netidee project-id: 1769

Project: mesaSolar (IOGA-AUT-01)

A solar powered charging station for refugee-community

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Executive Summary – mesaSolar, id: 1769

Use case:

Based on experience of a humanitarian crisis (refugee crisis 2015) the need for a reliable, decentral and transportable solution for power supply for communication devices became evident. The mesaSolar was designed to operate independently form any landline and facilitate the use of renewable energy sources as power supply for cell phones and small electrical appliances.

Function:

The mesaSolar is a table and bench combination with additional equipment to supply the public with off-grid internet, electric power and environmental data. The table was developed together with refugees and ultimately placed in a refugee community project in Traiskirchen, Lower Austria.

Features:

- Free WiFi
- Free electric power to charge cell-phones
- Use of renewable energy for sustainable and independent supply
- Involvement of refugee-workers in the development, construction and maintenance
- Measurement and public sharing of environmental data

Who are we?

Ingenieure ohne Grenzen Austria (Engineers Without Borders Austria,) is a non-profit association focused on social development cooperation with a background in engineering. The association offers a platform - primarily for engineers - to enable and promote social engagement in the context of development cooperation.

Inhalt

1 Introduction

.1 *Introduction Ingenieure ohne Grenzen Austria (IOG)*

We are a non-profit association whose purpose is to carry out projects in technical development cooperation. IOG offers a platform to enable and promote social engagement in the context of development cooperation.

.2 *Goals*

The project had the goal to develop a table and bench combination with additional equipment to supply the public with off-grid internet, electricity and environmental data . The table was developed together with refugees and ultimately placed in a refugee community project in Traiskirchen, Lower Austria.

Goals:

- Free WiFi
- Free electric power to charge cell-phones
- Use of renewable energy for sustainable and independent supply
- Involvement of refugee-workers in the development, construction and maintenance
- Measurement and public sharing of environmental data

Figure 1: The mesaSolar

.3 *Project History*

The project group was formed during the refugee crisis in Austria in September 2015. The first builds of charging stations (land line) were developed.

.4 *Acknowledgements*

We want to thank our sponsors for their generous contributions to this project: Netidee, Conrad, Semaf Electronics, Hutchison Drei and many more.

.5 *License*

2 Construction

.1 *Concept*

The mesaSolar was designed with the goal to provide a comfortable yet sturdy seating-accommodation, encouraging people to linger and making new acquaintances or simply enjoy nature. The desk's design is modular, facilitating transport and maintenance. To prevent bulkiness and improve weight distribution, battery, charge controller, as well as router and IoT-module are accommodated in separate compartments. Combined with different locks, this also enables separate access to the IoT-module for developers, conveniently placed on the tabletop.

.2 *Functions*

The mesaSolar consists of two separate benches and a table with a canopy.

The table features three separate locked boxes, two of them mounted between the table-legs. One contains the WiFi router, the other one battery and charge controller. The third box is placed on the tabletop, containing the IoT-module. There are two USB ports for charging mobile devices, as well as a micro-USB cable. There is a window cut out of the sleek box's lid, covered by acrylic glass, revealing an LCD-display and a QR-code leading to the project's website. The LCD-display perpetually shows current time, temperature, humidity and energy consumption.

The canopy featuring a flexible, curved solar panel sits asymmetrically on top of a mast, located at one end of the table. There are two trusses, preventing rotation and reducing torsion. On the lower side of the canopy there are two LED strips. These can be turned on either by manually pushing a switch on the mast or via timer in combination with a photoresistor.

For transport and maintenance, the canopy can be dismounted by removing three screws (one per truss and one on top of the mast). Additionally, the mast can also be dismounted from the table by removing two screws. Thus, the mesaSolar's height of slightly above two meters can be reduced by more than 50%.

Since there are electric leads mounted on the mast, coming from the solar panel and going to the LED-strips as well as the switch, there is need for two junction boxes, one at each site of the separation. There, the cables can be unplugged, separating mast and table/mast and canopy completely.

