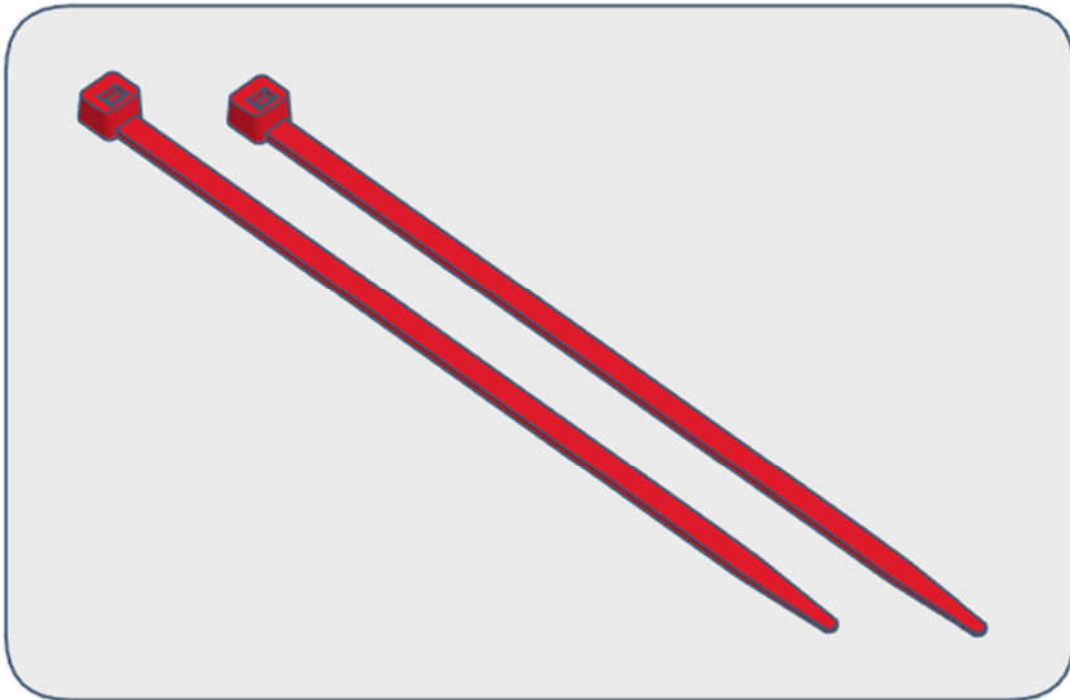
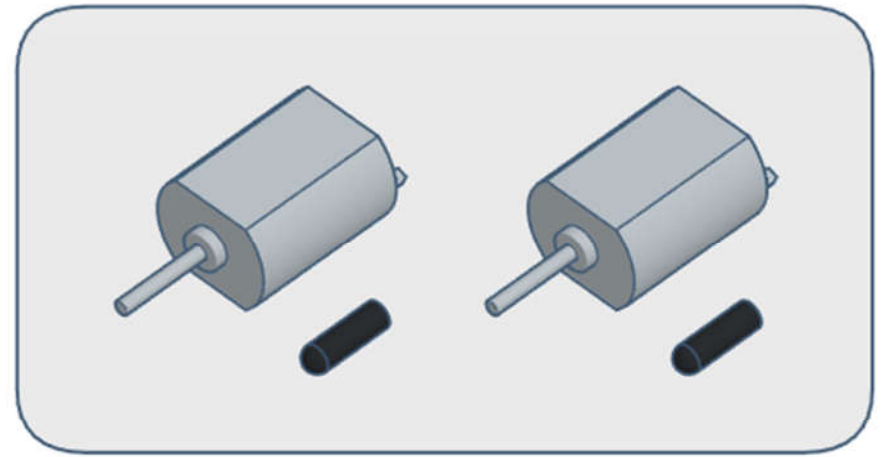
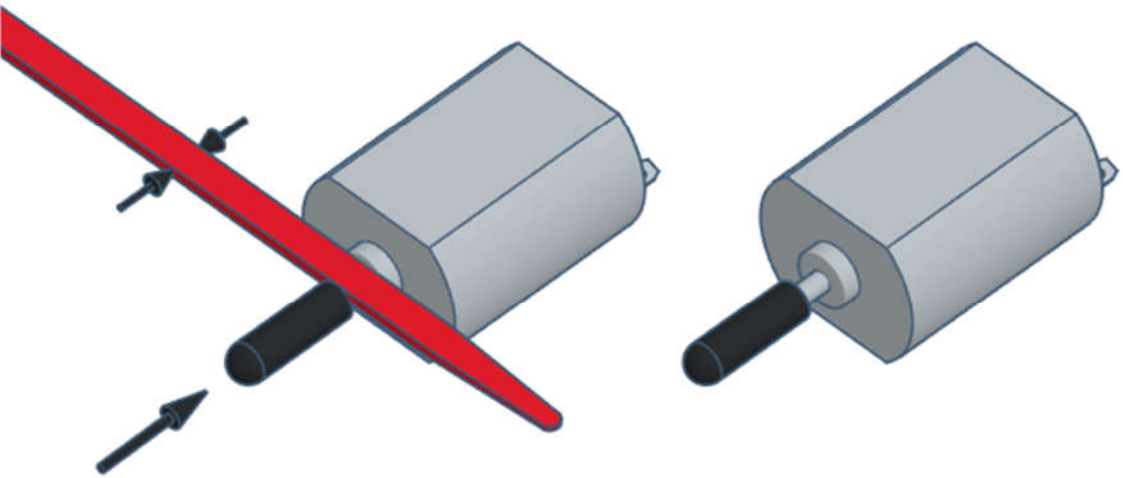
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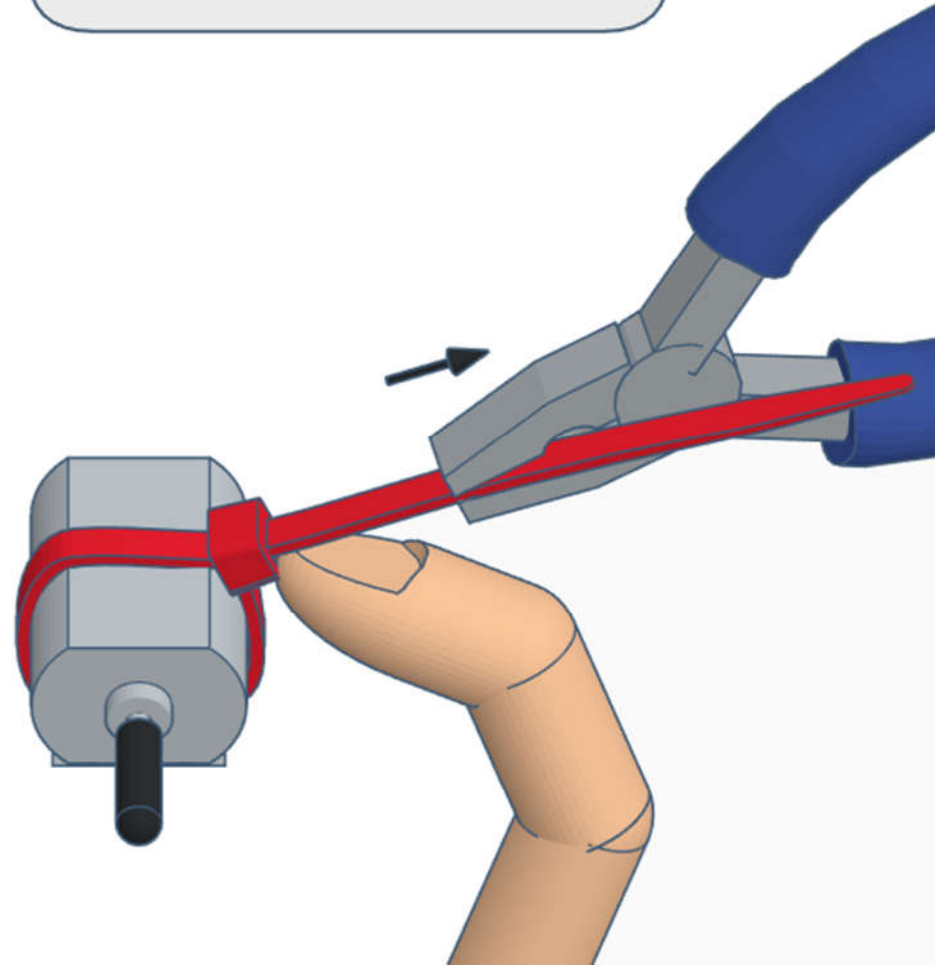
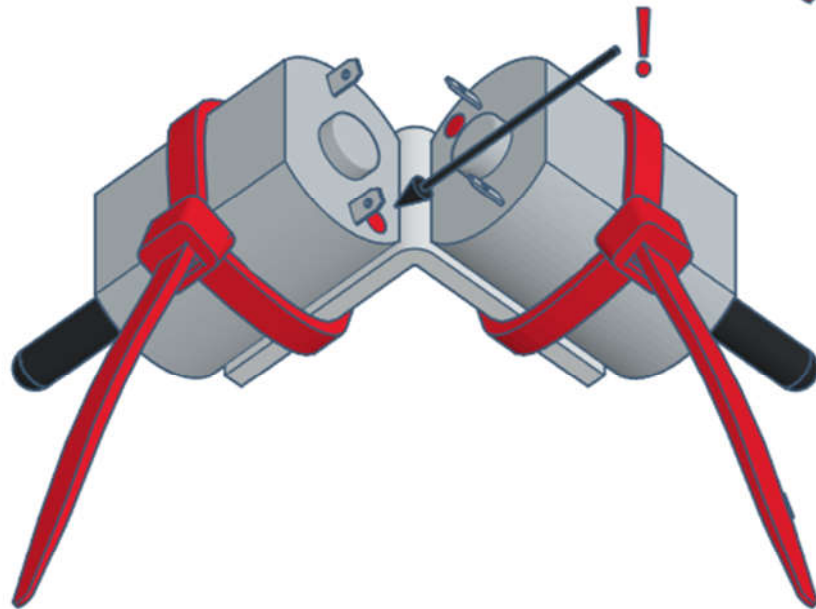
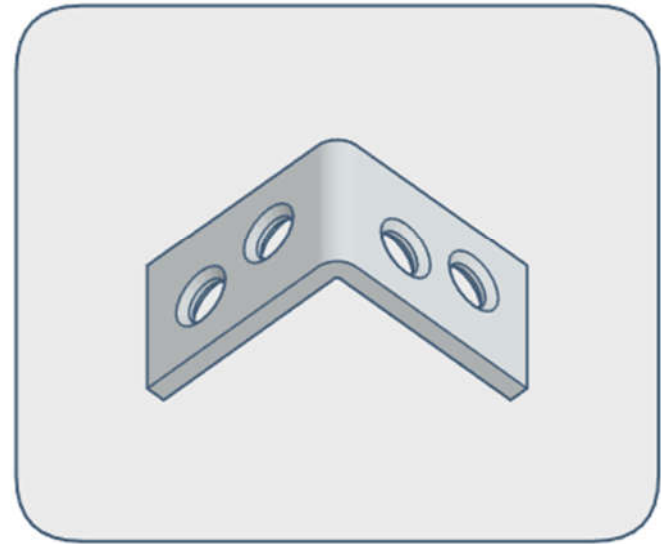
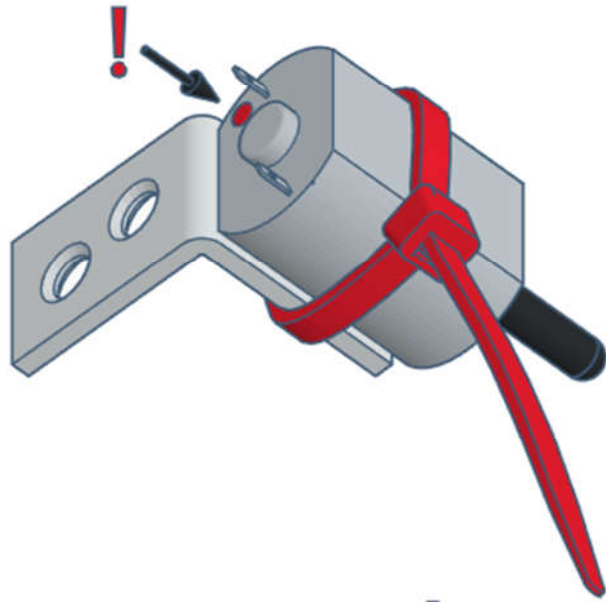
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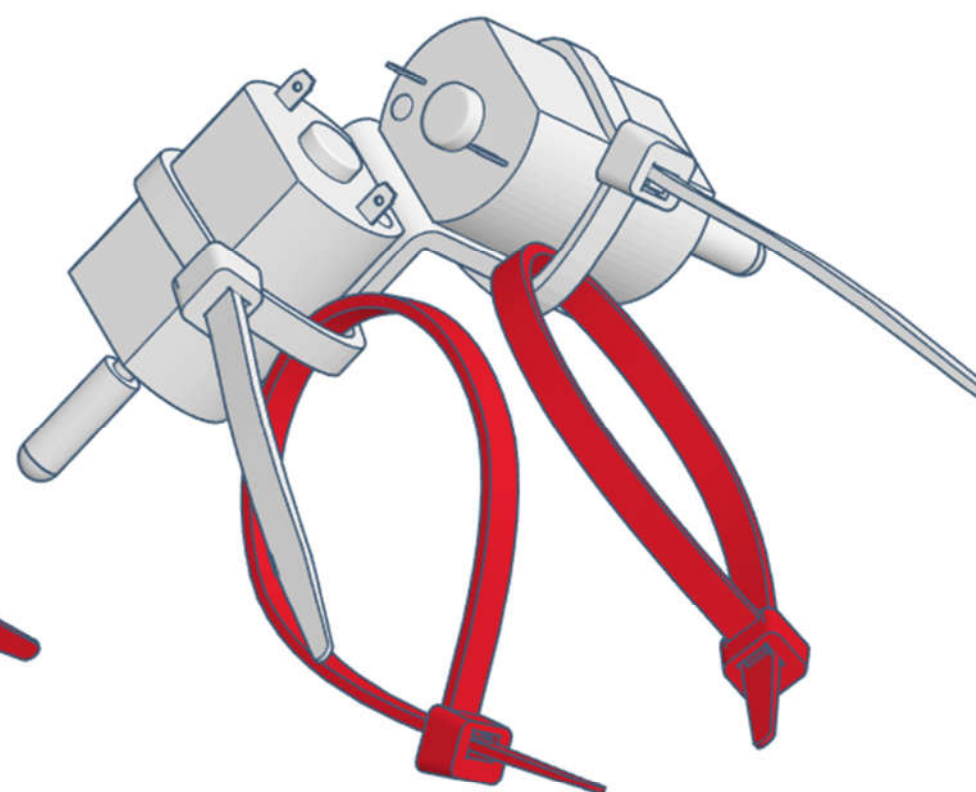
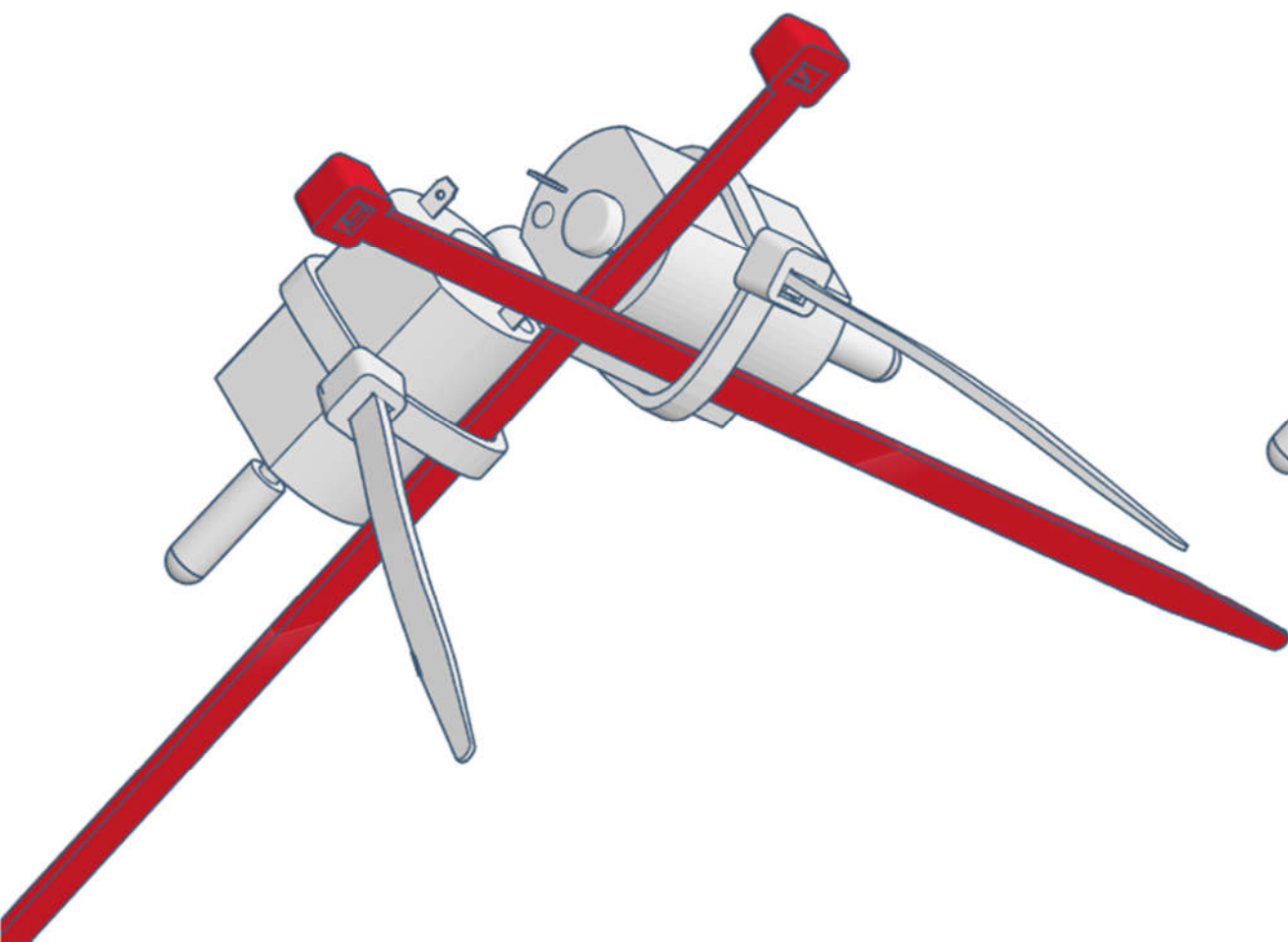
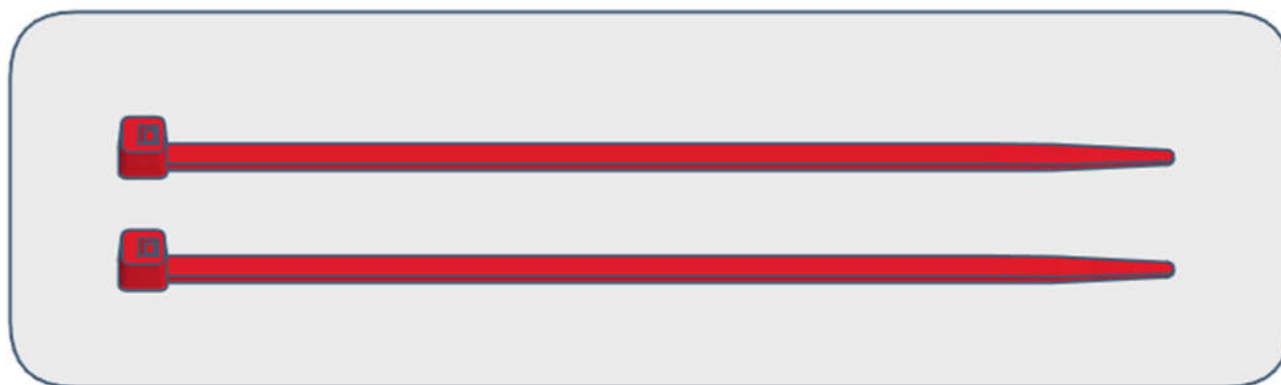
