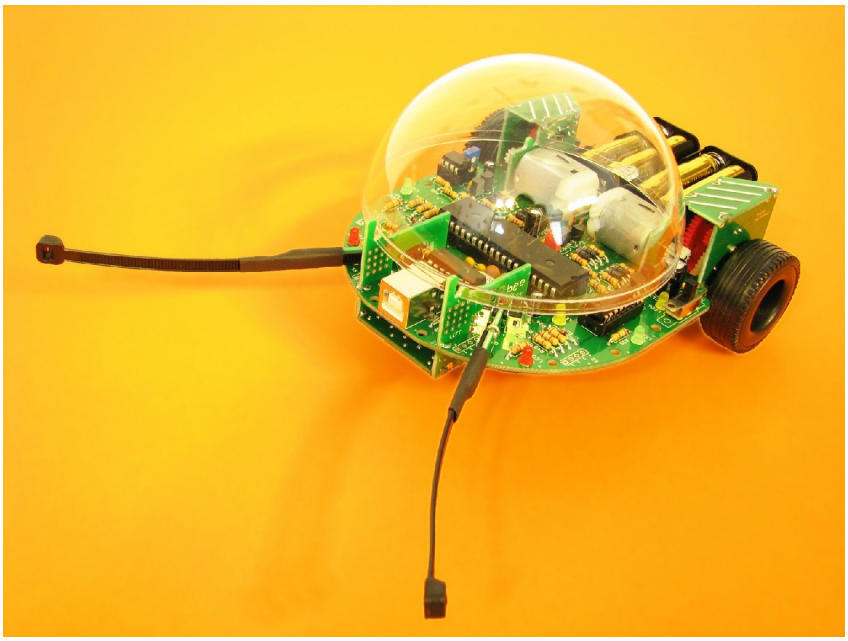
Robot kit NIBObee

Construction manual



nicai
systems

version 2014/12/01

Safety instructions

For construction and operation of the robot please consider the following safety instructions:

- The robot kit Nibo2 is designed for learning, teaching and experimental purposes only. The company does not accept any liability for other uses of the programming adapter. Any other use is at the users own risk.
- No machines must be attached to the robot. In particular the operation with devices on main voltage is forbidden.
- The robot must not be operated without supervision. When not in use the robot is to be separated from the power supply.
- The robot must be operated with stabilized DC voltage by 4,8 V. In particular the robot must be operated **with rechargeable batteries (1,2V) only** and never with normal batteries (1,5V).
- We take no responsibility for data loss of an attached computer.
- The robot must be used indoors only. In particular the usage of the robot is expressly forbidden on public roadways!
- For a usage deviating from these guidelines no warranty and no accountability are assumed, the operation is at your own risk!

For soldering please consider following points:

- Always work with extreme caution with the soldering iron!
- Inappropriate operation can lead to severe burns or cause fires.
- Never place the hot soldering iron on the table or on other surfaces.
- Never leave the soldering iron switched on unsupervised.
- Please consider the possible emission of poisonous fumes when soldering. Ensure there is sufficient ventilation and wash your hands thoroughly after work.
- Keep the soldering iron away from children!
- Please consider the safety instructions of the soldering iron manufacturer!
- Pay attention to a correct soldering tip temperature: High temperatures (400°C) may damage the tip, but also allow a short soldering time. Low temperatures (320°C) will increase the soldering time. This may damage the electronic components.

Table of contents

1 Introduction and overview

The robot kit **NIBObee** is a programmable autonomous robot which was especially developed for pupils and students. It can be programmed in C, C++, Java and assembler. NIBObee is a complete solution system with an ATmega16 as „thinking“ unit, different sensors for the perception of its environment and an integrated USB programmer, which also provides as battery charger for the rechargeable batteries. After assembling you can directly start with own programming.

For all electronic parts are placed amply dimensioned on the circuit board the robot is quite easy to solder. A construction manual with many illustrations explains the assembly and the necessary soldering step by step. In order to enable a quick and motivating introduction to the fields robotics, programming and control engineering the sensors are comfortable to program and to control.

A transparent half sphere and two feelers controlling four sensors give the NIBObee its distinctive appearance. The whole thing is completed by the NIBObee library which provides all important basic functions and a programming tutorial in C for the first steps.

1.1 Features

Technical data:

- Dimensions: (L x W x H) 126 x 159 x 50 mm (without sphere, feelers)
- Weight: 266g (with rechargeable batteries)
- Power supply: 4 AAA Micro rechargeable batteries with 1,2 V each
- Voltages: 4,8 V
- Dimensions of main circuit board: 110 x 80 mm

Equipment:

- ATmega16 (16 kB Flash, 1 kB SRAM, 15 MHz)
- ATtiny44 to control the integrated USB-programmer
- USB-programmer which also provides as battery charger for the rechargeable batteries
- 4 LEDs for own functions
- 3 status LEDs
- 4 touch sensors with feelers
- 2 odometry sensors
- Line following sensor with 2 IR-LEDs and 3 photo-transistors
- Powered by two motors with 25:1 transmission
- Jumper to deactivate motor control
- 5 extension ports, each with 2 bits for own ideas/experiments
- Transparent half sphere as chassis

Applications:

- Following lines
- Detection of obstacles
- Autonomous performance
- Determination of different flooring
- Following walls

Features:

- Main CPU with 16 kByte flash-memory
- Programmable in C, C++ and Java (GNU gcc and nanoVM)

1.2 Motors

The robot is driven by two motors with 25:1 transmission. The motors are driven by a H-bridge with a 14,7 kHz PWM-signal. The PWM-signal can be regulated by odometry-sensors, thus it is possible to drive with constant speed.

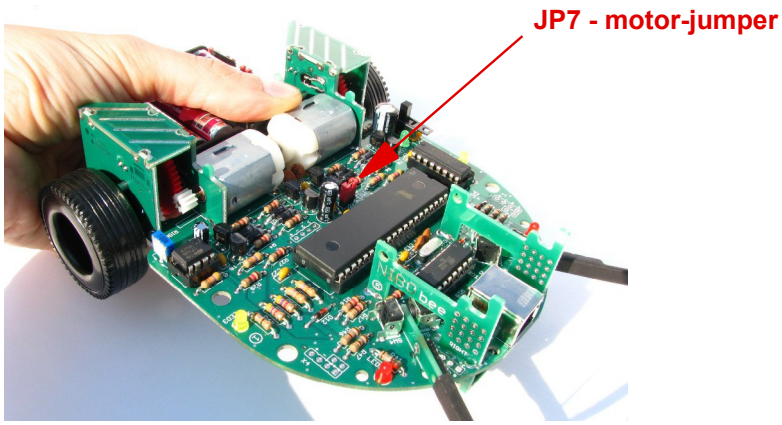
1.2.1 Odometry

The direction of rotation and the speed of the wheels is measured by two photo-transistors and two IR-LEDs on the middle gearwheel of the transmission. The speed is directly proportional to the frequency of the signal.

1.2.2 Motor bridge

The motor bridge is needed for current amplification and for voltage regulation of the microcontroller signals. The motor is controlled by one of three possible signal-combinations from the H-bridge: high/low (forward), low/high (backwards), high/high (short-circuit). The short-circuit operating (freewheel) is for better utilization of energy with PWM-control, since electricity does not have to flow against the supply voltage in this case. Additionally the freewheel stabilizes the torque for lower values.

It is possible to deactivate the motor bridge by removing the jumper JP7 for test cases.

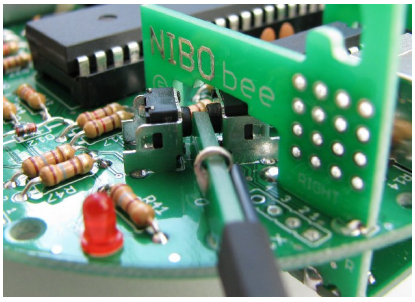


1.3 Sensors

The robot is able to learn and to react to environmental conditions by its sensors. The following subsections describe the sensors in detail.

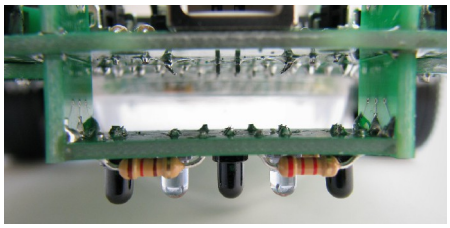
1.3.1 Touch sensors / feelers

NIBObee has two feelers and four touch sensors to detect obstacles. Each feeler is controlled by two touch sensors, so it is also possible to detect the direction of an obstacle:



1.3.2 Floor- and line-following sensors

To measure the reflection factor of the floor under the robot there are three IR-phototransistors and two IR-LEDs. So it is possible to detect sheers and to follow a black line. Additionally different floorings can be distinguished, if their IR-reflection factors are different. To avoid the influences of scattered light it is advisable to use a modulated signal. This method of measurement is implemented in the NIBObee library.



1.4 USB interface

The robot can be connected to a computer by the USB interface. It is possible to upload new software by this interface. Additionally the rechargeable batteries can be charged by this interface.

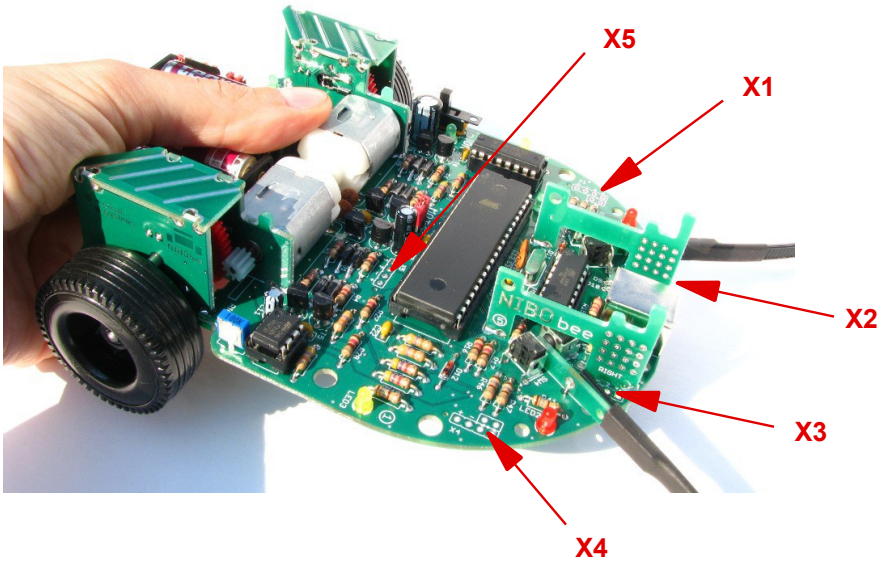
1.5 Interfaces / Extension ports

The NIBObee has 5 extension ports. Each of these ports has four contacts: plus, minus and 2 signal bits. The port X2 and the port X3 are located near to the small hole raster fields, where additional sensors e.g. photo-sensitive resistors or temperature sensors can be contacted.

All ports have additional functions:

Port	*Signal 1*	*Signal 2*	*Information*
X1	analog / digital	analog / digital	Two analog inputs
X2	analog / digital	digital	Analog input
X3	analog / digital	digital	Analog input
X4	SCL / digital	SDA / digital	I²C-interface
X5	Rx / digital	Tx / digital	Serial interface

The user can connect own extensions at the port **X4** by an I²C-interface. Extensions with a serial interface can be connected to the port **X5**.



1.6 Other hardware components

1.6.1 Status LEDs

The two yellow LEDs (LED0 and LED3) and the two red LEDs (LED1 and LED2) show the actual status of the robot. They can be controlled by own programming.

1.6.2 Function LEDs

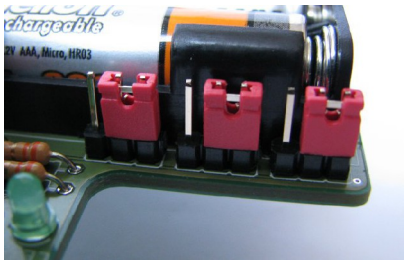
The green LEDs (LED4 - LED6) show the following functions:

LED4	***Programming***: flashes during the programming process
LED5	***Charging information***: flashes during the charging process
LED6	***Operating mode information***: flashes during the NIBObee is online

1.6.3 Voltage switch / Charging

The voltage switch S1 separates the battery voltage from the circuit and provides the possibility to charge the rechargeable batteries in combination with the jumpers JP1, JP2 and JP3 (see chapter 3.8).

Normal operation:



2 Assembling of the robot

Please read the following chapter completely before you begin with the assembly!

2.1 Necessary tools

You need the following tools for the assembly:

Soldering iron with sponge & electronic solder wire

Electronic cutting pliers

Small recessed head screwdriver

Universal pliers

Small hammer

Glue

If there occur problems after the assembly, you can use the following tools:

Soldering remover

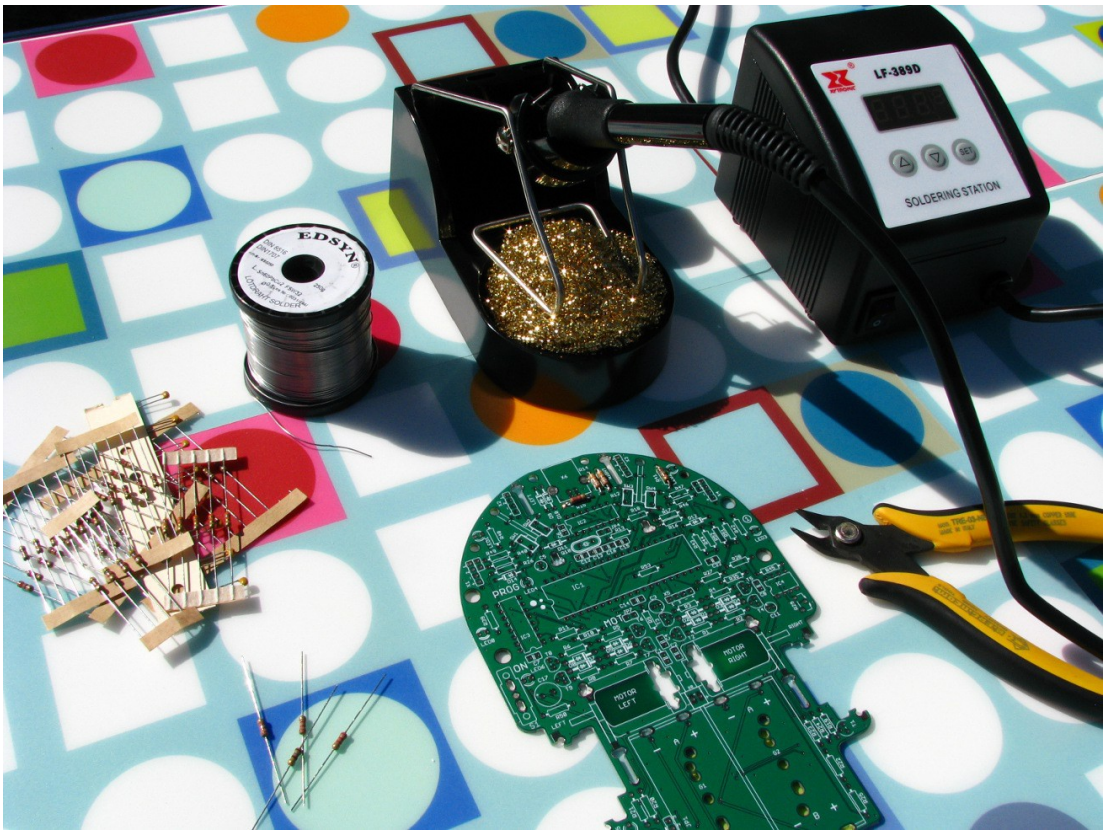
Multimeter (with continuity tester)

2.2 Soldering

For soldering you should use a **regulated** soldering station with **at least 50 W** and a fine tip.

