Disclaimer

All cables have been sized according to the conductor's 90°C temperature rating. If you use welding cable, the temperature rating of the conductor will be higher and smaller cables can be used. Make sure to look at the datasheet of the cable you will use before ordering it. You can find the table on calculating the wires here:

https://cleversolarpower.com/resources/

Sizing Wires and Fuses

I have made a complete guide on how to size your wire and fuses.

This is the method you will use for sizing the wire and fuse:

1. Figure out the current going through the wire, then multiply by 1.25
2. Decide the fuse size. This should be higher than the current from Step 1.
3. Decide the wire size. This is based on the fuse size. The fuse size should be below the maximum current of the wire.

To recap: fuse above normal current draw but below the wire rating.

How to size your wires:

https://cleversolarpower.com/calculate-wire-size-for-solar-system/

How to size your fuses

https://cleversolarpower.com/how-to-calculate-fuse-size-for-solar-system/

! If you have a 48V system, ensure you have fuses rated for 48Volts!

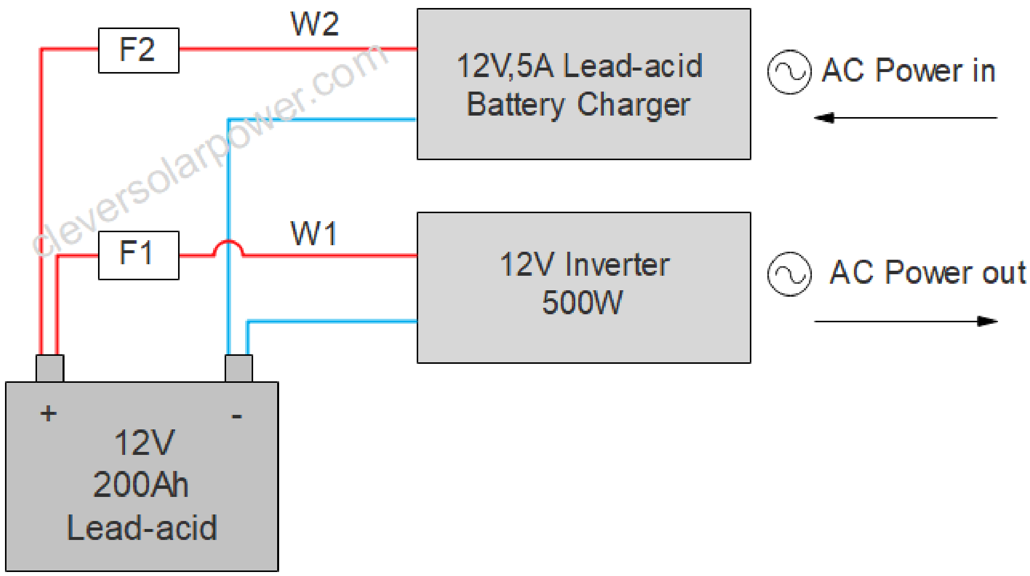
Systems in this guide

In the following systems, I will show you the diagram and why certain fuses and wire sizes are chosen. Everything will become clear if you read through these diagrams.

These are the systems included in this guide:

1. Emergency Backup Power System
2. Medium Solar System Backup
3. Small System with Solar Panels for Van or Small Cabin
4. Medium System for Cabin with Solar Panels for Fridge
5. Large system with 2kw of Solar and Server Rack Battery
6. 3kW Hybrid Inverter with 3kw Solar and 10kW Battery
7. 10kW solar, 5kw Inverter and 25kW Battery

1. Emergency Backup Power System



Uses

Used to power lights, televisions, and computers. This system is not able to power up refrigerators or microwaves.

Description

Since this will be an emergency system, we can use a lead-acid battery. This will reduce the price. We will have a 500W pure sine wave inverter and a lead-acid battery charger. This is an easy to make system with 8AWG (10mm²) and 16AWG (1.5mm²) wire. Keep the length of the wires as short as possible.

This system is sized correctly because we will have a maximum current draw from the inverter of 40 amps. The C-rate of lead acid is 0.2C (click here for more information about c-rate).

$$200Ah \times 0.2C = 40Amps$$

We can see that the current draw with 0.2C equals the current draw of the inverter. This will increase the lifespan of the battery.

Recharging the battery will take 20 hours, as you can see from the following calculation.

$$200Ah \times 12V = 2.400Wh$$

We need to divide the battery capacity by two because we can only use 50% of the battery because it's lead-acid.

$$\frac{2.400Wh}{2} = \frac{1200Wh}{(12V \times 5A)} = 20\ hours$$

Calculations

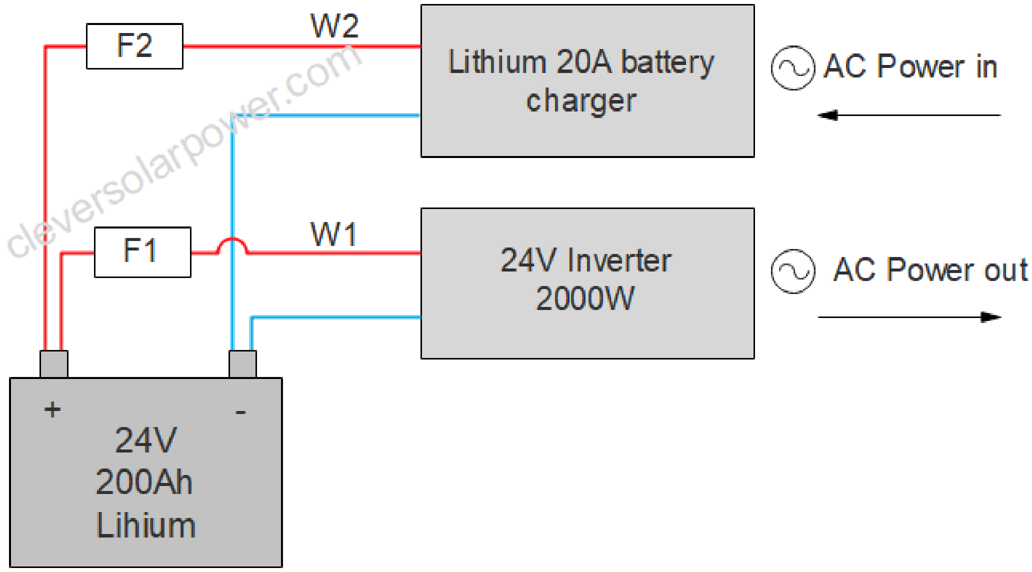
F1: $500W/12V = 41.6A \times 1.25 = 52A$ → 50A fuse

