PHABLABS 4.0

Photonics Workshop

Heliostat

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PROPOERTIES OF THIS WORKSHOP

PHOTONICS WORKSHOP HELIOSTAT (FOR INSTRUCTORS)

SUMMARY

Wouldn't it be cool to charge your cell phone with the power of the sun instead of simply plugging it into a socket? In this workshop we will built a Heliostat, which is a device that reflects and follows the sun's rays continuously in a fixed direction, in the manner of a sunflower for example.
Our heliostat will be able to store solar energy which then can be used e.g. to charge a cell phone. The heliostat which we are going to build won't look as simple as to one on the left image, but also won't be as big as the one on the right image, because at the end of this workshop you should be able to take the heliostat home with you.

TARGET AUDIENCE:

Students: 15-18 years

MAX. PARTICIPANTS:

The workshop easily can be implemented with around 10 participants and 3 instructors. If the participants have a lot of experience in soldering, maybe even 20 participants with around 5 instructors should be ok. In general the timing of the workshop depends on the soldering qualities of the participants.

SUGGESTED TIME PLANNING:

In total about 5 hours

TIMING IN MINUTES	ACTIVITY
0-15	Welcome group: Give a short introduction of the topic of the workshop and about solar energy
15-80	Part 1: construction of the Solar –USB charger
80-220	Part 3: Construction of an analog control for the tracking of the solar cell
220-250	Part 2: Build the mechanics of the Heliostat and test the functionality
250-280	Testing the Heliostat
280-320	Closing summary, feedback,..

The Workshop consists of three little parts: **Part 1:** In the first step we will built the "solar-USB charger."

Part 2: The second part of the workshop focuses on the tracking of the Heliostat: Via a motor and light sensors, the solar cell now, can be optimally adjusted, in order to capture sufficient sun light.

Part 3: In a last step we'll focus on the mechanics of the Heliostat. At the end of this step, we will have the fixture the Heliostat is placed on and a rotating plate.

Recommendation for performance of workshop:. Part 2 contains soldering and thus takes up most of the time. You should calculate with around 1 ½ -2 hours for this second part, including testing and troubleshooting of the soldered PCB. If time is short, the participants could also finish the mechanics part at home on their own. However, all parts are of course connected to each other ☺.

Background

Renewable Energy

In the fight against climate change, renewable energies play an indispensable part. One of the greatest advantages of renewable energies is that they don't emit greenhouse gases and thus are a viable solution to prevent environmental degradation.
There are many different sources of renewables used to get power from, such as: solar, hydroelectricity, wind, marine (wave and tidal), geothermal, bioenergy and hydrogen (http://www.thesolarspark.co.uk/the-science/renewable-energy/).
In general: a source of energy, that can be used again and again without running out and is coming from natural resources, is considered as renewable energy.

One of the biggest resources for renewable energy is the sun, since it has great power and won't stop burning that quickly. Did you know that, if just one percent of the Sahara Desert would be covered with solar panels, enough electricity to power the whole world could be generated? This is an impressive and promising fact. However, the potential to make use of solar power is yet not fully exploited.
In order to make use of the energy the sun sends out on earth, it needs to be transformed into another form of energy, which can be used more easily, such as electricity.
Solar furnaces, solar thermal heating systems and photovoltaics are ways to convert the power of the sun into energy that can be used. In this workshop we'll focus on photovoltaics, which enables to use the sun's energy to make electricity. This is not an old knowledge - in 1839 Alexandre Edmond Becquerel discovered the photovoltaic effect which explains how electricity can be generated from sunlight (http://www.explainthatstuff.com/solarcells.html).

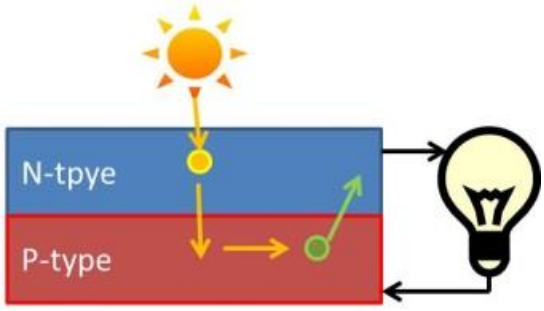
Solar energy

Solar energy is 'energy obtained from the sun'. It is an energy form that we all need and that is used in many different ways. It gives off heat and light, plants use it through the process of photosynthesis to grow and it can be used to create photovoltaic power for solar heating. In short: Without the sun, there would be no life. A big advantage of solar energy is that it is available in unlimited quantities and that it is for free ☺ On a cloudy rainy day the powerful rays from the sun can't reach us and solar energy is not available. However, there are solutions to solve this problem and additionally other renewable energy sources that can be used to produce electricity (http://study.com/academy/lesson/what-is-solar-energy-definition-lesson-quiz.html).

Photovoltaic cells

With a photovoltaic cell, also called solar cell, sunlight directly is converted into electricity. But how is a solar cell constructed and how is it possible to create electricity?
A typical photovoltaic cell is made out of silicon, since it is a semiconductor material. Usually this type of solar cell is composed of two layers of silicon: I) an n-type silicon and II) a p-type silicon. The solar cell generates electricity by using sunlight to make electrons move across the different silicon layers.

1. When sunlight shines on the cell, photons (light particles) bombard the upper surface.
2. The photons (yellow blobs) carry their energy down through the cell.
3. The photons give up their energy to electrons (green blobs) in the lower, p-type layer.
4. The electrons use this energy to jump across the barrier into the upper, n-type layer and escape out into the circuit.



5. Flowing around the circuit, the electrons make the lamp light up.

(http://www.explainthatstuff.com/solarcells.html)

Heliostat:

Taking a closer look at the word origin of the word 'heliostat' helps to explain the function of this device. The word 'heliostat' is composed of the Greek words helios (sun) and stat (stationary). Thus a heliostat can be described as a movable mirror, used to reflect sunlight in a fixed direction (https://en.wikipedia.org/wiki/Heliostat).
Nowadays heliostats are mainly used for the improved capture and storage of solar electricity. Unlike fixed solar panels, heliostats don't directly absorb the sun but use mirrors to redirect the sun's light and aim it at stationary solar panels for absorption. Mostly heliostats are controlled by computers, which calculate the sun's position in the sky in order to adjust the position of the heliostats towards the sun (http://www.makeuseof.com/tag/the-energy-of-the-future-today-how-do-solar-panels-and-heliostats-work/). An important idea for constructing a Heliostat is that a solar cell will provide more energy when it's aligned vertically towards the sun. In this workshop we will construct a small version of a Heliostat, demonstrating that this is a very useful device for capturing the sun's energy.

http://earthobservatory.nasa.gov/Features/RenewableEnergy/Images/solar_two.jpg / National Renewable Energy Laboratory

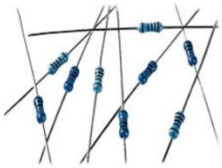
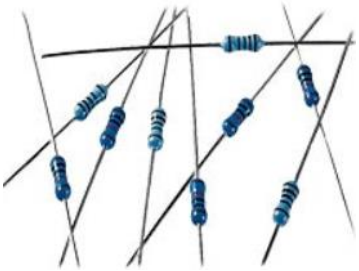
PART LIST

Photonics parts:

part	quantity
Solarpanel Offgridtec® 5W Poly 12V	1 

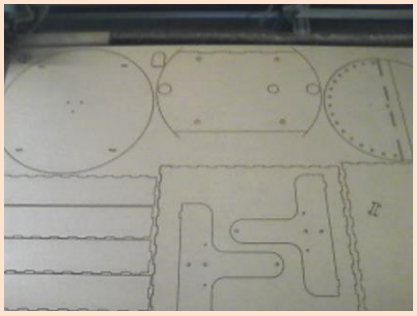
Electronic parts:

part	quantity
V-TEC 6V Mini 25D DC motor DC gear motor spur gear 177 RPM	1 
adjustable step-down voltage regulator Adjustable Power Supply Module	1 
AD USB OTG ABMB: USB micro B male > USB 2.0 A female cable	1 
Control:	
circuit board	1 
Power MOSFET N-channel Transistor IRFD 110	2 
Power MOSFET P-channel Transistor IRFD 9120	2 
Comparator, dual, DIP-8	1 
Metal film resistor 330 kOhm	4 

Metal film resistor 1K	1 
Metal film resistor 4,7K	2 
Potentiometer, horizontal, 6 mm, 25KOhm	2 
LDR resistor	2 
PCB Connector straight, 3 pin	1 
PCB connector straight, white, 2-pin	3 