Hint: The manual of the soldering station should definitely contain the word “regulated”. A regulated soldering station means, that it “knows” exactly the temperature of its tip. So it is able to readjust the temperature if its necessary. It is very helpful to have no temperature drop during soldering!

You should select a temperature of about 370 °C, depending on the soldering station the temperature can drift up to 400 °C. The best thing is to test it. You should use flux cored solder wire with a diameter of 0.5 mm. The best for beginners is to start with lead-containing solder wire (**SN60PB40**).



Soldering should work like this:

Video „Soldering in 30 seconds“ http://www.nicai.eu/soldering

If it doesn't work as seen in the video, it can be useful
to check the own soldering equipment and/or get someones help.

The soldering time should be limited to a few seconds (not minutes!) for each pad. Most electrical components react sensitively to high temperature.

For **very** sensitively components you can do the following:

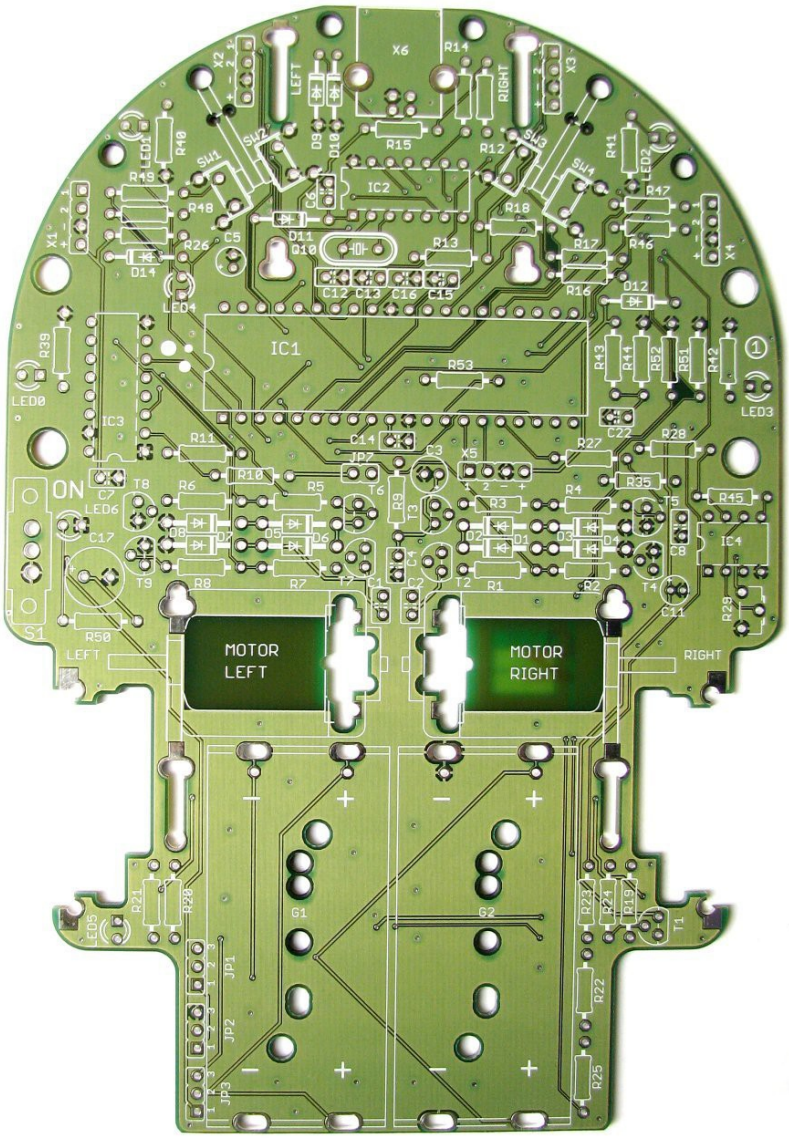
First you solder 3-5 seconds, if the soldering point isn't good enough yet, you let the component cool down and afterwards you solder again for 3-5 seconds.

The optical components (LEDs, IR-LEDs and phototransistors) are very sensitively components.

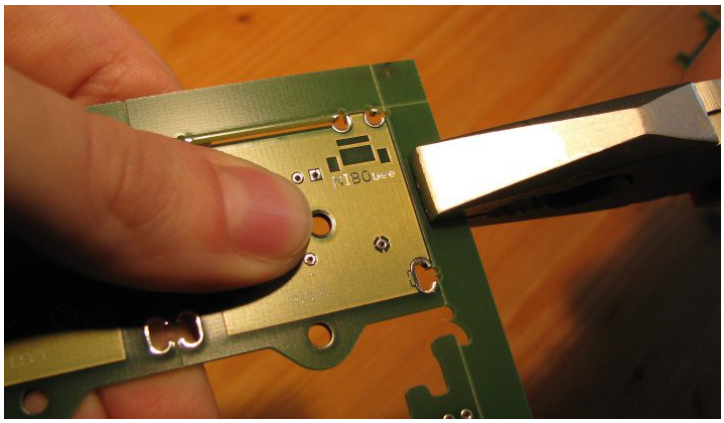
2.3 Placing components onto the circuit boards

This section describes how to place the electrical components onto the circuit boards. First of all an overview of the plain boards:

Main circuit board (board ①):

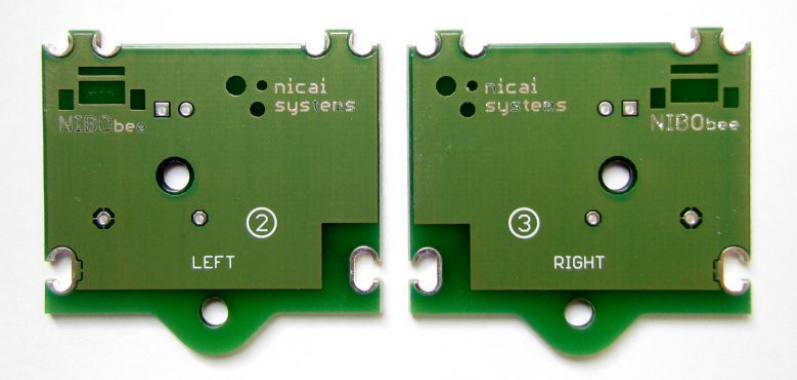


All boards must be separated from the frame first e.g. by a universal pliers:



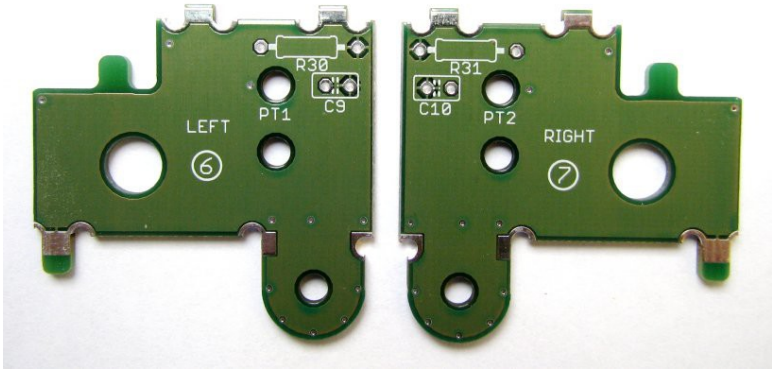
Tip: First of all keep all board parts, in order to miss no parts!

Boards ② and ③:

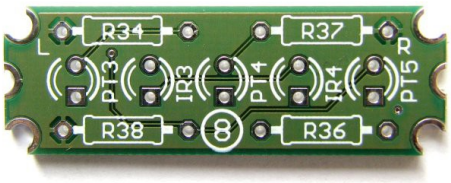


Boards ④ and ⑤:

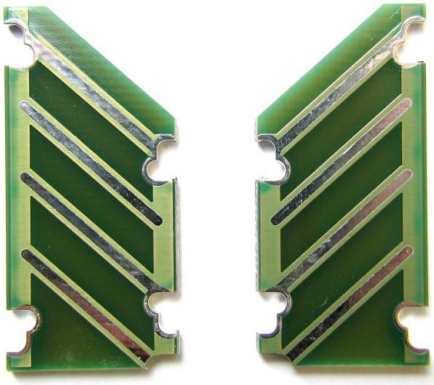
Boards ⑥ and ⑦:

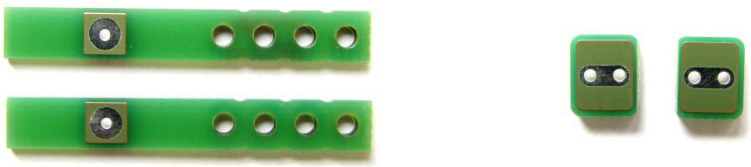


Board ⑧:



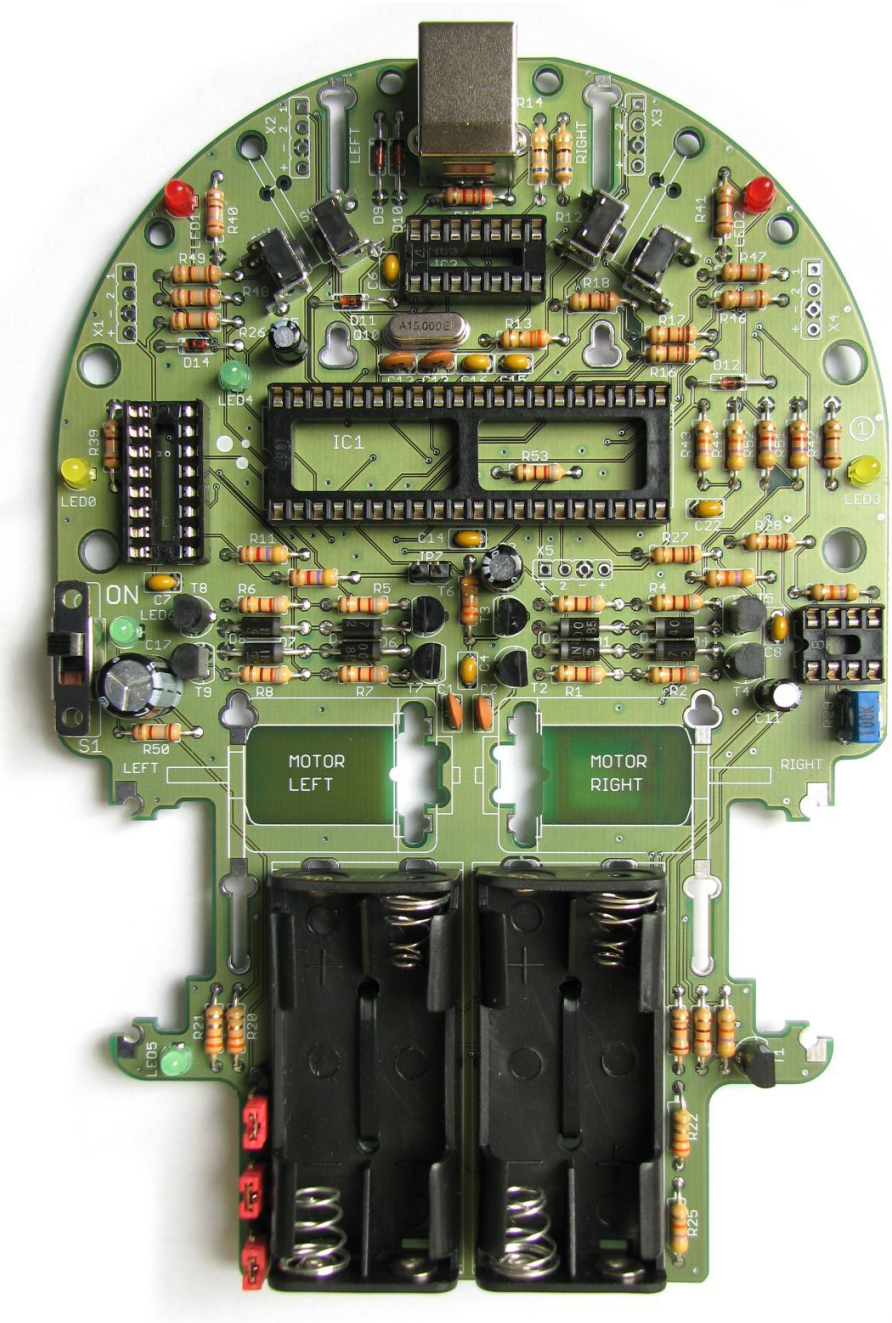
Supporting circuit boards:



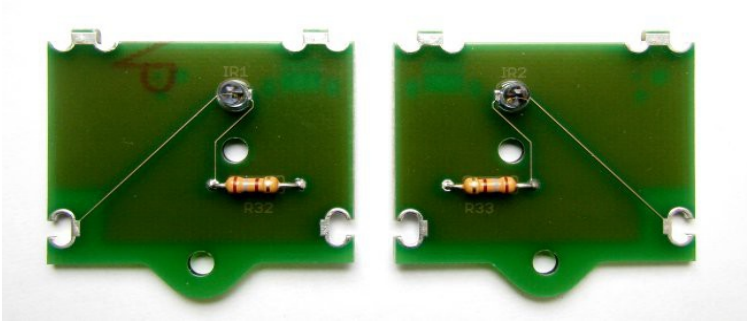


The finished circuit boards should look like this:

Main circuit board (board ①):



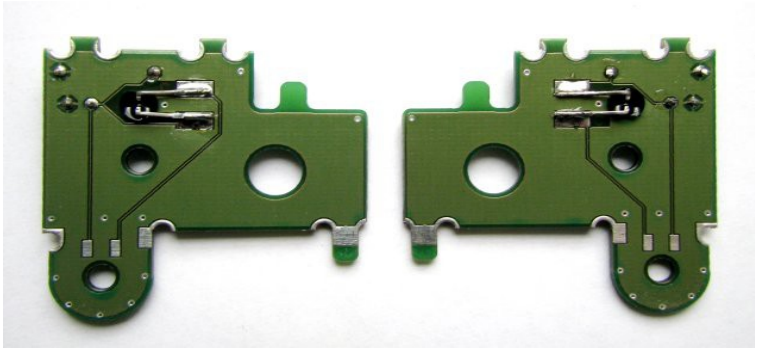
The circuit boards ② and ③ have to be soldered from the **bottom side**:



None electronic parts have to be soldered onto the boards ④ and ⑤.