W1: 50A fuse → 8AWG or 10mm²

F2: $5A \times 1.25 = 6.25A$ → 10A fuse

W2: 10A fuse → 16AWG or 1.5mm²

2. Medium Solar System Backup



Uses

Used to power lights, televisions, computers, a fridge, and microwave.

Description

This system uses a lithium battery and uses 24V with a 2000W inverter. You can charge the battery with a lithium battery charger.

The reason why we choose a 24V system is to keep the current low. This will reduce the cost of the wire, and if you want to add solar panels later, it will reduce the charge controller by a factor of two.

The maximum current the inverter will draw is 83A. A lithium battery can deliver 0.5C, meaning a 200Ah battery can provide 100A of current easily.

$$200Ah \ \times 0.5C = 100A$$

Recharging the battery will take 10 hours, as you can see from the following calculation.

$$200Ah \ \times 24V = 4.800Wh$$

$$\frac{4.800Wh}{24Vx20A} = \ 10 \ hours$$

Calculations

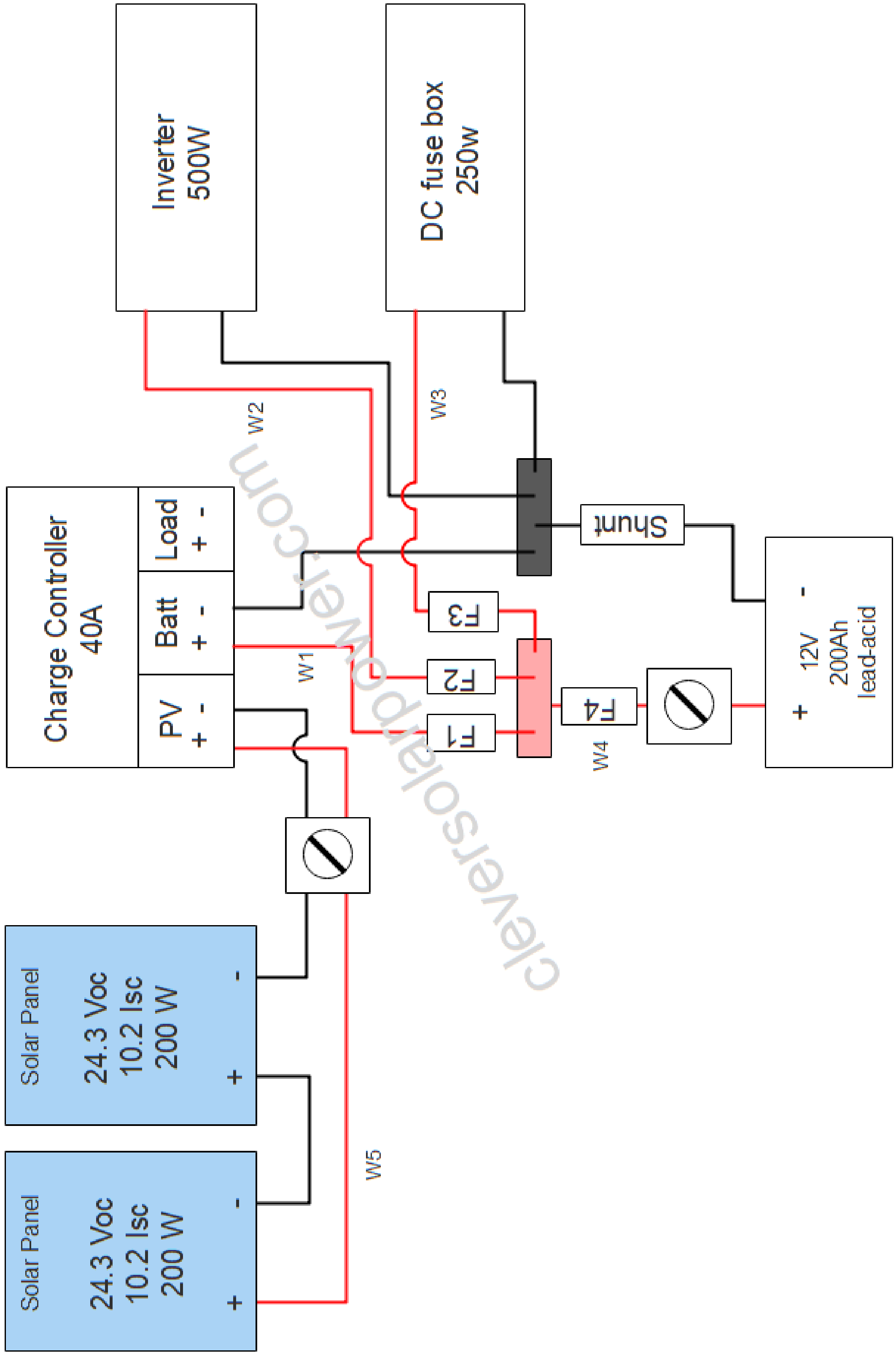
F1: $200W/24V = 83.3A \times 1.25 = 104A$ → 100A fuse

W1: 100A fuse → 3AWG or $35mm^2$

F2: $20A \times 1.25 = 25A$ → 30A fuse

W2: 30A fuse → 12AWG or $4mm^2$

3. Small System with Solar Panels for Van or Small Cabin



Uses

Used to power basics like lights and electronics. Not suited for fridge or microwave.