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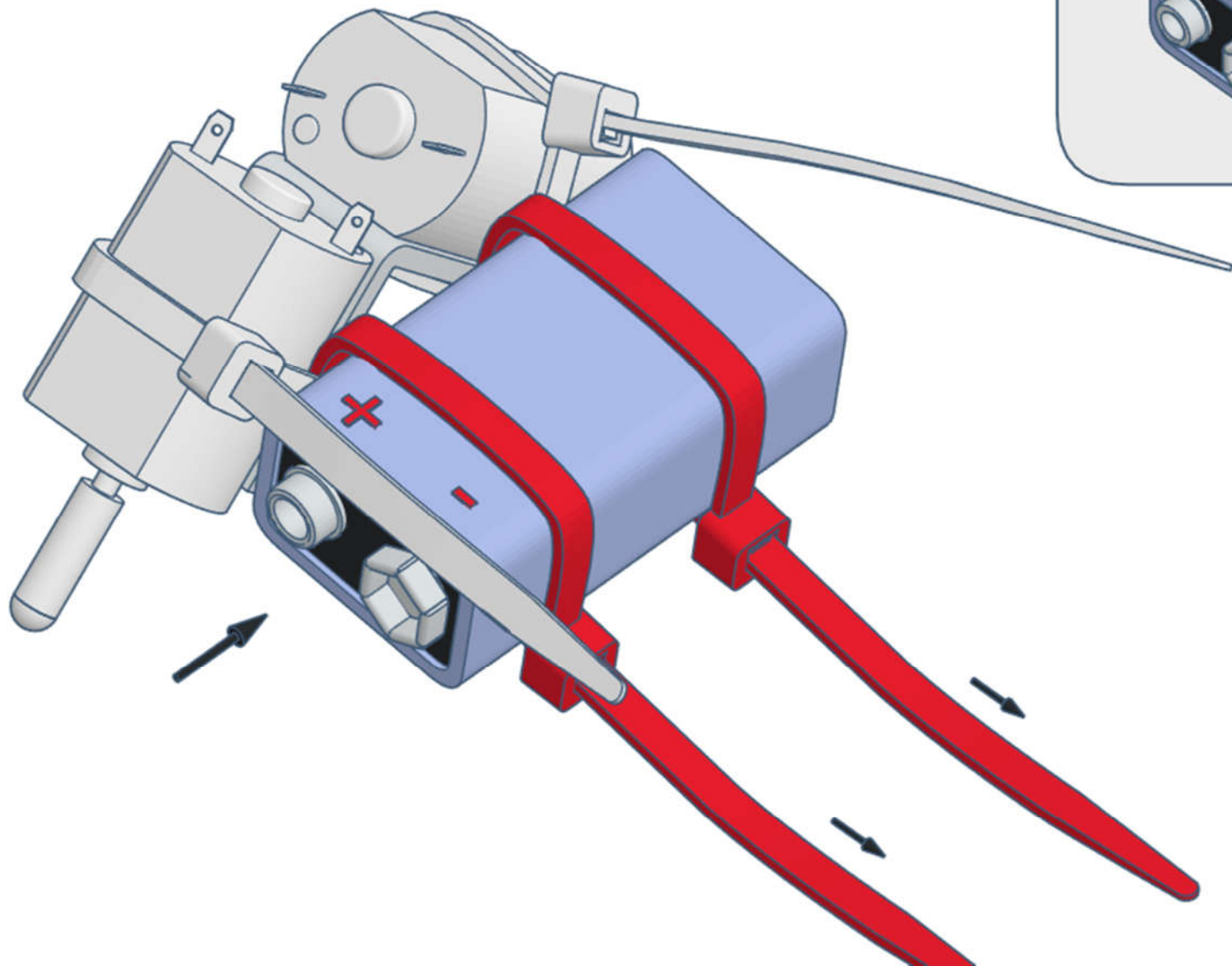
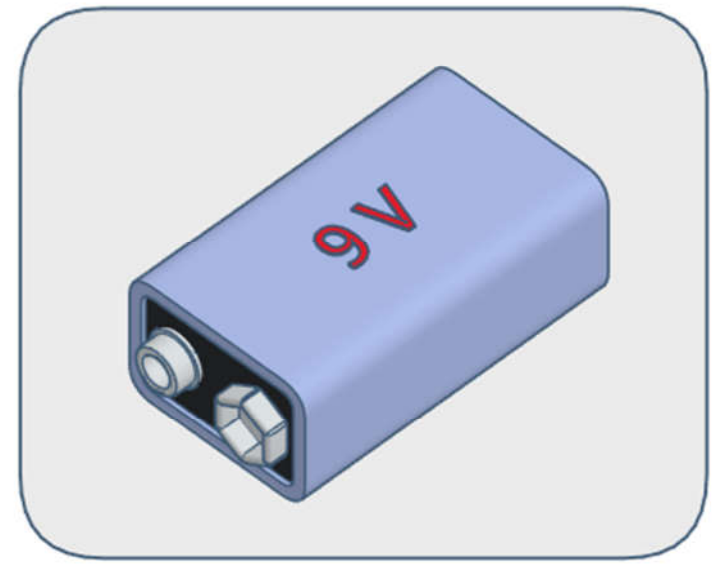
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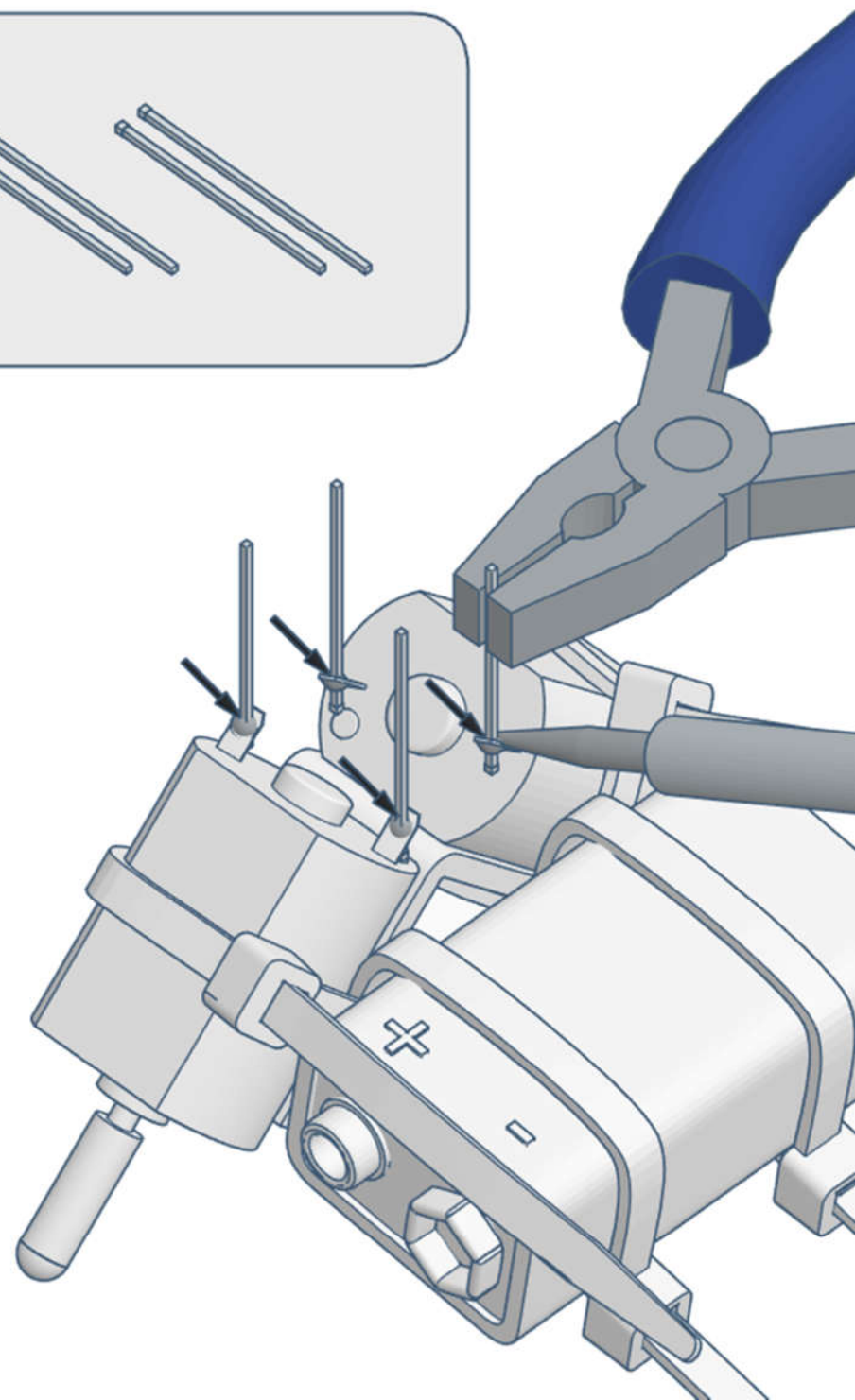
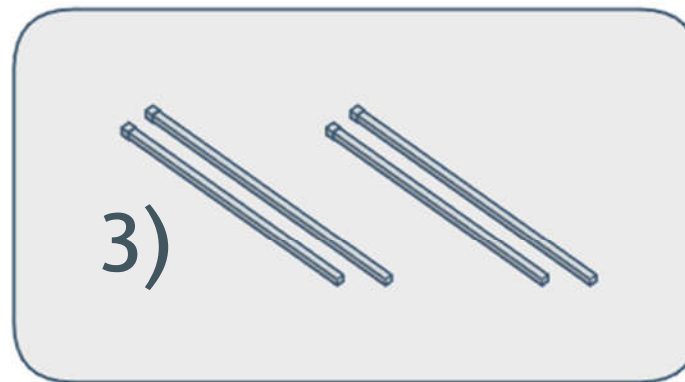
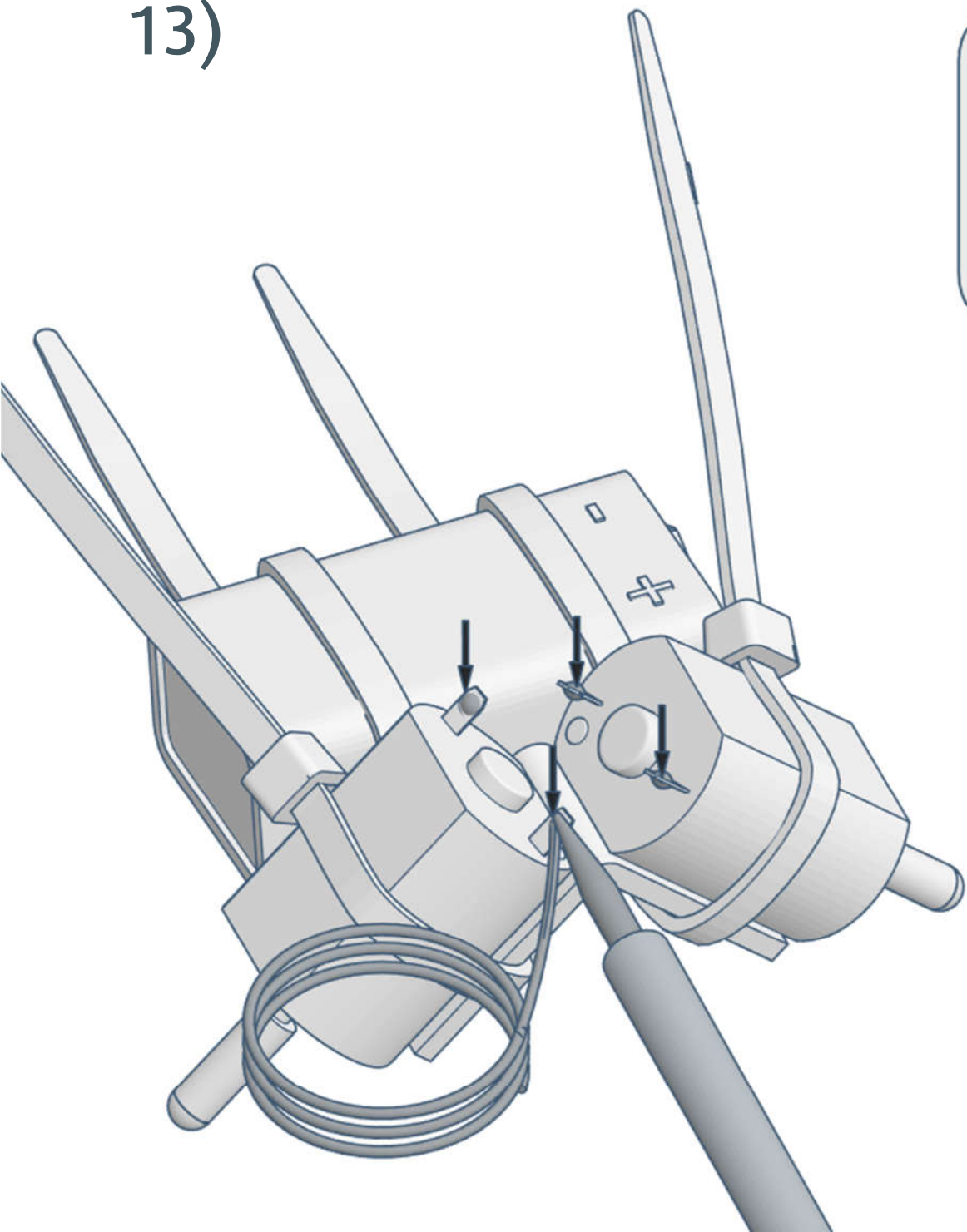
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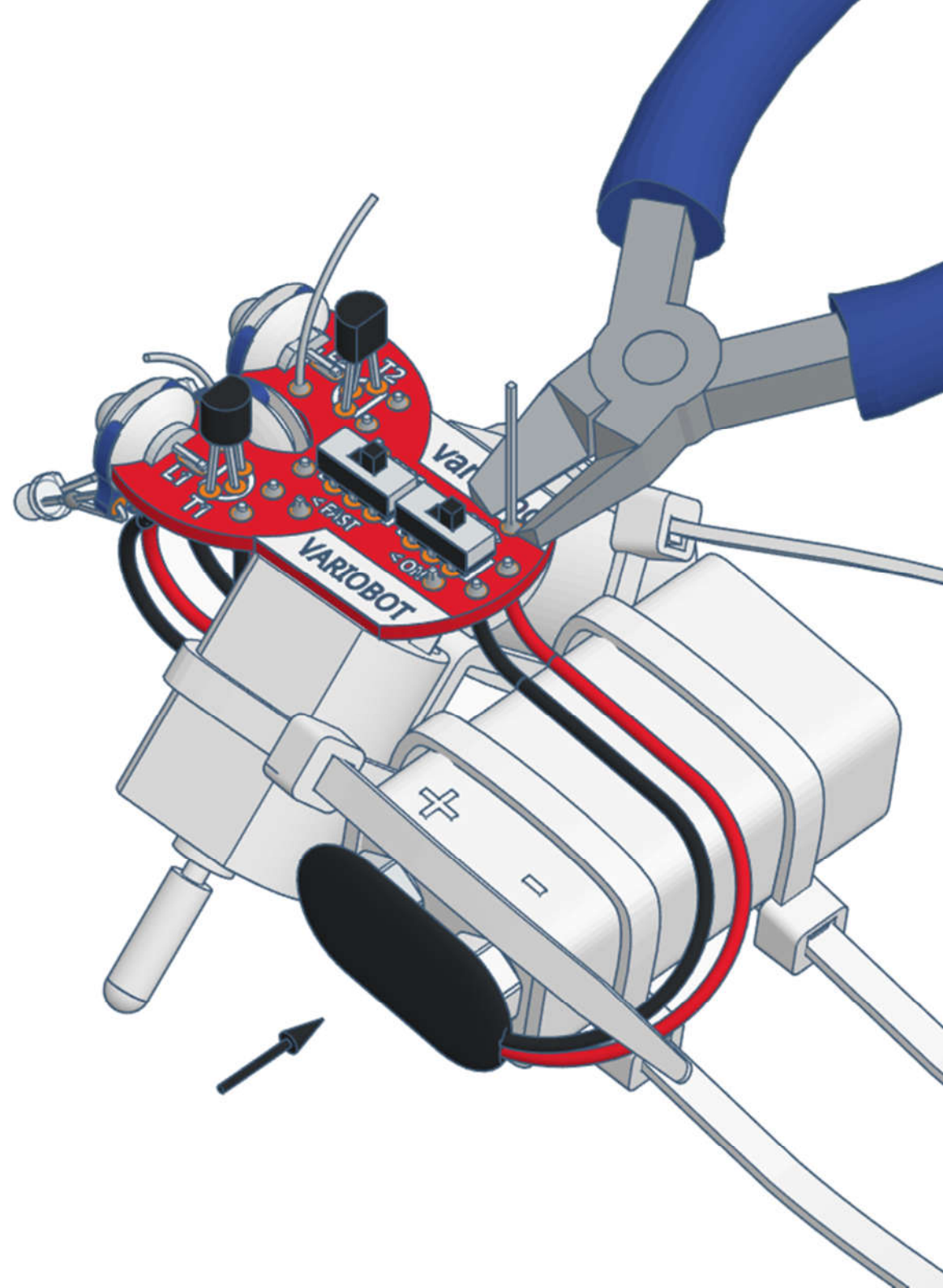
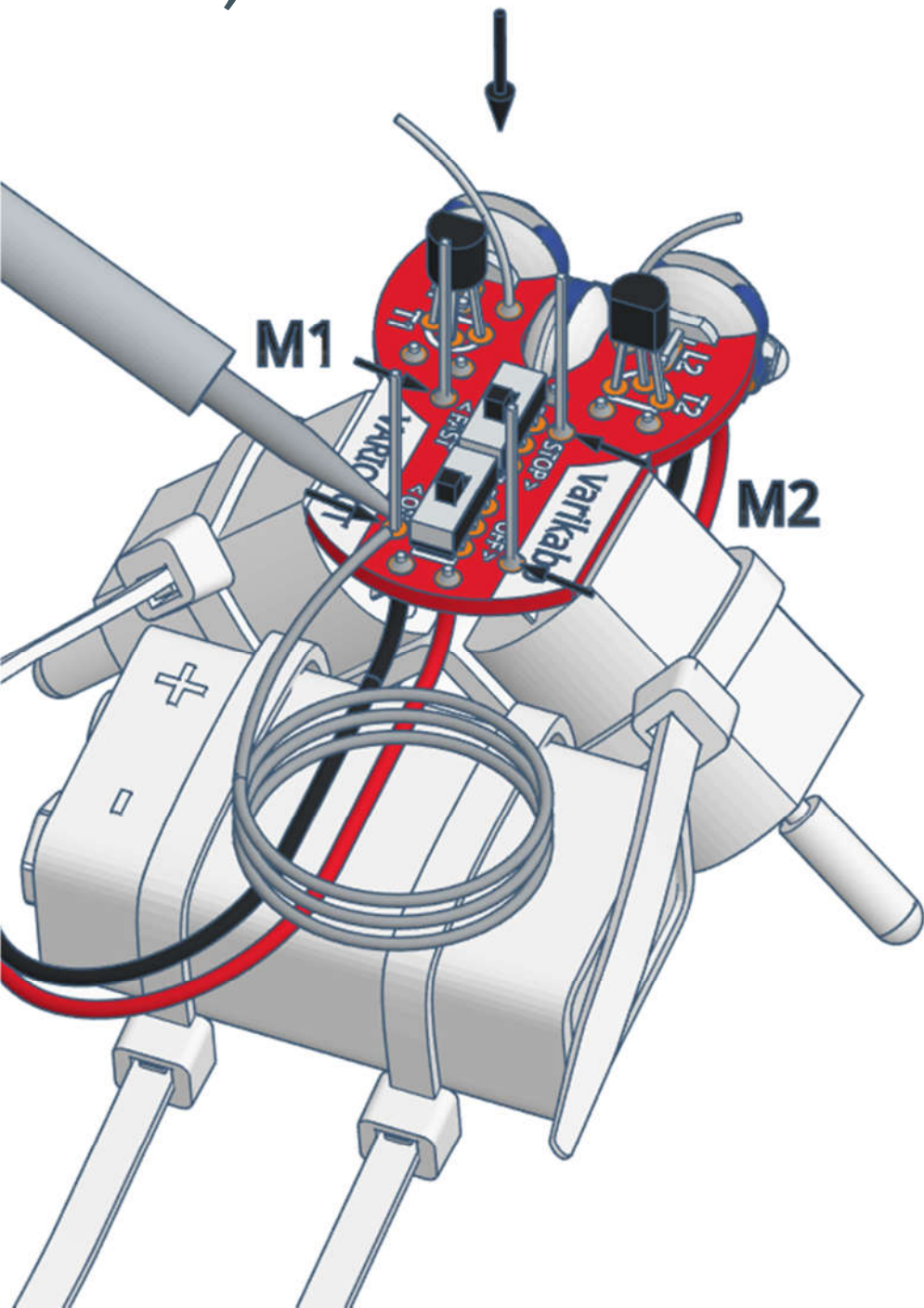