Figure 2: Simple and transport friendly construction

.3 *Execution*

During the design process numerous ideas were discussed and analyzed in several meetings. (e.g. futuristic looking, yet massive constructions were compared to light ones with organic shapes). Eventually though, we opted for a common "picnic table design" with an additional canopy for several reasons: The mesaSolar's purpose is easily recognizable, need for special tools, materials and knowledge is minimized and the table can easily be modified. Our goal was not to provide a perfect table for one special application, but to enable and encourage anyone to adapt their mesaSolar to their needs.

Once the design was final, detailed plans were drawn and lists of components made by three teammates. Timber was ordered and the bigger part of the mesaSolar (desk, benches, mast and canopy) was erected in a single day, by a varying group of ten to fifteen people. Later-on, several adaptations had to be made, though, to improve stability and functionality, as well as match changes in specifications (e.g. size of IoT-components).

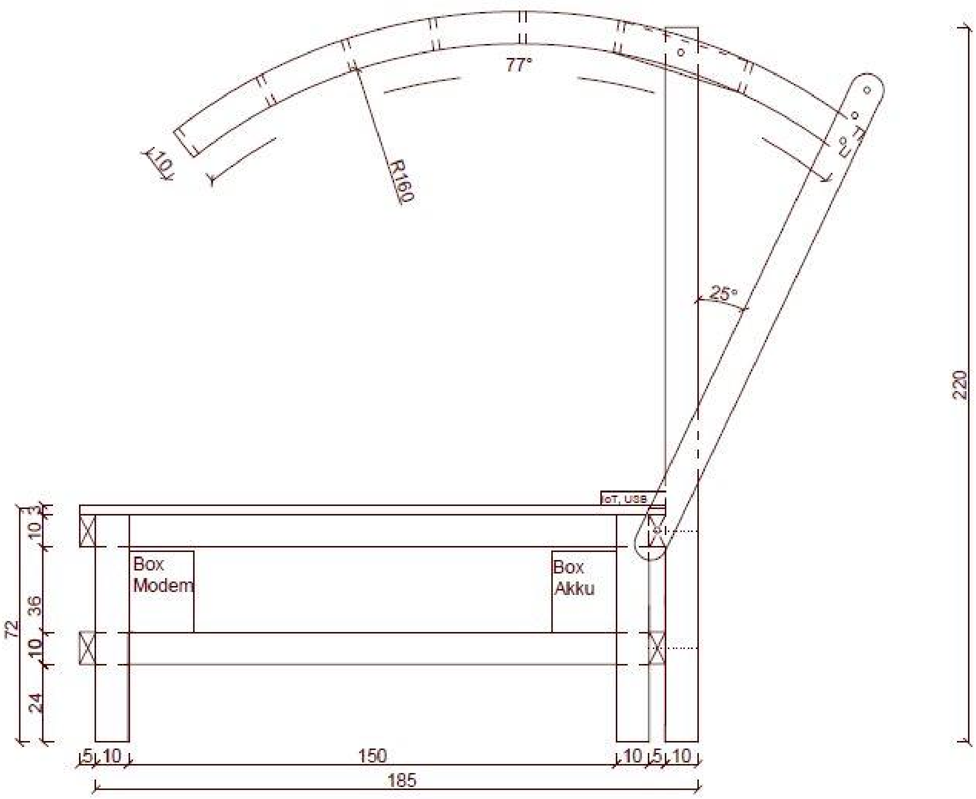


Figure 3: Construction plan mesaSolar, measurements in cm

.4 *Challenges*

During the design and planning process, only few dimensions of electronic components were already known. Thus, only suggestions and estimates could be made, regarding box sizes, and mounting of the solar panel. On the day of build, measurements were taken on-site for all available components. These measurements had then to be implemented into the plans, leading to slight elongation of the planning and building process. The box housing the IoT-components had to be rebuilt, since it turned out to be too small. Also, as already mentioned, some improvements were made concerning stability of the mesaSolar, as well as suggestions for further upgrades were included in the plans.