Description

This system uses a lead-acid battery and uses 12V with a 500W inverter. You can add a battery charger if necessary. In this example, we will add solar panels to charge the battery.

The maximum current the system will draw is 60A (750W/12V). A lead acid battery can deliver 0.2C of current to increase its lifespan. We will go a little over this value because you will seldom use the inverter and the 250W of DC simultaneously. We can be flexible in this.

$$\frac{60A}{200Ah} = 0.3C$$

It will take 3 hours to recharge the battery in full sun.

$$200Ah \times 12V = \frac{2.400Wh}{2} = 1.200Wh$$

$$\frac{1.200Wh}{400W} = 3\ hours$$

This makes the system correctly sized. You need to be able to recharge the battery in one day. One day equals 3 or 4 hours of direct sun on the panels.

Calculations

F1: $400W/14V = 33.3A \times 1.25 = 42A$ → 50A fuse

W1: 50A fuse → 8AWG or 10mm²

F2: $500W/12V = 42A \times 1.25 = 52A$ → 50A fuse

W2: 50A fuse → 8AWG or 10mm²

F3: $250W/12V = 21A \times 1.25 = 26A$ → 30A fuse

W3: 30A fuse → 12AWG or 4mm²

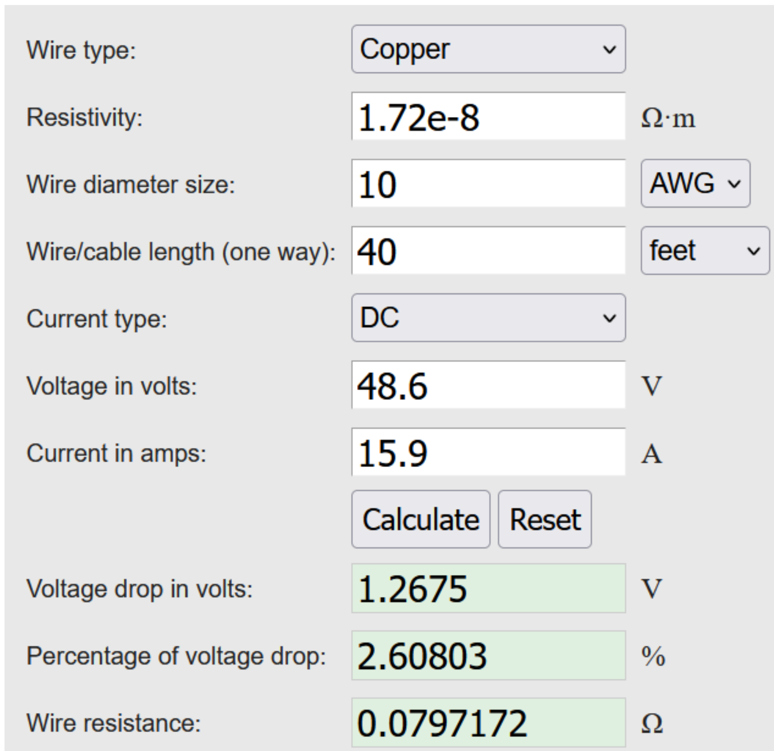
F4: $(500W + 250W)/12V = 62.5A \times 1.25 = 78A$ → 80A fuse

W4: 80A fuse → 4AWG or 25mm²

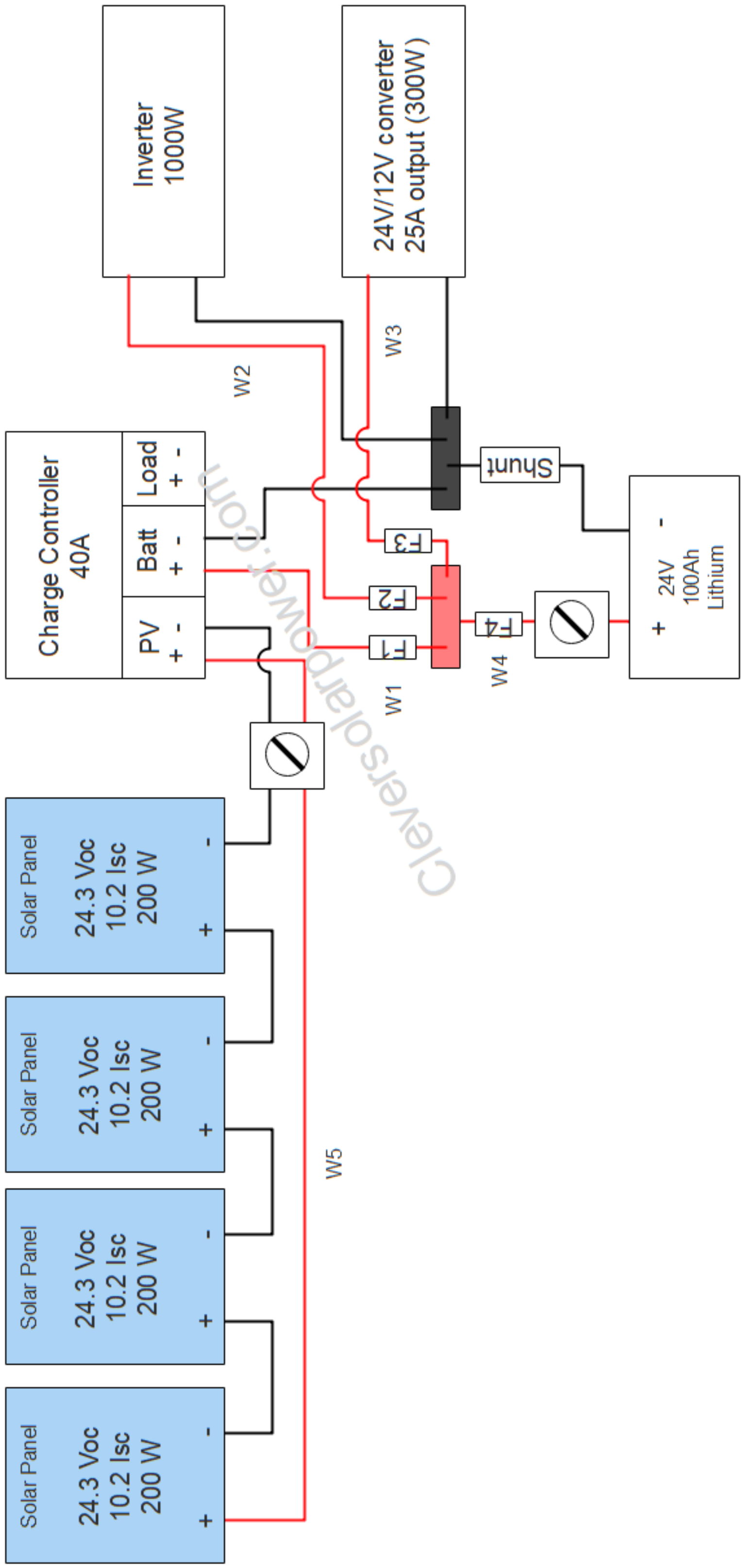
F5 (not neccesarry): $10.2A \times 1.56 = 15.9A$ → 20A fuse