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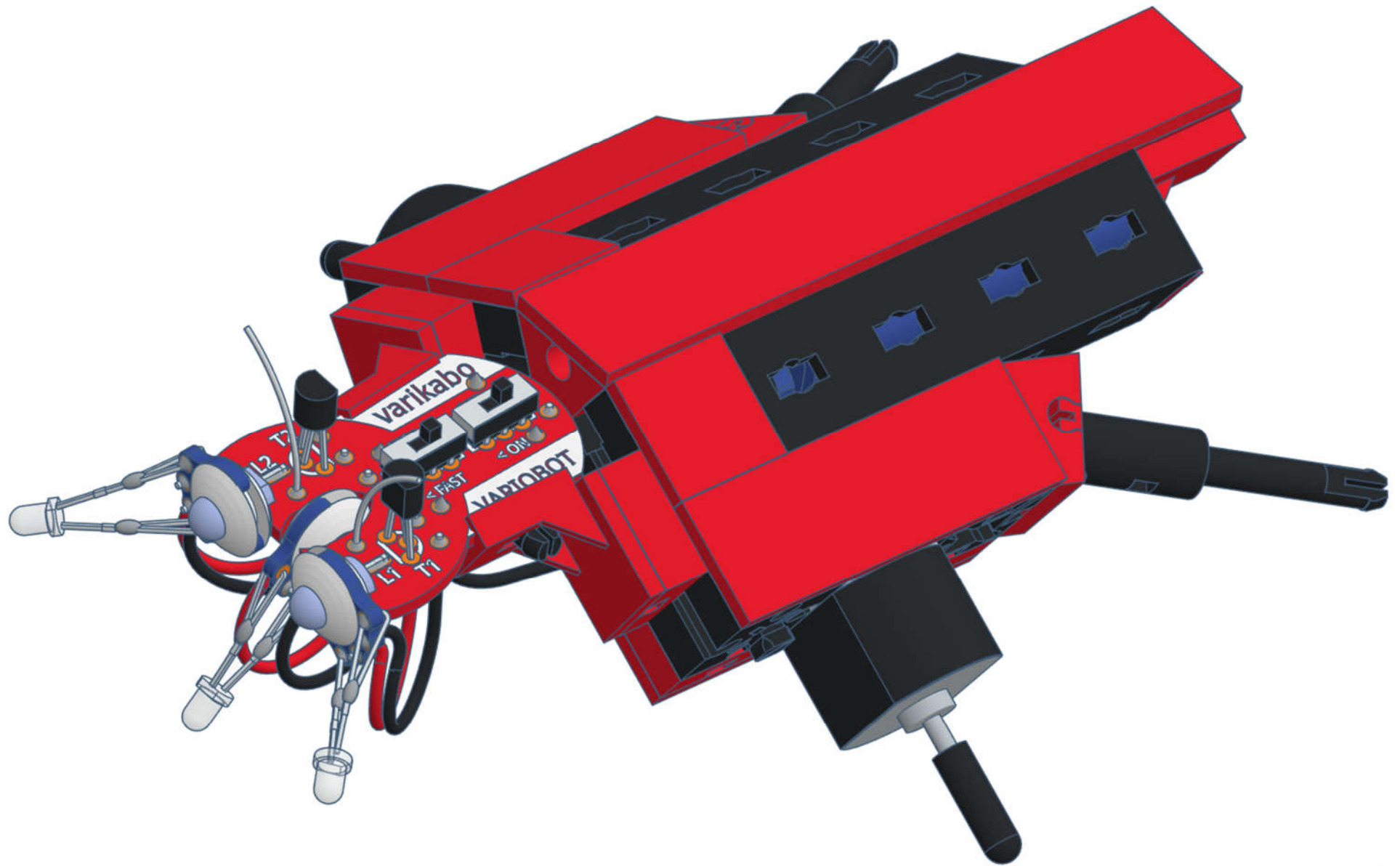
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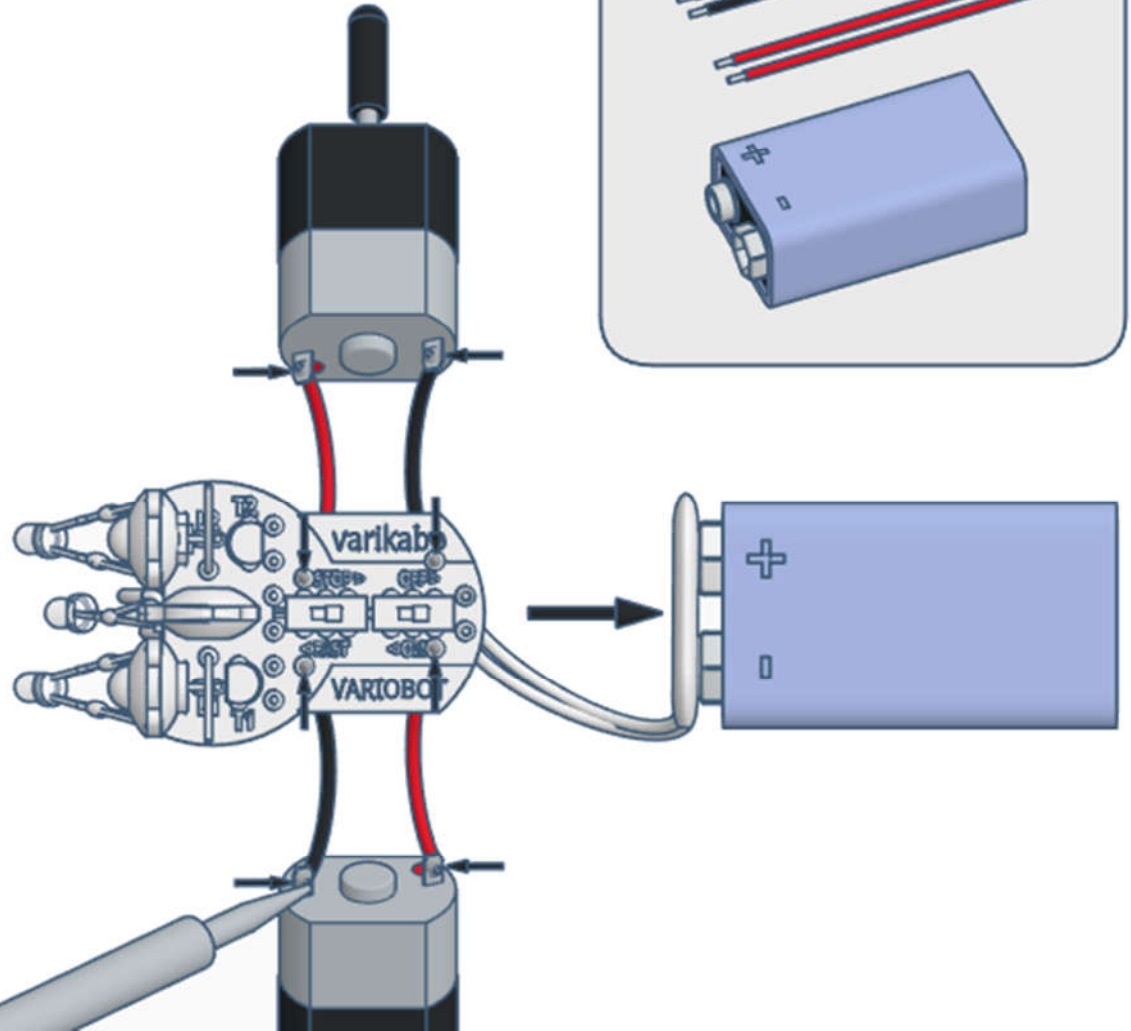
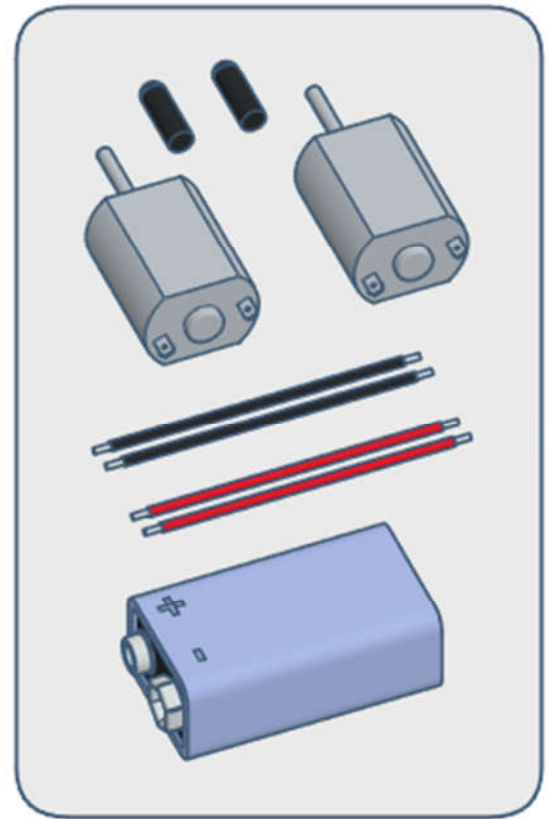
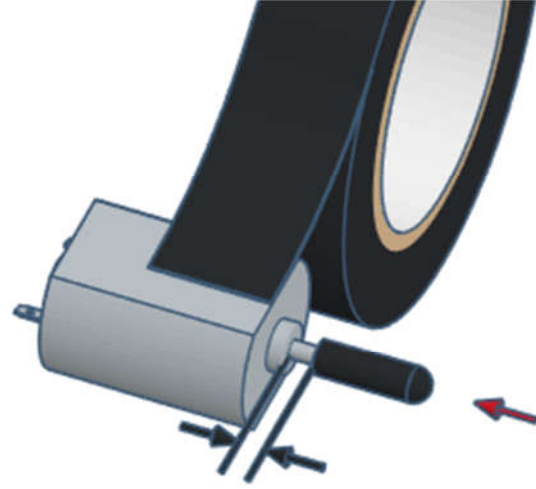
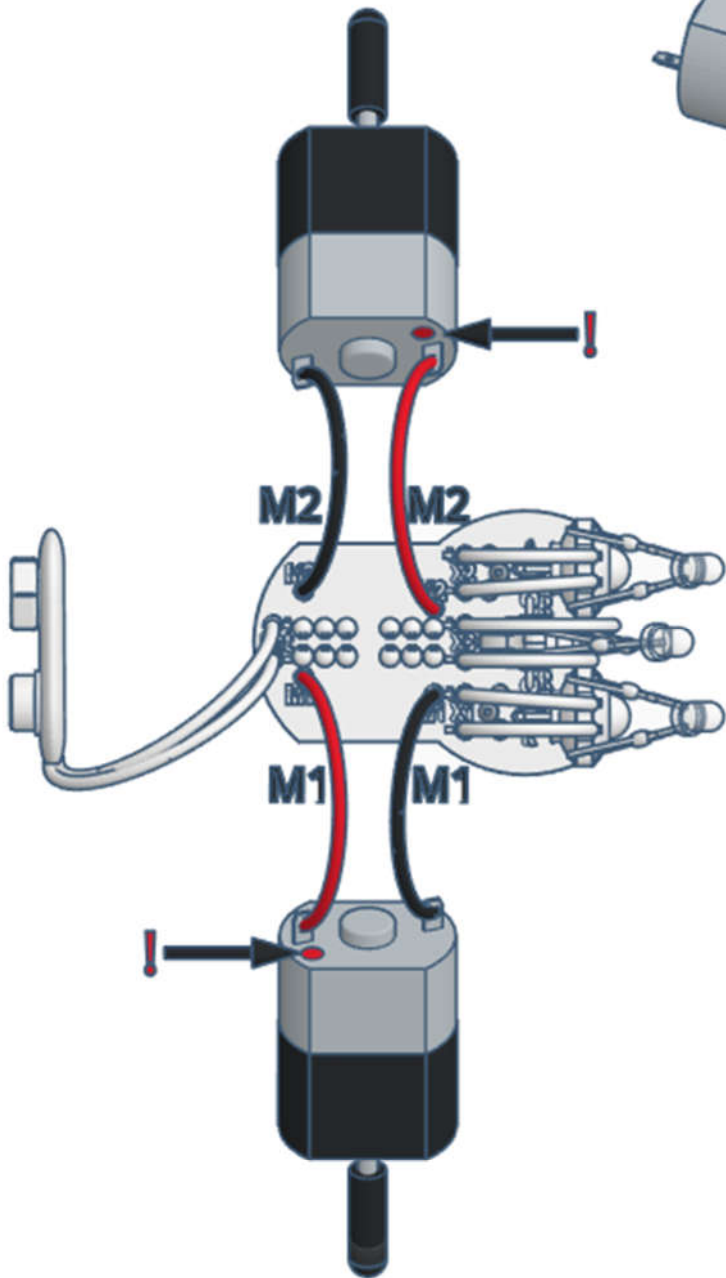
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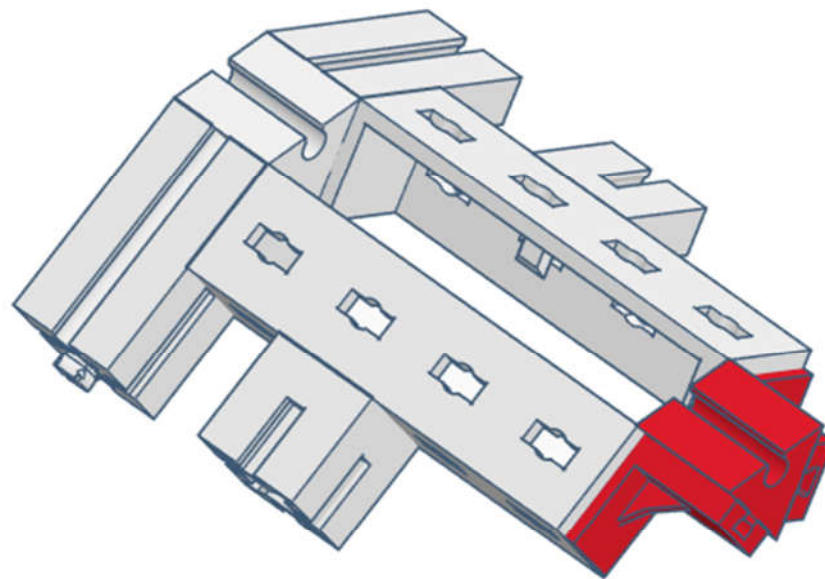
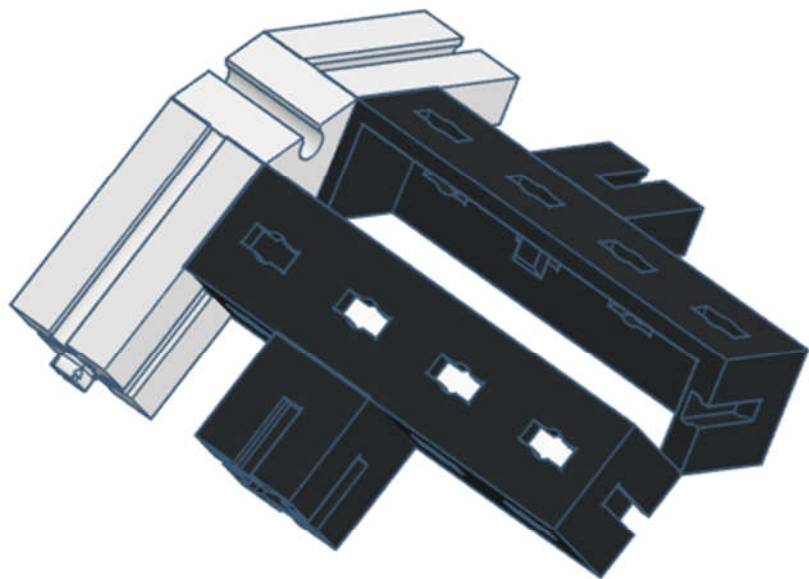
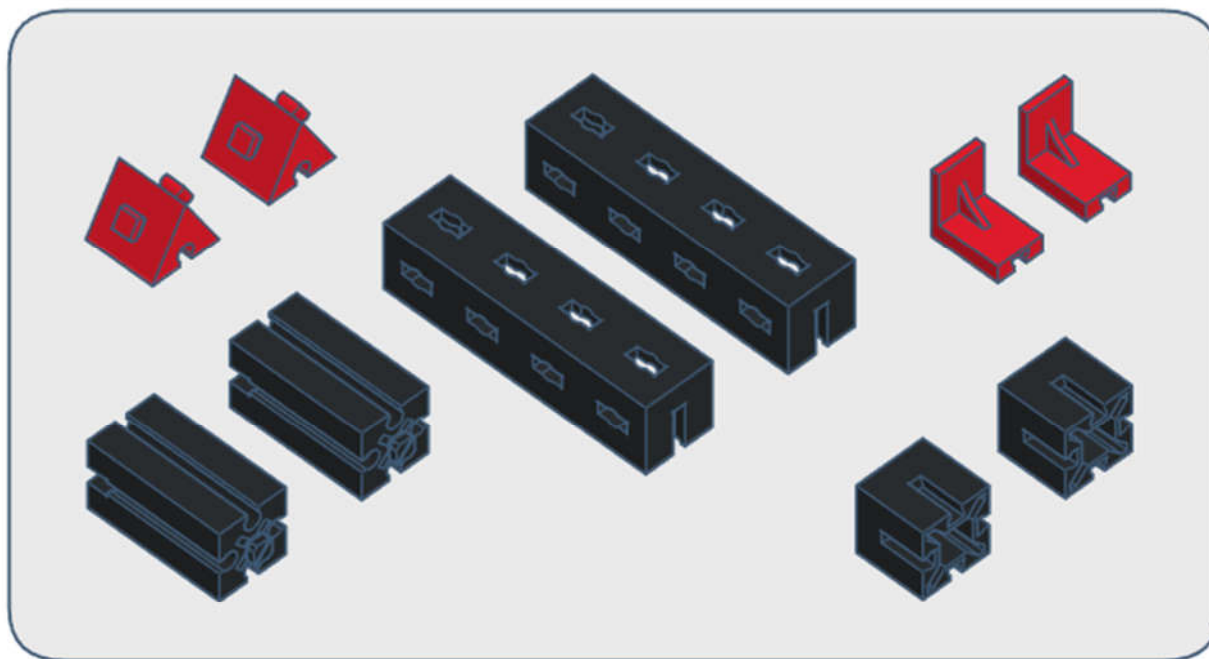
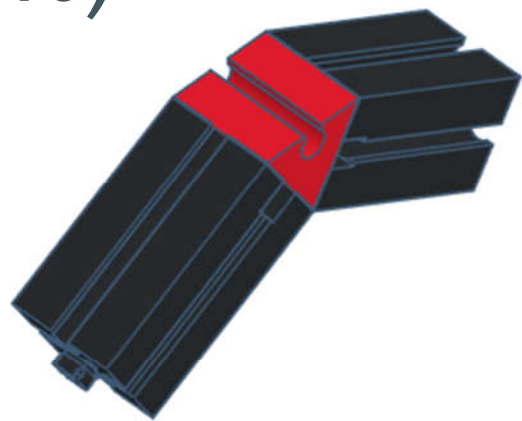
varikabo FT