Boards ⑥ and ⑦ (**Top sides**):

Boards ⑥ and ⑦ (**Bottom sides**):

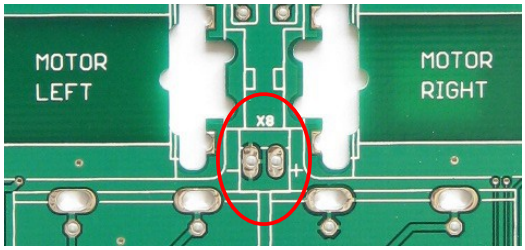


Board ⑧:

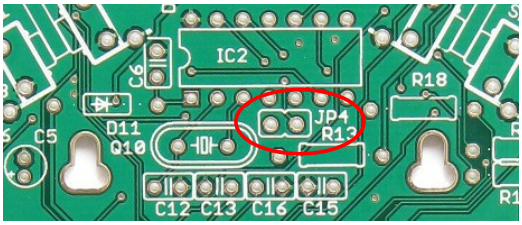
Information:

The version **1.14** of the circuit board will have some changes, which are desired from our customers. All changes are **optional extension possibilities** and will not be assembled. The kit includes no electrical parts for these extensions!

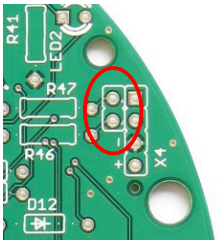
1. External power input:
   With the connector X8 the NIBObee can be powered by an external 5V power supply unit. Therefore the jumper JP1, JP2 and JP3 must be removed.



2. Jumper for a firmware update of the ATtiny44:
   With the jumper JP4 it is possible to make a firmware update of the ATtiny44 by the ATmega16.



3. Four additional data bits for the extension ports X1 and X4.
   To use these additional bits the two feelers have to be deactivated.



4. One of the circuit board parts is a bending help for the resistors and the transistors. It can be used if required.

The **sequence of placement** depends on the height of the components to make all soldering pads well accessible. The following subsections are sorted according to this criterion.

Information: All circuit boards (① - ⑧) are assembled in this chapter.

2.3.1 Resistors

The resistors are soldered horizontal onto the boards. You don't have to pay attention to the polarity. The legs must be bent over, as shown in the illustration.

The value of the resistors is indicated by a four band colour code on the resistor, which is explained in the appendix.

The following table shows the colour codes of the used resistors:

value	parts	colour code
3,3 Ω	R9, R13, R20, R21, R22	orange – orange – gold - (gold)
68 Ω	R12, R14	blue – grey – black - (gold)
120 Ω	R16, R17, R18, R27, R28, R36	brown – red – brown – (gold)
180 Ω	R23, R26, R32, R33, R39, R40, R41, R42, R46, R47, R48, R49, R50	brown – grey – brown – (gold)
820 Ω	R1, R2, R3, R4, R5, R6, R7, R8, R24, R30, R31, R53	grey – red – brown – (gold)
2,2 kΩ	R15, R34, R37, R38	red – red – red – (gold)
4,7 kΩ	R10, R11, R51, R52	yellow – violet – red – (gold)
47 kΩ	R19, R25, R35, R43, R44, R45	yellow – violet – orange – (gold)

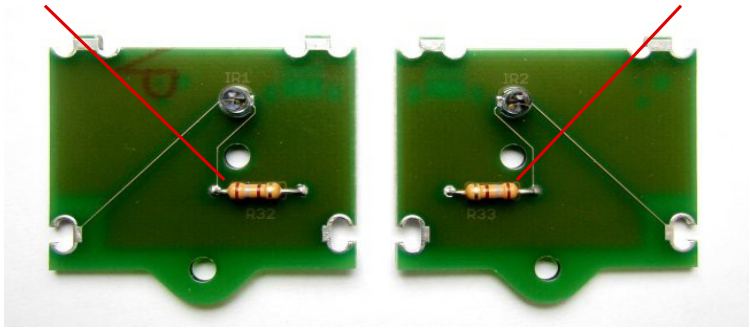
Tip: There is an **overview** of the placement of all resistors on the next pages!

The following resistors must be placed onto the **secondary circuit boards**:

R32 is to place on the **bottom side** of board ②, **R33** is to place on the **bottom side** of board ③:

R32 – 180 Ω
code: brown-grey-brown

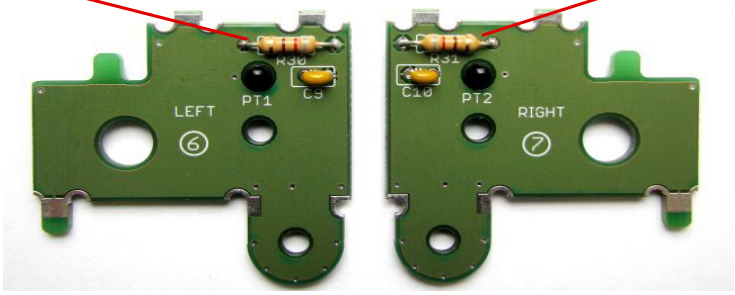
R33 – 180 Ω
code: brown-grey-brown



R30 is to find on board ⑥, **R31** is to find on board ⑦:

R30 – 820 Ω
code: grey-red-brown

R31 – 820 Ω
code: grey-red-brown

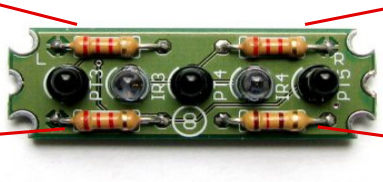


Hint: The resistors and the capacitors on the boards ⑥ and ⑦ have to be soldered plain onto the boards, so that they don't interfere with the driving unit in the end!

R34, **R36**, **R37** and **R38** have to be placed on board ⑧:

R34 – 2,2 kΩ
code: red-red-red

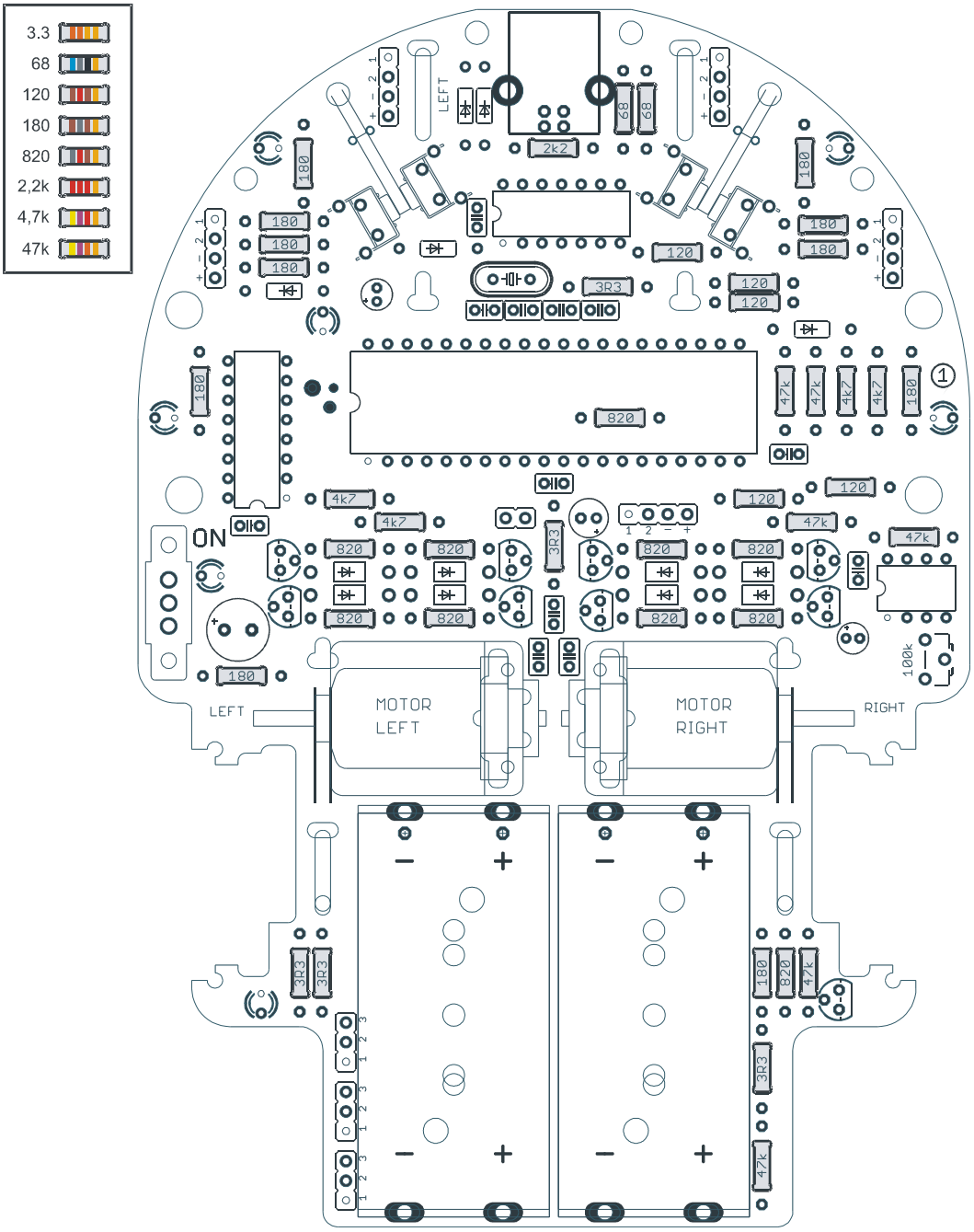
R37 – 2,2 kΩ
code: red-red-red



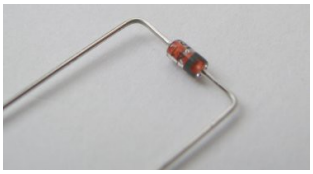
R38 – 2,2 kΩ
code: red-red-red

R36 – 120 Ω
code: brown-red-brown

The following overview diagram simplifies the placement of the resistors to the main circuit board. All resistors are shaded light grey, are thickly bordered and contain their specific value.

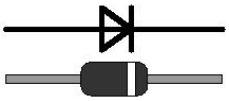


2.3.2 Zener-/Schottky-Diodes



type	*part*
BZX83 V003.6	D9 D10
BAT85	D11 D12 D14

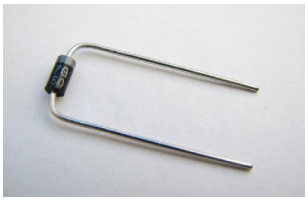
The Zener diodes **D9** and **D10** of type BZX83V003.6 (respectively 55C3V6) and the Schottky diodes **D11**, **D12** and **D14** of type BAT85 must be bend like the resistors before placement. **You have to pay attention to the polarity:** the cathode is indicated by the ring on the diode and must be soldered at the white line, respectively the symbol of the diode, marked on the circuit board.



The figure shows the symbol of the diode and below it shows the diode as electrical part. Before soldering you have to pay attention that the ring on the diode must be soldered at the side of the vertical line of the symbol.

Tip: The Schottky diodes are labeled with *BAT85* in small letters. They are packed as threesome.

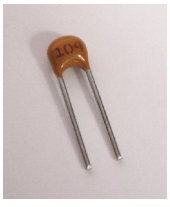
2.3.3 Silizium-Diodes



type	*part*
1N4007	D1 D2 D3 D4 D5 D6 D7 D8

Also the Silizium diodes **D1-D8** of type 1N4007 must be bend like the resistors before placement. **You have to pay attention to the polarity:** The white line on the board print, respectively the printed symbol of the diode, marks the position where the cathode (indicated by the ring on the diode) has to be soldered.

2.3.4 Ceramic multilayer capacitors



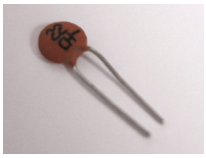
value	*part*
10 nF	C9 C10
100 nF	C4 C6 C7 C8 C14 C15 C16 C22

There are ten ceramic multilayer capacitors to be placed onto the board. The capacitors **C9** and **C10** have a value of 10 nF (imprint: 103). **C9** must be soldered onto the board ⑥. **C10** must be soldered onto the board ⑦.

The other capacitors (**C4**, **C6**, **C7**, **C8**, **C14**, **C15**, **C16** and **C22**) have a value of 100 nF (imprint: 104).
You don't have to pay attention to the polarity.

Info: the imprint 104 means 10*10^4 pF, or generally: the imprint *xyz* means a capacity of *xy**10^*z* pF.