W5: Use this voltage drop calculator.

We can see that we stay below 3% voltage drop, which is good. We will use 10AWG if the wire is shorter than 40ft or 12 meters.



4. Medium System for Cabin with Solar Panels for Fridge



Uses

Used to power higher loads like a fridge but no microwave, motors, or pumps.

Description

This system uses a lithium battery at 24V and a 1000W inverter. You can add a battery charger if necessary. In this example, we will add solar panels to charge the battery.

The maximum current the system will draw is 52A (1.250W/24V). A lithium battery can deliver 0.5C of current.

$$\frac{52A}{100Ah} = 0.52C$$

It will take 3 hours to recharge the battery in full sun.

$$100Ah \times 24V = 2.400Wh$$

$$\frac{2.400Wh}{800W} = 3\ hours$$

This makes the system correctly sized. You need to be able to recharge the battery in one day. One day equals 3 or 4 hours of direct sun on the panels.

Calculations

F1: $40A \times 1.25 = 50A$ → 50A fuse

W1: 50A fuse → 8AWG or 10mm²

F2: $1000W/24V = 42A \times 1.25 = 52A$ → 50A fuse

W2: 50A fuse → 8AWG or 10mm²

F3: $300W/24V = 12.5A \times 1.25 = 15.6A$ → 15A fuse

W3: 15A fuse → 14AWG or 2.5mm²

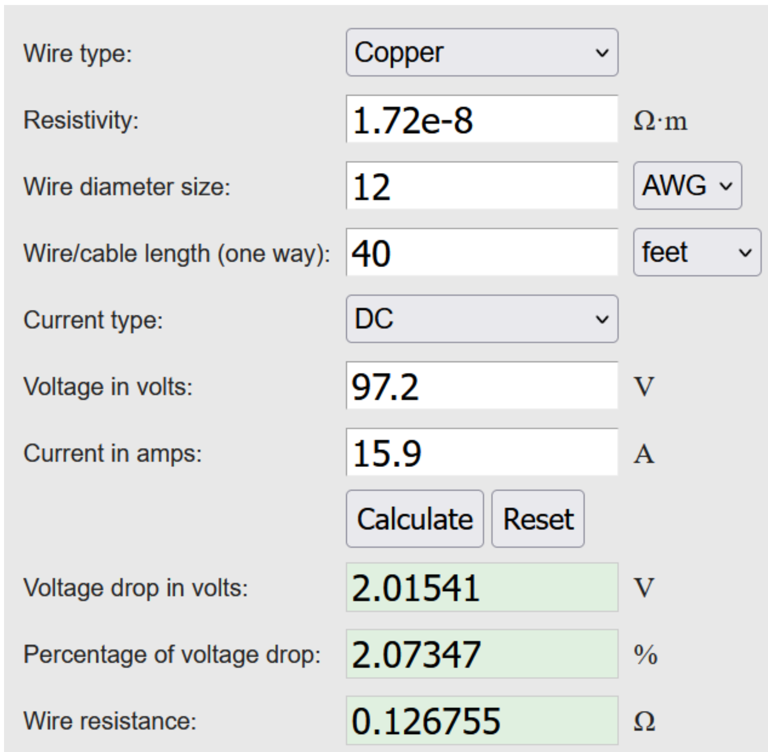
F4: $(1000W + 300W)/24V = 54A \times 1.25 = 68A$ → 70A fuse