3 Power Supply

.1 *Concept*

During the refugee crisis in 2015, where many thousand refugees were stranded in the border region between Austria and Hungary, power supply for communication devices was not available or lacking behind demand. Even in highly populated areas sufficient charging equipment's for cell phones and other appliances was not working properly, for example the Vienna main train station had no sufficient supply for weeks. Based on this experience, the need for a reliable, decentral and mobile solution became evident. Therefore, the main requirement when designing the mesaSolar was decentralized power and WiFi supply. The mesaSolar was designed to operate independently form any landline and facilitate the use of renewable energy sources as power supply. The final version is the product of various iterations of charging stations built and modified through the refugee crisis.

.2 *Function*

The mesaSolar has a built-in photovoltaic panel with a maximum power output of 150 W. The flexible solar panel was integrated in the design and provides a circular shape on top of the roof construction. Besides the electricity production, it serves as a minimum protection against rain and sun for the main table and electronics. A solar battery is placed in the lower compartment to supply the charging sockets, WiFi router and measuring equipment with electricity, especially at night.

The solar panel has an easy to connect cable string for fast disassemble (in case of transport). The system voltage is below 17.5 V and poses therefore no risk of electric shock to any kind of user interaction.

	Power rating	Source	Technology
Solar panel	150 W	DAS Energy Ltd., Austria	Polycristallin Silizium
Solar accumulator	12V @ 50Ah	Solarakku 12 V 60 Ah GNB Sonnenschein	Heavy Duty Lead Accumulator
Power outlet	3 x 5V @1A	-	USB Standard

Alternative sources of energy could be based on pedal power (bicycle powered generator) or wind power. In case of photovoltaic, a minimum of 100 W peak power should not be undercut.

Figure 4: Electronic compartment, charging outlets

.3 *Execution*

Before implementation, a calculation of required daily power demand was conducted. Following the demand calculation, the available solar panels and accumulators were chosen. The flexible solar panel was used due to the low weight and easy implementation into the design. The panel itself is only 0.8mm thin (no aluminum frame) and weights 3.5 kg. The panel was mounted onto a circular/cylindrical shaped wooden frame, it is kept in place by aluminum clamps. Cables run down the main pole to the lower compartments. The battery compartment is placed on the lowest point of the table and contains a battery and a charging controller. A temperature fuse is placed on top of the battery and serves as security feature against fire.

.4 *Challenges*

An initially acquired solar panel had to be replaced. The panel had a lower power output (only 115 W) and a lower open collector voltage. The voltage of 15.5V was not compliant to the standards used by charging controllers broadly available in the market. The minimum open collector voltage of a solar panel needs to be 2V above the end-charging voltage (=14.4V) of any 12V lead battery.

4 Software

.1 *Concept*

The mesaSolar houses a measurement box for environmental monitoring. It contains a Raspberry Pi 2 that controls some sensors and relays. It displays the collected data on an LCD screen and sends them to the cloud. The sensors measure temperature, humidity, light (photoresistor) and current (power consumption) of the LED. The LED is switched on by the Raspberry Pi via a relay, depending on the lighting conditions and time. Additionally, it can be switched on by pressing a light switch, which triggers a timer circuit that switches on the LED after 5 minutes. The mesaSolar also houses a WiFi router for free public WiFi.

The sensors and relays are controlled with scripts written in Python and C. We used cron jobs to execute the scripts regularly. Data is collected every minute and written to the LCD screen as well as sent to a ThingSpeak online application. Following a request by the current users of the mesaSolar we created a public channel in the ThingSpeak application and placed a QR code on the table for viewing it.

.2 *Functions*

We created a plug-and-play shell script system that is triggered by cron jobs. There are scripts that control the input and output of the Raspberry Pi and some that manage data storage, display and transfer. We use HTTPS requests to send the data to our ThinkSpeak online account.