2.3.5 Ceramic plate capacitors



The four ceramic plate capacitors **C1**, **C2**, **C12** and **C13** have a capacity of 22 pF (imprint: 22). You don't have to pay attention to the polarity.

value	*part*
22 pF	C1
	C2
	C12
	C13

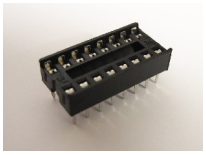
2.3.6 Crystal

The crystal **Q10** has a frequency of 15,000MHz. After positioning the housing should not be in contact with the board (Optimal distance to the board: 1mm). You don't have to pay attention to the polarity.

value	*part*
15 MHz	Q10

Tip: It helps to put a 1mm thick piece of cardboard between plate and crystal before soldering. After the crystal is soldered the cardboard can be carefully removed.

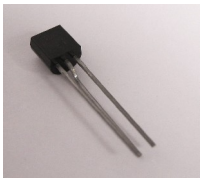
2.3.7 IC-socket



There are four IC-sockets to be soldered onto the board. The 40 pin socket is for the main controller ATmega16, the **14 pin** socket is for the ATtiny44, the **16 pin** socket is for the demultiplexer 74HC139 and the 8 pin one is for the operational amplifier LM358. The **notch** in the socket must point in the same direction as the mark on the board. **The ICs will be inserted later!**

type	*part*
40 pin	IC1
16 pin	IC3
14 pin	IC2
8 pin	IC4

2.3.8 NPN Bipolar-transistors

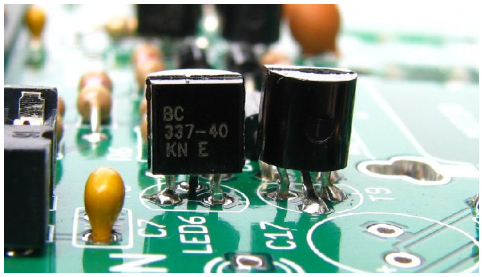


The four NPN bipolar-transistors **T4**, **T5**, **T8** and **T9** are of the type BC337. During placement you have to **pay attention to the polarity!** The **flat side** of the transistor is marked on the circuit board.

type	*part*
BC337	T4
	T5
	T8
	T9

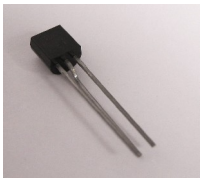
***Hint*:** The transistors are **not mounted flush** on the board, they have to be

mounted with a distance of about 2 mm:



!! Important !! The NIBObee must never be switched on **without inserted IC3** (74HC139), otherwise the **transistors will be destroyed**!

2.3.9 PNP Bipolar-transistors



The five PNP bipolar-transistors **T1, T2**, **T3**, **T6** and **T7** are of the type BC327. During placement you have to **pay attention to the polarity!** The **flat side** of the transistor is marked on the circuit board.

type	*part*
BC327	T1 T2 T3 T6 T7

2.3.10 IR-photo-transistors

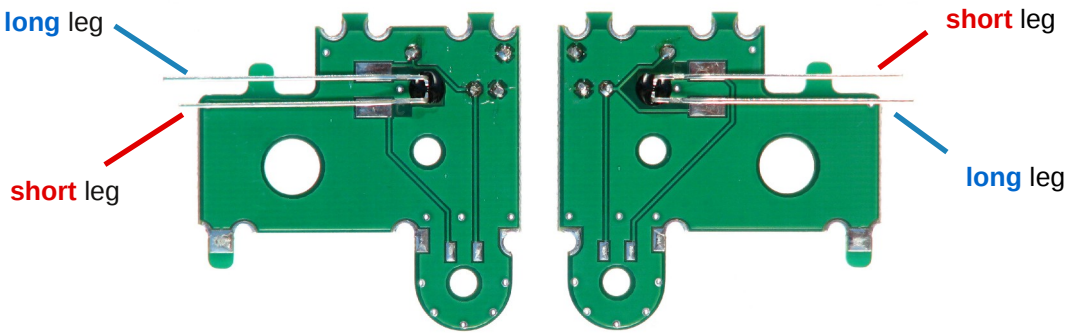
The photo-transistors **PT3-PT5** are for measuring the reflected IR-emission. They are soldered onto the board ⑧.
You have to pay attention to the polarity: the **short leg** must be placed into the **rectangular** soldering pad.

type	*part*
Photo-transis-tor	PT1 PT2 PT3 PT4 PT5

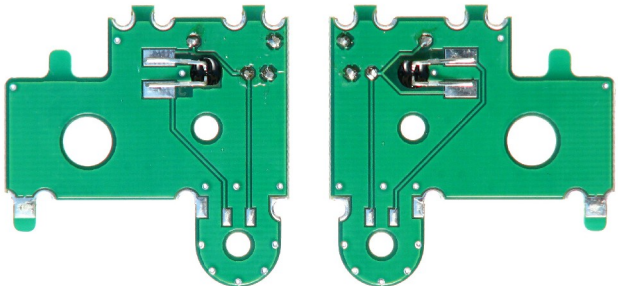
PT1 and **PT2** are for measuring the motor rotation speed. PT1 must be soldered onto board ⑥ and PT2 must be soldered onto board ⑦. Therefore the photo-transistors have to be put through the holes from the **bottom side**, so that the **shorter** leg will be placed near to the mark „**C**“ (cathode of the transistor). Afterwards the legs must be bend over towards

the longish soldering pads on the bottom side of the circuit board:

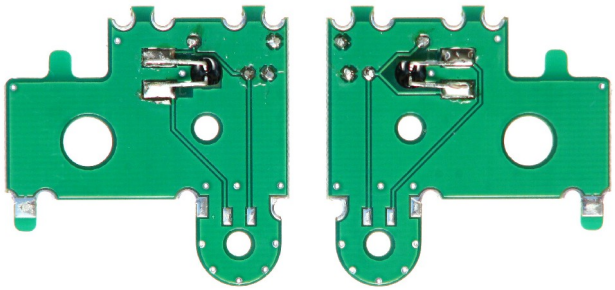
Bottom side of board ⑦: Bottom side of board ⑥:



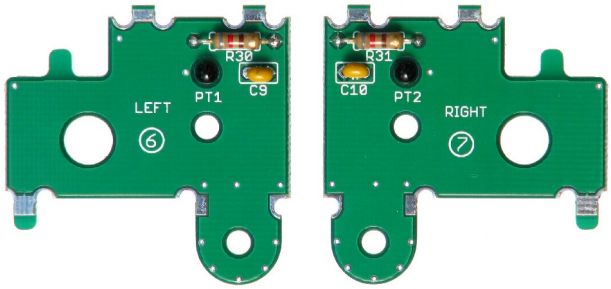
After bending, the legs have to be shortened to the right length:



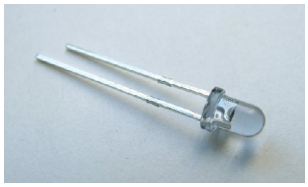
Now the components have to be soldered on the boards:



The top sides of the finished boards should look like this:



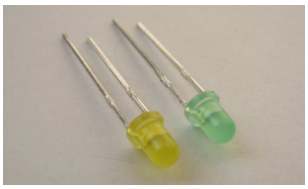
2.3.11 IR-LEDs



type	part
IR-LED	IR1
	IR2
	IR3
	IR4

The IR-LEDs **IR3** and **IR4** have to be soldered onto the board ⑧.
You have to pay attention to the polarity: the **short leg** must be placed into the **rectangular** soldering pad.
IR1 must be soldered onto the **bottom** side of board ②, below the label „IR1“. **IR2** must be soldered onto the **bottom** side of board ③, below the label „IR2“. The **short** leg must be placed into the **rectangular** soldering pad.

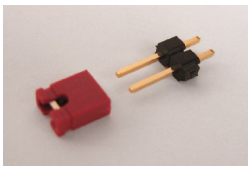
2.3.12 LEDs



type	part
LED yellow	LED0
LED yellow	LED3
LED red	LED1
LED red	LED2
LED green	LED4
LED green	LED5
LED green	LED6

The LEDs **LED0 - LED6** have got two legs, a short one (cathode) and a long one (anode). **You have to pay attention to the polarity**: The leg with the **short length** must be placed into the **rectangular** soldering pad.

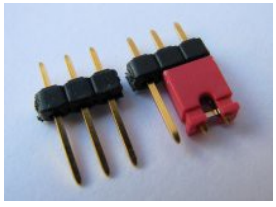
2.3.13 Jumper 2-pole



type	part
Jumper	JP7

The best way to place the jumper **JP7** onto the board is to solder them complete (connector and bridge). You should pay attention to a short soldering time so that the plastics do not melt.
After soldering the bridge must be **taken off** to **deactivate** the **motor function**!

2.3.14 Jumper 3-pole



type	part
Jumper	JP1
	JP2
	JP3

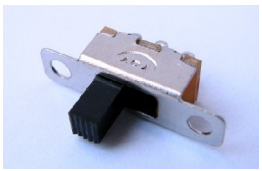
The 3-pole jumpers **JP1**, **JP2** and **JP3** have to be soldered analog to the 2-pole ones.
After soldering the jumpers must be connected respectively at pin 1 and pin 2.

2.3.15 Button

The placement of the buttons **SW1 - SW4** is protected against polarity reversal. You have to place it onto the board with soft pressure till it snaps in. (see the picture of the finished main circuit board on page 15).

type	*part*
Button	SW1 SW2 SW3 SW4

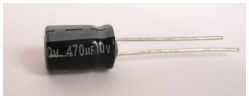
2.3.16 Switch



The toggle switch **S1** may be soldered onto the board in both possible orientations, the functionality stays the same.

type	*part*
Toggle switch	S1

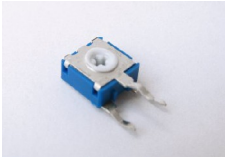
2.3.17 Electrolytic capacitors



During placement of the 470µF electrolytic capacitor (**C17**), the 100µF electrolytic capacitor (**C3**) and the two 4,7µF electrolytic capacitors (**C5** and **C11**) onto the board **you have to pay attention to the polarity**: The **positive** connections are marked with “+” sign on the board. The positive pin of the electrolytic capacitor is the **long leg** and the negative one is the **short leg**. The negative connections are implemented by thermal vias. You can find a “-” symbol on the housing of the capacitor.

value	*part*
470 µF	C17
100 µF	C3
4,7 µF	C5 C11

2.3.18 Potentiometer



Placing the potentiometer **R29** you have to **pay attention to the polarity**: there is only one possible orientation. The potentiometer is to adjust the sensitivity of the odometry sensors.

type	*part*
Potentio-meter	R29

2.3.19 USB socket

During installation of the USB socket **X6** you should pay attention to the fact that the smaller pins are not bent. The part is polarity safe. The USB socket is soldered at large at **6** soldering pads.

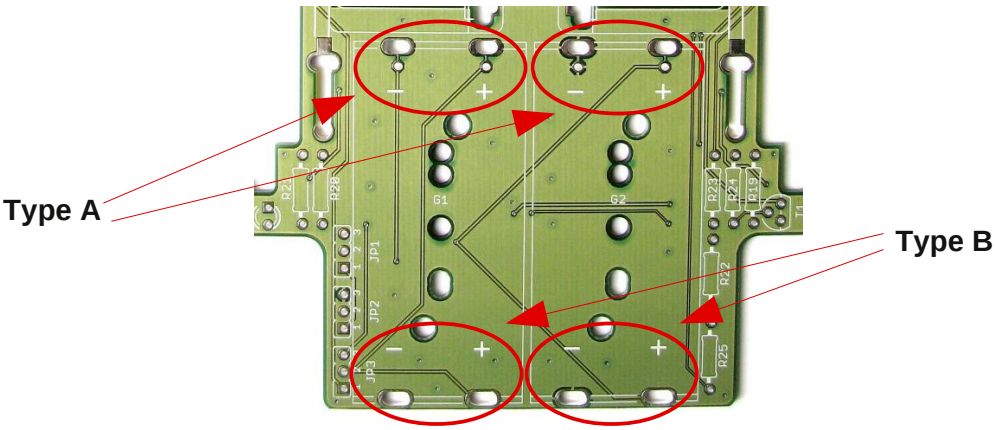
type	*part*
USB socket	X6

2.3.20 Battery packs

Now the two battery packs will be attached to the main circuit board. First of all they must be fixed each with one small cable strap.

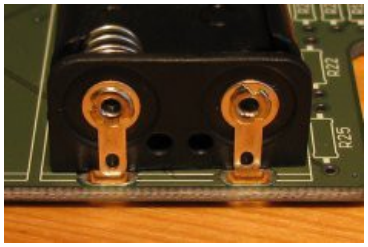
Depending upon the supplier the battery packs are different and must be **assembled differently**:

Before assembling the packs you have to pay attention to the **"+/-" labels** on the circuit board and to the "+/-" labels of the respective battery pack (the important side is the **side with the soldering contacts**: the outside contact plates).



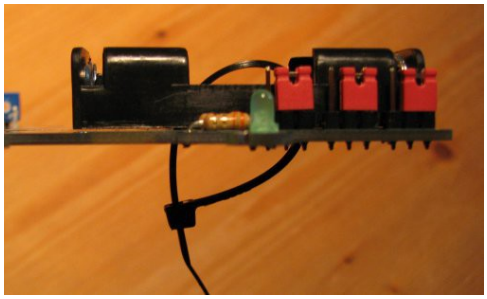
The "+/-" labels of the board and of the pack **only** has to suit at the **side with the soldering contacts**.

According to this the battery packs of the **type B** are put on the board with the soldering contacts (outside contact plates) pointing to the **edge of the board**:

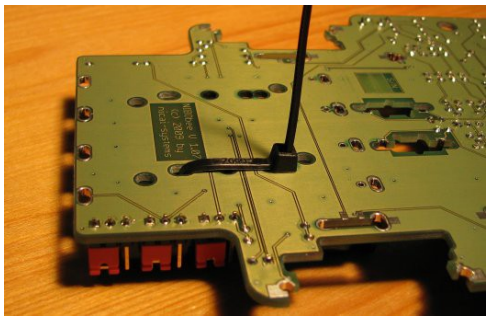


The soldering contacts of the battery packs of **type A** must point to the **middle** of the main **circuit board**.