W4: 70A fuse → 6AWG or 16mm²

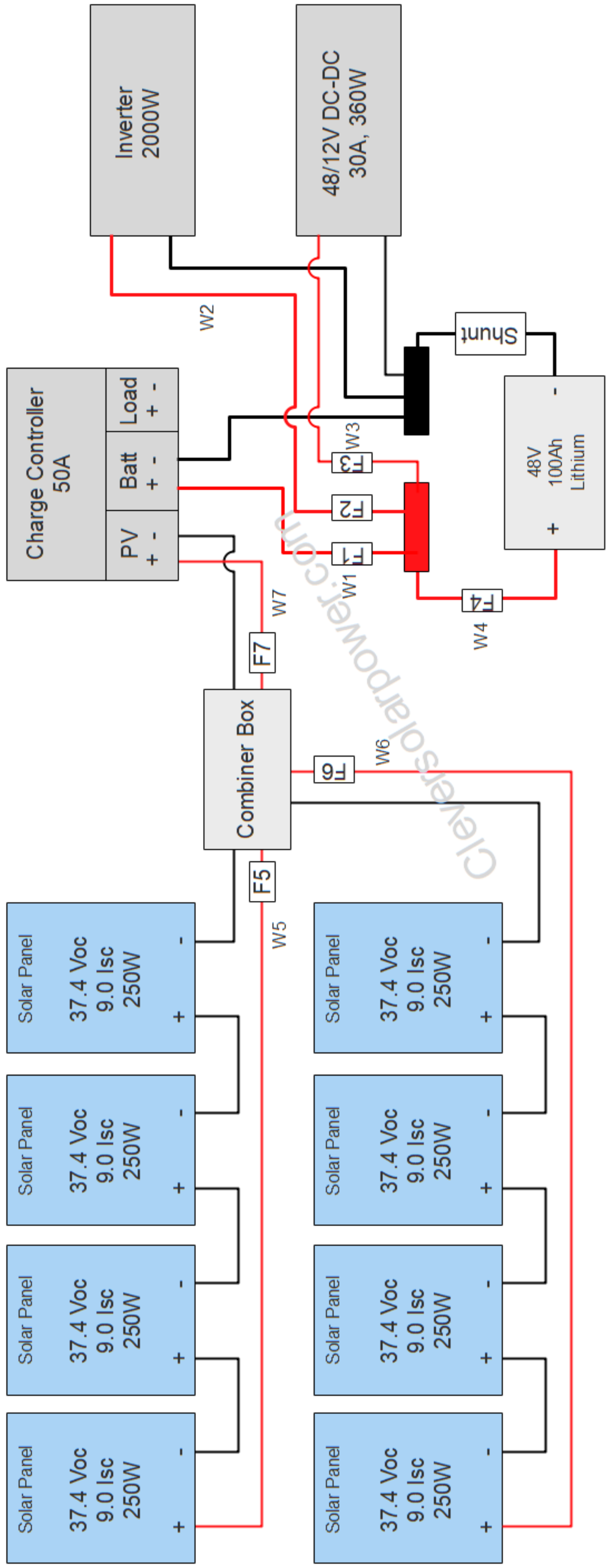
F5 (not neccesarry): $10.2A \times 1.56 = 15.9A$ → 20A fuse

W5: Use this voltage drop calculator.

We can see that we stay below 3% voltage drop, which is good. We will use 12AWG or 4mm² if the wire is shorter than 40ft or 12 meters.



5. Large system with 2kw of Solar and Server Rack Battery



Uses

This is a large off-grid system for a cabin. It is not an entire house system, but you can run appliances like a microwave, fridge, freezer, pumps, and small motors.

Description

This system uses a server rack battery. This battery is stackable and is easily expandable later. Because of the 48V, the current will be lower than a 24 or 12V system. This makes it possible to save money on wiring costs and charge controller.

The maximum current the system will draw is 50A (2.360W/48V). A lithium battery can deliver 0.5C of current.

$$\frac{50A}{100Ah} = 0.5C$$

Recharging the battery in full sun will take 2 hours and 24 minutes.

$$100Ah \times 48V = 4.800Wh$$

$$\frac{4.800Wh}{2.000W} = 2.4\ hours$$

This makes the system correctly sized. You need to be able to recharge the battery in one day. One day equals 3 or 4 hours of direct sun on the panels.

Calculations

F1: $50A \times 1.25 = 62.5A$ → 60A fuse

W1: 60A fuse → 6AWG or 16mm²

F2: $2000W/48V = 42A \times 1.25 = 52A$ → 50A fuse

W2: 50A fuse → 8AWG or 10mm²

F3: $360W/48V = 7.5A \times 1.25 = 9.3A$ → 10A fuse

W3: 10A fuse → 14AWG or 2.5mm²

F4: $(2000W + 360W)/48V = 49A \times 1.25 = 61A$ → 60A fuse

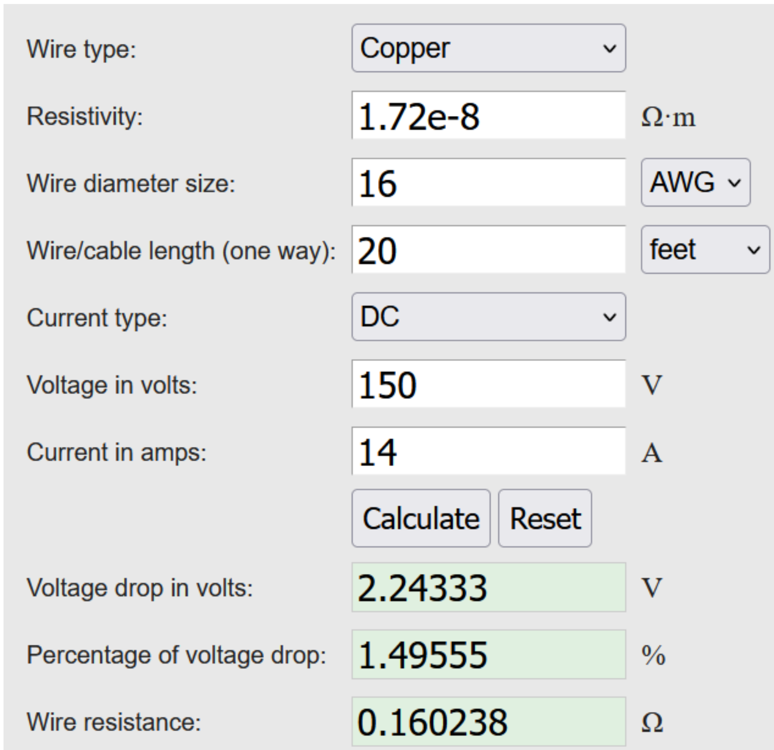
W4: 60A fuse → 6AWG or 16mm²

F5,6: $9A \times 1.56 = 14A$ → 15A fuse

Fuse 5 and 6 are placed inside the combiner box and then wired to F7.