A big advantage of using cron jobs and one single script per sensor is the adaptability of the system. Even people unfamiliar with software design can buy a sensor, download a script from the Internet and plug it into our script system. Similarly, maintenance is easy in case we want to replace a sensor with a different one.

The Raspberry Pi is connected to a separate protected WiFi network on the same router that also provides the free open access. A firewall prevents unwanted access attempts to the Raspberry Pi.

.3 *Execution*

We were an inhomogeneous and changing team with a small stable core. Therefore, it was very useful to create tasks in gitlab and regularly commit our code into an open source repository. We met once a week for a few hours in Metalab over a period of 6 months. Depending on the skills of the people present we worked more on the electronics, on the software or on the Linux and WiFi router configuration.

.4 *Challenges*

For most sensors we could find scripts online that just needed a few adaptions and configurations on the Raspberry Pi. But not all sensors were so well supported. We wanted to use a UV sensor to measure the lighting conditions. We tried a bunch of scripts, read the data sheet and wrote our own script, but the sensor refused to return reasonable values. In the end we opted for a simple photoresistor that should fulfill our purpose.

5 Environmental Measurement Unit and Lighting Control

.1 *Concept*

The mesaSolar can function as measurement hub for environmental data such as temperature, humidity, irradiance, wind speed, CO_2, NOx, SOx, fine dust, noise etc. The LED lighting switches on and off depending on the surrounding situation, be it irradiance levels or people present at the mesaSolar, and can also be controlled by the users themselves. The measuring unit is set up in a plastic hard case with a simple buildup.

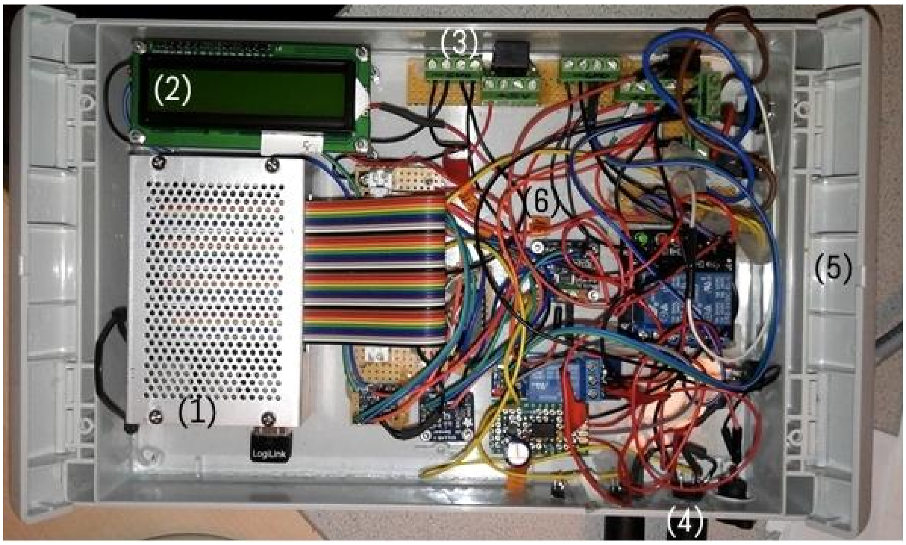


Figure 5: Main electronics

1) Raspberry Pi 2/3
2) Display for data output
3) Power supply (DC-DC)
4) Sensor input
5) IP65 casing
6) AD converter, relay, various auxiliary electronic

.2 *Functions*

An AM3201 sensor is used for measuring temperature and humidity. A 4-channel logic level converter connects the sensor break-out data to the raspberry pi. The sensor itself is mounted underneath the table and connected to the housing via mini-din cable.