Before soldering the battery packs must be fixed with the small cable straps at the circuit board. The cable strap has to put through the two holes of the board:



Then the cable strap is to be fastened:

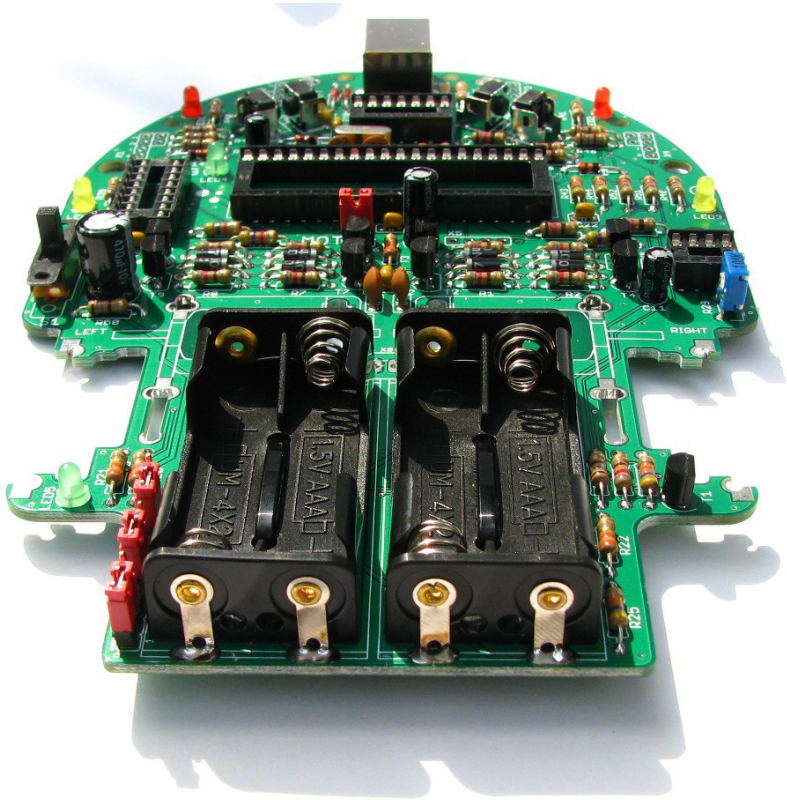


The cable strap has to be cut shortly with an electronic cutting pliers.

The other battery pack has to be fixed the same way.

Finally the packs must be soldered (each at two contacts) to the circuit board.

The following photo shows the result with battery packs of the **type B**:



2.4 Visual inspection of the circuit board

Before the board is attached for the first time to a power supply, all electrical components must be checked for the correct assembly. Therefore you have to check all values.

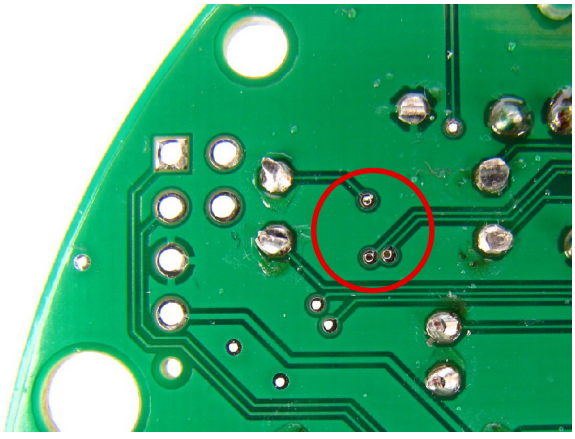
Afterwards you have to pay attention to the polarity and the correct installation respectively.

Finally check the board for short circuits and make sure that neither on the top side nor on the bottom side of the board remains any solder or wire.

!! Important !!

The NIBObee must never be switched on **without inserted IC3** (74HC139), otherwise the **transistors** for the motor-control **will be destroyed**!

Information:
Particularly the via's (v*ertical interconnect access*), the picture shows three of them for example, should not be connected together with solder spots!

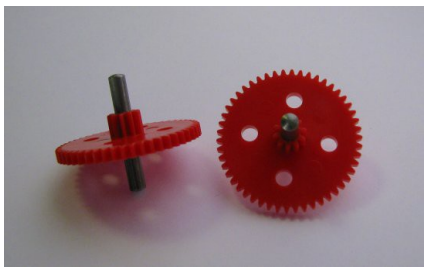


2.5 Assembling of the modules

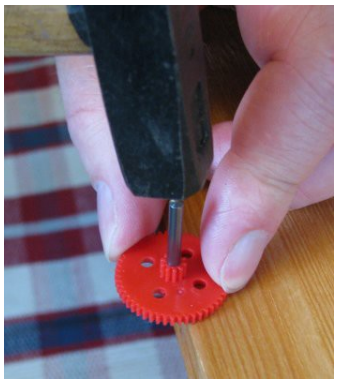
2.5.1 Preparatory operations

The two **red** double gearwheels must be pressed onto the two **short** steel axes (3x20 mm). Therefore you have to press the axis with the help of a small hammer into the side of the gearwheel with the **smaller** gear:

Then you have to press the axis **carefully** with the small hammer through the gear. Afterwards the gearwheel should be in the middle of the axis:



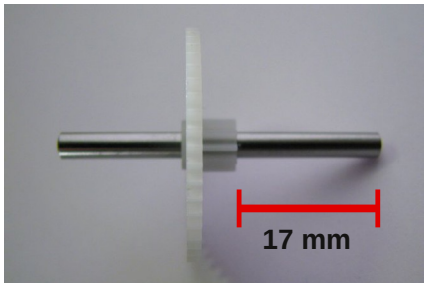
Tip: This works easier e.g. with the help of a table edge:



Now the both **white** double gearwheels have to be pressed onto the two **long** steel axes (3x37 mm). Therefore you have to press the axis with the help of a small hammer into the side of the gearwheel with the **smaller** gear.

Then you have to press the axis **carefully** with the small hammer through the gear.

The distance from the smaller gear to the end of the axis should be 17 mm:



With the help of the stencil inside the package, you can easily proof the distances:

2.5.2 Assembling of the engine section / transmission unit

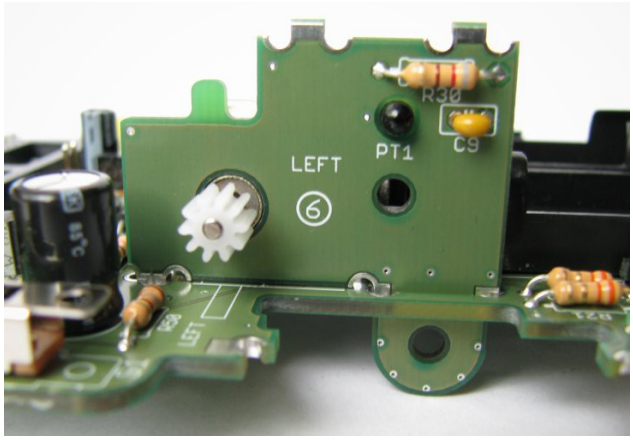
Now the two **motors** and the circuit boards ⑥ and ⑦ have to be fixed to the main circuit board.

First of all put the motor axis through the boards as shown below. The soldering contacts of the motors must point downward.

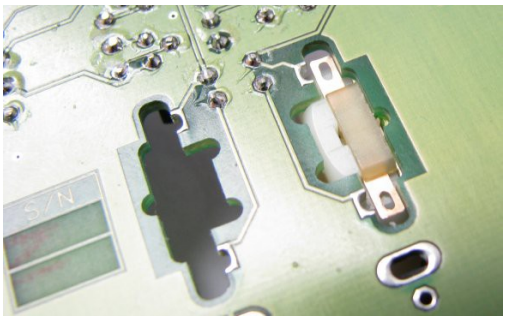
In case of one motor does not fit correctly into the hole, the hole can be carefully widened with a 6mm drill bit.

We start with the **left side** (to driving direction):

Put the board ⑥ through the fitting slots of the main circuit board so that the motor will be planar onto the “MOTOR LEFT” field.



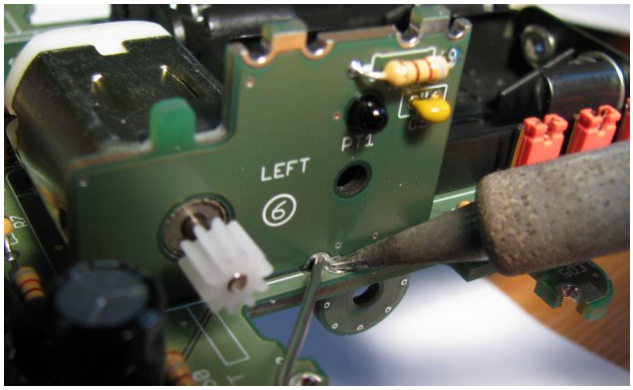
The soldering contacts of the motor have to fit exactly into the recess of the main circuit board:



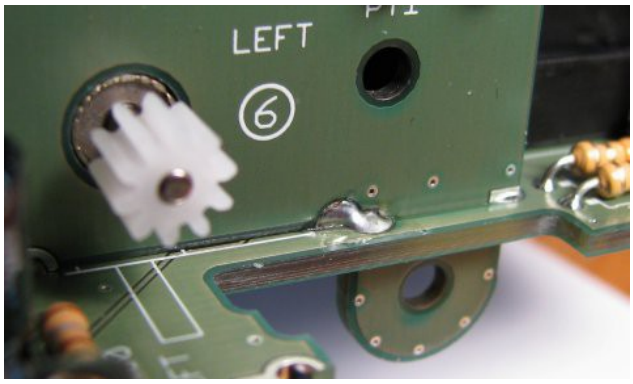
As soon as the motor fits correctly the board ⑥ is soldered to the main circuit board beginning with the middle soldering contact (see pictures).

The mechanical soldering joints work with the help of capillary action: you tin the respective point **sparse** with tin-solder and heat the point afterwards about **10 seconds** with the soldering iron. Because of the capillary action the tin-solder will be pulled inwards and the boards will be fixed together.

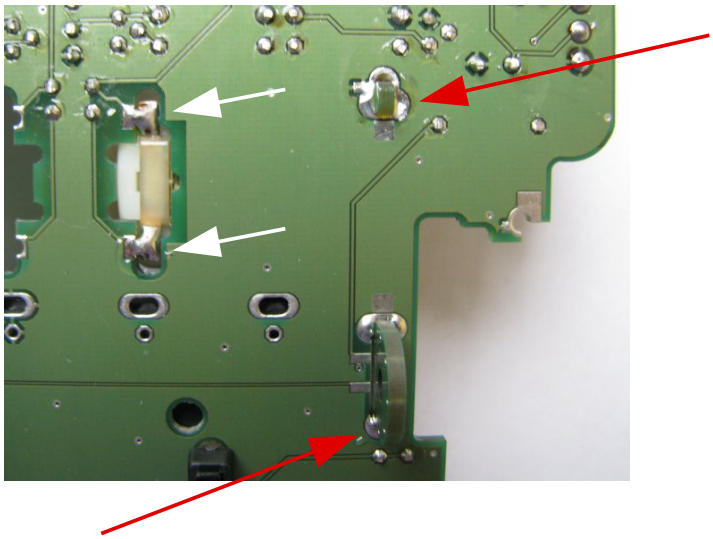
Tip: While soldering the transmission unit you have to pay attention that the several circuit boards are **orthogonal adjusted**. It is not easy to disassemble the unit afterwards.



The result should look like this:

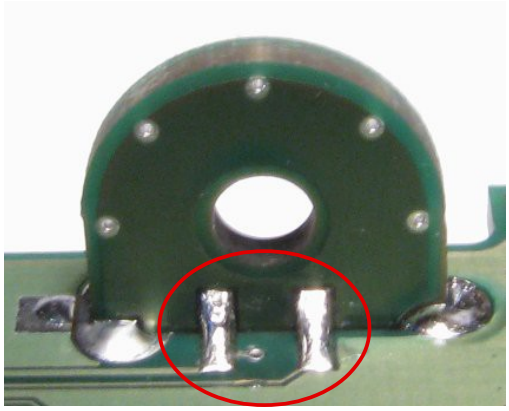


Now the other mechanical connections (red arrows) must be soldered from the **bottom side** of the main circuit board. **Don't** use **too much** tin-solder!



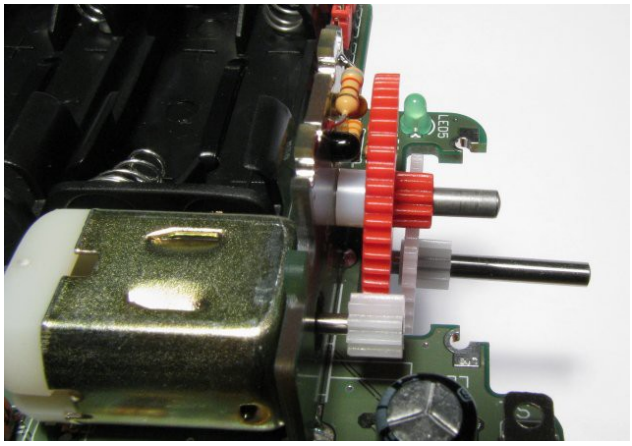
Then the motor contacts have to be soldered to the board (white arrows).

