Van Er Vento - Electronics

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This document serves to preset the concept for the electronics for a camper.
Here, several possible solutions are evaluated.
The goal is to find the easiest and also most cost effective approach.

Introduction

The idea is to have a simple and nice solar system for Robertas van.

Solar panels

The idea is to use tape to mount felxible panels on the roof

KISS - the most simple way.

The amount of panels should be low, big panels > small panels.

Though, bigger panels are more expensive, so most likely we go with ~ 100 W Panels.

Table 1: Deciding which kind of solar panel

CIGS	Flex	Glass
bigger	smaller	smaller but thicker
less efficient	efficient	efficient
hotter	cooler	cooler
lightweight	heavier	very heavy
easy to mount	easy to mount	difficult to mount

Specification of the Solar panels

The Specs should be:

- High efficiency (because of limited space)
- operating voltage above battery voltage
- Power => Surface area

Electically, we assume that the System batter is around 24 Vdc, means 20 V to 30 V.
Flex Panels are recommended for their robustness and efficiency, even though they are more expensive than the other options.

Solar module	mean Voltage	min Voltage	max Voltage	Power
Flex	30 V	24 V	100 V	min. 400 W

Example Proposition

Price should be ideally around 50 € / 100 W.
For the price to be that low, we cant use big panels, but several smaller ones.

520W Flexibel Solarmodul 4*130W Solarpanel Mono Camper Wohnmobil Balkonkraftwerk

Figure 1: 4x 140 W Flex Panels

Roof Mounting Proposal

Goal is to keep the Van watertight and using inexpensive materials with no high effort. That said, it is possible to create watertight long-life bolt-through connections, but that can be quite hard, and can be avoided.

Table 3: Solving the mounting challange

Problem	Fix/ Workaround
Uneven Surface	
Heat	Gap between Roof and Module

Usage of sticky tape and plastic sheet base

As shown in Tutorial RV-Mounting Panels

1) Avoiding the need to drill holes for the panels -> use sticky tape

The tape should be around the modules to keep them fixed - the tape to be used is for roof application.

- EternaBond RSB-6x50 Dachdichtungsband für Dach Wohnmobil wasserdicht Abdichtband für Kunsttoffdach 10cm breit
- 3M VHB Tape Montage Klebeband

The cables should be taped down with single-sided tape, the panels and the plastic sheets with double-sided tape.

Figure 2: single-sided roof sealing tape and double-sided tape

2) Uneven surface and heat & water buildup -> use plasic base

To place the Solar modules on a spacer prevents heat and water buildup under the panel. This is to keep an air gap for cooling and to create a even surface.

- Corrugated Plastic Sheets
  Kunstoffplatte
  colorful plastic sheets:

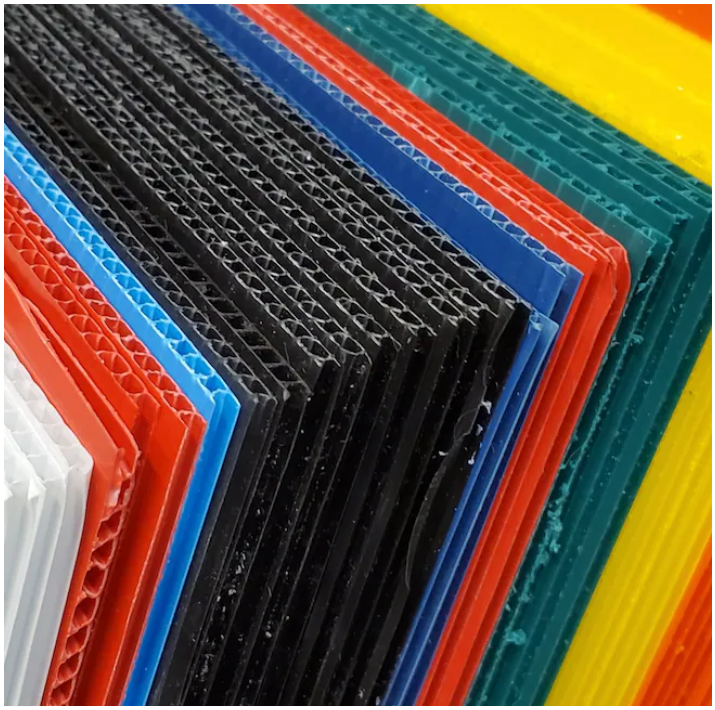

Figure 3: corrugated plastic-sheets

Cable duct through the roof

One hole is required to guide the cables into the van. A professional cable through is proposed:

As shown in Tutorial installing a roof-cable-duct

- Scanstrut DS-HD6 Dachdurchführung Kabeldurchführung

Figure 4: cable duct

Battery considerations

Recommendation: 24 V LiFePo4 Block

Type

Regarding the Type or Chemistry of the battery: I would recommend getting a LiFePo4 (Lithium Iron Phosphate) Battery. The main reason is:

- Safety (no thermal runanway possible)
- Many charge and discharge cycles, so that it doesnt have to be thrown away in a few years, reducing trash
- Its more lightweight than lead batteries (ist a bus - need to not exceed max. road legal overall weight)

Comparison LiFePo4 - Li-Io - Lead:

- LiFePo4 is more expensive than lead batteries but higher charge-discharge cycles
- LiFePo4 less expensive but heavier than Li-Io

Table 4: List of Types of Batteries

Type	Pros	Cons
Lead-Acid	cheap	low cycle n, heavy, big, need maintenace
AGM	cheap	low cycle n, heavy, big
Li-Io	small	expensive low cycle n, dangerous
Li-FePo4	medium weight	high cycle n

Voltage

Because the electronic devices running on 24 V are the least expensive for power usage of around 200 W usually, and rarely at a maximum of 2 kW. So thats my recommendation for the voltage level.
Personally i would use 48 V for higher power transfer efficiency, but here, as lights, fridge and laptop is the power consumption, i would propose to use 24 V.
A 12 V System would mean that very high current is necessary to run at the peak power consumption, which is not good.

Type related safety system: integrated BMS

So, to make it easy and least expensive, a 24 V Battery with integrated BMS (Battery Management System) is proposed.

The BMS will shut down the Battery in case of a fault:
* Overcurrent * Overtemperature * Overdischarge * Overcharge

The BMS is the last safety barrier, so the external electronic modules are taking care that the limits are not reached.

Specification for the battery:

- Type/ Chemistry: LiFePo4
- Voltage: 24 V
- Capacity: 100 Ah
- Stored Energy: 2,4 kW

Buy or DIY

Table 5: Buy Batteries

Name	Voltage	Capacity	Price	Price per kW
Pylontech US5000	48 V	4,8 kWh	940 €	195,8 €/kWh
Langzeit LiFePO4	12 V	1,200 kWh	169 €	140,8 €/kWh
Langzeit AGM	12 V	1,200 kWh	123 €	102,5 €/kWh
Power Queen	24 V	2,4 kWh	428 €	178 €/ kWh

Table 6: Buy/ build from kit w/ cells

Name	Spannung	Kapazität	Preis	Preis pro kW
Basen Green Sheila	48 V	14,6 kWh	3500 €	240 €/kWh

Example diy kit:
Basen Green Sheila EU US Stock Lifepo4 Batterie kästen und Racks 51,2 V 48V 14 kWh 15kWh Gehäuse Leere DIY Metall batterie Zubehör

Buy recommendation

Get any 24 V 100 A Battery w/ BMS for the least amount of money:

2,4 kWh Battery: 24 V 100 Ah for 290 € on ebay

Figure 5: battery

Electronics, severeal discrete modules

Solar input

For charging the battery from the solar panels.

- MPPT (maximum power tracker) To regulate the solar input to the battery. This is DC, depending on the choice of module probable 20 Vdc to 100 Vdc.

Device Name	Input Voltage	Output Voltage	Notes
Solar Panels to Battery - MPPT DC-DC Converter	40 V	30 V	-

Recommendation: EPEVER VS6048AU

I have good experiences with that one, its quite reliable and survived several festivals since i bought it.

Figure 6: EPEVER_MPPT.png

Technical specifications

- Model of manufacturer VS6048AU
- Related Charge current 60A
- Max. PV open circuit voltage 96V
- USB output 5VDC/2.4A
- Nominal voltage 12/24/36/48V DC Auto
- Grounding Positiv
- Temperature -20°C bis +55°C
- Dimension 214 * 128,7 * 72,2mm
- Weight 1040g
- Enclosure IP30

Car generator input

The battery should be charged while driving:

- DC Charging Car engine generator DC converter For charging the system battery with the car engine/ generator. The input is arounf 14 Vdc.
  We have to take care that below 14 Vdc, the car engine/ generator is off, and we would use energy from the car battery, which we do not want to do. So the DC-DC Converter needs to bea switched on only when the input Voltage is above 14 Vdc.