Other parts:

part	**quantity**
heat shrink tube 6 cm	5
welding wire 3x120mm	
screw M3 x 16mm	13
screw nut M3	13
Cylindrical Hex Screws M4*10	8
screw nut M4	8
countersunk screw M2*6	3
litz wire red 0,75² *50 cm	2
litz wire blue 0,75² *50 cm	1

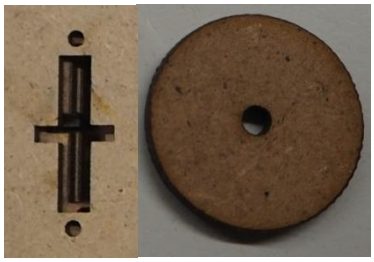
litz wire black 0,75² *50 cm	2
cable lugs for 0.75 ²	2
solid steel wire	4x1,6cm length (for the axis)
Laser-cut wooden parts	

Tools

- Laser Cutter
- 3D printer
- Soldering iron
- Diagonal pliers
- Bolt Cutter / Wire cutter
- Wood glue
- Screwdriver
- Hot glue gun
- Small hacksaw
- Metal drill 4,5 mm
- 12V power supply (or 9V battery)
- Multimeter
- exposure meter (luxmeter) - optional

PREPARATION BEFORE THE WORKSHOP:

- Cut out all **wooden parts** with the laser cutter – the laser time is around 16 minutes
- print the **gear** with the 3D printer
- Cut out **axis** (4 per participant) (length around 1,6 cm) of a solid steel wire, they later have to fit through the hole of the circle plate and should not be longer than the horizontal line, seen here in the first image
- Cut **plastic conduit pipe** with a diameter of 20mm and 40 mm length (for the axis) and another with a diameter of 32mm and 2 cm length (for the light sensors). Each participant needs one pipe of each length and diameter



- Pack little packs for the participants containing all electronics components that need to be soldered onto the PCB.

STEP 1: CONSTRUCTION OF THE "SOLAR-USB CHARGER"

Before soldering, the participants should be asked, if they have already soldered and how experienced they are. Even if the participants have a lot of soldering experience, the principle of soldering should be explained with an easy example, to make sure that everyone is more or less on the same level.

safety instructions soldering: ⚠

The temperature of the hot soldering iron is above 300 °C (this is three times hotter, as really really hot water). Incorrect handling can cause burns! The following notes have to be considered carefully:

- Carefully lay all power cables on the table so that they can not be damaged by the soldering iron.
- Work on a heat-resistant surface, making sure that there are no flammable objects (such as plastics, wood, etc.) around you.
- Only remove the soldering iron from the holder when everything is ready for soldering.
- Always hold the soldering iron over the table, only solder it over the work board.
- Work in a well ventilated area and use a fume extractor. Do not inhale fumes from the soldering processes.
- Use a third hand, a circuit board vice, pliers, tweezers, or clamps for holding components to avoid burns.
- Do not have food or drink near the working area. The solder is usually a tin/lead alloy and lead is toxic. The flux is a chemical used to help metal parts soldered together. It is acidic and toxic. Clean up spilled flux immediately. Wash hands after soldering. Flux can cause acid burns to the skin or damage clothing. In case of acid burns, flush immediately with water.
- Always return the soldering iron to its stand when not in use. Never put it down on your workbench. The soldering iron tip is very hot (about 400°C). Avoid touching plastic, wire insulator, or any flammable material in the working area with the soldering iron.
- Turn the soldering station to standby or off if not used for more than few minutes. Turn unit off or unplug it when done.
- Dripping solder is very dangerous – even on clothes

More information: http://www.riccardobevilacqua.com/SolderingSafety.pdf

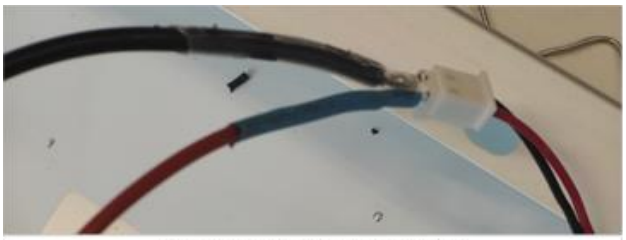
WHAT WE NEED FOR THIS STEP:

Voltage regulator | USB cable | 2pin connector | solar cell | cable | solder and soldering iron

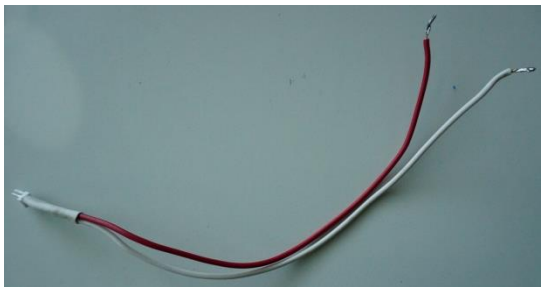
In the first part of the workshop we are focusing on the construction of the "solar-USB charger". This is the essential component of the Heliostat since it brings the energy of the sun to the USB charger. First, we need a connection from the solar cell to a voltage regulator. In general, a USB connection can provide a 5 V supply. The solar cell however, is able to supply 12V. We need to insert the voltage regulator in order to lower the electric power that the USB cable is supplied with.

Take the 2-pin connector and a black and red cable, which we need to extend the cable of the 2-pin connector. Unpin the 2 pin connector and

solder a 22cm long red and 22cm black cable onto the pin (marked in red on the left image). Use a red cable to solder it onto the red cable of the pin connector. Use a black cable to solder it onto the black cable of the pin connector. Before soldering make sure, that you solder the red and black cable onto the right pin of the 2-pin connector. You can test it, when inserting the pin-connector into the small “socket”. When you have soldered the cables onto the pin you can use a heat shrink tubing in order to fix the solder joint better. Your pin-cable extension should look like this now (instead of a black cable, a white cable was used.) *General Note: It technically doesn’t*



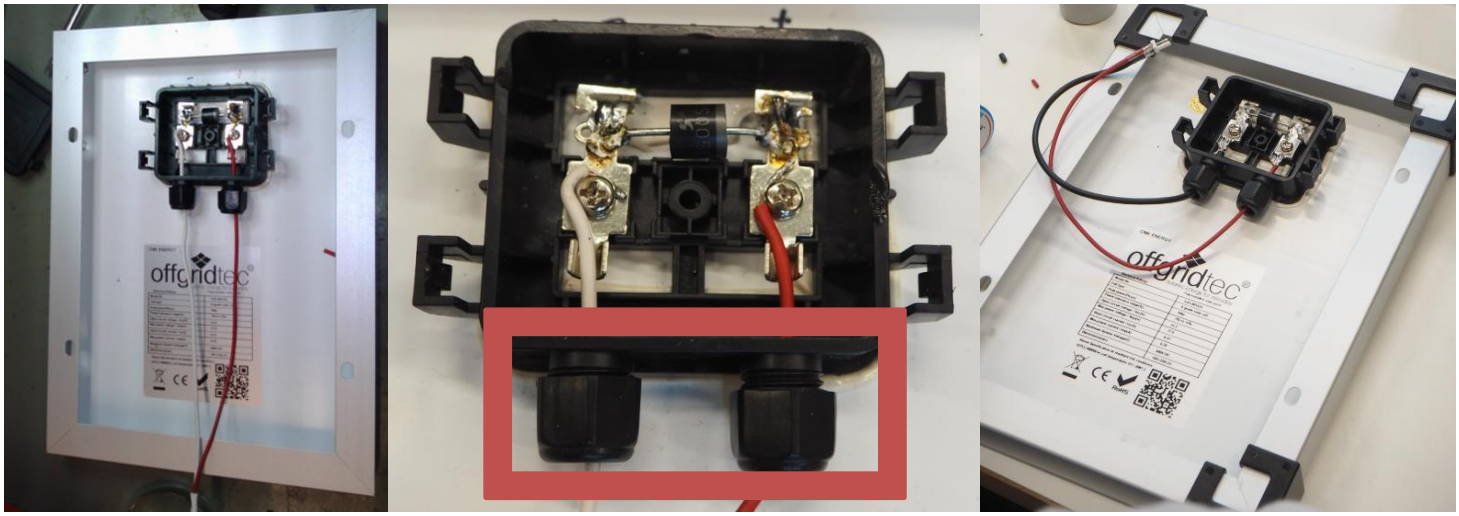
Shrink tube around cables



Pin with extension

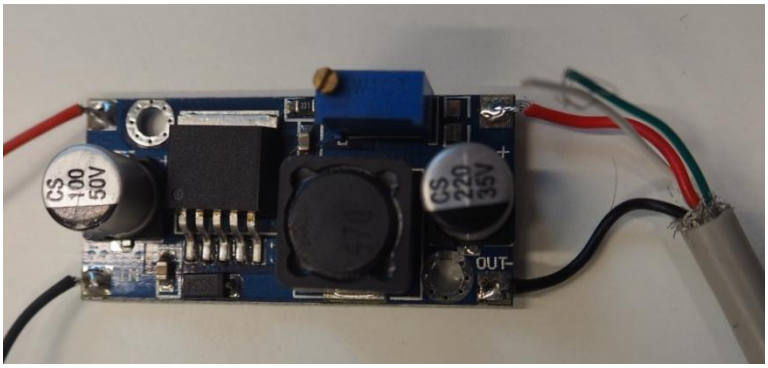
matter, which cable colour you are using, but for a better orientation it is advised to always use the same colour for the plus pole and another for the minus pole connection.