W5,6: Use this voltage drop calculator.

We can see that we stay below 3% voltage drop, which is good. We will use 16AWG or 1.5mm² if the wire length is shorter than 20ft or 6 meters.



F7: $9A \times 1.56 \times 2\ strings = 28A$ → 30A fuse

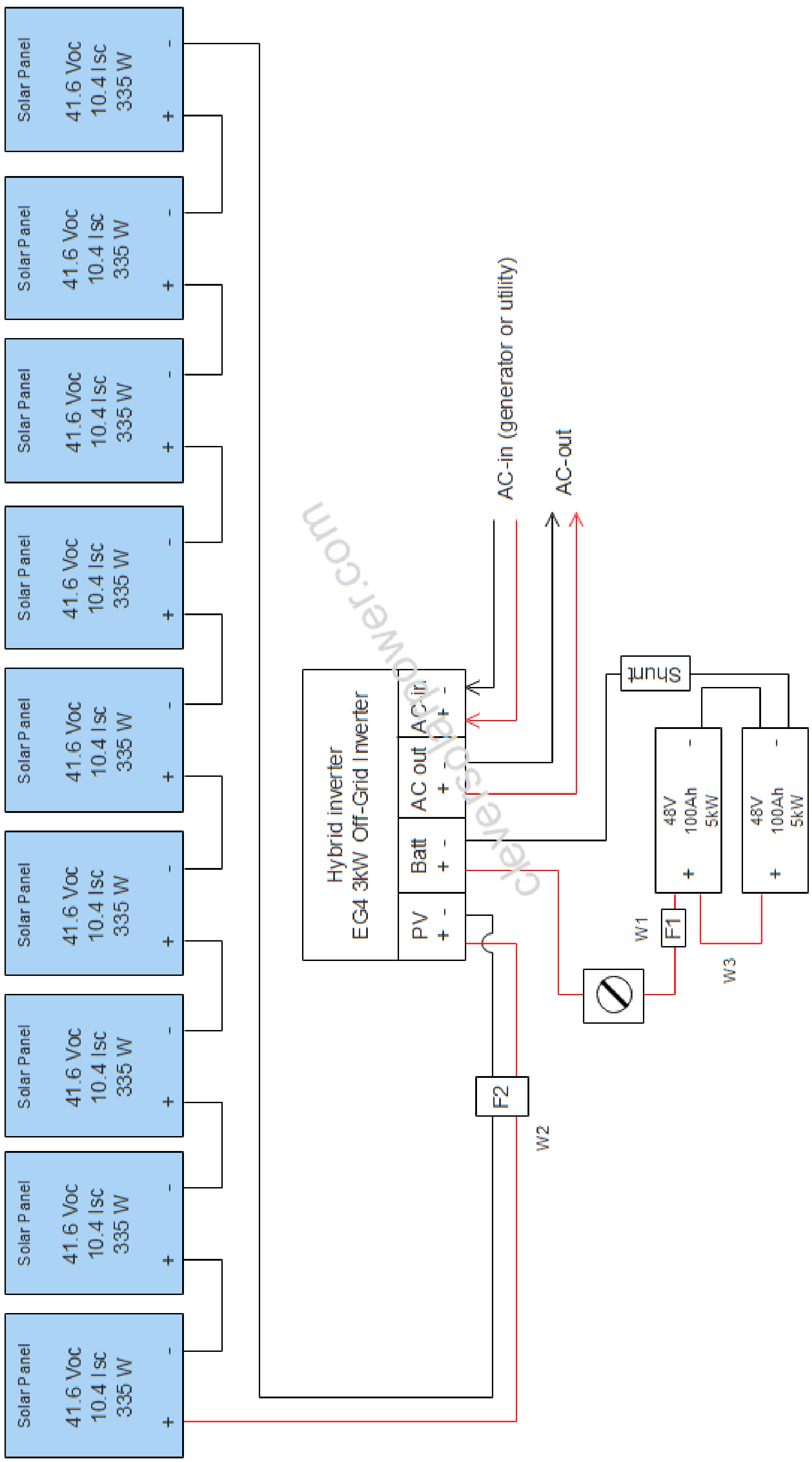
This can be a DC circuit breaker. If you have a circuit breaker, you don't need a solar disconnect switch anymore. These can all fit in the combiner box.

W7: Use this voltage drop calculator.

We can see that we stay below 3% voltage drop, which is good. We will use 12AWG or 4mm² if the wire is shorter than 40ft or 12 meters.

Wire type:	Copper	
Resistivity:	1.72e-8	Ω·m
Wire diameter size:	12	AWG
Wire/cable length (one way):	40	feet
Current type:	DC	
Voltage in volts:	150	V
Current in amps:	28	A
	Calculate Reset	
Voltage drop in volts:	3.54915	V
Percentage of voltage drop:	2.3661	%
Wire resistance:	0.126755	Ω

6. 3kW Hybrid Inverter with 3kw Solar and 10kW Battery



Uses

This system can be used for a luxurious off-grid property or an entire house system if you heat and cook on natural gas. This system will be compact because of the hybrid inverter. It has a high solar input voltage so that we can wire many panels in series.

Description

This system has 3kW of solar and a 3kW hybrid inverter. It has two lithium server rack batteries, with each a storage capacity of 5kW.