Device Name	Input Voltage	Output Voltage	Notes
Car to MPPT DC-DC Converter	12 V	30 V	off below 14 V input Voltage

There is a high power DC-DC converter:

- Product name: High-power non-isolated DC boost module power supply.
- Product model: 100A2000W.
- Input voltage: DC12V-60V.
- Input current: 100A (maximum).
- Input power: 2000W (maximum).
- No-load power consumption: less than 2W.
- Output voltage: DC15V-80V.
- Output current: 50A (maximum).
- Output power: 1850W (maximum).
- Conversion efficiency: 92-96% (efficiency is related to input and output voltage and current).
- Working temperature: -20~50°C.
- Price: around 100 €

DC-DC Converterm, 100 A input, 2 kW, 100 on ebay

Figure 7: DC-DC 24V Geni to Bat

Utility (fridge) and lights output

To regulate the charging and discharging, some electronic functions, in discrete/ seperate modules or integrated in one module, have to be implemented:

- Load output - battery discharge protection The lights and the fridge should run on DC power from the battery. To run them on 230 V means one conversion step that can be ommited. More conversion steps is less efficient than running the fridge an the lights on the battery directly.

The MPTT Tracker has such an Output, this will be used.

MPTT Tracker with Load output

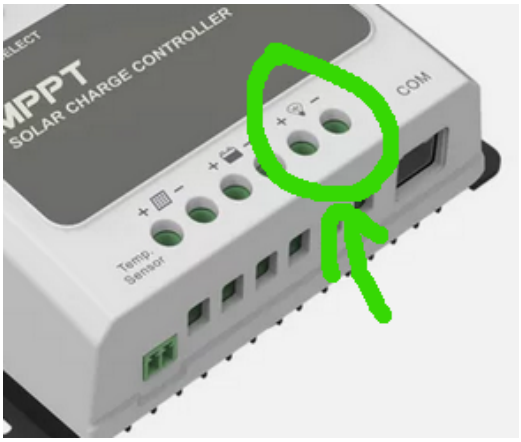

Figure 8: example MPPT Load Output

See Specs VS6048AU - 60 A Output.

eBike charger, using another MPPT

For efficient charging of the ebike, i would recommend to use a DC-DC charger instead of connecting it via the 230 Vac outlet.
Basically the same system consideration as with the lights and the fridge - less conversion steps means higher efficiency.
Instead of DC to AC to DC, we can use a DC-DC converter.

To save some money, we can go for another MPPT here, which meets our requiements of being a battery charger foir the eBike.

The ebike has a charging voltage of 36 Vdc (i think?). It should be charged from the battery which has 24 Vdc.

So the suggestion is, to use a MPPT tracker for this situation, because it is pretty cheap, and i have good experiance with it:

MPT-7210A Manual

Figure 9: second MPTT Solar Charge controller as eBike charger

Specs:

- Input voltage: DC12-60V
- Output voltage: DC24V-72V adjustable
- Output Current: 0-10A key adjustable
- Output Power: 600W max

230 Vac Inverter

For all devices that use a regular houshould plug, there should be a socket availible.

I do recommend a pure sine wave inverter to not destroy sensible loads. For Motors, sine wave is required anyway.

For example:

12V/24V/48V to 230v 800W/1500W/2000W/2500W/3000W wechselrichter reiner sinus

Figure 10: Inverter 254 Vdc to 230 Vac

Electronics, integrated MPTT and Inverter module

To save money and space, we can use onbe module which integrates the main electric components.

Main Specs would be:

- Battery voltage: 24 V
- Solar input: Anything above 24 V
- DC Load output
- 230 V Inverter

Recommendation: Easun 3200W Solar Off Grid Wechselrichter 24V 80A MPPT Ladegerät 230V mit WiFi

Price on Ebay is 190 €.