Now, take the solar cell, turn it around and open the black box on the back of the solar cell. Insert the long red cable, you have just soldered into the pin through the black hole, marked in red on the image below. Solder the red cable onto the plus pole of the solar cell. The polarity of the solar cell is indicated on the lid of the black box of the solar cell. Take the long black /white cable and solder it onto the minus pole of the solar cell.

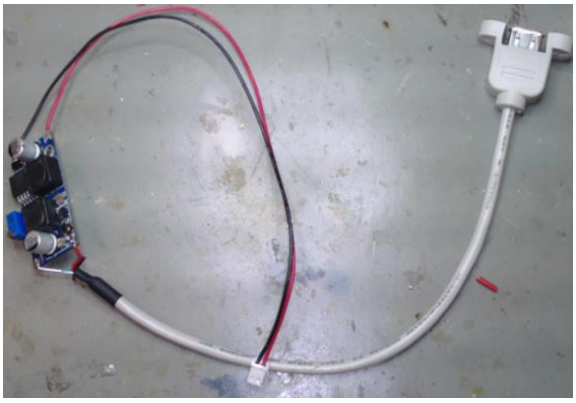


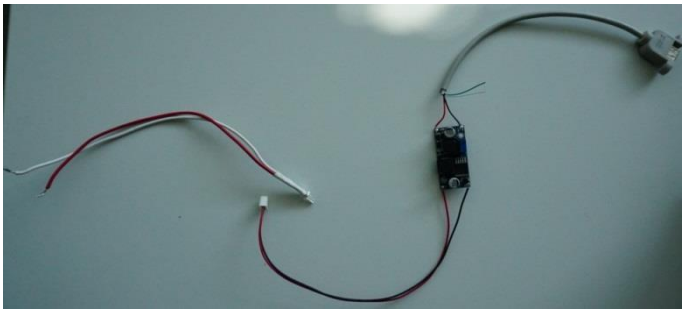
We now need to connect the solar cell with the voltage regulator as well as USB-charger.
Take the USB-charger now and cut off the black plug (marked in red below) of the USB socket. Four cables should be visible at the end of the USB cable now. We only need the red and black cable to connect to the voltage regulator to. The other cables can be ignored.

Take the voltage regulator now, and solder the red cable of the USB charger onto the **output** plus side of the regulator and the black cable of the USB cable onto the minus pole of the **ouput** side of the voltage regulator. The voltage regulator is now connected to the USB cable



The voltage regulator now needs to be connected to a 2pin PCB connector cable. Solder the red cable of the PCB connector (the pin is already soldered onto the solar cell) onto the plus pole of the **input** side of the voltage regulator and the black cable onto the minus pole of the **input** side.





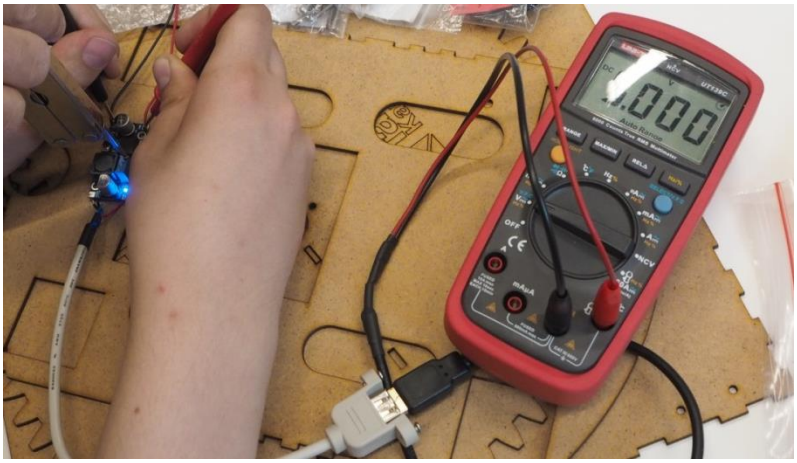
ATTENTION! VERY IMPORTANT NOTE!

Since the solar cell (or later the battery) provides 12V, but USB devices are designed only for 5 V, the adjustable step-down voltage regulator needs to be set to 5 V.

To measure the voltage we now need a 12V power supply (or a 9V battery) and a voltmeter (multimeter). Set the multimeter to voltage measurement and disconnect at output.Connect the USB charger to the multimeter.

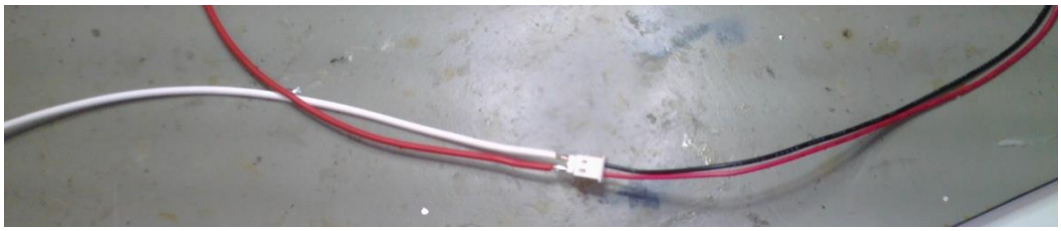
We can connect the multimeter to the free spots of the wires of the input side of the voltage regulator, or use an old USB cable as an adapter.

Connect the voltage source to an input 12V power supply (or a 9V battery), then turn on the voltage source and turn the adjusting screw on the voltage regulator until the meter reads 5V. The tolerance for the voltage should be + -5%.

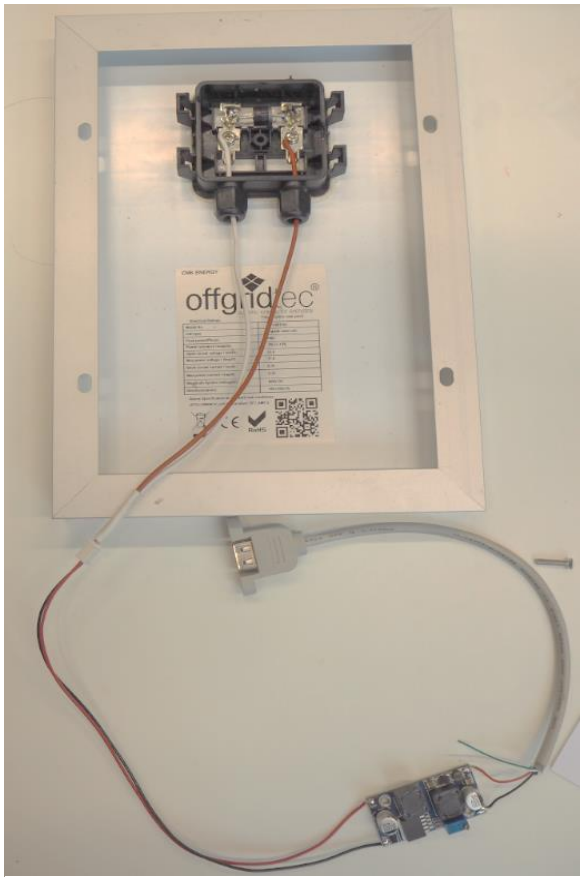


Your voltage regulator now properly adjusted, in order to transmit sufficient energy from the solar cell to the USB charger.

Next, we want to connect the voltage regulator to the solar cell. Thus, we simply stick the pin into the pin connector soldered onto the voltage regulator and USB charger.



The voltage regulator is now fixed onto the solar cell and the “Solar-USB-charger” completely build together.