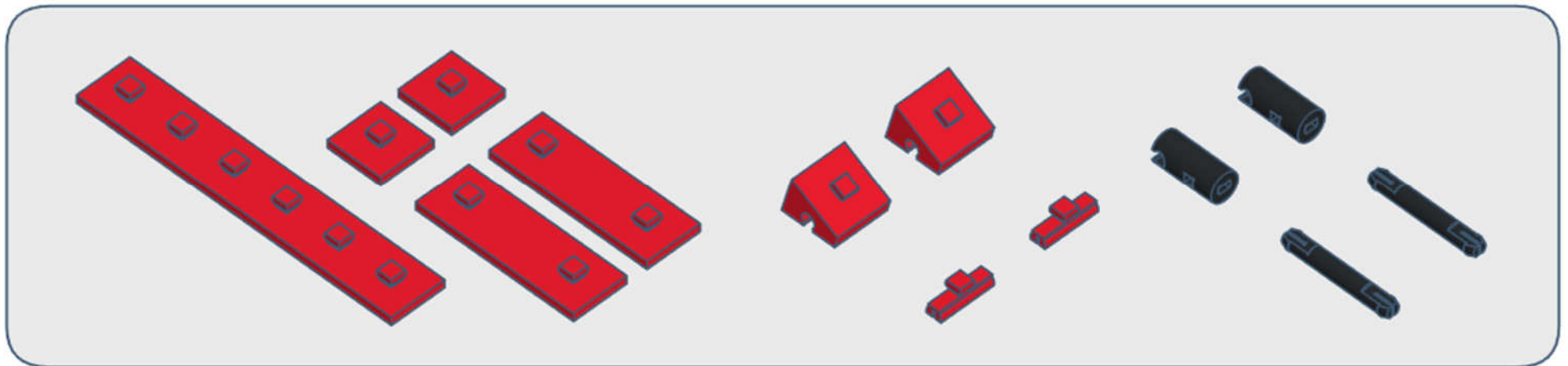
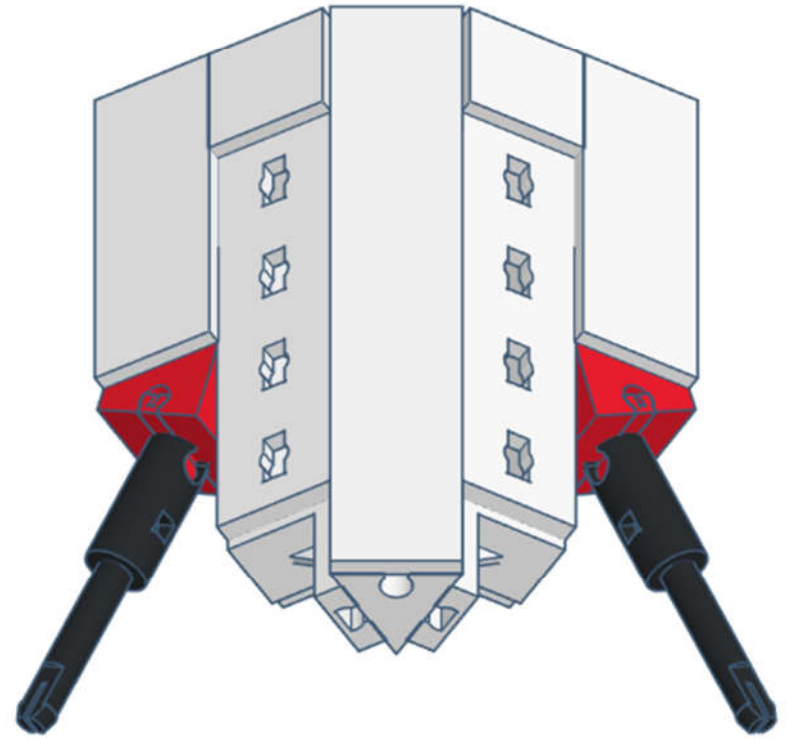
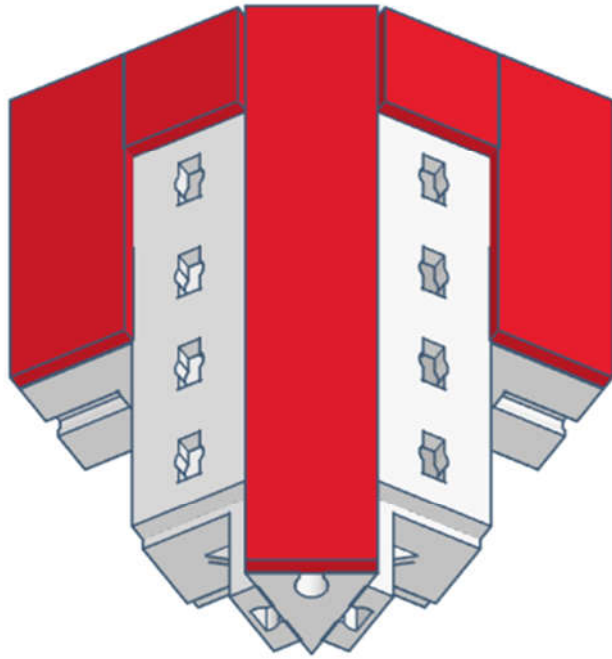
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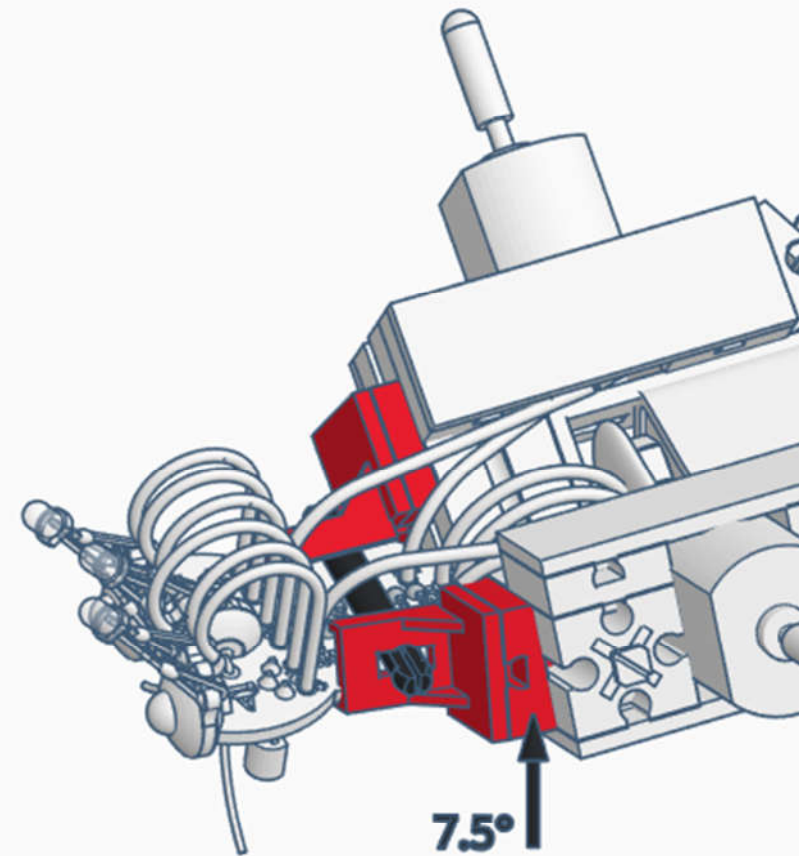
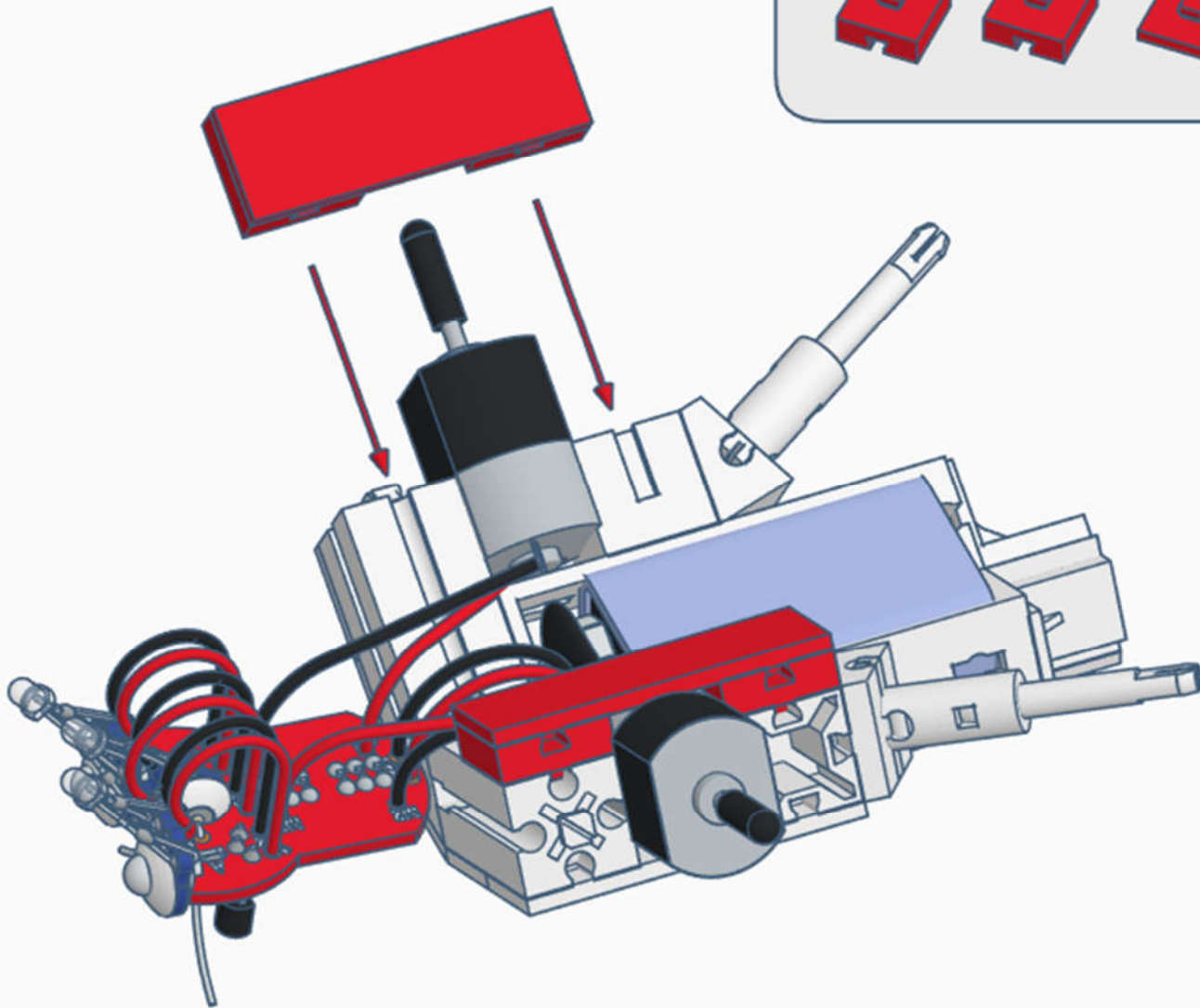
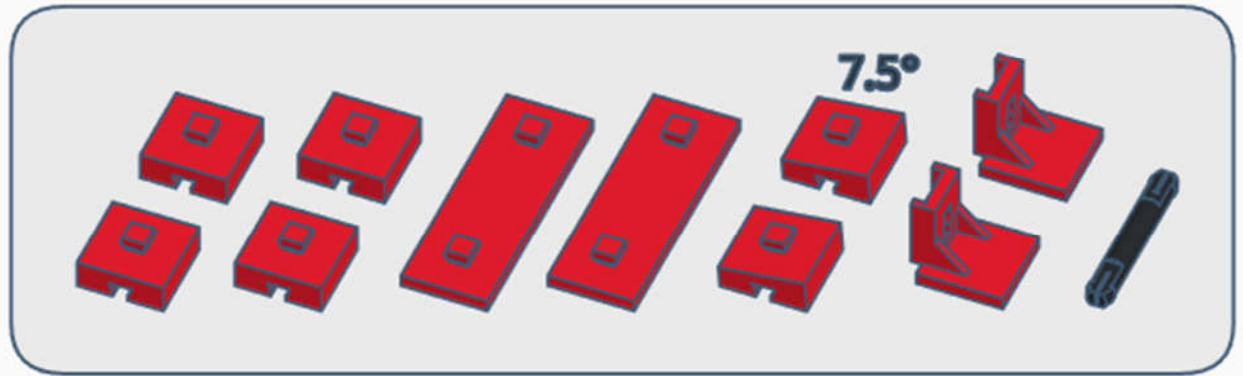
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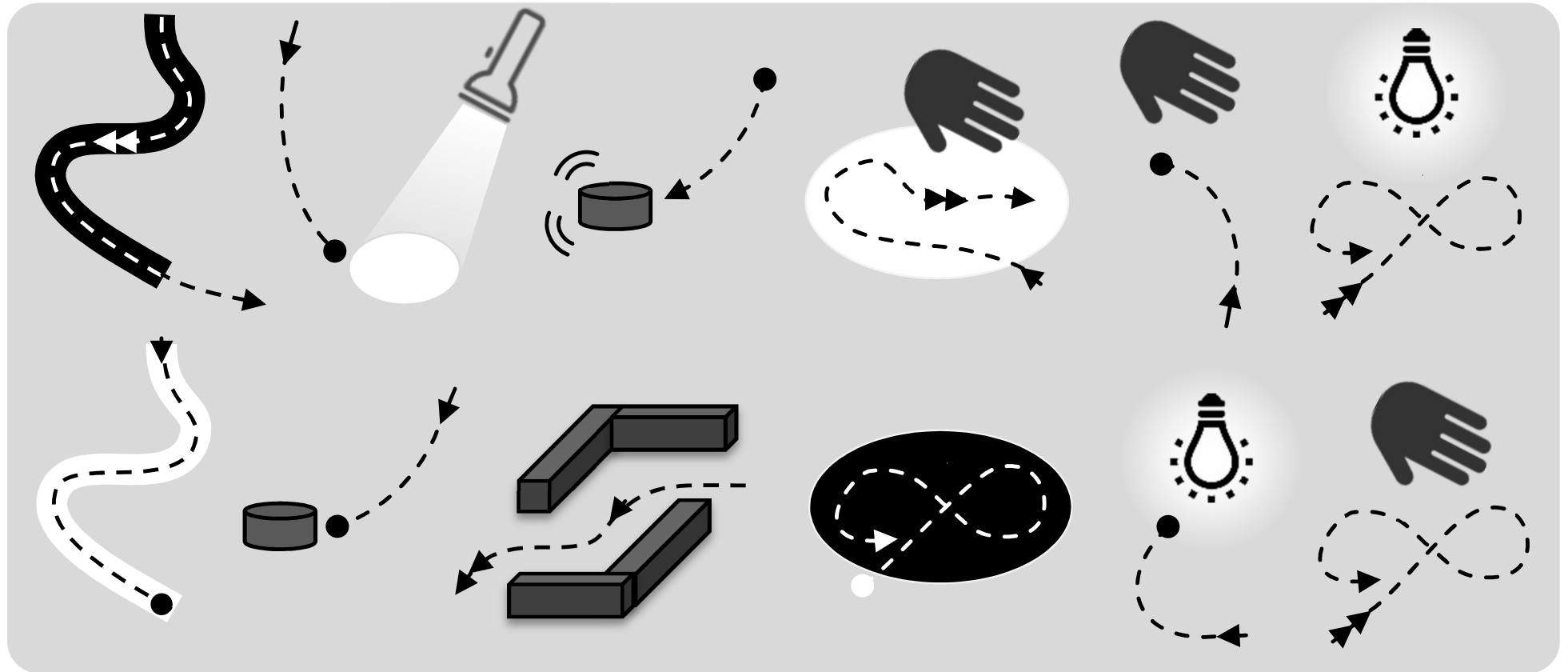