Device

Model: ISolar-SMG-II-3.2KW
Rated Power: 3.5KW

Input

Voltage: 230Vac
Selectable Voltage Range: 170Vac~280Vac) ±2% ; (90Vac~280Vac)±2%
Frequency Range: 50Hz/ 60Hz (Auto detection)

Output

AC Voltage Regulation (Batt.Mode): 230VAC ±5%
Wave Form: Pure Sine Wave

Battery & Solar Charger

Nominal Battery Voltage: 24VDC
Floating Charge Voltage: 27VDC
Overcharge Protection: 33VDC
Maximum Charge Current: 60A

Solar Charger

MAX.PV Array Power: 4000W
MPPT Range @ Operating Voltage: 55-450VDC
Maximum PV Array Open Circuit Voltage: 450VDC
Maximum Charging Current: 100A
Maximum Efficiency: 98%

Physical

Dimension (D*W*H mm): 330x278x98mm
Net Weight (kgs): 4.5kg
Communication Interface: RS232/RS485(Standard) / GPRS/WIFI(Optional)

Environment

Humidity: 5% to 95% Relative Humidity (Non-condensing)
Operating Temperature: 10°C to 55°C
Storage Temperature: -15°C to 60°C

Figure 11: MPTT & Inverter integrated module

Beispiel 2: POW-HVM2H-12V-N, pow-hvm3.2h-24v-n

Beispiel 3: VEVOR 2-in-1-Hybrid-Solar-Wechselrichter 3500W Solar Inverter Reiner Sinus MPPT

Beispiel 4: BlueWalker Inverter 3000 PWM, Wechselrichter

Housing and Cables

All electronics shall be in a nice case.

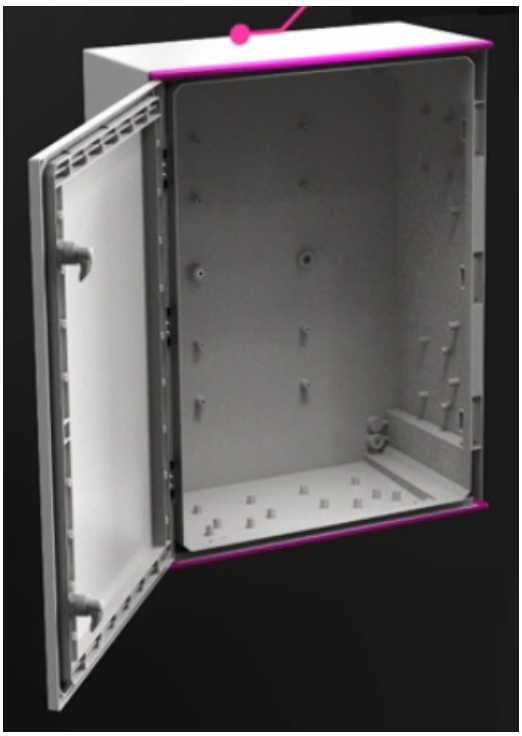

Figure 12: Example: Schaltschrank-AX-Kunststoff-250x350x150mm-IP66-Outdoor

Cables

Yes, we should specify them.

Schematic and system layout

The Drawing is created with KiCAD [1]