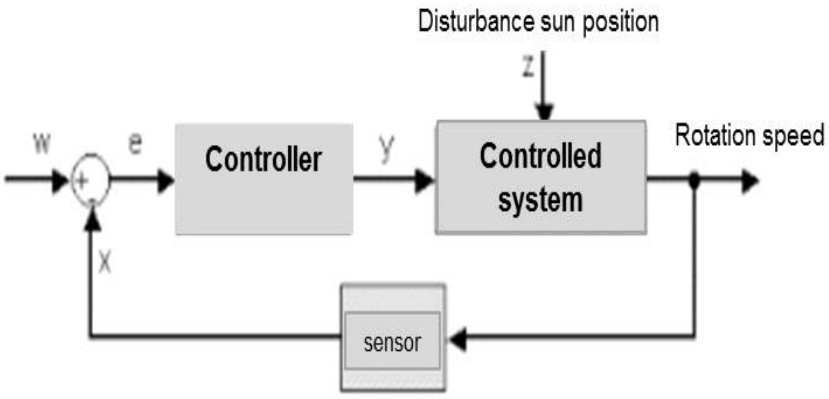
The solar cell connected to the voltage regulator and USB cable.

STEP2: CONTROL

In this part of the workshop we are focusing on the tracking system of the Heliostat.
By using light sensors and a motor, the solar cell can be optimally aligned. To control the motor, an analogue control will be built now.

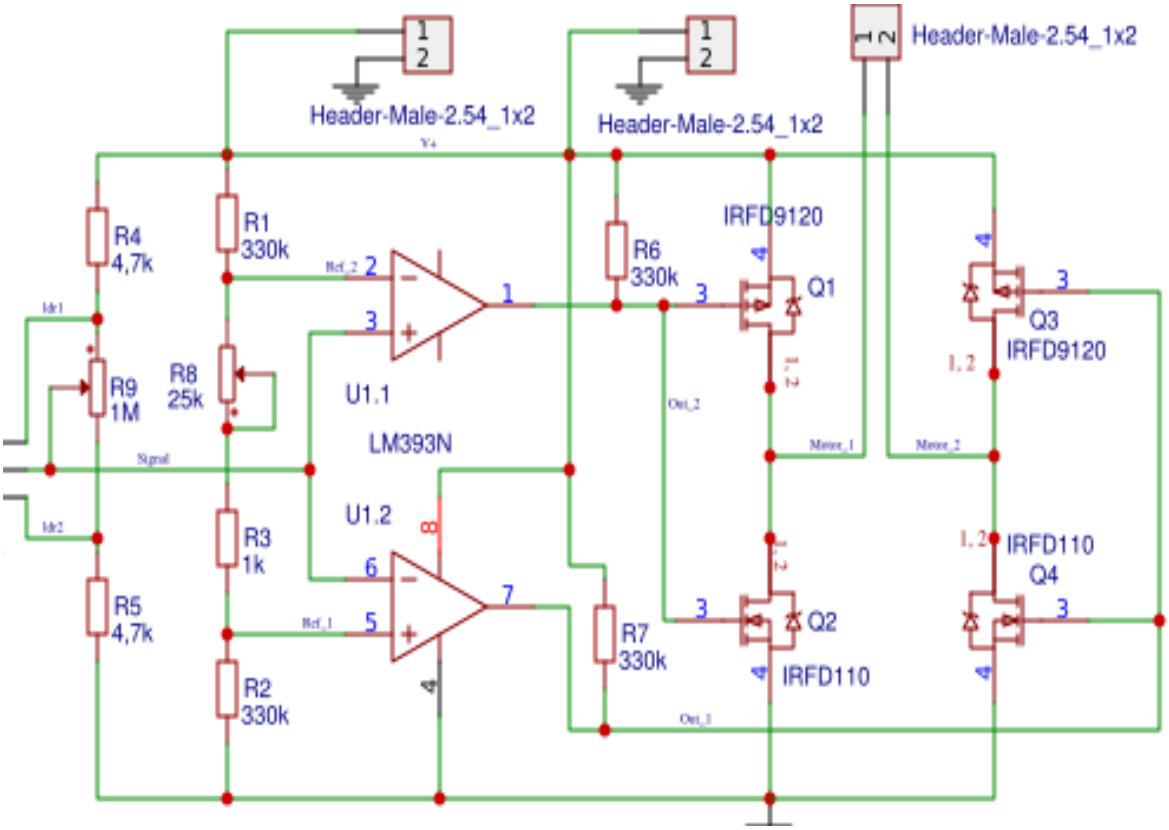
We use two small light sensors to tell an electronic unit which direction the motor should turn, in order to achieve an equal illumination. As light sensor, we use LDR resistors.

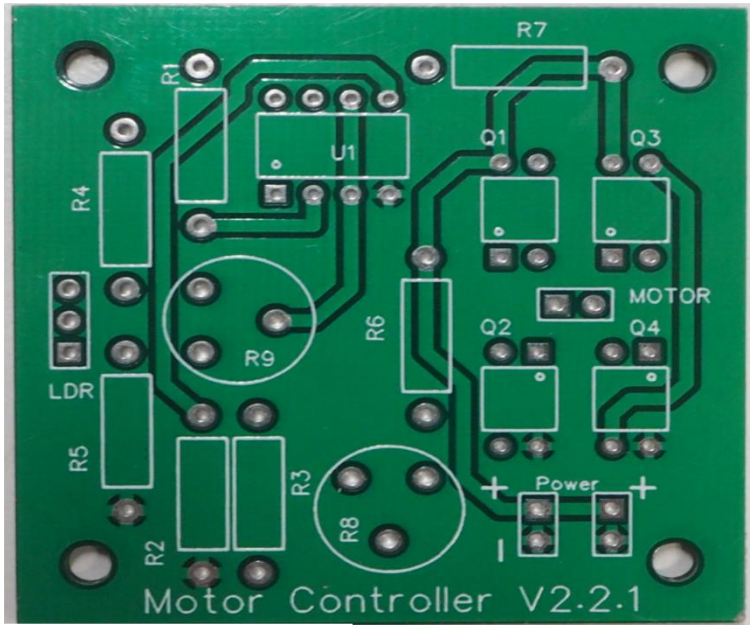
The control is not available as a finished module. That's why we need to build the control on the circuit board.



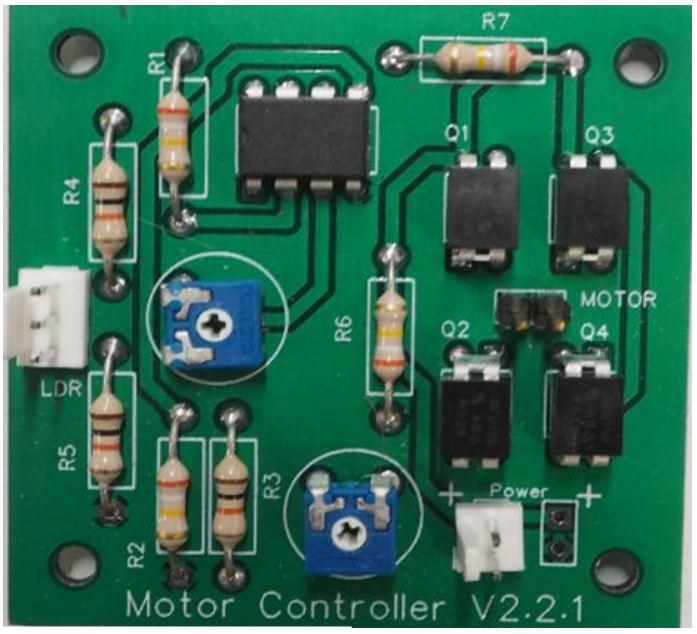
2.1 SOLDERING PROCEDURE OF THE CIRCUIT BOARD

According to the below shown circuit diagram and layout of the circuit board, the different electronic parts will be soldered onto the circuit board.