The maximum current the system will draw is 62A (3kW/48V). A lithium battery can deliver 0.5C of current.

$$\frac{62A}{200Ah} = 0.31C$$

Recharging the battery in full sun will take 3 hours and 12 minutes.

$$200Ah \times 48V = 9.800Wh$$

$$\frac{9.800Wh}{3.000W} = 3.2\ hours$$

This makes the system correctly sized. You need to be able to recharge the battery in one day. Depending on your location, one day equals 3 or 4 hours of direct sun on the panels.

Calculations

F1: Which one is greater? Solar power or inverter? In this case, the solar power will be greater. Thus, we calculate according to solar power.

$3015W \times 48 = 63A \times 1.25 = 78A$ → 80A fuse

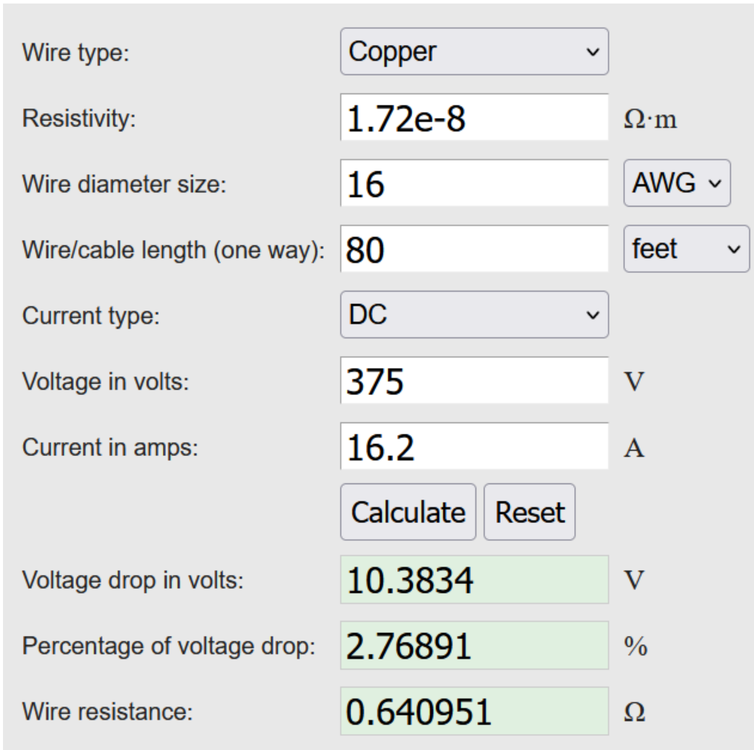
W1: 80A fuse → 4AWG or 25mm²

The cable interconnecting the batteries needs to be the same size.

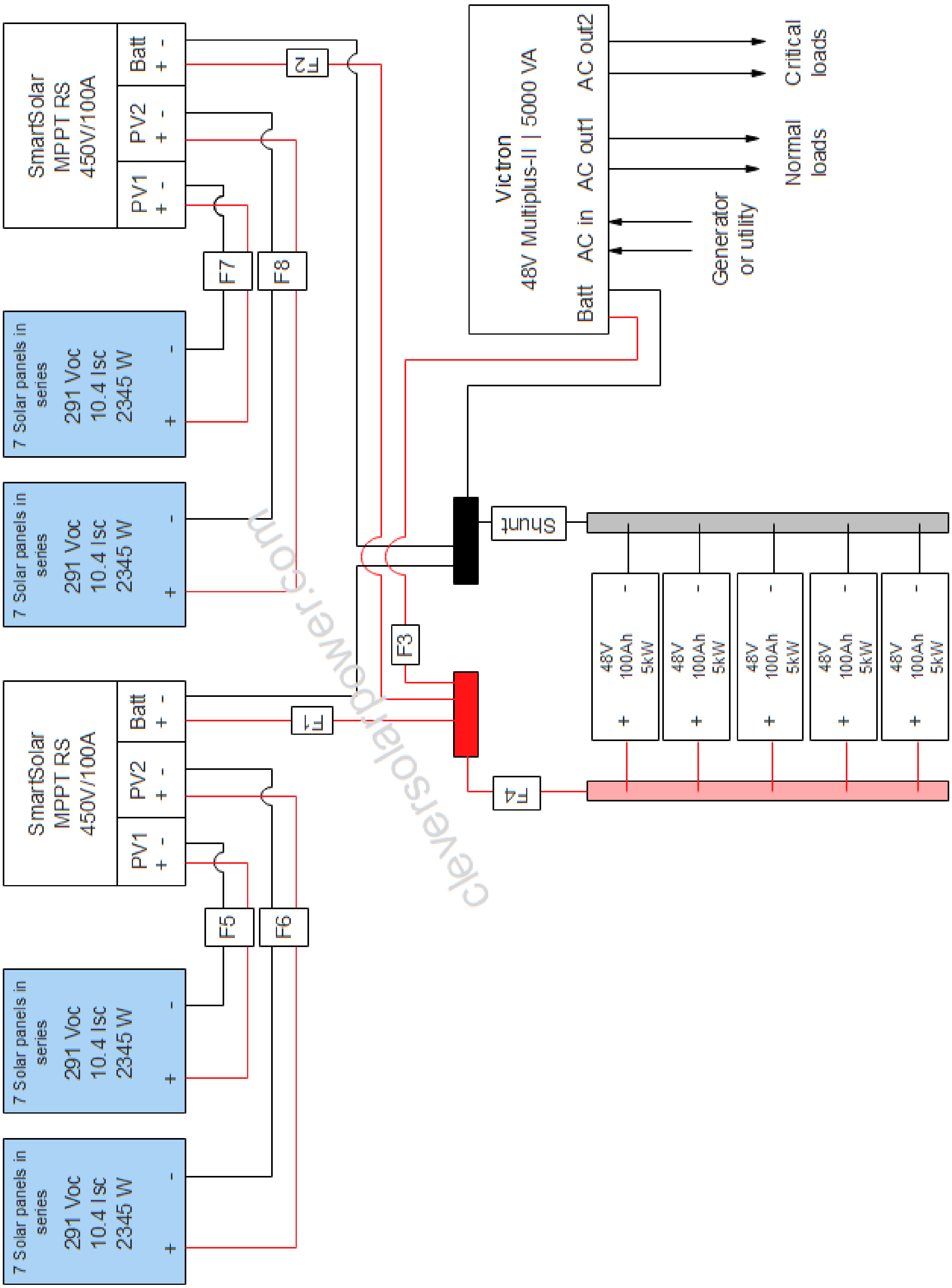
F2: $10.4 \times 1.56 = 16.2A$ → 20A fuse