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Circuit Overview

Sheetfile: overview.kicad_sch

Sheetname: Block Diagram

Block Diagram

Sheetfile: block_diagram.kicad_sch

Sheetname: Material

Material

Sheetfile: Material.kicad_sch

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Sheet: /

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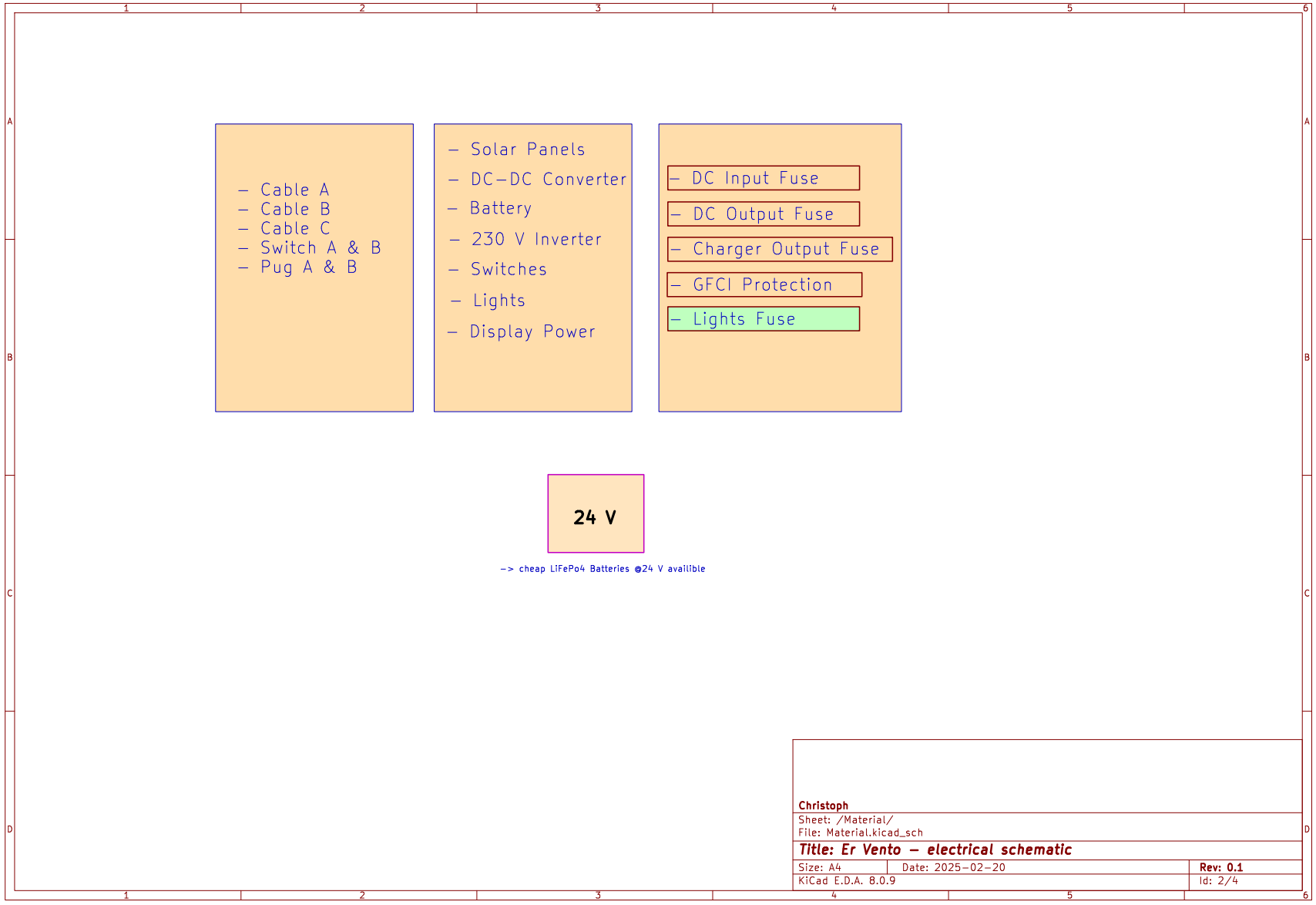
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– Cable B
– Cable C
– Switch A & B
– Pug A & B
– Solar Panels
– DC–DC Converter
– Battery
– 230 V Inverter
– Switches
– Lights
– Display Power
– DC Input Fuse
– DC Output Fuse
– Charger Output Fuse
– GFCI Protection
– Lights Fuse
24 V
–> cheap LiFePo4 Batteries @24 V availible
Christoph
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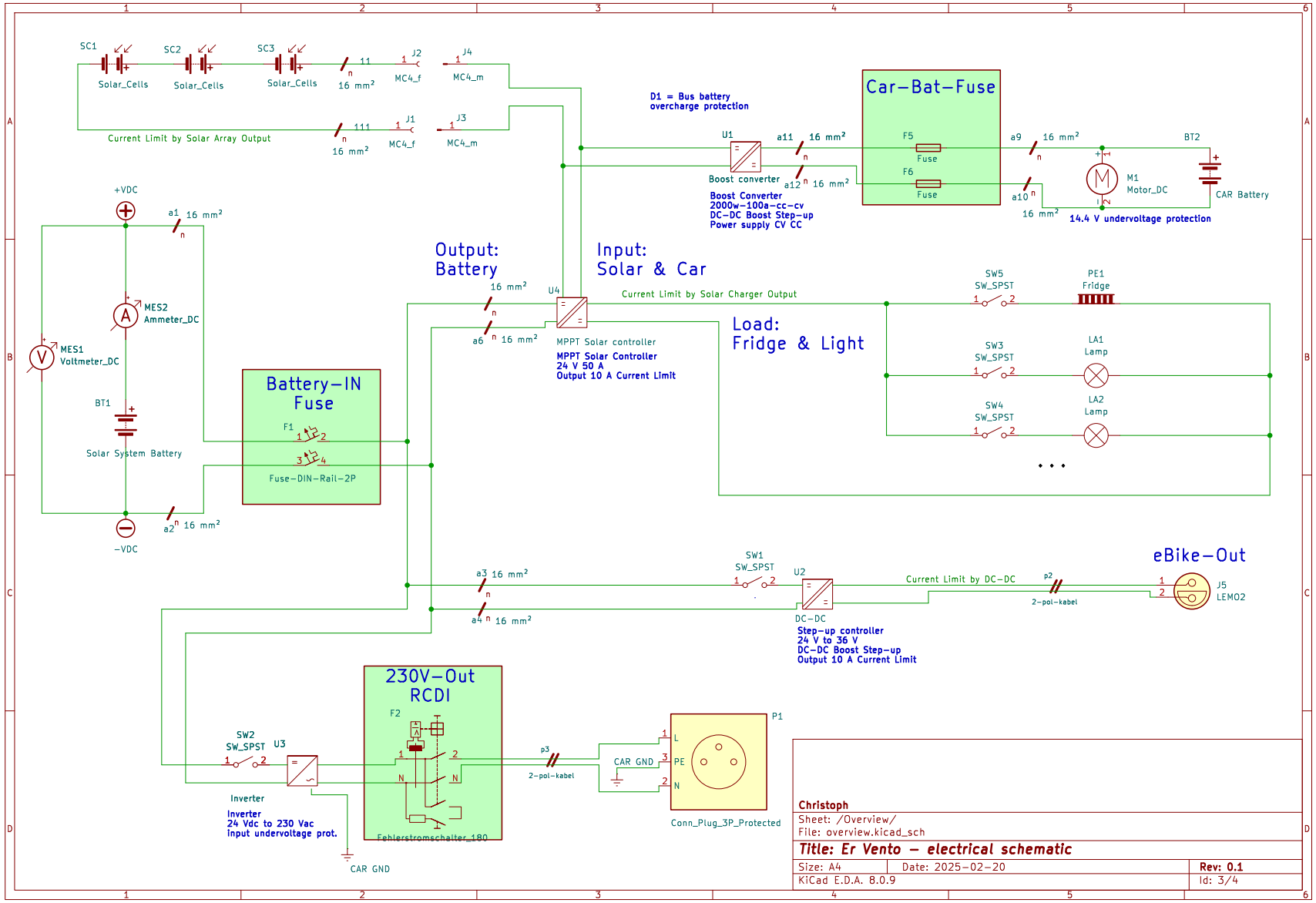
SC1
SC2
SC3
Solar_Cells
Solar_Cells
Solar_Cells
11
16 mm²
J2
MC4_f
J4
MC4_m
Current Limit by Solar Array Output