To ensure low energy use as well as user-friendly behavior of the installation, the LED lighting can switch on and off automatically depending on levels of irradiance and time of day. As mentioned before, the SI1145 UV sensor could not be ported to Raspberry Pi. The LED switches on and off automatically depending on the measured voltage passing through a photoresistor. As a photoresistor has a specific current curve, it can function as a switch but cannot provide reasonable irradiance data. A manual switch based on a push button connected to the precision timer NE555P that controls a relay is built in to provide the users with individual control.

.3 *Data output*

The data output was built on the premise of "easy access". A simple 2-line display placed in the electronic box on top of the table should provide basic sensor data without requiring any user interaction. The display has backlight and continuously displays data from all sensors.

Figure 6: Data output

The second path for data output is the webservice thingspeak, all our sensors data is mirrored online. The data is publicly available.

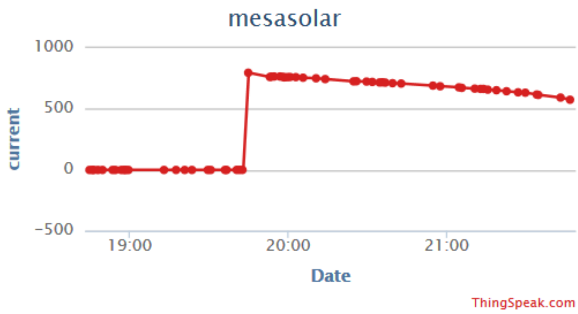


Figure 7: Dataoutput current sensor

https://thingspeak.com/channels/307375

Channel ID: 307375

Author: iogamesasolar

Access: Public

.4 *Execution*

Installing the temperature and humidity sensor was relatively straightforward. There are a lot of examples on the internet. The sensor and all corresponding circuitry could also be tested very well indoors. The sensors are also rather cheap compared to others.

The photoresistor circuit is mounted next to the PV-panel to ensure that shading does not affect it. The cable runs down along the main beam into the measurement box. Data is passed to the Raspberry Pi via an analog-digital converter. When a defined threshold is reached, a pin on the Raspberry Pi is set to high and the relay switches on. A separate relay is used for the manual switch so that the circuits can work independent of each other. The NE555P precision timer had to be incorporated in a circuit as shown below.

.5 *Challenges*

There were few challenges with the temperature and humidity sensor. They were mainly about getting the data to show up on the LCD-screen in the desired manner. As for all the project components, it should be noted that it is very important to have at least two sets of the same components. In that case it is possible to work and test in parallel. In our case, we could test scripts and circuit options only one after the other and had to decide whether soldering or code testing is done first. It is also very favorable to have a systematic approach, tie up wires and label all connections and pins. If this project were developed into a full-fledged consumer product all the circuits would certainly be printed on one PCB.