12)



2) Functions

The different circuit variants allow varikabo twelve functions. The circuits and features of the functions are described in detail below.



varikabo stands still



varikabo drives slowly



varikabo drives fast

Notes on Lighting

Unlike many other robots, varikabo does not need to emit infrared light to detect lines or objects in front of it. This simplifies the circuit and reduces power consumption. Since varikabo reacts on brightness differences in the environment, it is essential to use a suitable light source.

Note:

The light of LED lamps or fluorescent lamps has a low red component and is not well perceptible for varikabo's sensors.

When using these light sources, a sufficiently strong illumination must therefore be provided.

To avoid that varikabo's sensors are not blinded by the light source, attention must also be paid to a suitable position in relation to lamps or windows.

Note:

Most functions can be performed best under a sufficiently distant lamp or under a window on the floor.

In the case of lateral light incidence varikabo would follow this light or its own shadow instead of driving to the desired target.

If varikabo is supposed to follow or avoid a structure on the ground, make sure that the ground does not reflect light.

The Four Basic Settings

You can remove the left and right sensor from the LEDs and swap them. This determines whether varikabo is heading for dark or light.

- **Sensor cable parallel:** varikabo moves towards dark (shadow follower)
- **Sensor cable crossed:** varikabo moves towards light (light follower)

With the selector switch you decide whether the sensor signals are connected directly (=) or reversed (×) to the transistors (T1/T2) or the motors (M1/M2).

This allows you to select the fast or slow speed range.

- **Switch to "FAST (=)":** varikabo accelerates in case of shadow on the middle sensor
- **Switch to "STOP (×)":** varikabo stops in case of shadow on the middle sensor

Note:

In acceleration mode, varikabo's eye LEDs light red and in braking mode they light blue.

Aligning the Sensors

With its three swivelling brightness sensors varikabo reacts sensitively to lines, objects, light or shadow. By aligning the sensors downwards, forwards or upwards, you determine whether varikabo prefers to perceive impressions on the ground, in front of it or above it.

Setting the Functions

On the following twelve pages you can see how to set the respective functions. Proceed as follows:

- 1) Attach lateral sensors parallel (shadow follower) or crossed (light follower).
- 2) Align lateral sensors according to the first illustration.
- 3) Set the selector switch to "FAST" (acceleration mode) or "STOP" (braking mode).
- 4) Align the middle sensor according to the second illustration.

Once you've gotten to know all the different functions, you can adjust them even faster using the four diagrams at the end of the section.

Note:

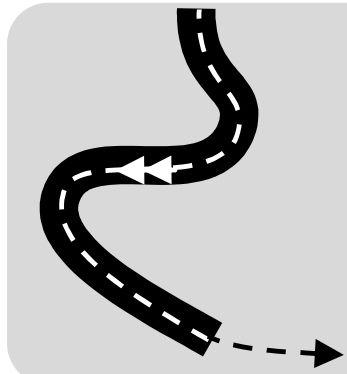
With circuit 10 and 12, the side sensors are mounted facing backwards.

If varikabo does not behave immediately as expected, readjust the alignment of the sensors.

Note:

The brightness ratio between the lateral sensors determines the direction of varikabo. The brightness ratio between the middle sensor and the side sensors determines varikabo's speed.

1) Following Dark Lines

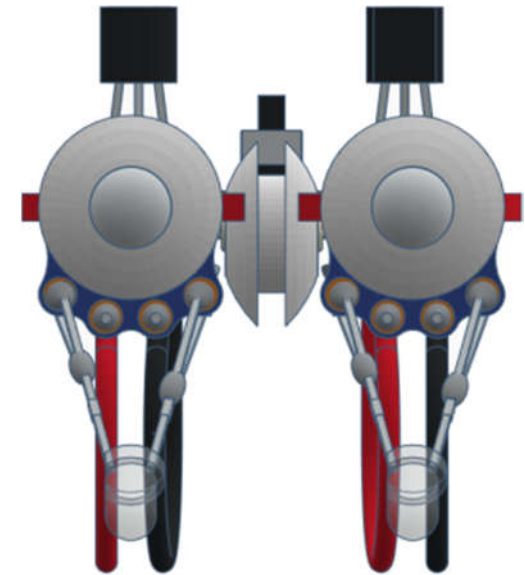


- Searches for a dark line (e.g. black tape)
- Drives along the line
- Accelerates on straight stretches and brakes in curves

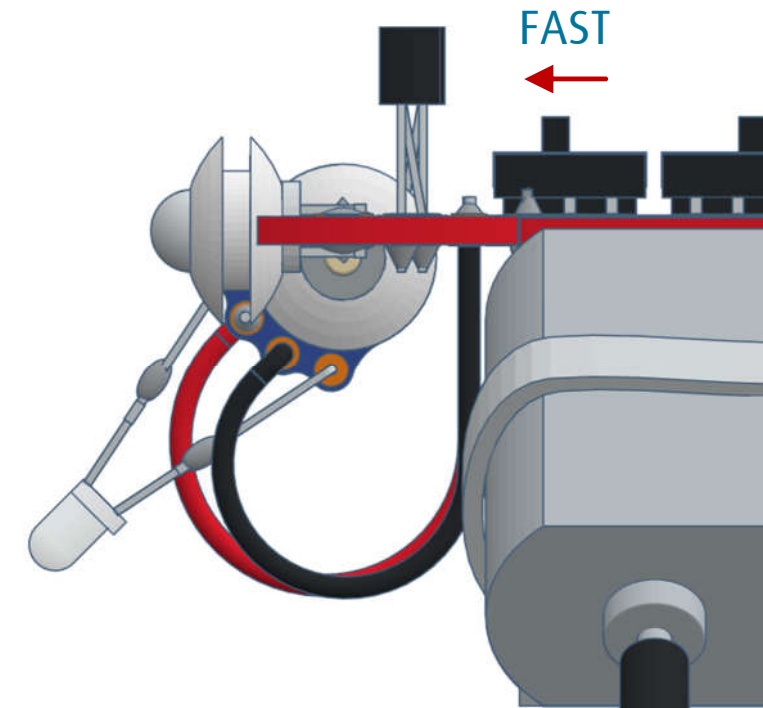
Setting: Shadow Follower / Acceleration Mode

With the distance between the outer two sensors you can adjust the accuracy with which varikabo is supposed to drive on the line. Ideally, they are a little off the line. If they are too close to the line, varikabo will permanently adjust the direction and drive serpentine.

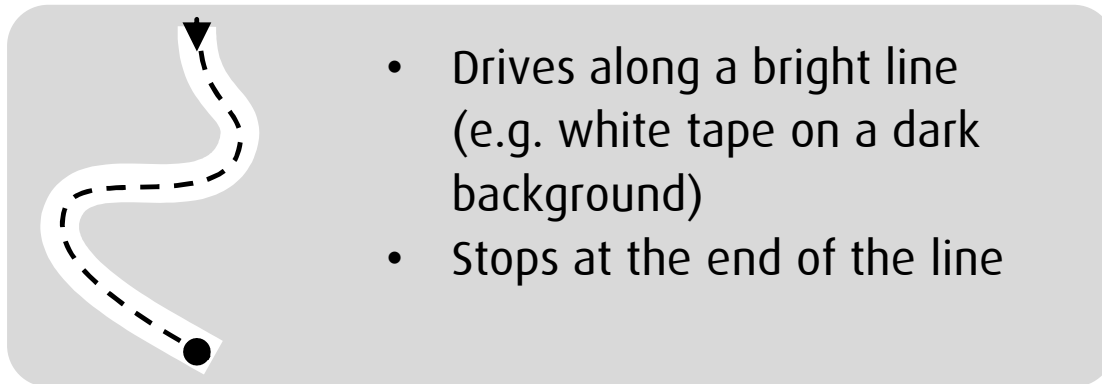
In addition, it will not be able to activate its turbo, because for this more light must fall on the outer sensors than on the one in the center.



sensor cables parallel



2) Following Light Lines



Setting: Light Follower / Braking Mode

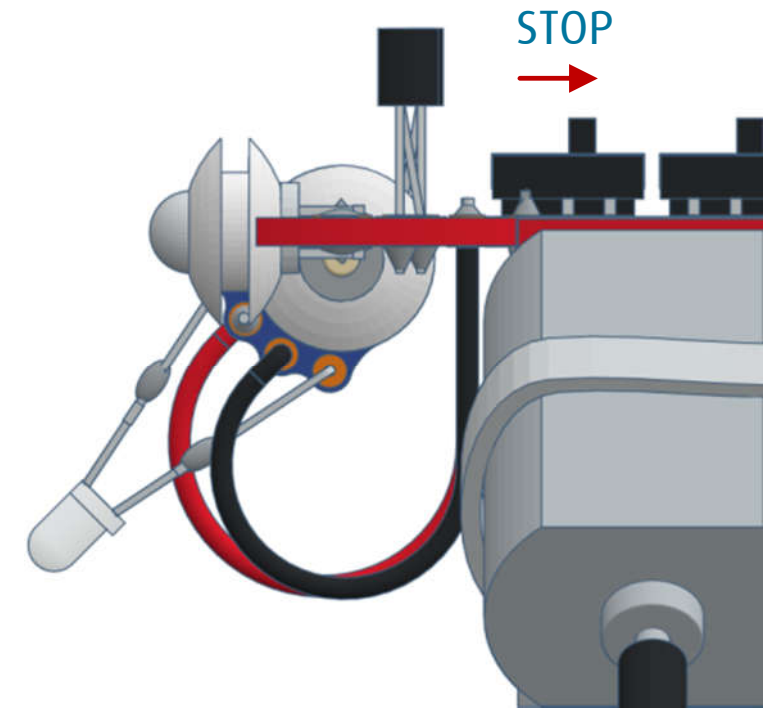
If you do not have white adhesive tape, you can place white sheets of paper on a dark floor, for example.

With the distance between the outer two sensors you can adjust the accuracy with which varikabo is supposed to drive on the line.

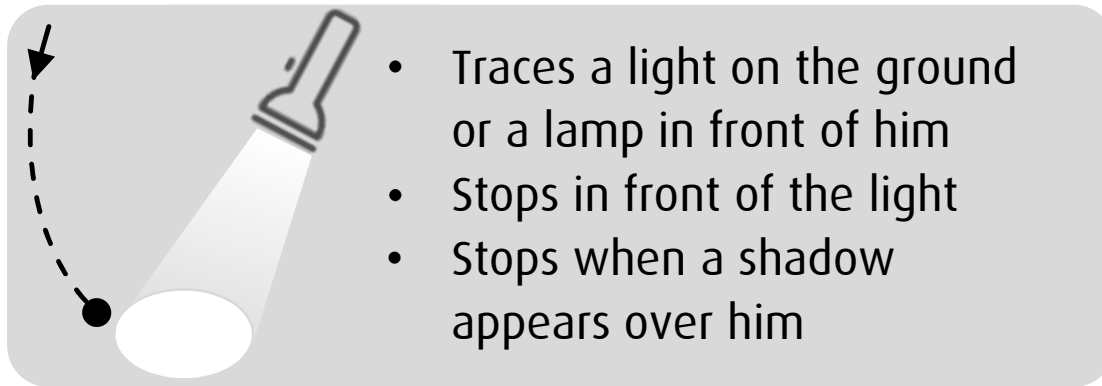
To make varikabo stop at the end of a line (on a dark background), direct the center sensor further down than the two lateral sensors.



sensor cables crossed



3) Tracking Light



Setting: Light Follower / Braking Mode

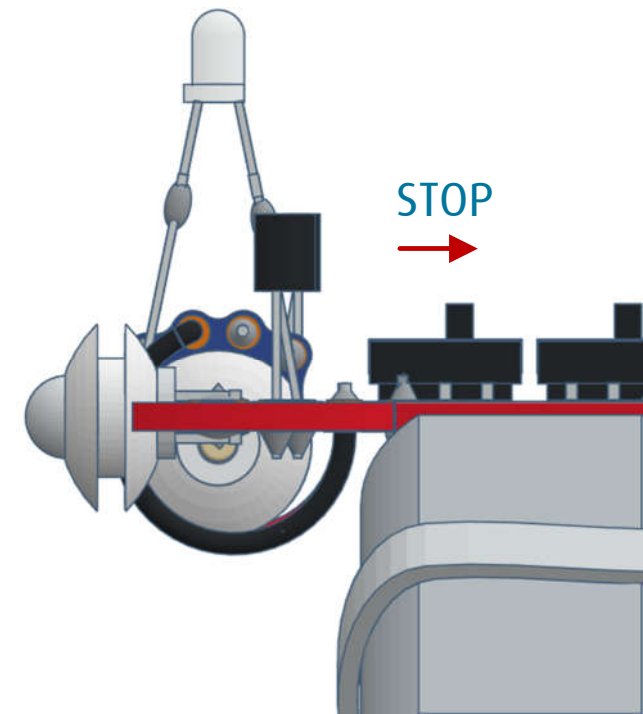
The ambient light should not be too strong for this function, so that the contrast is strong enough.

Align the side sensors in parallel or just slightly to the side so they can simultaneously keep a frontal light in sight.

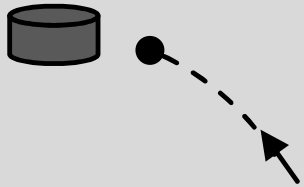
The more light hits the outer and the less the center sensor, the sooner varikabo will come to a standstill. This ratio can also be adjusted with the inclination of the center sensor.



sensor cables crossed



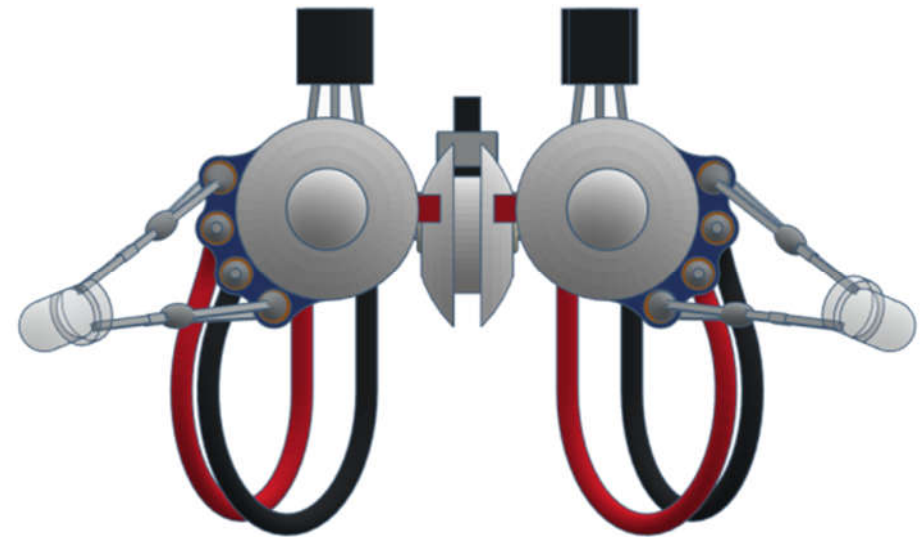
4) Tracking Objects



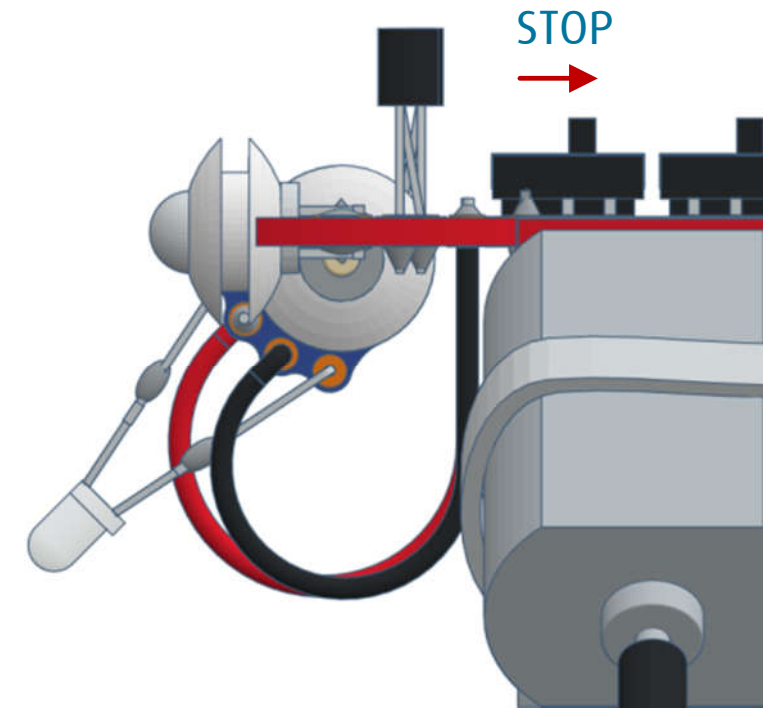
- Moves towards dark objects in front of him
- Keeps distance and stops in front of them or tracks moving objects

Setting: Shadow Follower / Braking Mode

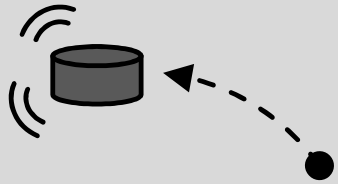
Adjust the distance of the lateral sensors to the size of the object to be tracked. The further forward they are directed, the more exactly varikabo will follow the object. However, if they are both directed to the object, varikabo will not be able to stop in front of it. Use the tilt angle of the center sensor to adjust the distance to the object being tracked. The more you point it down, the closer varikabo will approach the object.