Now the two electrical contacts between the main circuit board and the board ⑥ have to be soldered:

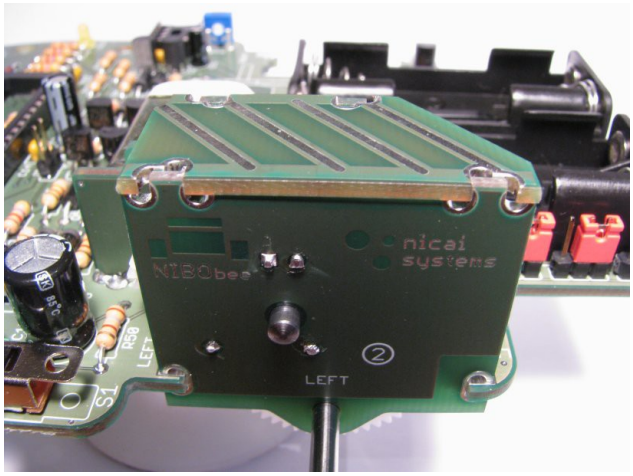


Now the **left side** of the **transmission unit** has to be assembled:

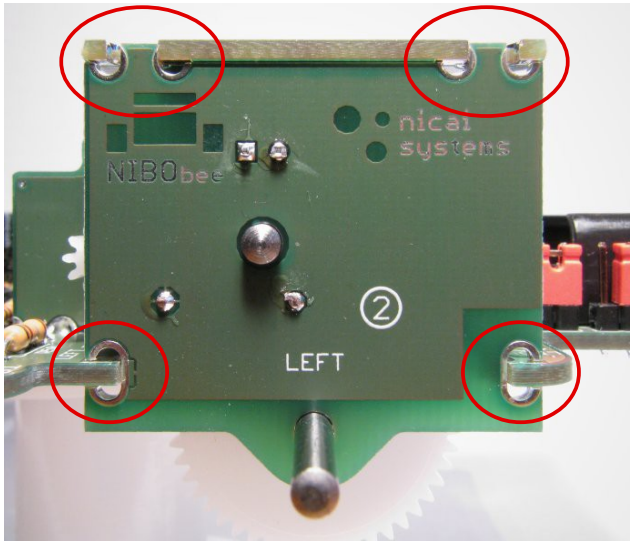
Put the white plastic distance ring to the short axis with the red gearwheel (to the opposite side of the little gearwheel). Then the axis must be put (with the distance ring ahead) into the borehole below the photo-transistor PT1. Afterwards you have to put the long axis with the white gearwheel (the little gearwheel outwards) into the lower borehole:



The transmission is fixed by the board ② (the electronic parts of the board ② point inwards). Finally the covering plate is pressed onto the boards ⑥ and ② with careful pressure (see image).

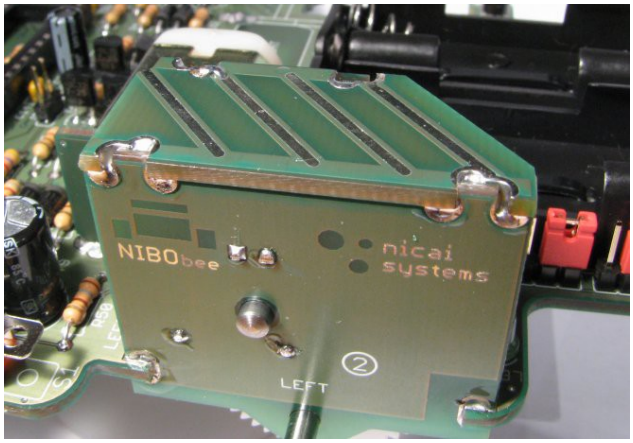


From the outside the boards have to be soldered at four points:

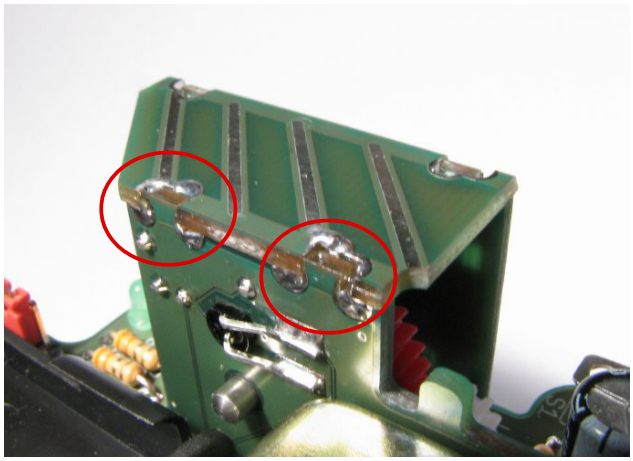


Tin the respective points **sparse** with tin-solder and heat the points afterwards about **10 seconds** with the soldering iron.

The result should look like this:



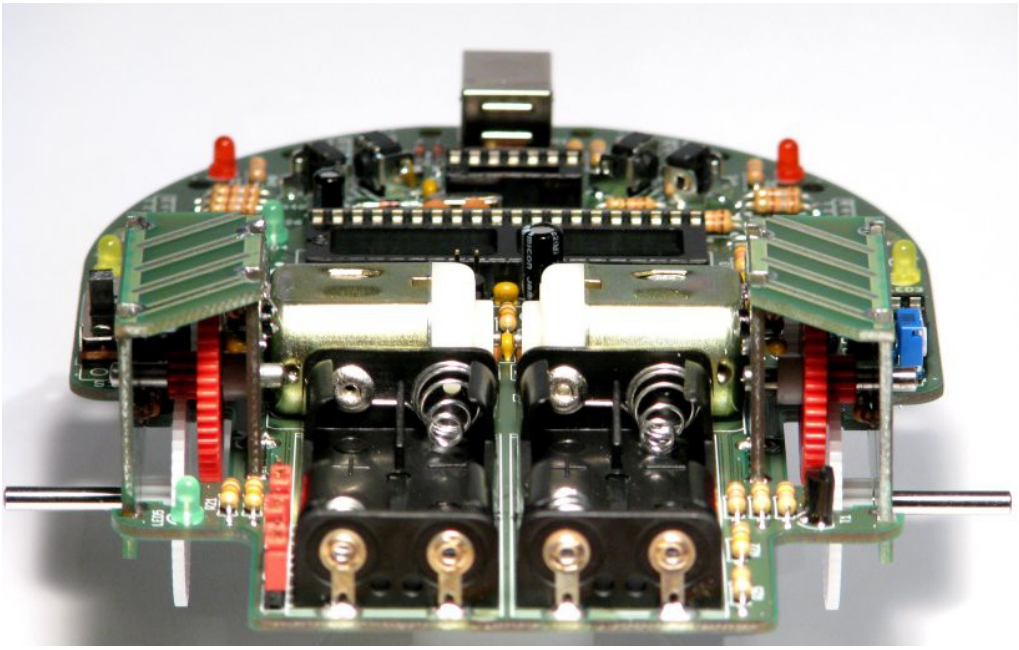
At the internal side you have to solder two points:



Now the left side of the transmission unit is completed.

The **right side of the unit** must be assembled according to the left side.

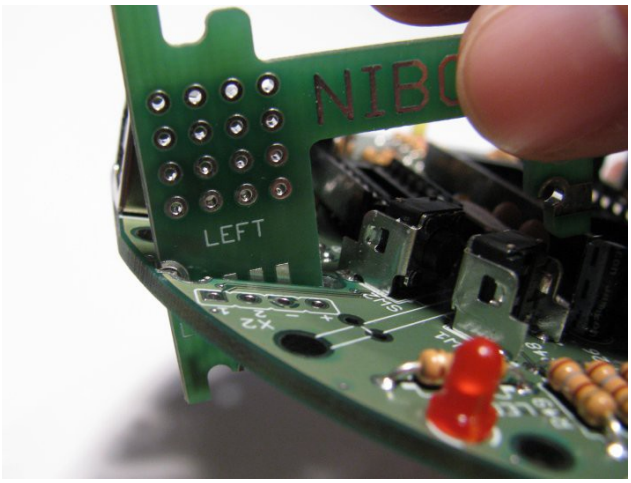
Tip: You can reduce the operating noise by careful greasing the transmission (see chapter 3.4 on page 48).



2.5.3 Assembling of the sensor boards

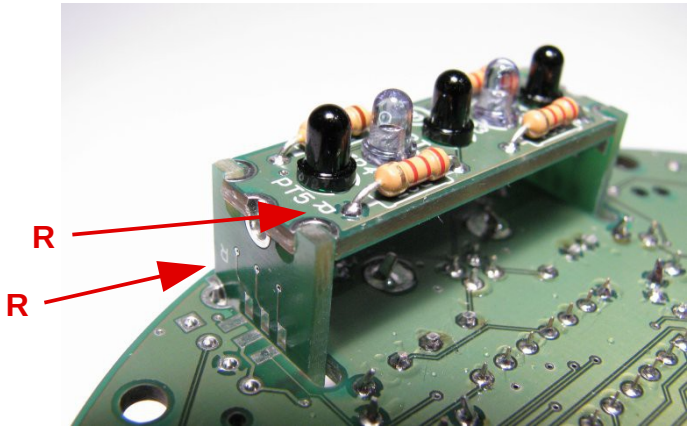
The sensor circuit boards ④ and ⑤ must be put into the main circuit board. For easy assemblation you take the board a little bit sloped and put the front side first through the main board. **The boards are not soldered yet!**

The board ④ is labeled with “LEFT” and must be put into the slot LEFT. The board ⑤ has to be put into the right side.

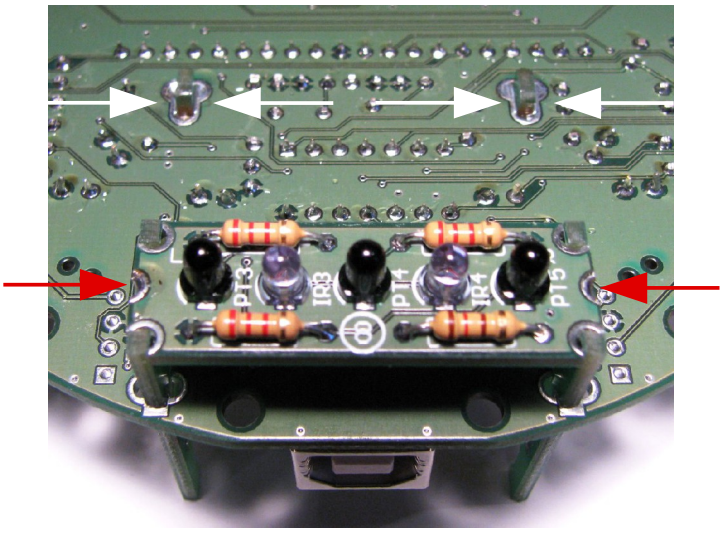


Now the board ⑧ must be pressed on from the bottom side. Therefore you hold the boards ④ and ⑤, turn the main circuit board and press the board ⑧ on so that you can see the electronic parts of the board ⑧.

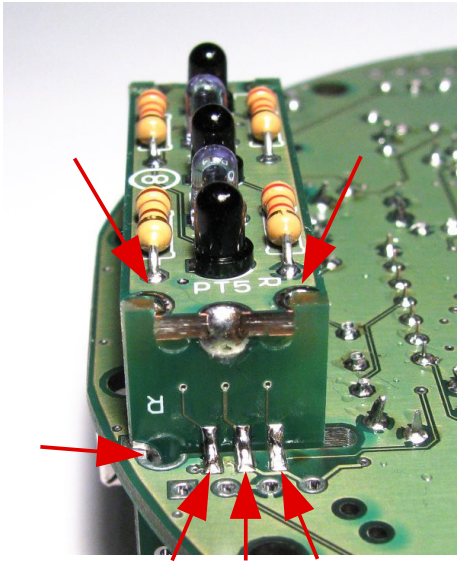
Pay attention to the orientation!
The circuit boards are labeled with **R** and **L**:



If everything is **well aligned**, the boards are now fixed by soldering. First of all just the both **middle placed** soldering points of the board ⑧ are soldered (red arrows). Then the boards ④ and ⑤ are soldered with the main circuit board (white arrows).



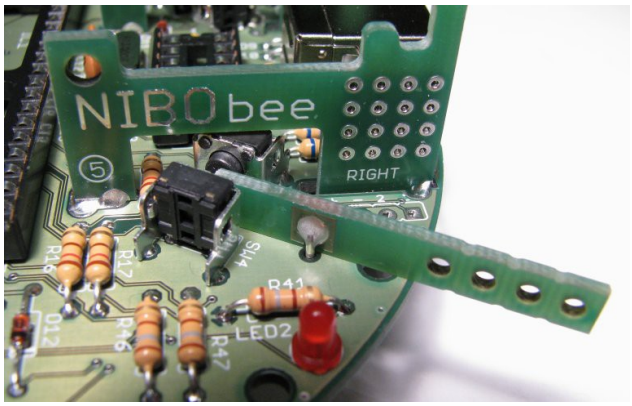
Now the mechanical assembly should be fixed. Finally the remaining contacts have to be soldered on **both sides** (all in all **12** contacts):



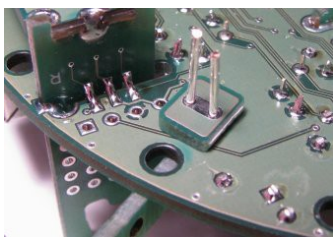
2.5.4 Assembling of the feelers

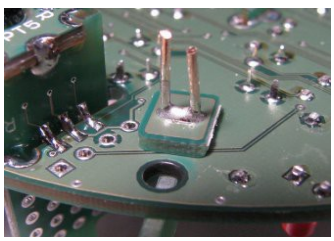
Now the both oblong supporting circuit boards have to be prepared. Cut the silver wire into two similar halves and put each one through the boards as shown below. Then the wire has to be bent over at both sides:

The wire must be soldered to the contacts of the board on both sides. Then it has to be put through the boreholes of the main circuit board:



At the bottom side the wire must be fixed with the small square supporting circuit boards. First put the wire through the boards and then fix it by soldering:

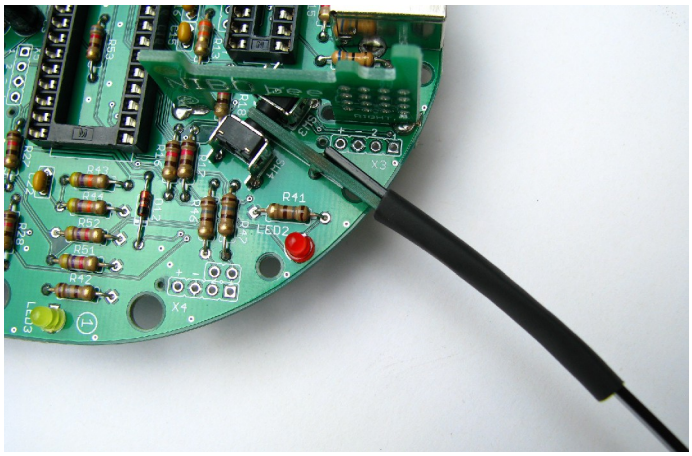




Finally the spare wire has to be cut.

Now the two long cable straps have to be shortened to 10 cm each (cut off at the correct side!) and they must be slightly formed as shown in the pictures. The enclosed heat-shrinkable tubing must be divided into two similar halves:

The pieces of heat-shrinkable tubing must be pushed over the oblong supporting circuit boards and then they are fixed by shrinking with the soldering iron. The **left** feeler should be left-facing and the **right** one should be right-facing.