Layout of circuit board



Final circuit board

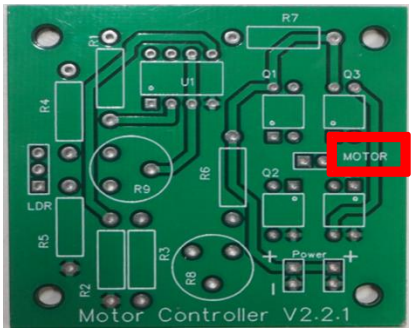
1. Soldering of the resistors 4,7k on positon R4 and R5

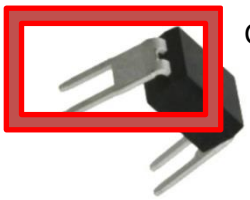
2. Soldering of the resistors 330k on position R1, R2, R6 and R7

3. Soldering of the resistor 1K on position R3

4. Soldering of the potentiometer to R8 and R9

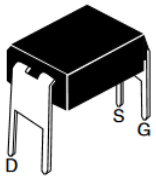
5. Soldering of IRFD110 to position Q2 and Q4
! Please note: The “legs” of the “IRFD” vary. On one side the legs are connected, on the other side not. When soldering these components onto the circuit board, make sure, that the “connected legs” are inserted towards the middle of the circuit board, in other words: the connected legs always have to face towards the description motor (marked in red below)



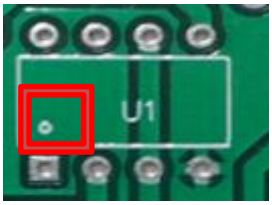


Connected legs

6. Soldering of IRFD91/20 to Q1 and Q3
! Please note the explanation in step 5 regarding the direction the IRFD91/20 needs to be inserted.



7. The comparator is soldered on position U1. The small circle on the bottom row of the legs (marked in red in the picture below) indicates were the first pin of the comparator needs to be inserted into the circuit board. The first pin of the comparator is identifiable with a small notch.



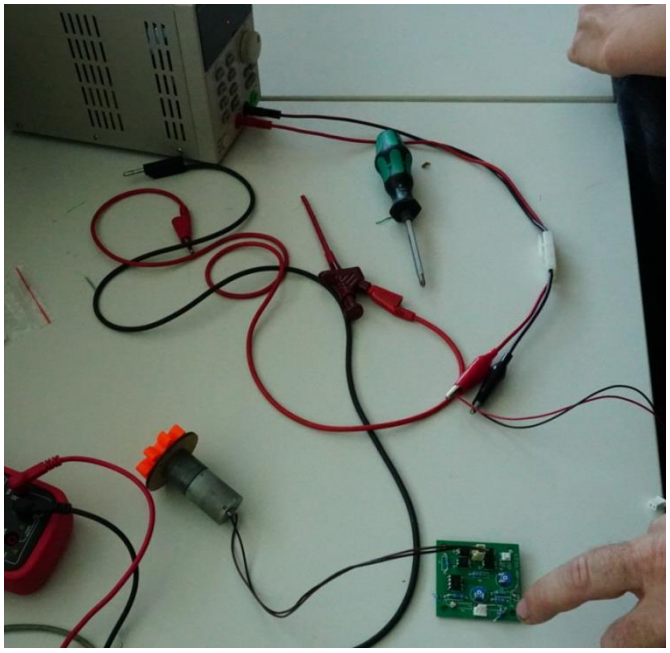
8. Stick the 3 pin of the 3-pin connector for the LDR into the corresponding mark on the circuit board.

9. The 2-pin of the 2-pin connector is soldered onto one of the positions named as “power”. Pay attention to the polarity and insert the pin correctly. It should be only possible to insert the pin in one correct direction.
10. Solder a 2-pin of the 2-pin connector onto position marked with “motor”.

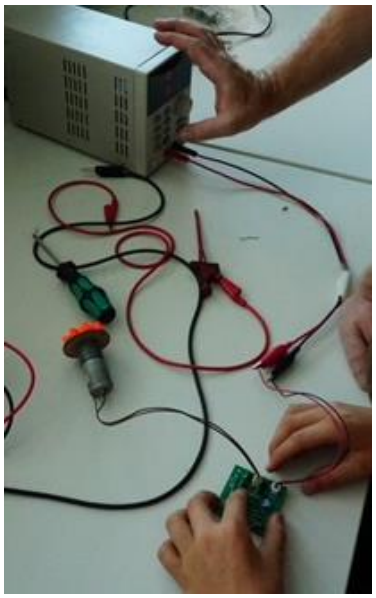
TESTING OF THE CIRCUIT BOARD

When all electronic components are soldered onto the circuit board, the functionality of it should be tested. For the test we need a power supply, a test motor, connected to 2pin-connector and a screwdriver. We will test, if the motor will turn, if it is supplied with power and additionally, if the motor changes its direction. This is essential for our Heliostat, since it always needs to be aligned towards the sun.

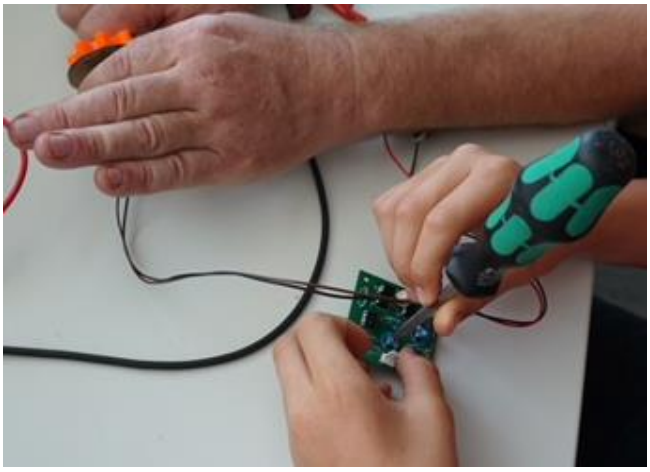
Provide the PCB with power by sticking the 2-pin connector into the pin with the description “power” and connect the red cable onto the red clamp of the power supplier and the black cable onto the black clamp. Then connect the motor onto the PCB onto the pin marked with “motor”.



Then, turn on the power and the motor should start turning.



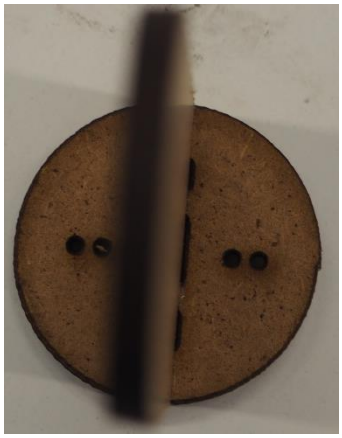
Take a screwdriver and turn the potentiometer on position R9 into the middle, until the motor stops moving. Turn the screwdriver into the other direction in order to test, if the motor gear is turning as well the other way round. If that is working, everything is fine and the light sensors will be able to turn towards the sun as well. Turn the potentiometer into the middle position again and only then, turn off the power supply. If your motor is not turning around, start troubleshooting.

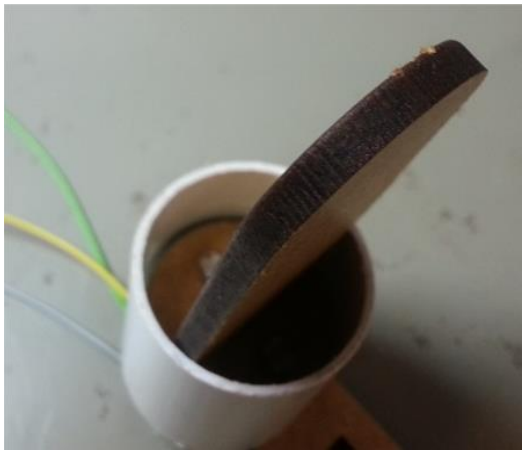


2.2. LIGHT SENSORS

Our Heliostat always should be aligned perfectly to the sun, in order to store as much energy as possible. Thus, we need a mechanism assuring that the Heliostat always stays in the sun/is aligned towards the sun. With the help of photoresistors (or light sensors), we make sure, that the Heliostat turns towards the sun again, as soon, as one of the photoresistors is in the shade.

Our light sensors will be placed above the solar cell. First we need to stick the two wooden parts (as seen in the picture below) together and insert the two light sensors into the respective holes.

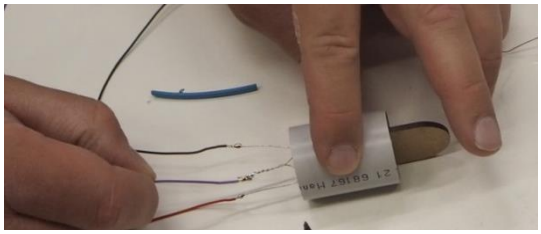


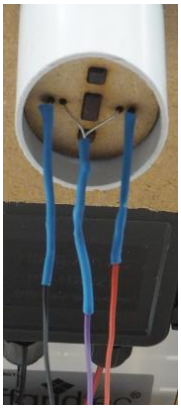


Then put the complete light sensor holder into a round plastic conduit pipe with a diameter of 32mm and 2 cm length.