sensor cables parallel



5) Pushing Objects

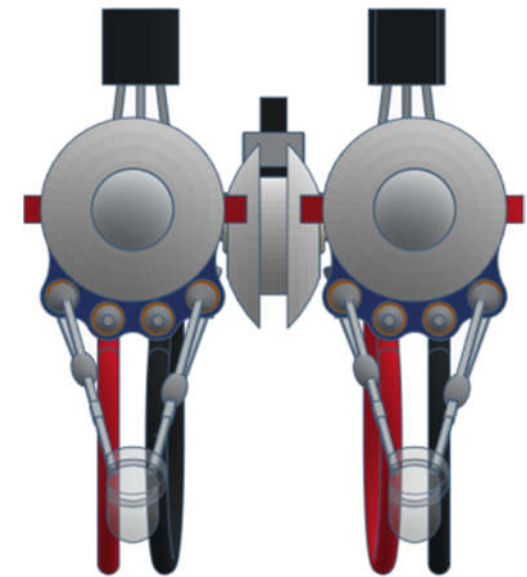


- Stands still when no dark object is in sight
- Starts moving when an object is in front and follows it
- pushes small things forward

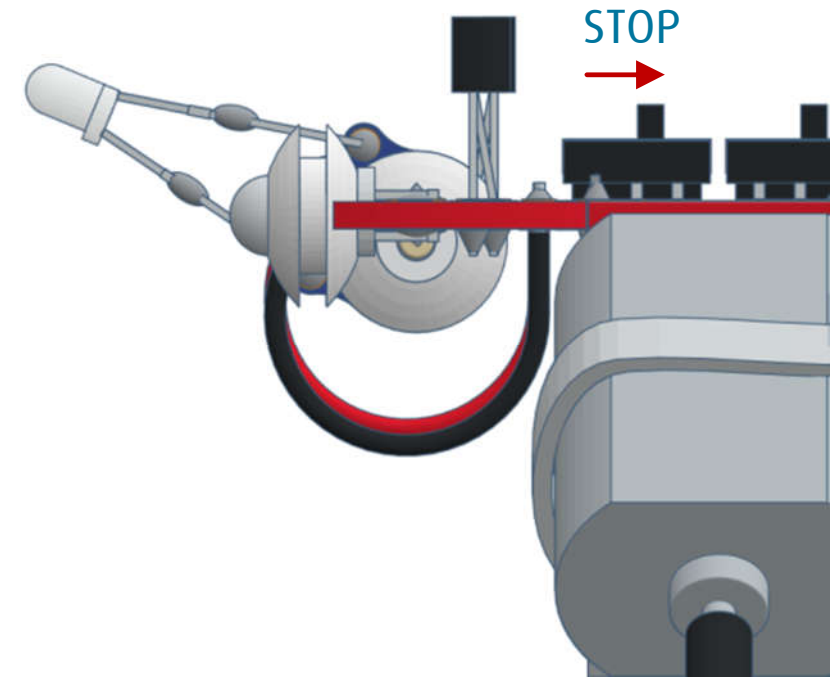
Setting: Shadow Follower / Braking Mode

Adjust the distance of the lateral sensors to the size of the object to be tracked. Both sensors should have the object in view at the same time.

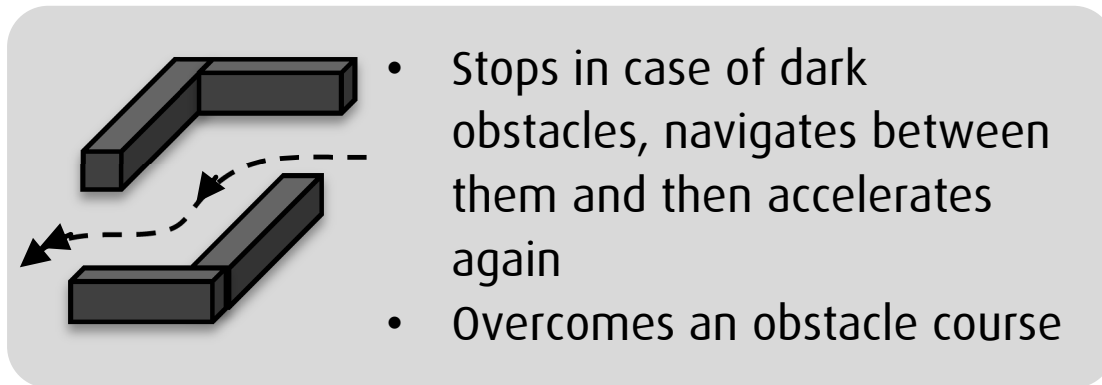
Adjust the angle of inclination of the middle sensor so that it is only slightly over the object. If the middle sensor points too steeply upwards, varikabo remains constantly in motion and can only be stopped by a shadow from above.



sensor cables parallel



6) Avoiding Obstacles

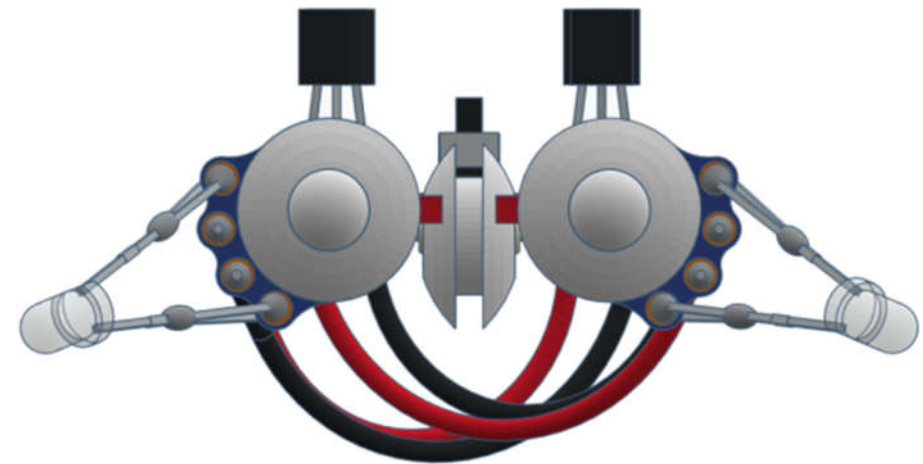


Setting: Light Follower/ Acceleration Mode

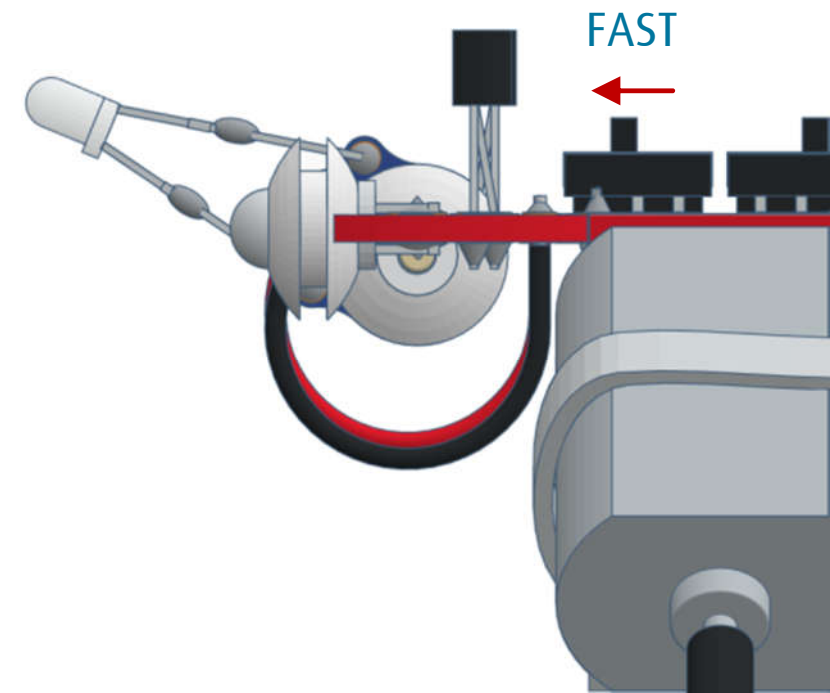
In order for varikabo to reliably avoid obstacles, these must be darker than the ground.

Align the lateral sensors about 45° to the side and slightly to the ground. The further the sensors are directed downwards, the closer varikabo will approach obstacles before swerving.

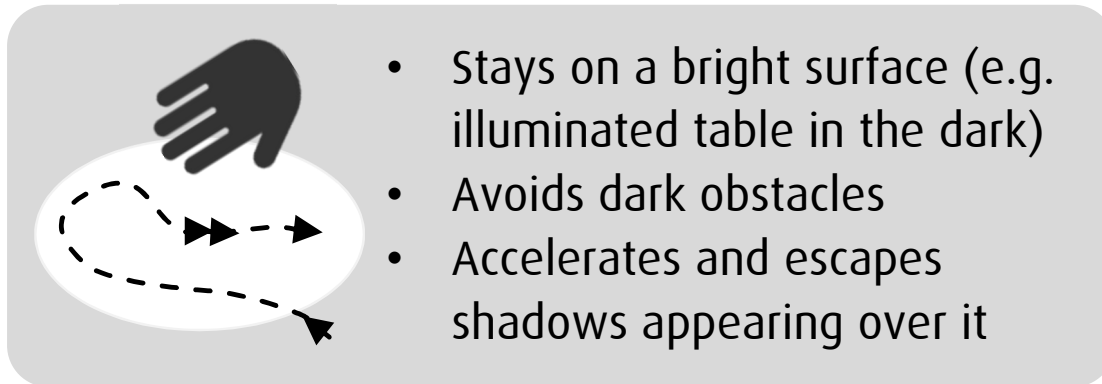
Adjust the tilt angle of the center sensor in the way that it is only slightly directed above the obstacles so that varikabo will be able to accelerate on free track.



sensor cables crossed



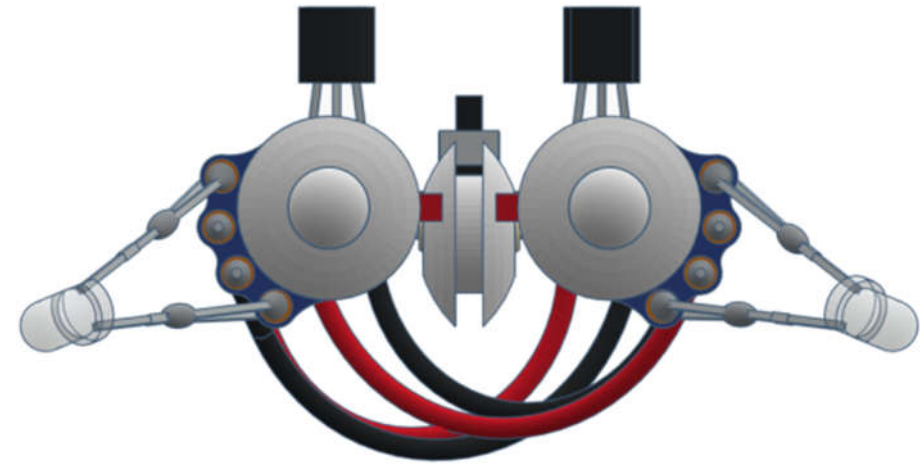
7) Avoiding Dark



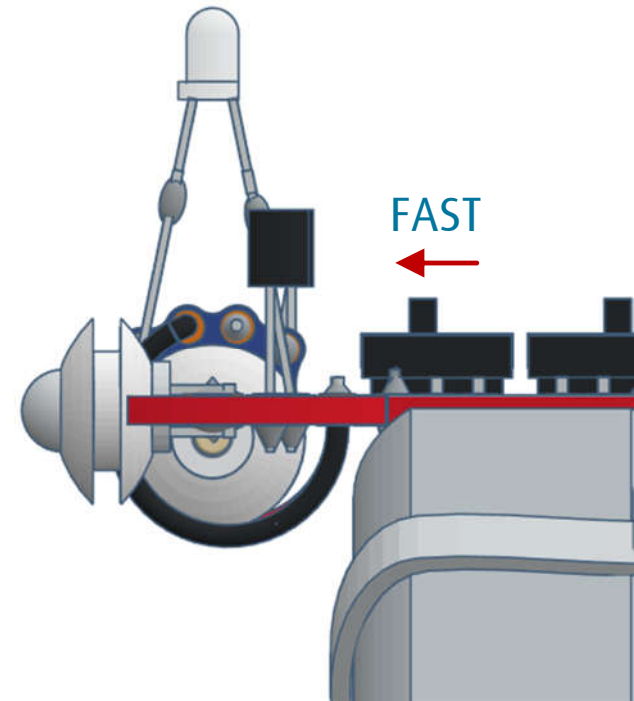
Setting: Light Follower/ Acceleration Mode

The bright area can be e.g. your room floor or a clear table illuminated from above. You can also place white sheets of paper on a dark background. Avoid lateral light incidence from windows. For varikabo to recognize the edge of the table well, the optimum angle of inclination of the two lateral sensors must be found.

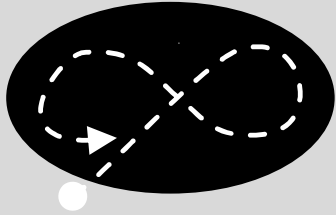
Caution: If you hold your hand above varikabo, it will only drive straight ahead without paying attention to its surrounding.



sensor cables crossed



8) Avoiding Light



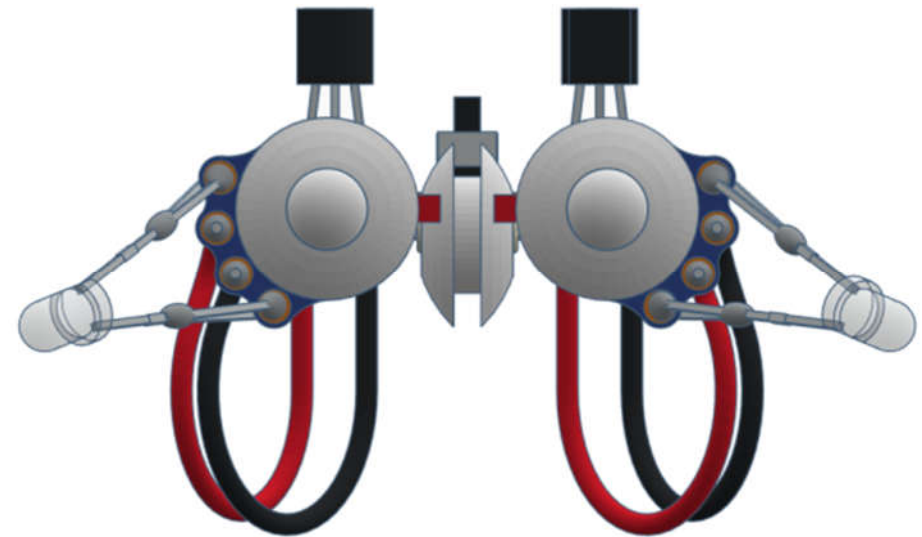
- Stands still on a light surface
- Drives steadily on a dark ground
- Turns away from light or stops in front of it

Setting: Shadow Follower / Braking Mode

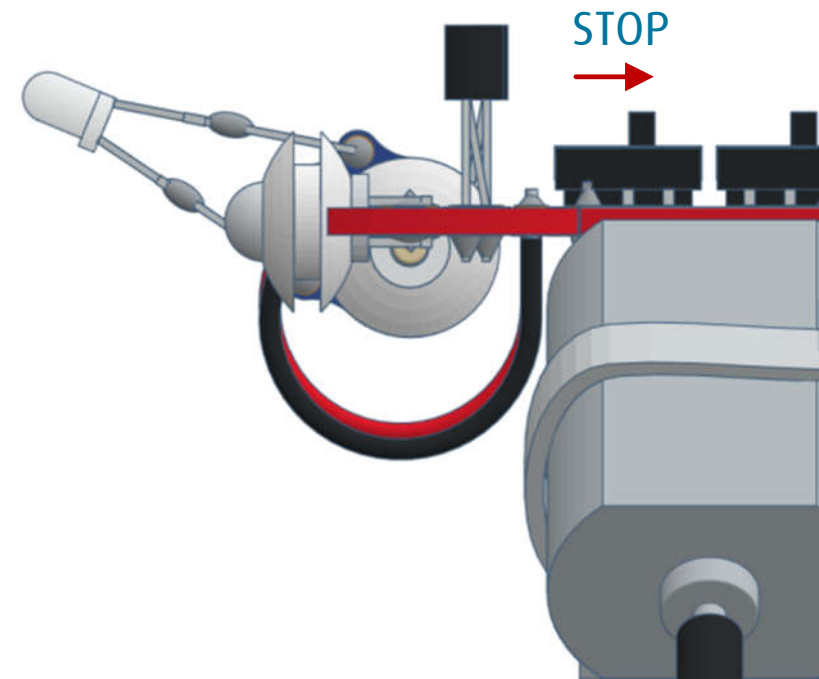
For the dark background, for example, you can cut black paper and place it on a light floor. The surface should be round and have a diameter of at least 30 cm.

Adjust the inclination of the two lateral sensors in the way that varikabo will turn at the edge in time.

Adjust the tilt angle of the middle sensor in the way that varikabo will always keep moving on the dark surface but stops on a light surface.