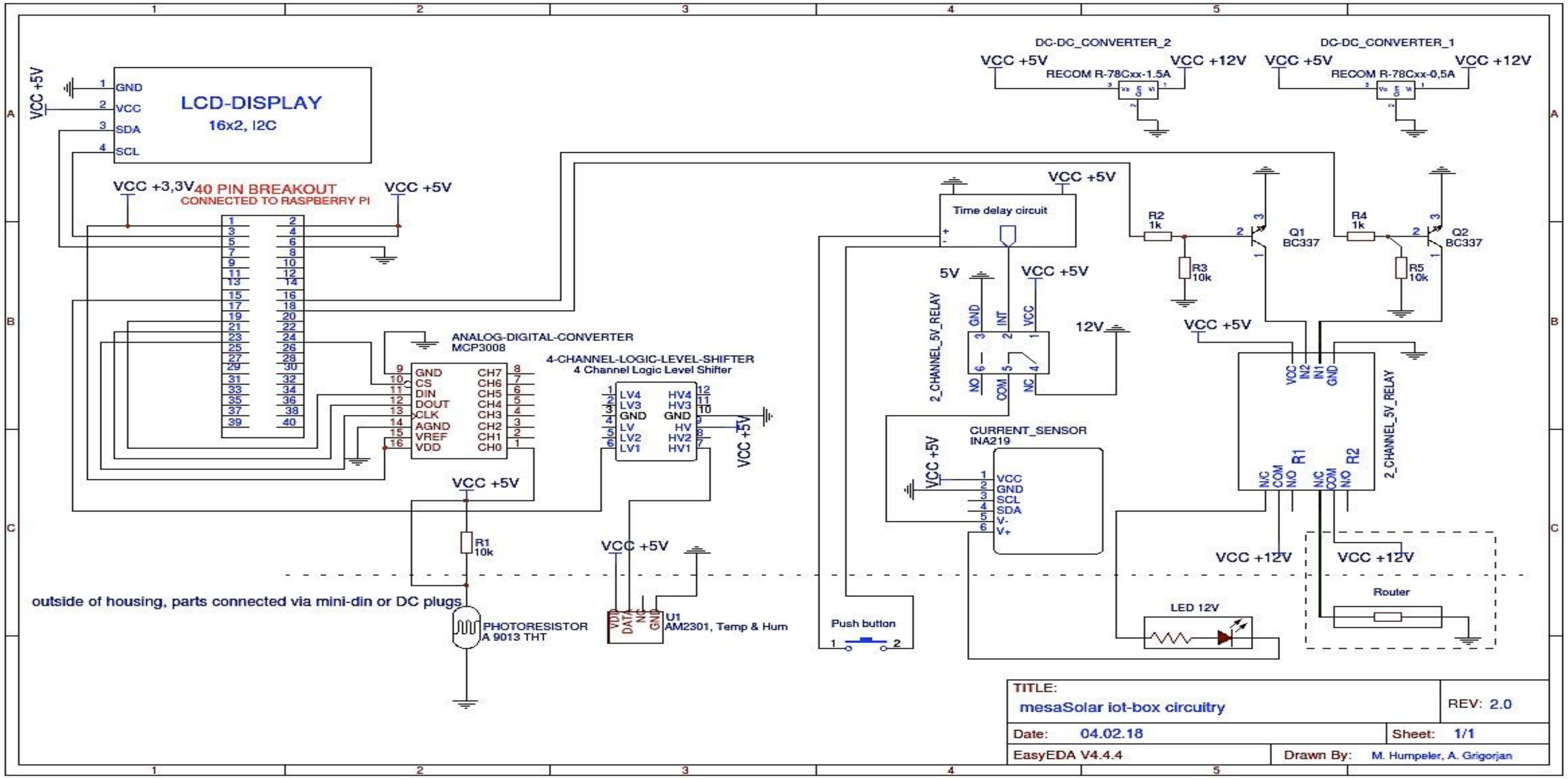
The option to switch the light on and off automatically depending on time of day could not be implemented in a satisfactory manner. The time received from the Raspberry Pi depended on the Raspberry Pi being connected to the Internet all the time. In case it disconnected, the time forwarded to the script, which then controlled the relay was off. The same was true for the router as mentioned above.

In general, a course or workshop in soldering basics is a good point to start of the project. Soldering skills should be perfected along the whole project development. Always read the technical data sheets before you connect components, even if you feel sure that you are doing it right. Components may look the same, but have different pin assignments (and then burn out). Always keep the space inside the housing in mind and think about how you will mount all the components.

The electric components for the measurement box are listed in the annex (in German). They cost around 400 Euro. We got part of them sponsored and bought the other part from local suppliers. We used the Raspberry Pi for easier handling, but in case of integrated circuits cheaper systems with less options tailored towards the functions provided would work as well.