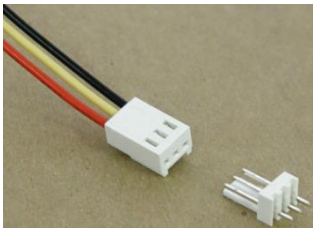
Now, we need a connection of the photoresistors to the circuit board. Take three cables (each around 60 cm long) and solder them onto the light sensors. Solder the red and black cable onto

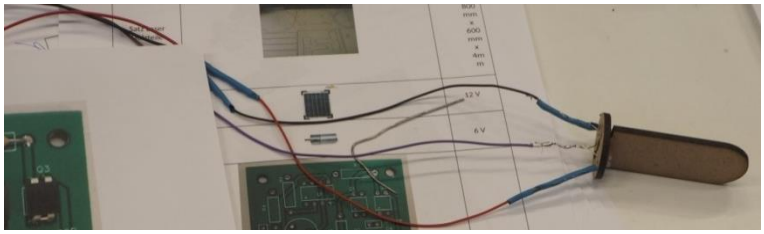
the outer sticks of the light sensors. Normally the black cable is soldered onto the minus pole and the red cable onto the plus pole of the photoresistor. Turn the two remaining middle sticks around each other and solder a third cable between the black and red cable onto the sticks. Use shrinking tubes to stabilize the just soldered connection.

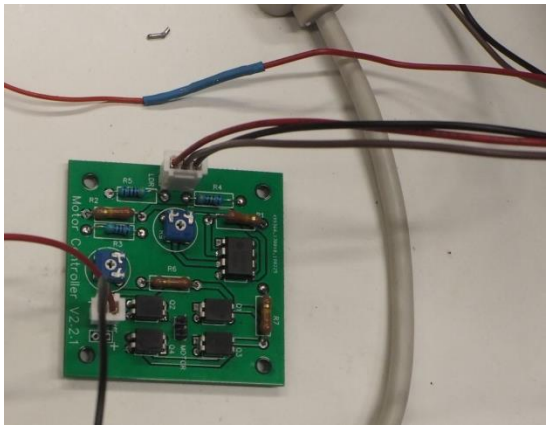




We now need to connect the photoresistor with the circuit board. Thus, take the 3 pin PCB connector and solder the three cables onto the cables connected to the photoresistors. The Pin of the pin-connector will be stuck into the circuit board later.

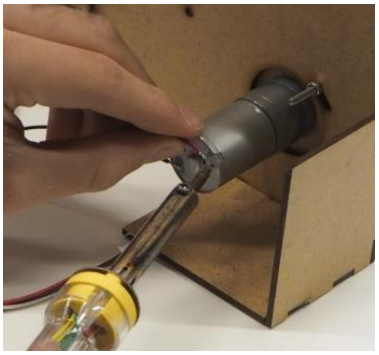






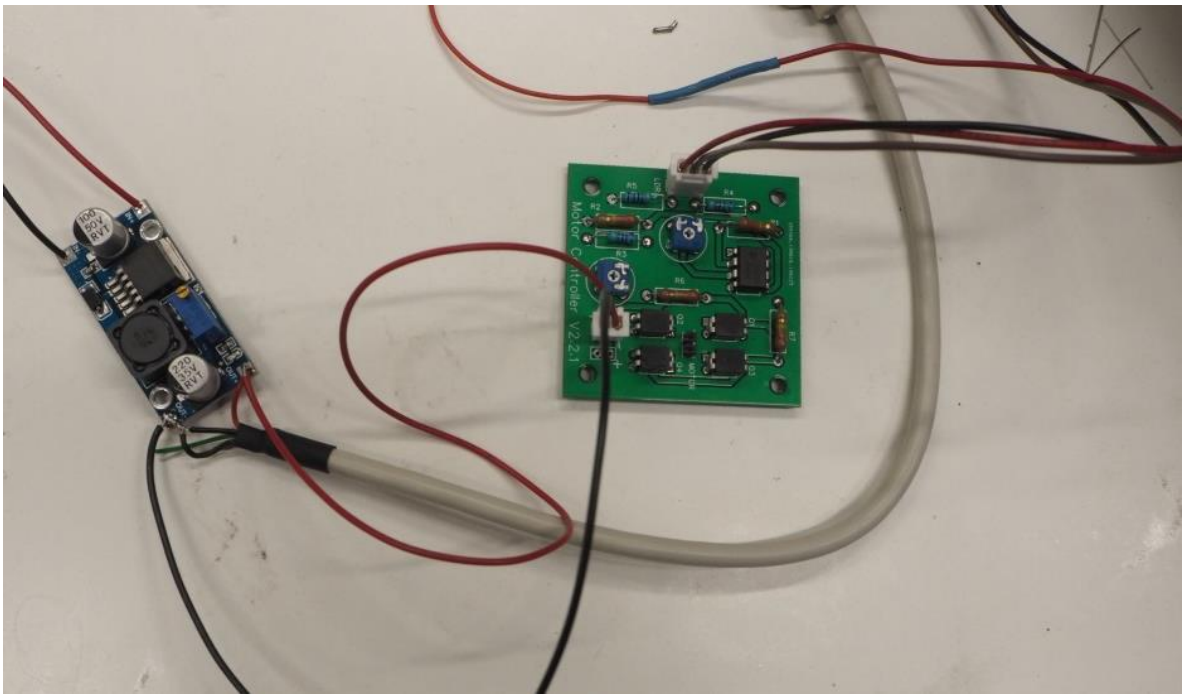
2.3. MOTOR

We'll continue with the remaining soldering parts, in order to finalise the soldering.
Take the motor now and a 2 pin connector.
Solder a 2 pin PCB connector cable onto the motor. The motor will be inserted onto the base plate of the Heliostat. In order to do so, we now will start with the mechanics part of the workshop.



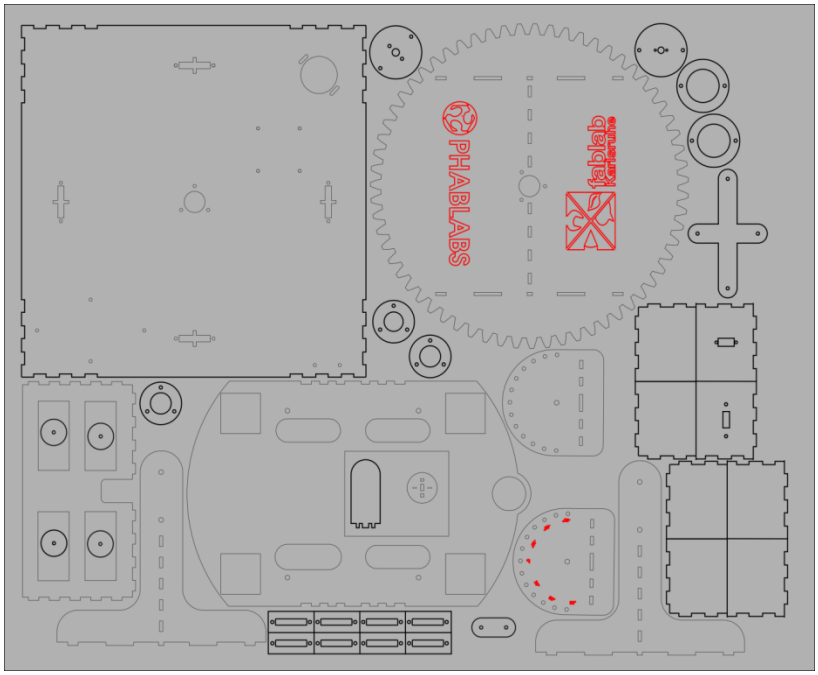
2.4. Connecting the voltage regulator with the PCB

For the next step make sure to turn of the voltage at your voltage regulator!
In order to supply the circuit board with power, we need a connection from the voltage regulator to the circuit board. Take a 2 pin PCB connector and solder the red cable onto the plus output of the voltage regulator. Then, solder the black cable onto the minus output of the voltage regulator. Then stick the connection plug of the motor into the one of the step down voltage regulator.