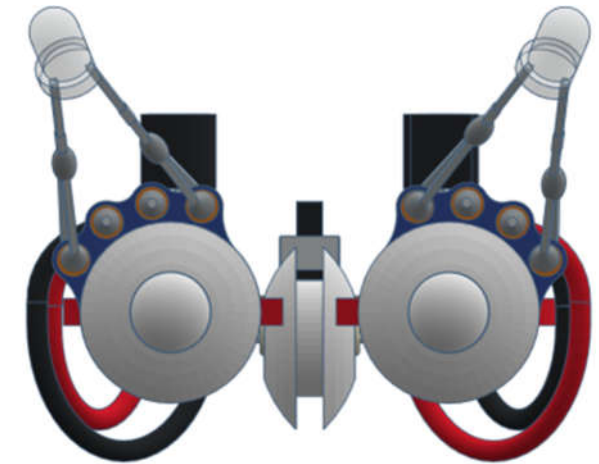
sensor cables parallel



9) Following Shadows



- Avoids light and seeks shade
- Drives towards a shadow
- Stops in the shadow
- Tracks the shadow as it moves

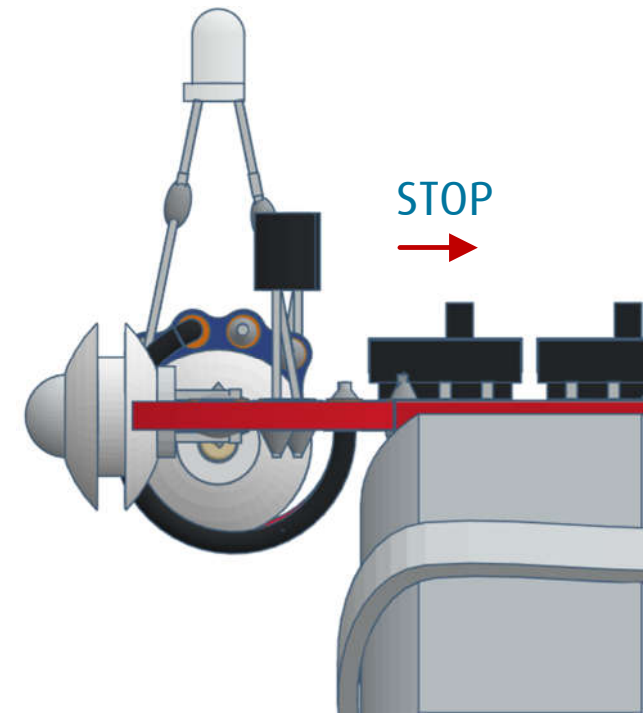


sensor cables parallel

Setting: Shadow Follower / Braking Mode

Choose a place outdoor or underneath a light source, which is placed at least one meter high. Your hand is the best shadow. However, be careful not to wear clothes with dark sleeves, otherwise varikabo would prefer to follow the shadow of your arm.

When you hold your hand over varikabo, it stops. Then slowly move your hand forwards or sideways so that varikabo can follow it.



10) Search Light



- Searches for a light above him and drives towards it
- Stops under the light
- Turns away of shadow and drives back into the light

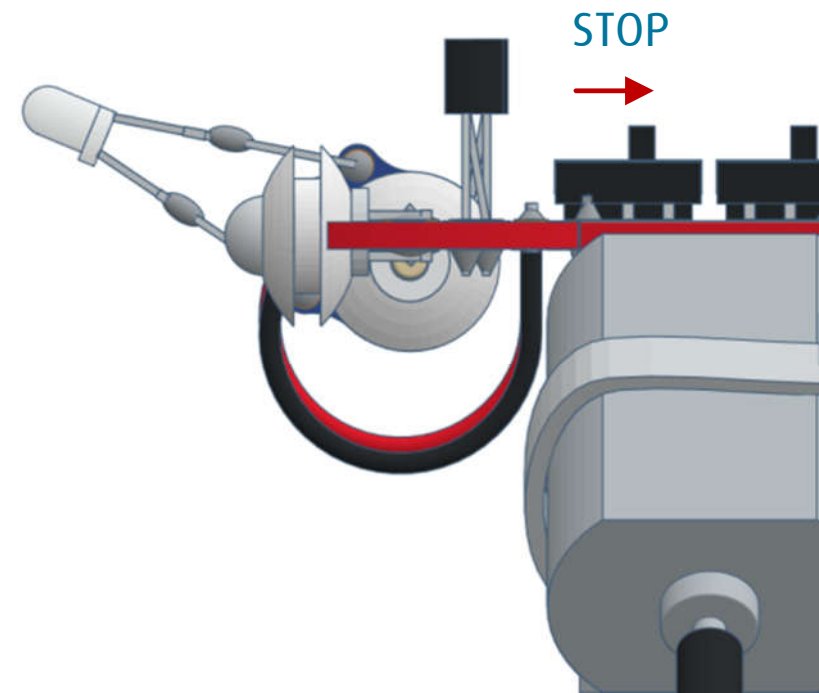
Setting: Light Follower / Braking Mode

For this experiment you need a dark room and a lamp about 30 to 100 cm above varikabo. Ideally, you can also move the lamp. However, a flashlight is not very suitable because of its focus.

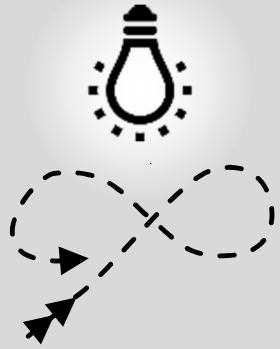
The more you direct the center sensor upwards, the further varikabo will move towards the center of the lit area before it stops. If you hold your hand between varikabo and the lamp, varikabo will try to return into the light.



sensor cables crossed
sensors to the rear



11) Circling Around Light



- Looks for a light and drives fast towards it
- Then below the light it moves on slowly in circles
- Accelerates when shadow is above



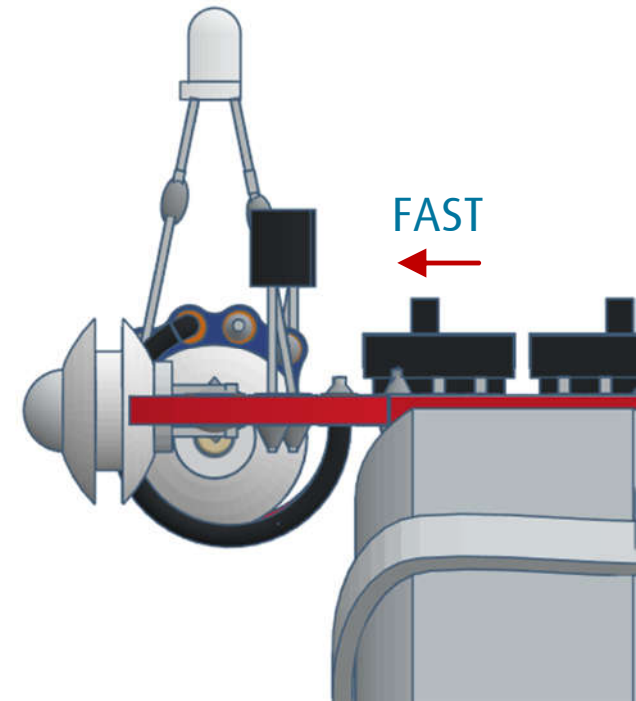
sensor cables crossed

Setting: Light Follower/ Acceleration Mode

For this experiment you need a dark environment and a lamp about 30 to 100 cm above varikabo. A flashlight is not suitable because of its strong focus.

If you place varikabo on the ground in some distance from the lamp, it will quickly approach the light.

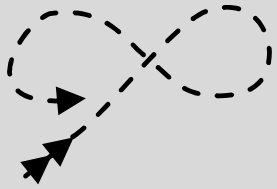
Below the lamp, it will slow down and keep turning in order not to move away from the lamp. With the inclination of the sensors you choose at which distance varikabo will make the turn.



12) Circling Around Shadow

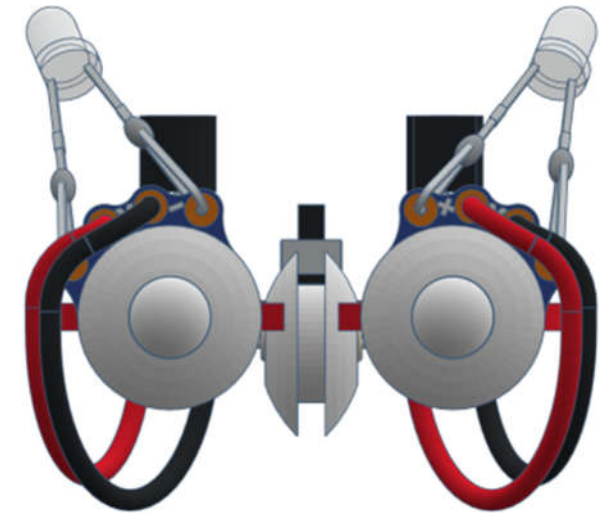


- Turns away from light
- Accelerates when shadow is above
- Tries to stay in the shade and turns again and again

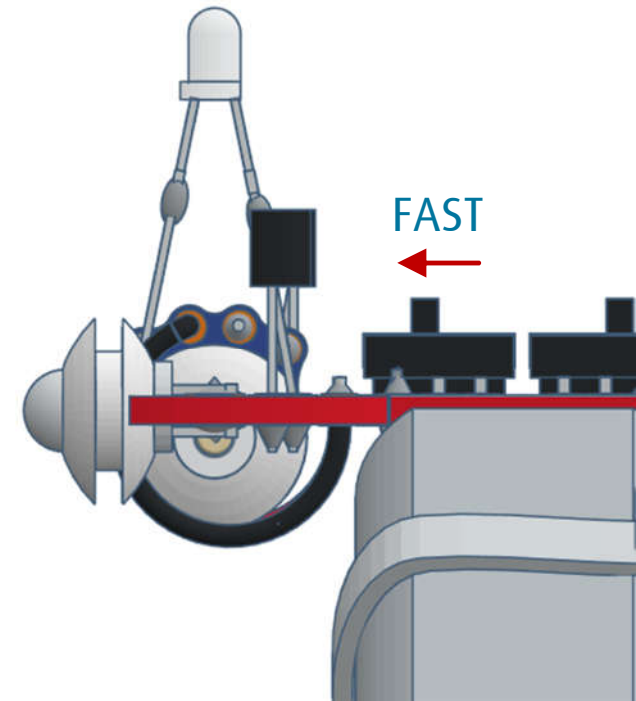


Setting: Shadow Follower / Acceleration Mode

Choose a place outdoors, but not in the sun, or a room with uniform ceiling lighting. If you hold your hand or a larger object over varikabo, it will accelerate briefly and then turn steadily in order not to move out of the shadow. With the inclination of the sensors you set when varikabo will turn back each time. The two side sensors must always be directed slightly further backwards than the center sensor.