111
16 mm²
J1
MC4_f
J3
MC4_m
D1 = Bus battery
overcharge protection
U1
Boost converter
Boost Converter
2000w-100a-cc-cv
DC-DC Boost Step-up
Power supply CV CC
a11
16 mm²
a12
16 mm²
Car-Bat-Fuse
F5
Fuse
F6
Fuse
a9
16 mm²
a10
16 mm²
BT2
CAR Battery
M1
Motor_DC
14.4 V undervoltage protection
+VDC
a1
16 mm²
MES2
Ammeter_DC
MES1
Voltmeter_DC
BT1
Solar System Battery
−VDC
a2
16 mm²
Output:
Battery
Input:
Solar & Car
16 mm²
a6
16 mm²
U4
MPPT Solar controller
MPPT Solar Controller
24 V 50 A
Output 10 A Current Limit
Current Limit by Solar Charger Output
Load:
Fridge & Light
SW5
SW_SPST
PE1
Fridge
SW3
SW_SPST
LA1
Lamp
SW4
SW_SPST
LA2
Lamp
Battery-IN
Fuse
F1
Fuse-DIN-Rail-2P
SW1
SW_SPST
a3
16 mm²
a4
16 mm²
U2
DC-DC
Step-up controller
24 V to 36 V
DC-DC Boost Step-up
Output 10 A Current Limit
Current Limit by DC-DC
p2
2-pol-kabel
eBike-Out
J5
LEMO2
230V-Out
RCDI
F2
Fehlerstromschalter 180
SW2
SW_SPST
U3
Inverter
Inverter