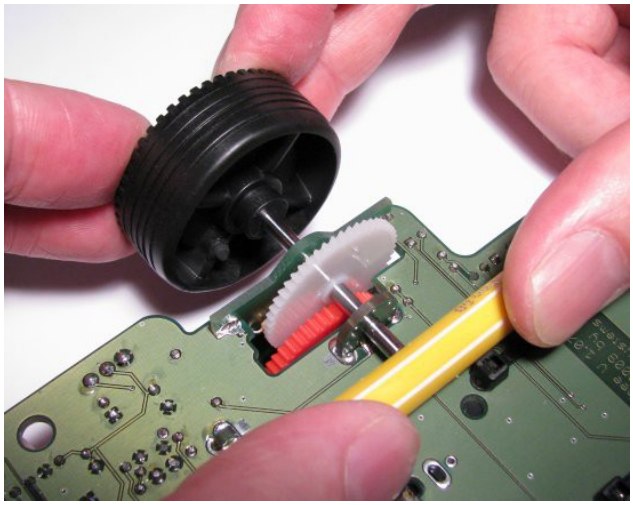


While shrinking the soldering iron should have at least 3 mm distance to the heat-shrinkable tubing.

The result should look like this:

2.5.5 Attaching the wheels

The both wheels have to be put onto the drive shafts so that they are performing well. To avoid damaging the transmission you shall press (e.g. with a crayon) against the opposite side of the axis:



2.5.6 Insertion of the ICs

!! Important !!

The NIBObee must never be switched on **without inserted IC3** (74HC139), otherwise the **transistors** for the motor-control **will be destroyed**!

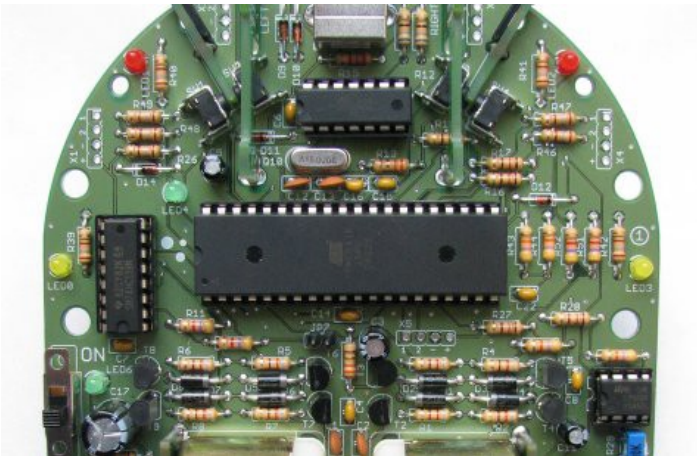
The four ICs must be put with careful pressure into the sockets. **The notch on the IC has to point in the same direction as the marks on the board and the socket!**

IC1: ATmega16

IC2: ATtiny44

IC3: 74HC139

IC4: LM358



ICs are sensitive to electrostatic damage!

Electrostatic sensitivity means that these electronic parts can be destroyed only by being touched by an electrically charged person. A person can get electrically charged e.g. by wearing clothes of fleece material, or by walking on a carpet. By touching grounded metal the person can easily get discharged.

3 Preparation for operation

After finishing the preparations the NIBObee can now be activated step by step for the first time.

!! Important !!

The NIBObee must never be switched on **without inserted IC3** (74HC139), otherwise the **transistors** for the motor-control **will be destroyed**!

1. **Switch-off** the NIBObee
2. **Take off** the jumper **JP7**
3. Insert 4 x Micro AAA 1,2V rechargeable batteries

Now the NIBObee has to be **switched on**, then the green **LED6** near to the switch **must** flash.

It is possible that the yellow and the red LEDs are now also glowing. We will use them for the further tests:

3.1 Floor sensors test

Now the NIBObee is placed on a **white** sheet. Then both red LEDs (**LED1** and **LED2**) should flash. Holding the NIBObee in the **air**, these two LEDs should **not** glow.

3.2 Testing and adjustment of the odometry sensors

In this chapter we want to test the functionality of the odometry sensors. Further it should be tested whether the photo-transistors are able to detect the turns of the wheels. The sensitivity must be adjusted with the potentiometer R29. This can be done with the help of a small recessed head screwdriver. The sensitivity is correctly adjusted if turning the **right** wheel causes the **yellow LED3** to flash and turning the **left** wheel causes the **yellow LED0** to flash.

3.3 Testing of the feelers

Press the **left** feeler **forward** (in driving direction) – **LED1** must glow, LED0, LED2 and LED3 must be dark.

Press the **left** feeler **backward** – **LED0** must glow, LED1, LED2 and LED3 must be dark.

Press the **right** feeler **forward** – **LED2** must glow, LED0, LED1 and LED3 must be dark.

Press the **right** feeler **backward** – **LED3** must glow, LED0, LED1 and LED2 must be dark.

3.4 Motor control test

Now the jumper **JP7** has to be **placed**.

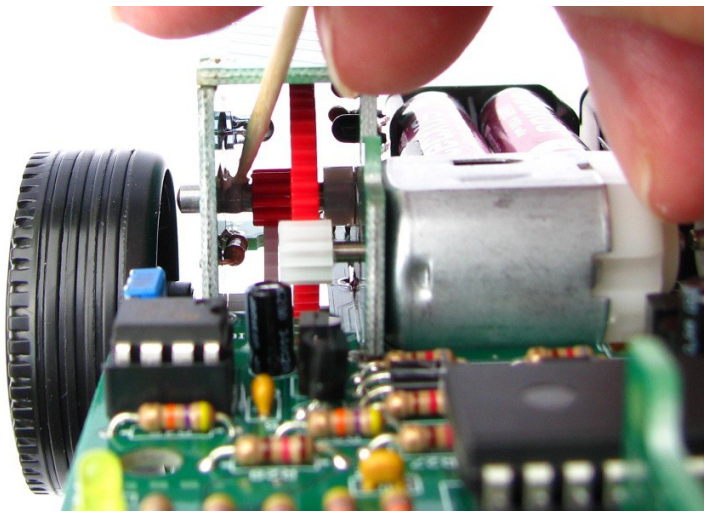
Caution - the NIBObee is able to drive with the jumper JP7 in place!

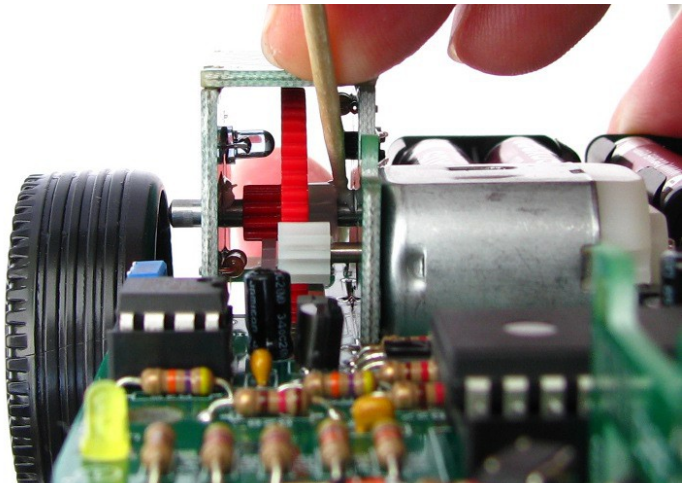
While pressing the left feeler forward (in driving direction) the left wheel should turn forward. While pressing the left feeler backward the wheel should turn backward.

The same applies to the right side.

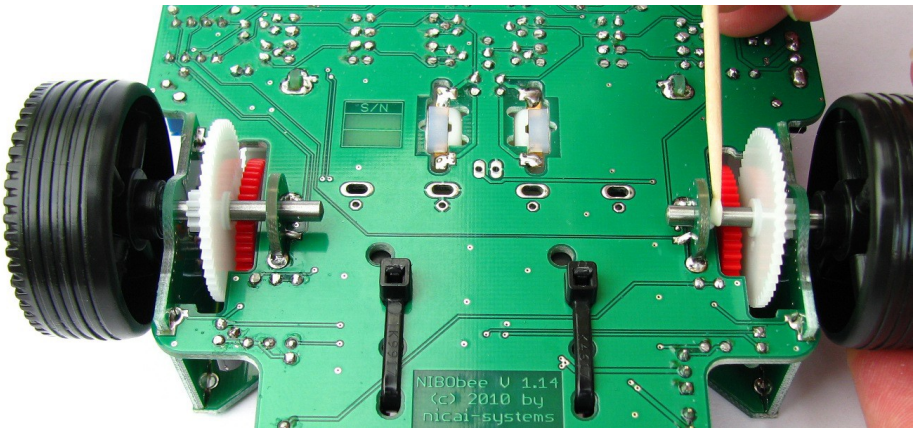
Hint: You can reduce the operating noise by greasing the transmission for example with a greasy ointment and a toothpick.

The axis of the red wheels can be greased at both sides:



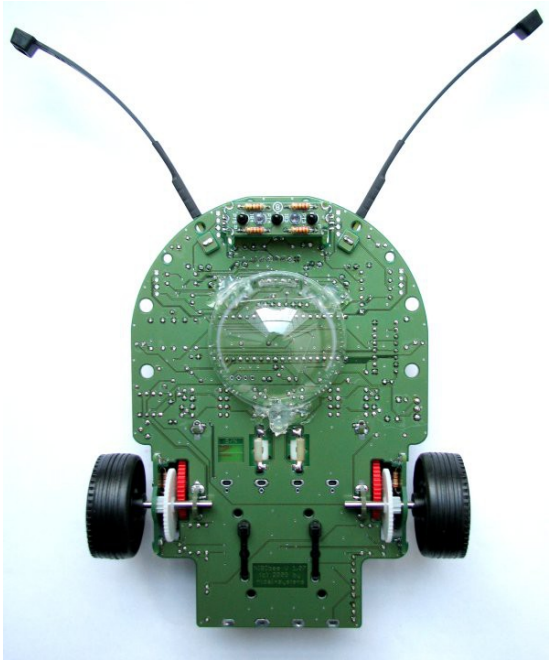


Additional the axis of the white wheels can be greased:

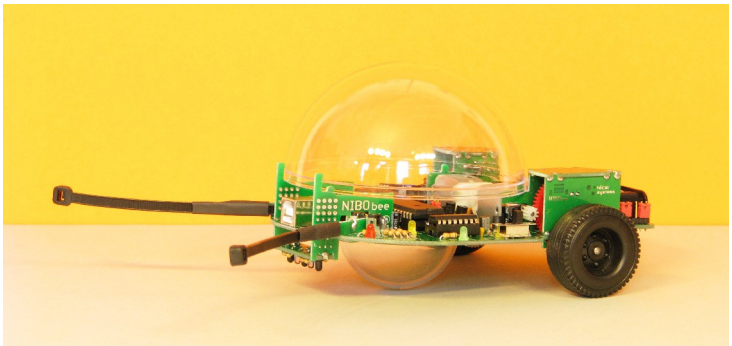


3.5 Fixing the half sphere

The smaller half sphere must be fixed (e.g. with glue or hot glue) to the bottom side of the main circuit board:



Finally the big half sphere must be put onto the NIBObee – now the robot is ready for takeoff!



3.6 Installation of the NiboRoboLib

Now the NiboRoboLib has to be installed. The **latest** version and an **installation manual** (.pdf) are to find here:

http://www.roboter.cc/niboRoboLib

All files are also available on the enclosed CD.

The **NiboRoboLib** contains:

- All necessary **drivers** for NIBO2
- All necessary **drivers** for NIBObee
- **RoboDude** (transmission programm for `.hex`- and `.xhex`-files)
- **C-library** and **test programms** for NIBO2
- **C-library** and **test programms** for NIBObee
- **Calibrating programms** for the sensors
- **ARDUINO**-library for NIBO2
- **ARDUINO**-library for NIBObee

During installation it is possible to choose the desired packages.

After the installation the NIBObee is ready to use!

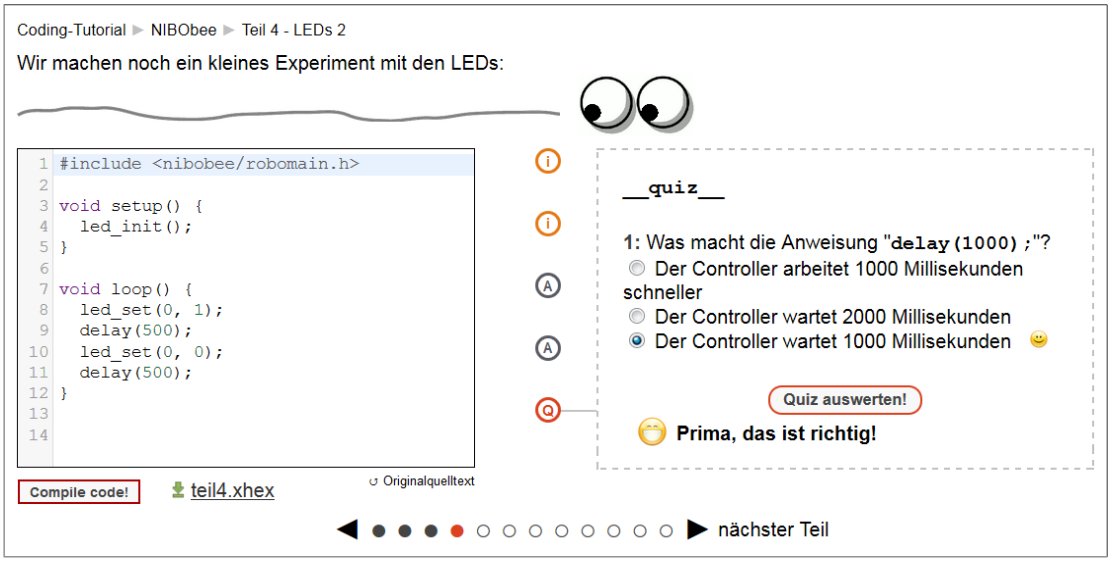
3.7 Programming

There are different possibilities / programming environments for NIBObee:

3.7.1 NIBObee Coding Tutorial (german)

Possibility 1:

You can easily start programming with the interactive *NIBObee Coding Tutorial*. It guides you through all functions of the robot and simultaneously you learn programming:



http://www.roboter.cc/codingTutorial/nibobee

3.7.2 Online-Compiler – Roboter.CC

Possibility 2:

Additionally you have the possibility to program the NIBObee online at the Roboter.CC platform:

Roboter.CC is an open-source platform. You can create own robotic projects, manage and compile them at the platform.