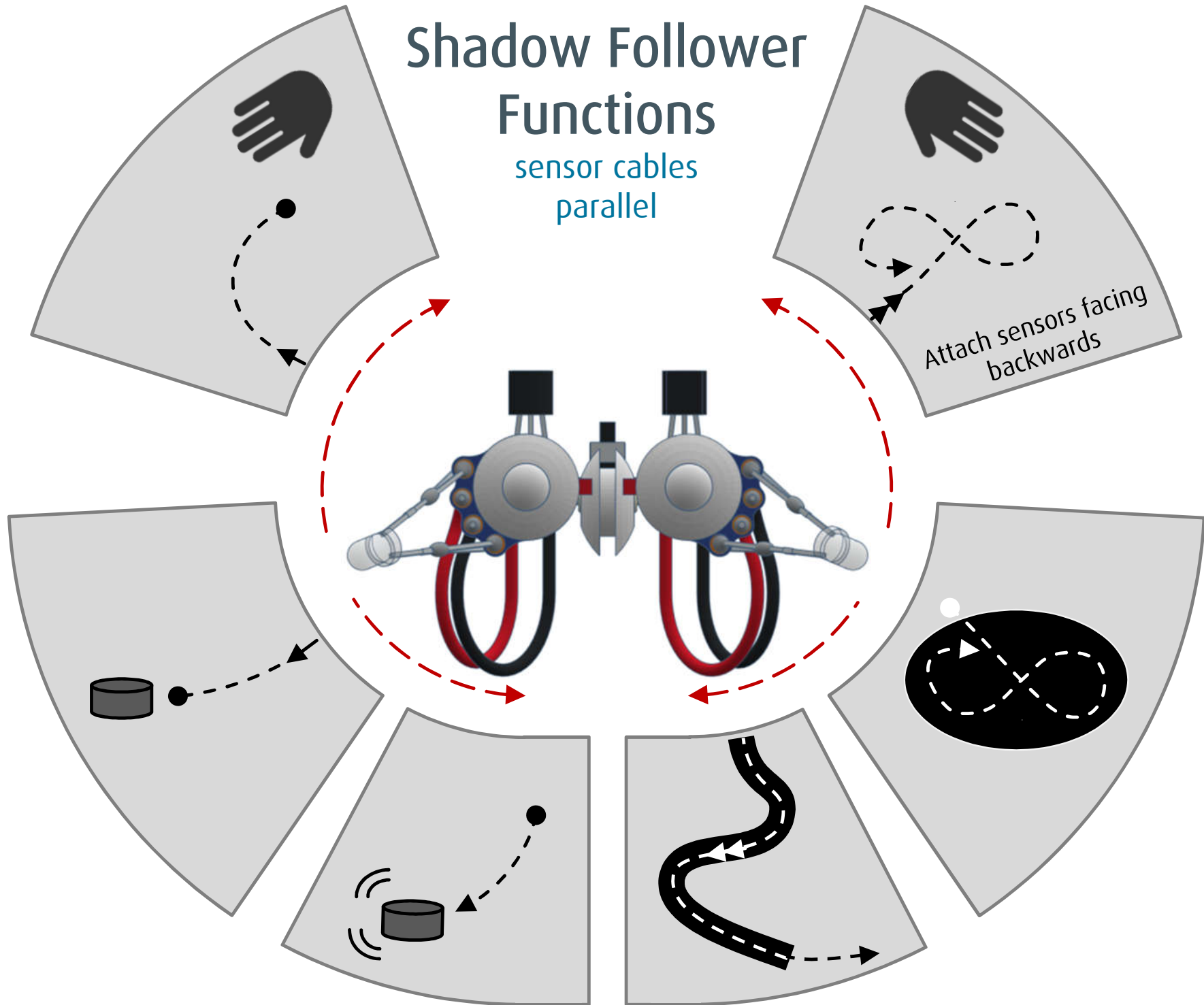


sensor cables parallel
sensors to the rear



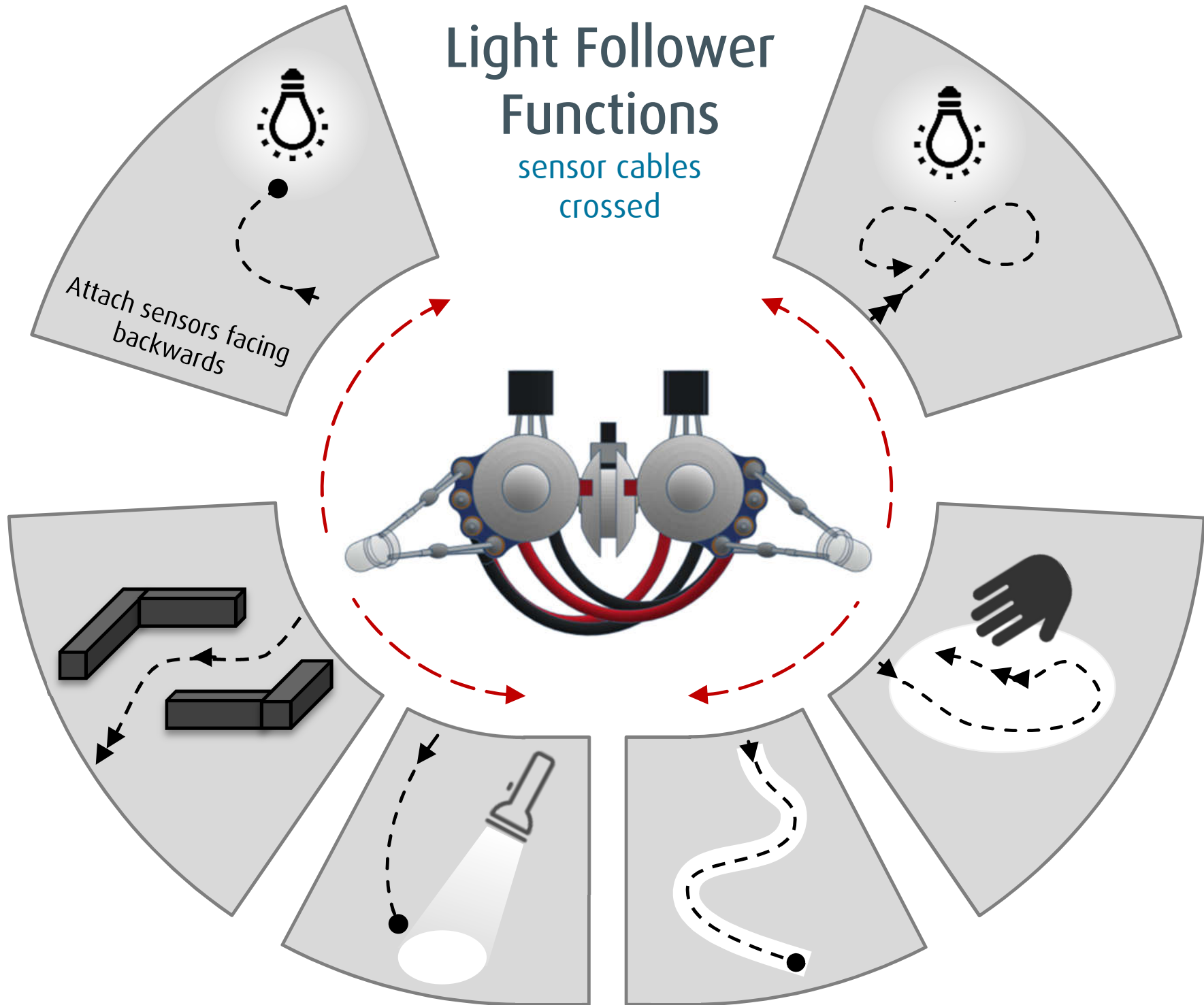
Shadow Follower Functions

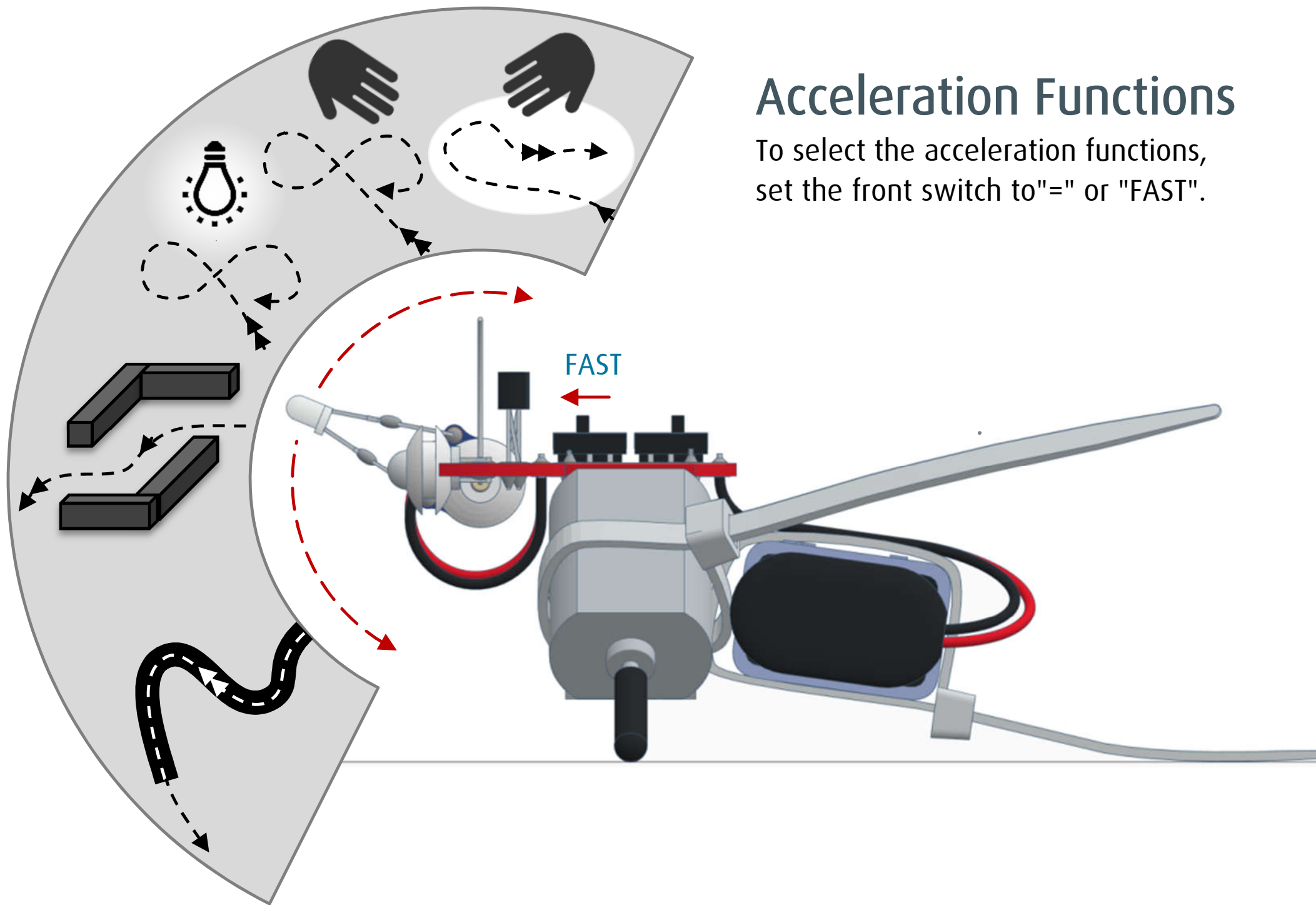
sensor cables
parallel



Light Follower Functions

sensor cables
crossed



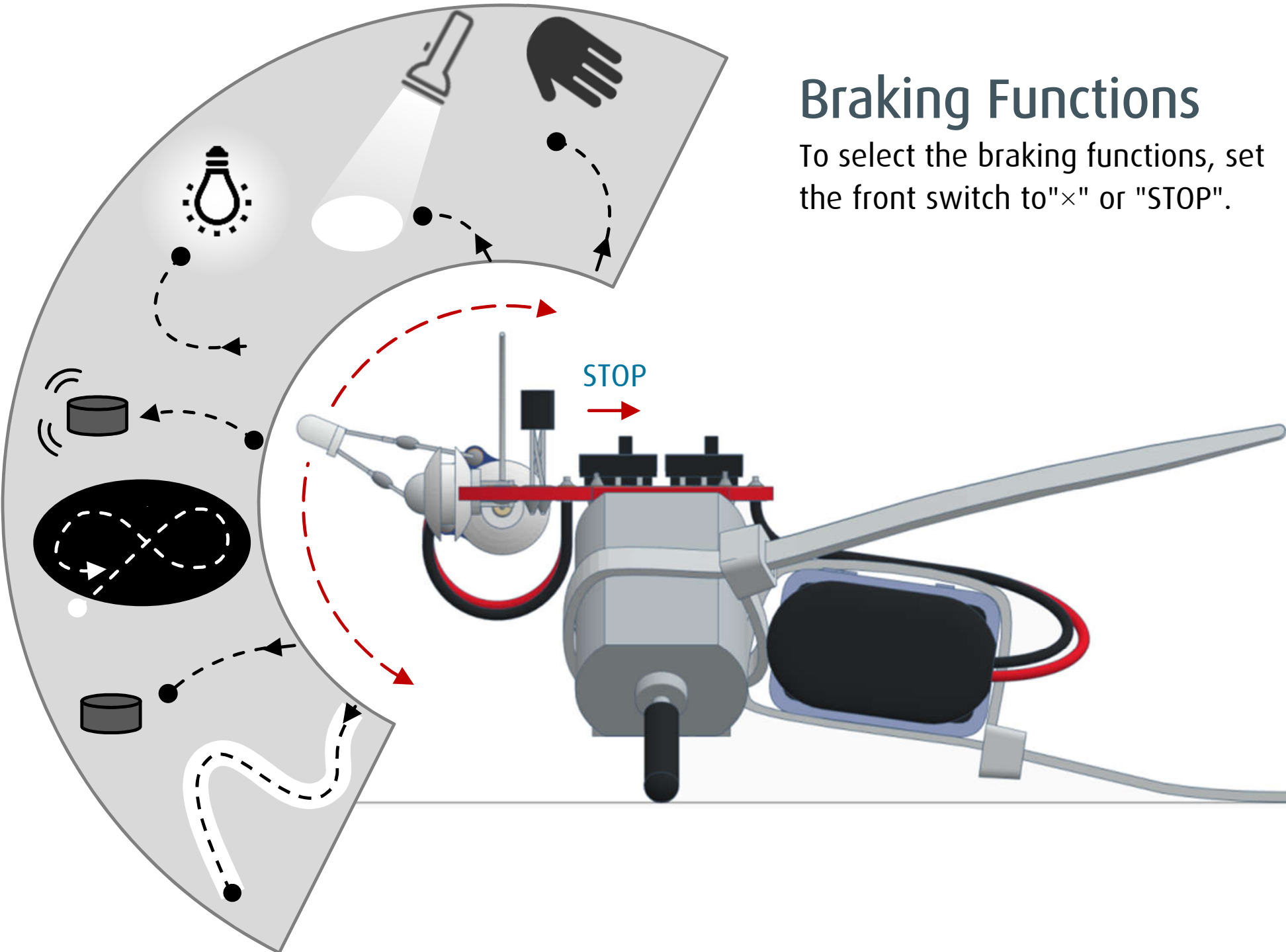


Acceleration Functions

To select the acceleration functions, set the front switch to "=" or "FAST".

Braking Functions

To select the braking functions, set the front switch to "×" or "STOP".



Fault Diagnosis

Problem	Possible Reasons
varikabo does not move at all.	<ul style="list-style-type: none">• The left and right sensors are connected with the wrong polarity.• The battery clip is not on the 9V battery.• The battery is empty or defective.• The rubber caps are too far on the motor shafts.
Only one of the motors is running.	<ul style="list-style-type: none">• The left or the right sensor is connected with the wrong polarity.• A transistor is soldered with the wrong polarity.• A rubber cap is pushed too far on the motor shaft.
A motor turns backwards.	<ul style="list-style-type: none">• This motor is connected with the wrong polarity.
varikabo only drives straight ahead.	<ul style="list-style-type: none">• The center sensor is connected incorrectly.
The LEDs light up differently.	<ul style="list-style-type: none">• One LED is soldered with the wrong polarity.
varikabo gets stuck on the ground.	<ul style="list-style-type: none">• The surface is too bumpy for varikabo.

If none of these causes apply to your problem, check carefully that all components are installed as described in the construction plan.

If you need help, please contact us with a detailed error description and preferably a photo of your robot: *info@variobot.com*

3) Operating Principle

Depending on how the sensors are connected to the transistors via switch S_2 and whether the sensors FT_1 and FT_2 are arranged parallel or crossed, there are four basic control variants.

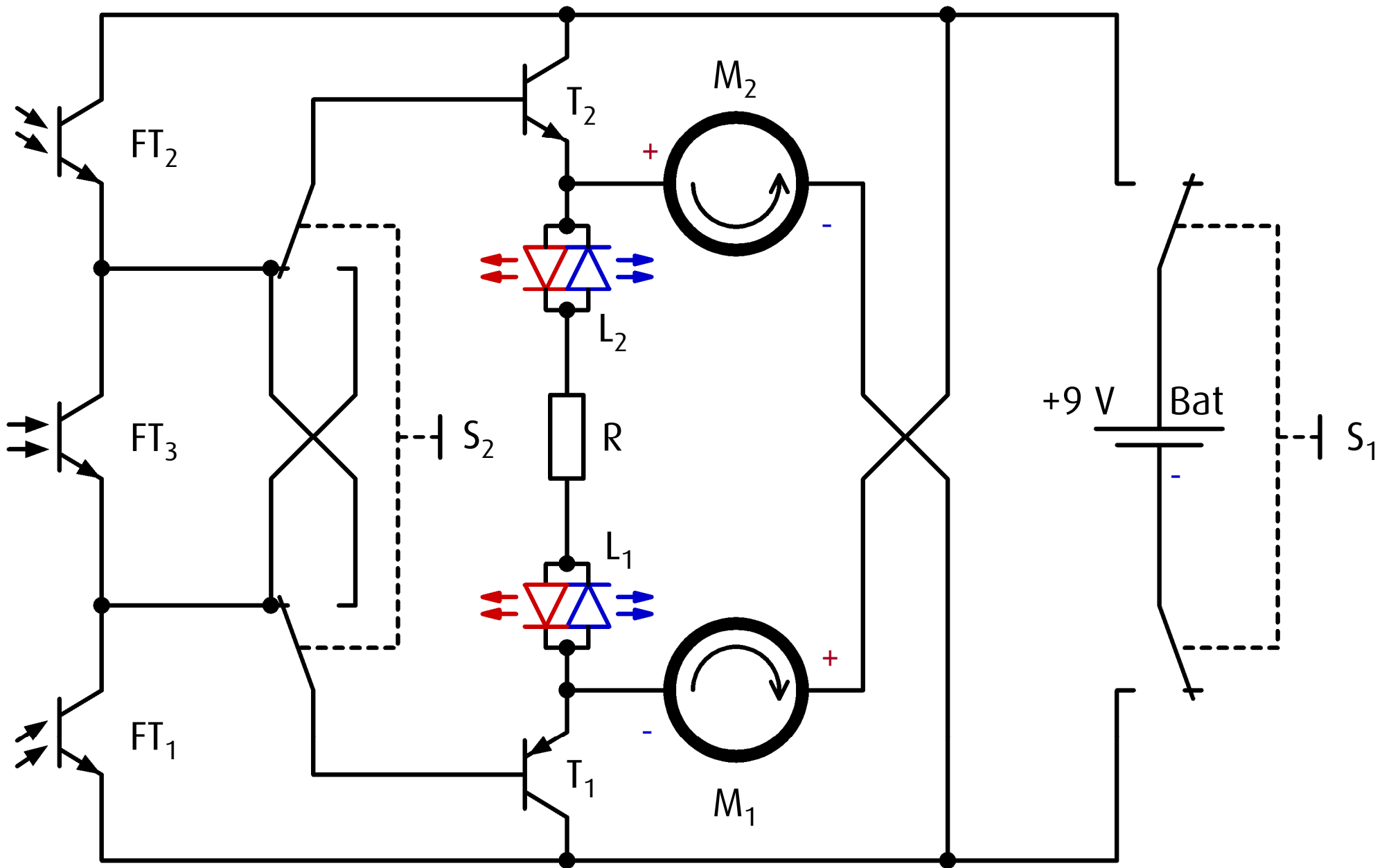
- Acceleration Mode/ Shadow Follower
- Acceleration Mode/ Light Follower
- Braking Mode/ Shadow Follower
- Braking Mode/ Light Follower

All other features of the 12 functions are set by aligning the sensors.

In the following circuit diagram the sensors are arranged as shadow follower. The selector switch S_2 is in the position for acceleration mode.

The two bi-colour LEDs are connected in series with the resistor and arranged between the transistors. They light red when the current flows through both transistors. They light up blue when the current flows through the motors in the other direction, as long as they stand still.

Circuit



The Transistors

A transistor is a simple electronic amplifier with three connections: base (B), emitter (E) and collector (C).

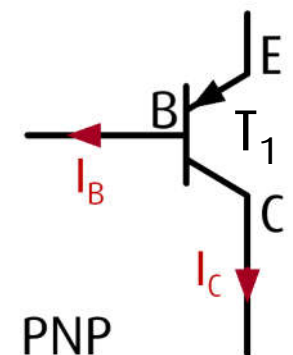
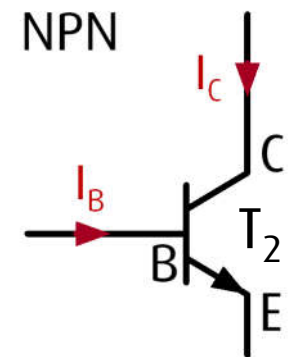
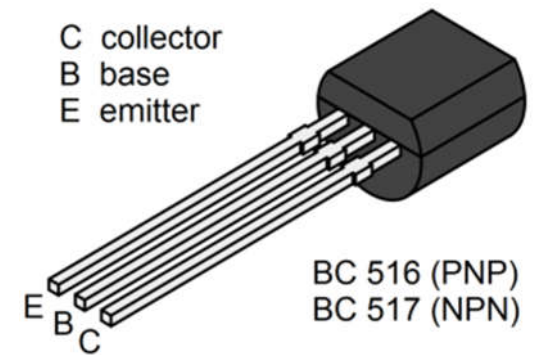
At a sufficiently high voltage of about $U_{BE} = 0.7 \text{ V}$ ($\text{V} = \text{Volt}$) between base and emitter, the transistor reduces the resistance between collector and emitter and - it is said - it switches through.

The collector current I_C for ordinary transistors can be about 100 to 800 times larger than the base current I_B .

varikabo uses Darlington transistors with a very high current amplification of 30 000. To supply the motor and LEDs with a current of 0.03 A (amps) = 30 mA (milliamperes), a base current of only 1 μA (microampere) is required:
 $30 \text{ mA} / 30.000 = 0.001 \text{ mA} = 1 \mu\text{A}$

A Darlington transistor consists of two transistors connected in series and requires about $U_{BE} = 1.4 \text{ V}$ instead of 0.7 V to switch through. To ensure that the motors react to the sensor signals in opposite directions, varikabo uses a complementary pair of transistors:

one PNP transistor for T_1 (BC516) and one NPN transistor for T_2 (BC517).



The adjacent figure shows a simple circuit with a battery, a motor and an NPN transistor. Underneath, the corresponding circuit is shown with a PNP transistor. The current flows in the direction of the black arrow from plus to minus in both cases.

There are three different basic circuits with a transistor. varikabo uses the so-called collector circuit.

It is called collector circuit because the collector (C) is connected to a constant voltage (battery).

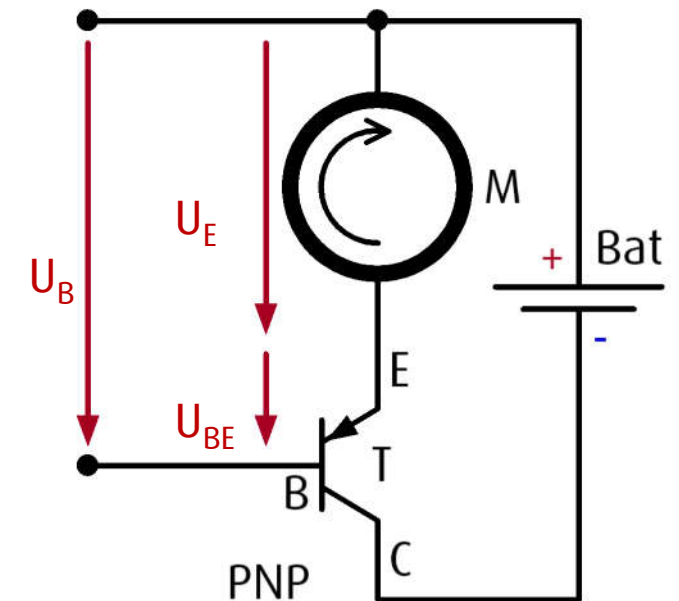
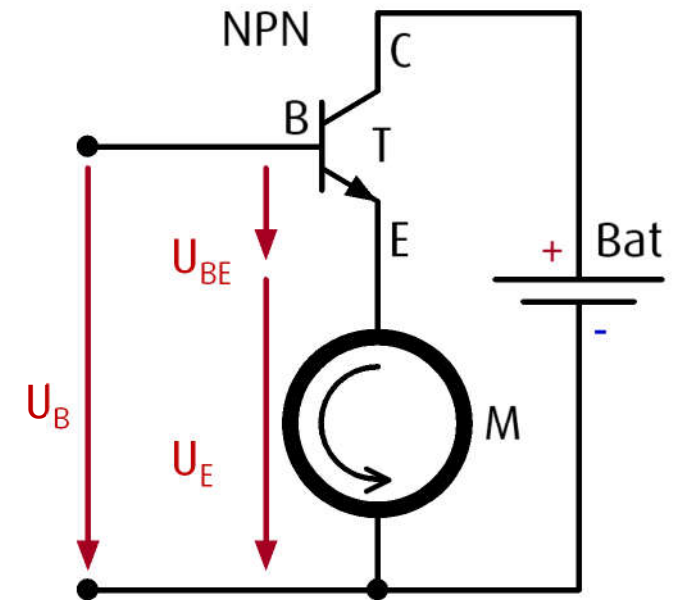
The red arrows symbolize the voltages. You can notice that the voltage at the motor U_E is lower by the base-emitter voltage U_{BE} than the base-voltage U_B .

$$U_E = U_B - U_{BE} = U_B - 1.4 \text{ V}$$

Note:

Because the voltage at the emitter (E) follows the voltage at the base (B) except for the difference of U_{BE} , this circuit is also called emitter follower.

With the control voltage U_B and a very low current I_B , the voltage U_E and thus the speed of the motor can be controlled.



The Sensors

varikabo's phototransistors (FT) are similar in design to a transistor. The collector (C) is on the plus side and the emitter (E) is on the minus side. Instead of a basic connection, however, they have a light-sensitive area.

The incidence of light determines the permeability between the collector and the emitter.

The circuit diagram shows that the three phototransistors FT_1 , FT_3 and FT_2 are all connected. They say they're in series. This series connection results in a so-called voltage divider, which divides the voltage of the 9 V battery depending on the illumination of the sensors.

Examples:

- With exactly the same amount of light, the voltages at the sensors are three volts each, regardless of the brightness: $U_2 = U_3 = U_1 = 3 \text{ V}$
- If, for example, the middle sensor FT_3 were illuminated four times brighter than FT_2 and FT_1 , a voltage four times lower would drop at FT_3 and the supply voltage would be divided as follows: $U_2 = 4 \text{ V}$, $U_3 = 1 \text{ V}$, $U_1 = 4 \text{ V}$

Note:

The two variable voltages between the three sensors control the speed of the two motors.