6 Annex (all)

.1 *IOT-box electronic schematic*



.2 *Component list*

Components for iot-box	Number of components bought
LED Strip 17cm, 10-12V, 600mA, 7W, 5000K	1
Raspberry Pi B+	1
Heatsink Aluminium Set	1
Heatsink Copper	1
Netzwerkkabel 3m CAT5	1
LCD 16x2 i2c Modul	1
AM2301 DHT21 temperature humidity sensor	1
Aluminium Gehäuse	1
GPIO ribbon cab	1
Pi T-Cobbler 40 Pin	1
Breadboard 830 Pins	1
Dupont Jumper Wires 65 Stück	1
Sil-Siff Silikonkabel für außen (Meterware)	6
Wasserdichter Kabelverbinder 3-Pol	1
Sandisk Microsdxc-Karte 64GB	1
4 Channel Logic Level Converter	1
INA219 High Side DC Current Sensor Breakout 26V	1
2 Channels 5 V Relay Module	1
SI1145 Digital UV Index / IR / Visible Light Sensor	1
Bocube G B 261706 PV-V0_G RAL7035 D KLAR / 706934	1
Mini-Din-Stecker 4polig / 732010	3
DC/DC-Wandler Innoline R-78E5.0-0.5 SIP3/ 157954	2
Datenkabel 2x2x0,6mm 10Mbps / 1180013	5
Euro-Platte 160x100 Punktraster / 530753	1
Netzgerätestecker XNES/J210 schwarz / 738688	1
Netzgeräte-Einbaukupplung / 738687	1
Mini-Din-Steckdose 4pol senkr. Montage / 738398	3
Wippenschalter R13-213A-03 SW / 700977	1
Leiterplattenhalter MMR5 / 534191	15
10er Zylinderschr.DIN84 Kunststoff M3X15 / 815810	1
10er Kunststoff-Sechskant-Mutter M3 / 815969	1
Datenleitung Unitronic Liycy 4x0,14 / 601601	1
Stahl-Gewindestange M2x500MM / 237230	1
Druckschalter R13-23B-05 SW Tast / 701054	1
100er Sechkant-Mutter verzinkt M2 / 815608	1
DC-Stecker 2,1MM/5,5MM/9,5MM gerade / 530391	1
Einbaubuchse mit Schaltkontakt 5.5/2.1 / 733946	1
Printklemmenblock MKDS 1,5/4-5,08 / 743477	1
Printklemmenblock MKDSN 1,5/3 / 743531	1
Löt-Schraubklemme Liftprinzip RM2.54 / 567757	2
Löt-Schraubklemme Liftprinzip RM2.54 / 567615	2
Fotowiderstand A 9013 / 145475	1

Transistor TIP110 T0220 / 161683	1
DC-Stecker / 530391	1
Einbaubuchse mit Schaltkontakt 5.5 / 733946	1
PIR Sensor SER00166	1
LCD 20x4 i2c Modul SER00014	1
Spannungsregler L78S05CV T0220 STM / 179345	2
DC/DC-Wandler R-78B5.0-1.5L	1
Logilink Wlan USB 2.0 Nano Adapter 150 / 987133	1
Renkforce USB2.0 OTG Kabel Micro-B/A-BU / 1360259	1
DC/DC-Wandler R-78B5.0-1.5L	1
Miniatur Kippschalter (2pol) / 172226	1
Batterieklemme abgewinkelt / 841375	1
Transistor BC337-40(TO-92) / 140536	5
Fotowiderstand A 9013 / 145475	1
IC-Fassung 16polig / 189529	1
IC ADC MCP3008-I/P PDIP-16 MCP / 651456	1
MET.-WID 1/4W 1K 1% / 1089968	5
MET.-WID 1/4W 10K 1% / 1089968	5
MET.-WID 1/4W 10M 1% / 1090144	20
IC NE555P DIP8 TID / 152184	1
Elko Rad 105°C 0,22uF 50V RM1,5 / 445684	1
Feuchtraum Taster mit Kontrollleuchte / 620148	1
NE555P Timer / SER90008	1
Channel 5V Relay / IS120710007	1
Channel 5V Solid State Relay / SER00558	1
12V Coldwhite LED	1
Elko 1000uf 6,3V / SER00417	1
Kondensator 10nF 50V / SER00530	1
Diode Small Signal 1N4148 / SPC08588	1

.3 *Software concept*