W2: Use this voltage drop calculator.

We can see that we stay below 3% voltage drop, which is good. We will use 16AWG or 1.5mm² if the wire is shorter than 80ft or 25 meters.



7. 10kW solar, 5kw Inverter and 25kW Battery



Uses

This is a whole house off-grid system. The multiplus adds intelligent displays to the system. A generator can be added if it's the right size. This is what I would consider the ultimate off-grid solar system.

Description

This system uses five server rack batteries for 25kW of storage. The inverter is rated for 5kW of output. Plenty to power your appliances. If you need more power, you can parallel more inverters. It has 28 panels of 335W each.

The good thing about this inverter from Victron is that it is also a charger. You can add shore power or a generator to charge the battery. I have calculated the cables to be either solar or charger. If you want to charge the batteries simultaneously, add another cable and recalculate the wiring and fuses.

The system's maximum current will be the charging current of the solar panels, not the inverter. The total solar power is 9.380W.

$$\frac{9.380W}{48V} = 195A$$

$$\frac{195A}{500Ah} = 0.39C$$

Recharging the battery in full sun will take 2 hours and 30 minutes.

$$500Ah \times 48V = 24.000Wh$$

$$\frac{24.000Wh}{9380W} = 2.5hours$$

This makes the system correctly sized. You need to be able to recharge the battery in one day. One day equals 3 or 4 hours of direct sun on the panels.

Calculations

F1,2: $100A \times 1.25 = 125A$ → 125A fuse

W1,2: 125A fuse → 2AWG or 35mm²

F3: $5000W/48V = 104A \times 1.25 = 130A$ → 200A fuse

W3: 200A fuse → 2/0AWG or 70mm² (this is recommended by Victron)

F4: Which is the highest? Solar or load to the inverter? Here the solar panel power is higher than the power required for the inverter (9.380W vs. 5.000W)

$9340W/48V = 195A \times 1.25 = 234A$ → 250A fuse

W4: 250A fuse → 4/0AWG or 2x 70mm²

It is possible to wire the charging cables from the solar charge controllers directly to the battery busbar (if you have one). This bypasses the system's main busbar. If that is the case, we need to calculate this wire based on the inverter power, which is 500W.

F4: $5000W/48V = 104A \times 1.25 = 130A$ → 150A

W4: 150A fuse → 1AWG or 50mm² (only if solar panels bypass the main busbar)

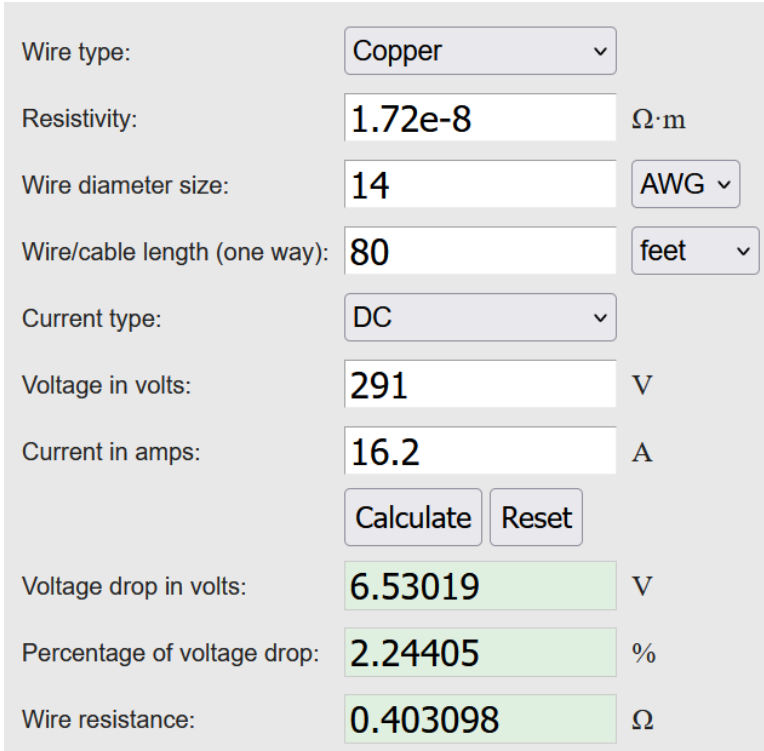
Interconnecting cables use the same size.

F5,6,7,and 8: $10.4A \times 1.56 = 16.2A$ → 20A fuse

I recommend using DC circuit breakers for these wires. You can place all four on a din-rail right before it enters the charge controllers. Then you take care of the fusing and switch at the same time.

W5,6,7, and 8: Use this voltage drop calculator.

We can see that we stay below 3% voltage drop, which is good. We will use 14AWG or 2.5mm² if the wire is shorter than 80ft or 25 meters.



Final words

I appreciate your interest in off-grid solar power!

Visit www.cleversolarpower.com for more informational articles.

Happy building!

Nick