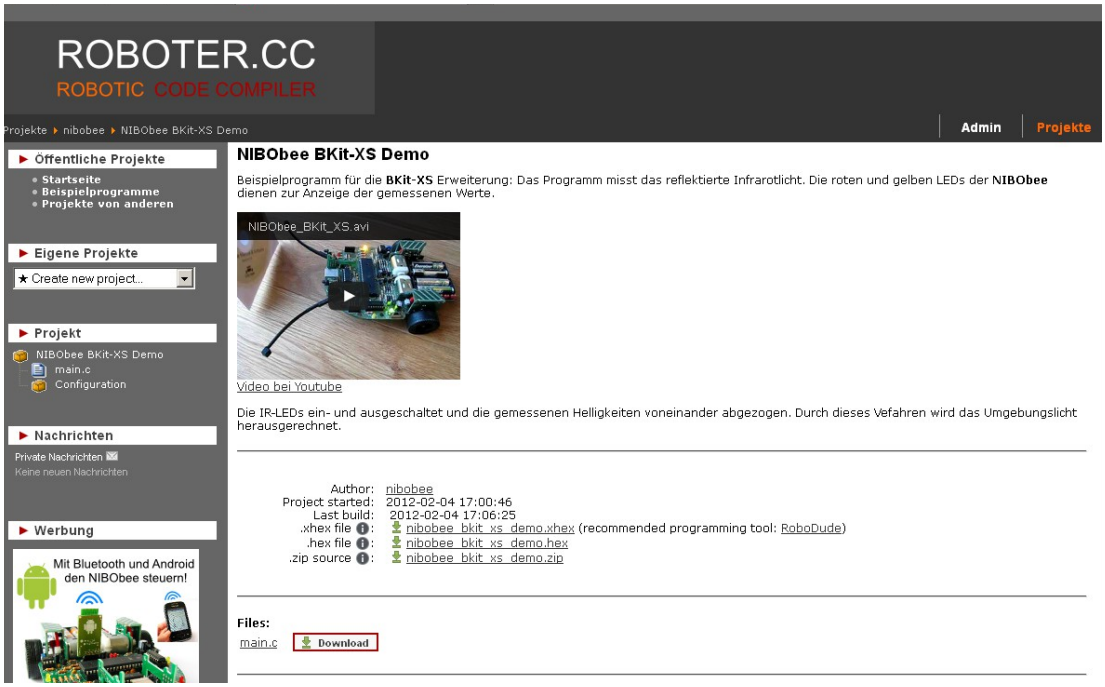
You can also easily test existing program examples. All projects are compiled online at **Roboter.CC** – it is not necessary to install a local programming environment – the library links are working automatically.

Easily:

1. Choose robot type and programming language
2. Write the program code
3. Transfer the resulting XHEX-file with *RoboDude* to the robot

Or:

1. Choose an already existing XHEX-file
2. Transfer the XHEX-file with *RoboDude* to the robot



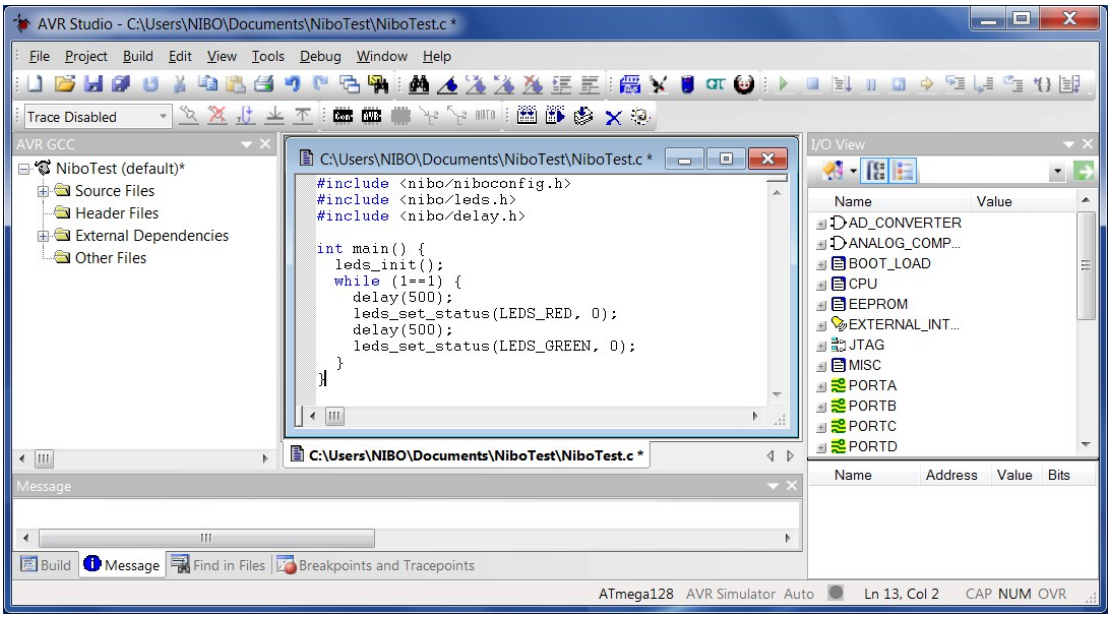
There is also a user forum (german) with lots of additional information, ideas, questions and answers!

http://www.roboter.cc

3.7.3 NIBObee C-programming tutorial (german)

Possibility 3:

You can also program the NIBObee with the Atmel **AVR-Studio** programming environment:



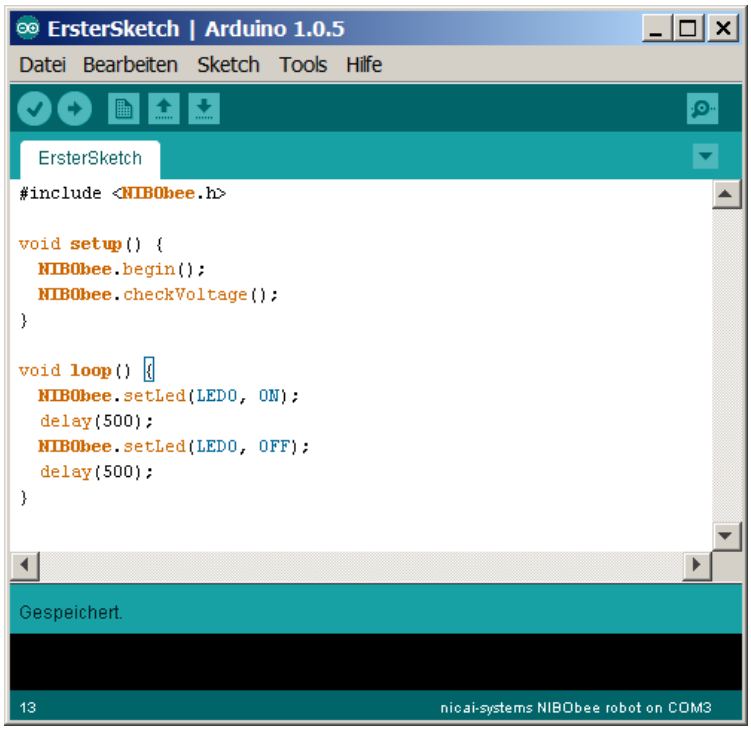
A german **C programming tutorial** inclusive **installation manual** with lots of examples and explanations is to find here:

http://www.nicai-systems.com/nibobee.html?lang=de#downloads-links

3.7.4 NIBObee ARDUINO Tutorial (german)

Possibility 4:

It is also possible to program the NIBObee in **ARDUINO**:



A german **programming tutorial** inclusive **installation manual** with lots of examples and explanations is to find here:

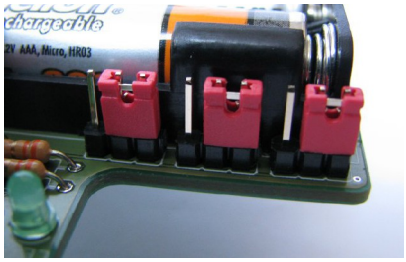
http://www.nicai-systems.com/nibobee.html?lang=de#downloads-links

3.8 Charging the rechargeable batteries by USB

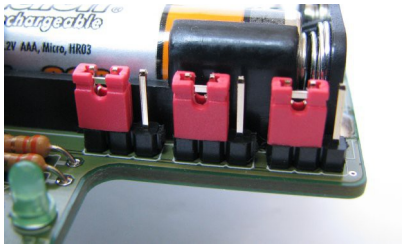
The rechargeable batteries of the NIBObee can be charged as follows:

1. The robot is **switched off** and
2. It is **connected** over USB with the **computer** and
3. The position of the jumpers **JP1**, **JP2** and **JP3** is changed into „the **front position**” (see photos):

Normal operation:



Charging mode:



The **green LED5** (shown on the photos) indicates the **state of charge**:

LED5	*meaning*
off	no charging
on, with quick interrupts	charging
flashes every 2 seconds	finished charging
flashes 2 times a second	error
½ second on ½ second off	no rechargeable batteries / jumper position error

The charging mode terminates automatically after 7 hours.

3.9 Additional information

The *NIBO-Wiki* provides additional information like **FAQ's**, service links for replacement parts, technical details and much more:

http://www.nibo-roboter.de

4 Appendix

4.1 Resistor colour codes

The values of the resistors are indicated by a four band colour code:

colour	band 1	band 2	band 3 (factor)	band 4 (tolerance)
silver	—	—	$1 \cdot 10^{-2}$ = 10 mΩ	±10 %
gold	—	—	$1 \cdot 10^{-1}$ = 100 mΩ	±5 %
black	—	0	$1 \cdot 10^{0}$ = 1 Ω	—
brown	1	1	$1 \cdot 10^{1}$ = 10 Ω	±1 %
red	2	2	$1 \cdot 10^{2}$ = 100 Ω	±2 %
orange	3	3	$1 \cdot 10^{3}$ = 1 kΩ	—
yellow	4	4	$1 \cdot 10^{4}$ = 10 kΩ	—
green	5	5	$1 \cdot 10^{5}$ = 100 kΩ	±0,5 %
blue	6	6	$1 \cdot 10^{6}$ = 1 MΩ	±0,25 %
violet	7	7	$1 \cdot 10^{7}$ = 10 MΩ	±0,1 %
grey	8	8	$1 \cdot 10^{8}$ = 100 MΩ	—
white	9	9	$1 \cdot 10^{9}$ = 1 GΩ	—

4.2 THT parts list

Name	Type	Value	Package
C1, C2, C12, C13	ceramic plate capacitor	22pF	C-EU025-025X050
C17	electrolytic capacitor	470µF	CPOL-EUE3.5-8
C3	electrolytic capacitor	100µF	CPOL-EUE2-5
C4, C6, C7, C8, C14, C15, C16, C22	ceramic multilayer capacitor	100nF	C-EU025-025X050
C5, C11	electrolytic capacitor	4µ7	CPOL-EUE1.8-4
C9, C10	ceramic multilayer capacitor	10nF	C-EU025-025X050
D1, D2, D3, D4, D5, D6, D7, D8	diode	SB140	
D11, D12, D14	Schottky diode	BAT85	
D9, D10	Zener diode	BZX83V003.6	BZX55
G1, G2	battery pack		
IC1	microcontroller	ATMEGA16-P	DIL-64
IC2	microcontroller	ATTINY44-P	DIL-14
IC3	logic IC	74HC139N	DIL-16
IC4	operational amplifier	LM358N	DIL-8
IR1, IR2, IR3, IR4	IR-LED		LED3MM
JP1, JP2, JP3	jumper	3-pol	JP2E
JP7	jumper	2-pol	JP1Q
LED0, LED3	LED	yellow	LED3MM
LED1, LED2	LED	red	LED3MM
LED4, LED5, LED6	LED	green	LED3MM
PT1, PT2, PT3, PT4, PT5	IR-photo-transistor		LED3MM
Q10	crystal	15MHz	CRYSTALHC49S
R1, R2, R3, R4, R5, R6, R7, R8, R24, R30, R31, R53	resistor	820	R-EU_0207/10
R10, R11, R51, R52	resistor	4k7	R-EU_0207/10
R12, R14	resistor	68	R-EU_0207/10
R15, R34, R37, R38	resistor	2k2	R-EU_0207/10
R16, R17, R18, R27, R28, R36	resistor	120	R-EU_0207/10

Name	Type	Value	Package
R19, R25, R35, R43, R44, R45	resistor	47k	R-EU_0207/10
R23, R26, R32, R33, R39, R40, R41, R42, R46, R47, R48, R49, R50	resistor	180	R-EU_0207/10
R29	resistor	100k	TRIM_EU-CA6H
R9, R13, R20, R21, R22	resistor	3R3	R-EU_0207/10
S1	switch		
SW1, SW2, SW3, SW4	button		
T1, T2, T3, T6, T7	PNP transistor	BC327-40	TO92
T4, T5, T8, T9	NPN transistor	BC337-40	TO92
X6	USB-B socket		

5 Links

In this subsection you can find a selection of links to web pages with related topics.

Development environments:

Atmel: http://www.atmel.com
Web page of the microcontroller manufacturer. There are data sheets, application notes and the development environment AVRStudio.

WinAVR: http://winavr.sourceforge.net/
AVR-GCC compiler for Windows with many add ons, especially for AVRStudio.

AVRDude: http://savannah.nongnu.org/projects/avrdude/
free programmer software (suits for the NIBObee).

Roboter.CC: http://www.roboter.cc
Online code compiler & robotic online community, especially for robotic projects with lots of examples and user forum.

Further informations:

- **Nibo mainpage**: http://nibo.nicai-systems.de
  NIBO manufacturers web page. Provides technical information, the construction manual and additional links.
- **Nibo Wiki**: http://www.nibo-roboter.de
  provides all information about the NIBObee and the Nibo2.
- **Mikrocontroller**: http://www.mikrocontroller.net
  information about microcontroller and their coding.
- **AVRFreaks**: http://www.avrfreaks.net
  information about the AVR.