24 Vdc to 230 Vac
Input undervoltage prot.
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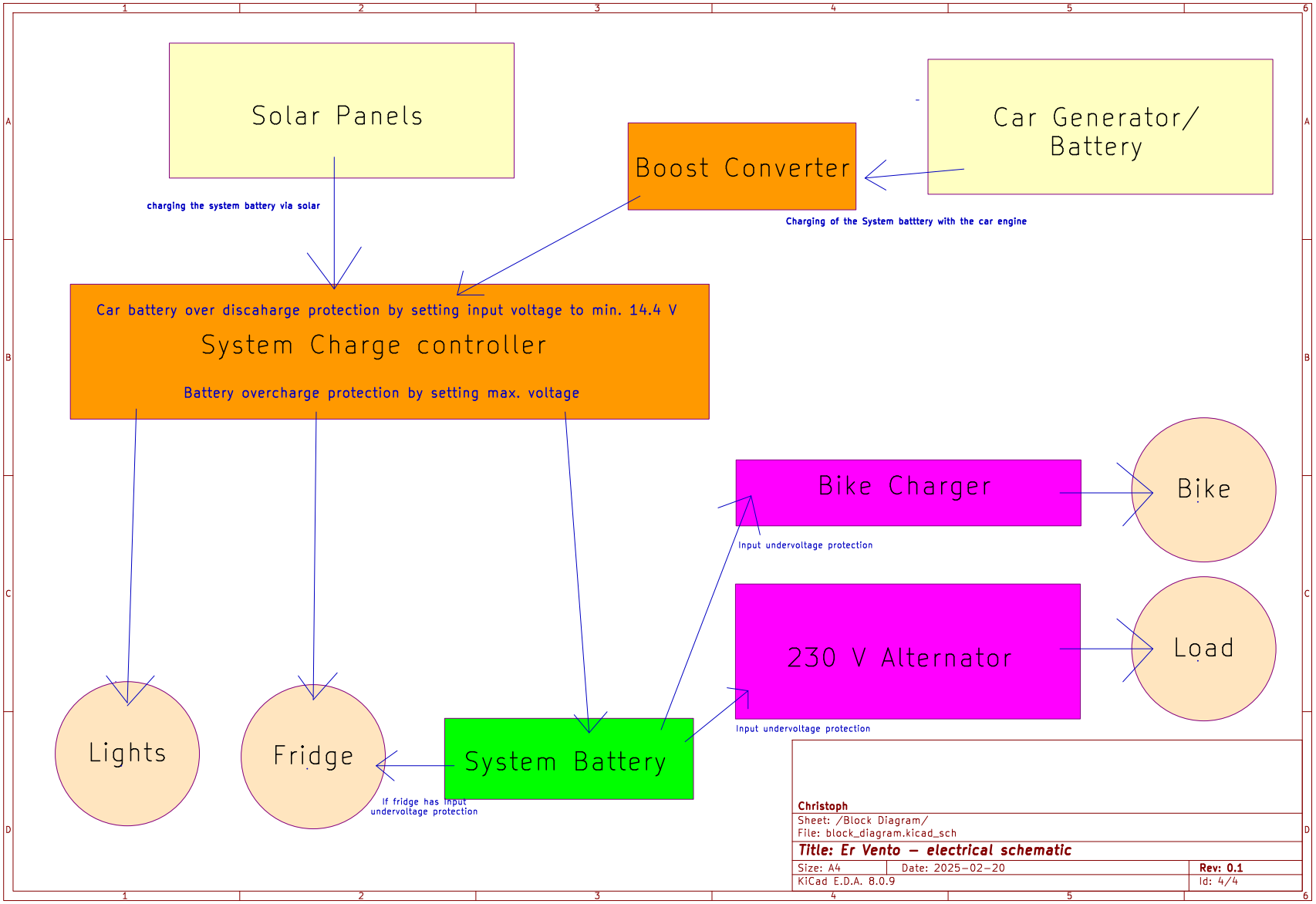
Solar Panels
Car Generator/
Battery
Boost Converter
charging the system battery via solar
Charging of the System batttery with the car engine
Car battery over discaharge protection by setting input voltage to min. 14.4 V
System Charge controller
Battery overcharge protection by setting max. voltage
Bike Charger
Bike
Input undervoltage protection
230 V Alternator
Load
Input undervoltage protection
Lights
Fridge
System Battery
If fridge has input
undervoltage protection
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Rev: 0.1
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Id: 4/4

Thanks

Thanks to Roberta for letting me participate in building something unique.

Citations and Quotes

[1] https://www.kicad.org/about/kicad/s, *Created with KiCad*. Available: https://www.kicad.org/