Step 3: Assembling the Base plate of the Heliostat – Mechanics Part

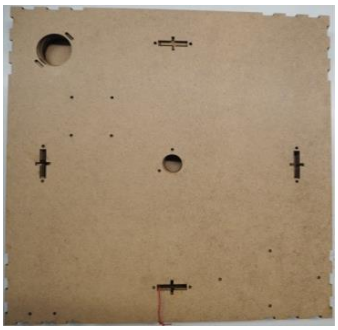
The mechanical structure of the Heliostat consists of a base designed as a box on which the rotatable mounted base plate is placed. On this base plate, the actual solar cell is then mounted adjustably in the elevation angle. The mechanical parts need to be cut by the laser cutter. A wooden plate with the following dimension is necessary: 800 mm x 600 mm x 4mm. The laser time is about 16 minutes:



Heliostat svg file

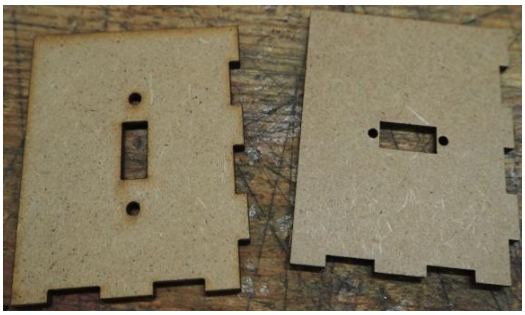
3.1. Base plate of the Heliostat

In the next step, we will assemble the base plate, on which the solar cell will be placed on.
Take the base plate and the eight feet that need to be fixed onto the corners of the bas plate, in order to stabilise it. Among the eight feet, there are 2 with a hole. The plate with the horizontal aligned hole is needed for the USB connector. The other plate with hole, can be ignored.



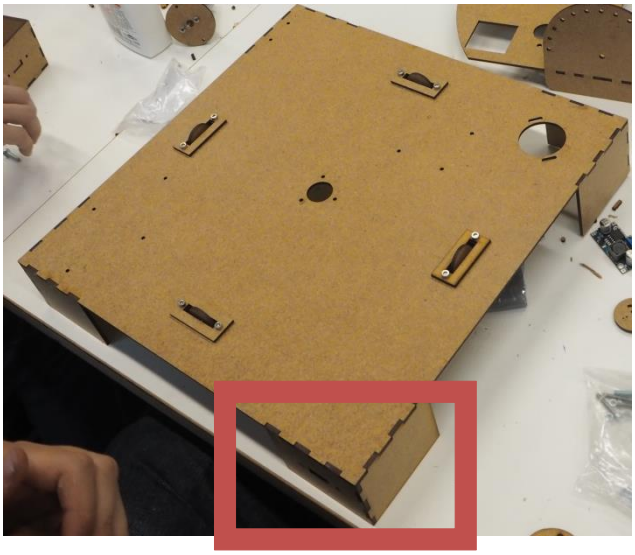
Base plate

feet

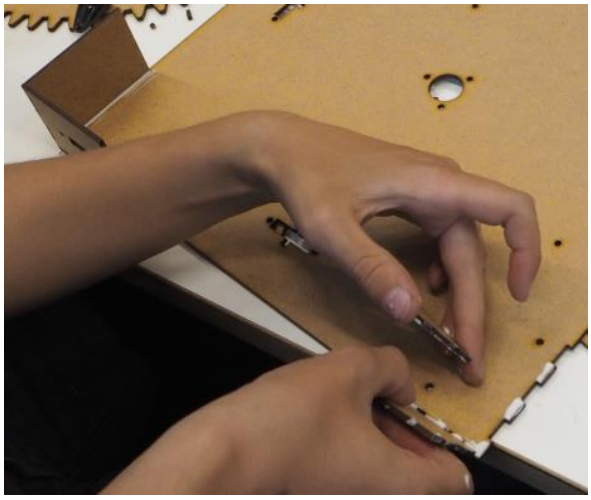


feet for USB cable

Lay the base plate in front of you and make sure, that the big hole is located in the upper right corner. Assemble the feet onto the four corners of the base plate and pay attention to place the plate with the horizontal square in the lower right corner of the plate, (opposite the round hole on the base plate, where, the gear motor will be inserted).



The feets should be fixed and stable just by inserting onto the base plate. However, in order to make the base plate more stable, the feet can be fixed with wood glue onto the base plate.



3.2. ROTARY PLATE

In a next step, we need to insert the wooden wheels into the ground plate, on which we will place our solar cell. Thus, the Heliostat will be able to turn towards the sun.
As axes, we use 1,5cm long steel wire, which – in order to save time – can be cut before the workshop.
The following parts are needed to fix the wheels onto the base plate:

- 4 axes
- 4 wooden wheels
- 8 rectangle wooden plates with a rectangle hole
- 8 M3 screws and nuts

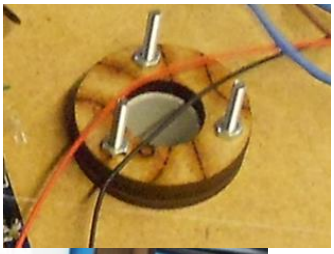



Fix the four wheels as shown in the schematic image below.


3.3. MIDDLE AXIS

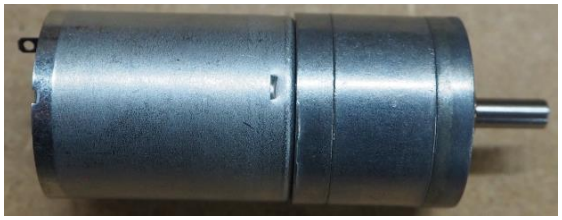
In the middle of the base plate, an axis (round plastic conduit pipe with a diameter of 20mm and 40 mm length) shall be inserted.
For stabilization three wooden rings will be fixed with screws from below onto the ground plate. The diameter of the ring marked with a star is a bit smaller than the two other ones. This ring has to be placed above the two other ones, in other words, first place the two other rings onto the base plate and above the ring marked with a star. Then fix the rings with screws and insert the conduit pipe. Later you can insert the cables from the solar cell through the pipe.






3.4. ASSEMBLING OF THE MOTOR

Take the round wood plate with a hole in the middle and two smaller sides on the outer sider of the plat and attached the motor onto it.

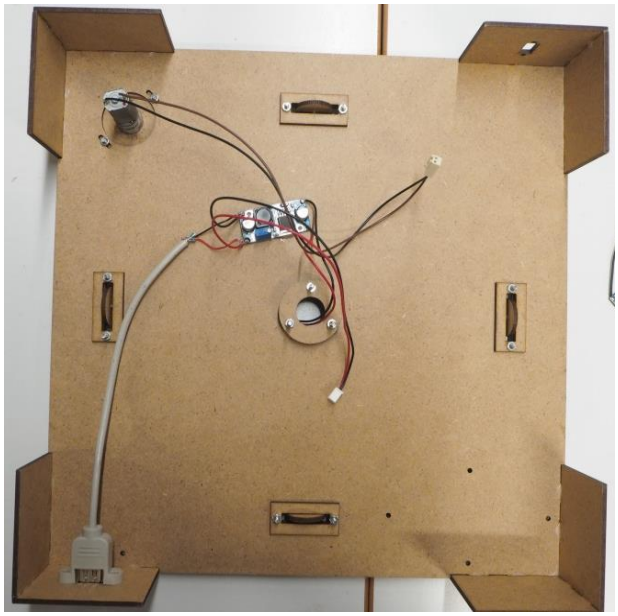


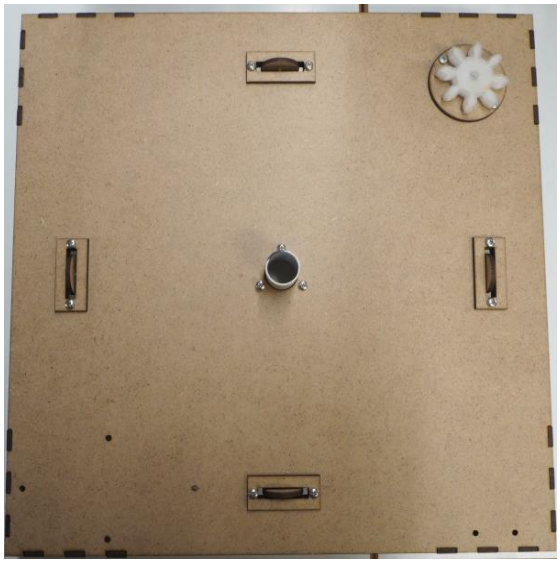
Insert the motor into the hole of the base plate. Then, turn the base plate around and mount the motor onto the wooden ring with screws and fix them with nuts. Turn the base plate around and

stick the drive gear onto the motor.

Then, the USB cable can be fixed with screws into the corresponding fixture of the feet as well.

Your base plate should look like this now:

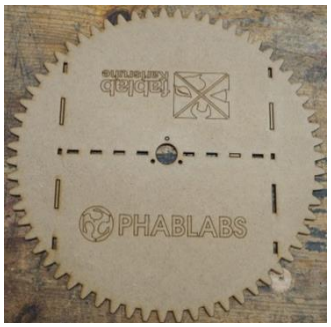


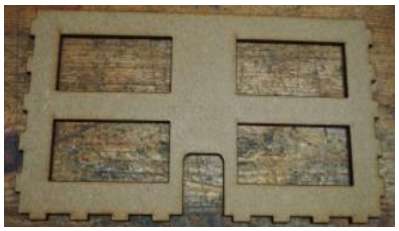


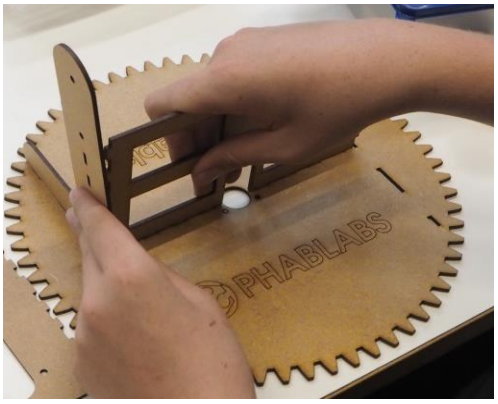
We will now continue with the construction of the solar cell holder.

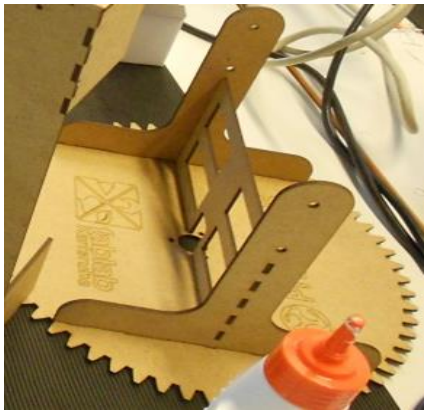
3.5 : ASSEMBLING THE SOLAR CELL HOLDER

In a next step take the wooden plate looking like a **gear** and insert the two feet of the solar cell holder into the fixture of the “gear”. Stabilize the feet with the middle part



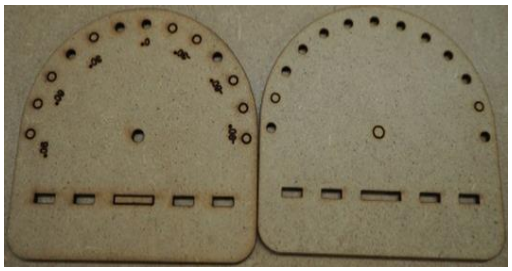


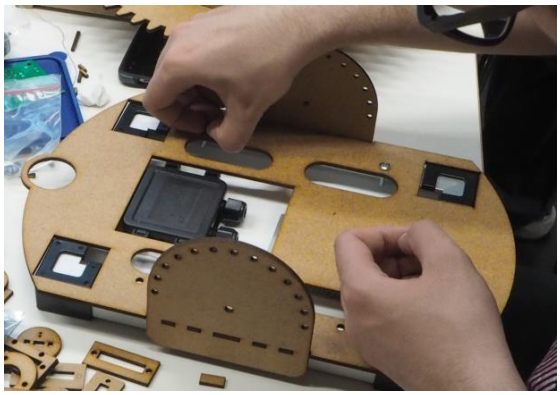




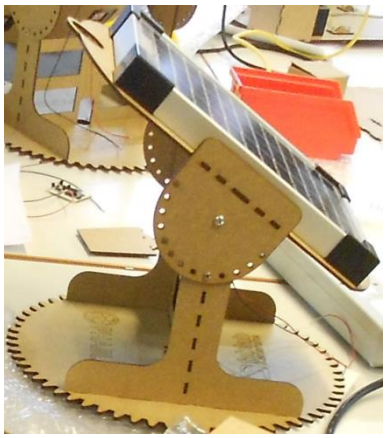
Please note!! The noses of the feet are not completely symmetrical with the small holes on the “gear plate”, where the feet need to be inserted. Same applies to the middle part. Before inserting the feet on the plate, please pay attention to the direction you insert them into. If the feet don’t fit in, try to insert them the other way round! When the parts are inserted correctly, they additionally can be fixed with wood glue.

Next the solar cell shall be fixed with 4 M4*16 screws onto the carrier plate.

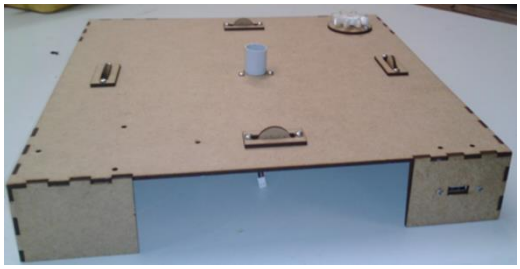




Then put the side holders into the corresponding fixture on the side of the carrier plate and fix it onto the solar cell holder with M4 screws. Fix the solar cell onto the feet (standing on the base plate). Your Heliostat consists of the solar cell holder and base plate now and shall look like this:

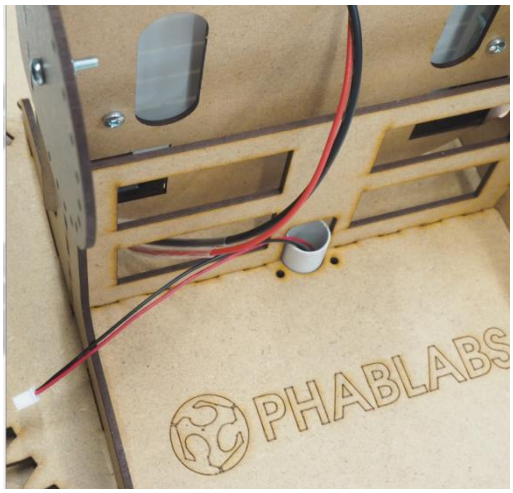


Solar cell holder

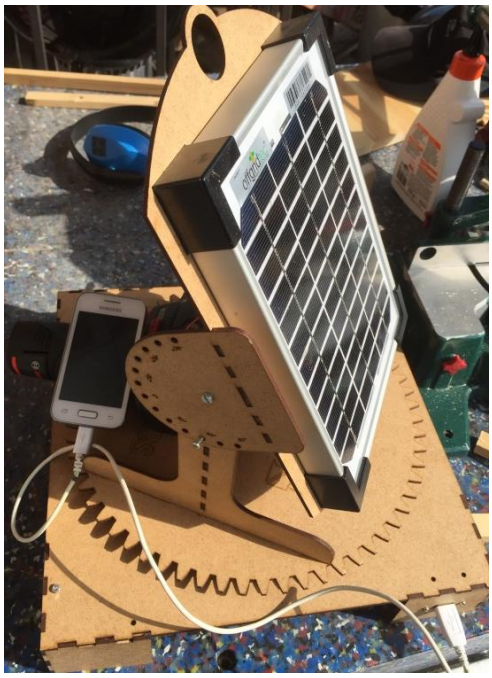


Base plate of Heliostat

With finishing the base plate and solar cell holder, we have finalised the mechanics part of the Heliostat. Also, we have finished the remaining soldering parts. We now should have a put together base plate and a fixture for the solar cell, which can be placed onto the base plate. Before placing the Heliostat together, make sure to put the PCB cable, the light sensors will be connected to, through the middle axis of the Heliostat.



Before finishing the workshop, we need to perform a few last checks, to test the functioning of the Heliostat. Go outside and place our Heliostat into the sun to test if it is alining towards the sun. If your Heliostat is turning away from the sun, you photoresistors might not be inserted correctly. Simply turn the conduit pipe the other way round and your Heliostat should move towards the sun now.
If your Heliostat has passed all the tests you can fix the circuit board onto the back of the base plate with hot glue.



The Heliostat now is ready to be placed outside into the sun! Connect your charging cable of your mobile phone to the USB socket and see how the sun will charge your cell phone!

END OF WORKSHOP AND CONCLUSION

What we have learned

- solar energy is a very important renewable-energy, that easily can be used in daily life as well
- thanks to the light sensor, circuit board and motor, the solar cell is always aligned in the best position to capture most of the sun. Because light can move a whole device.
- Solar cell work most efficient, when they are aligned vertically to the earth's rotation – they will then capture up to 20% more energy

PHABLABS 4.0 is a European project where **two major trends** are combined into one powerful and ambitious innovation pathway for digitization of European industry:
On the one hand the growing awareness of **photonics** as an important innovation driver and a **key enabling technology towards a better society**, and on the other hand the **exploding**

network of vibrant Fab Labs where next-generation **practical skills-based learning** using KETs is core but where photonics is currently lacking.

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This workshop was set up by the Fablab Karlsruhe in close collaboration with Steinbeis 2i GmbH

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