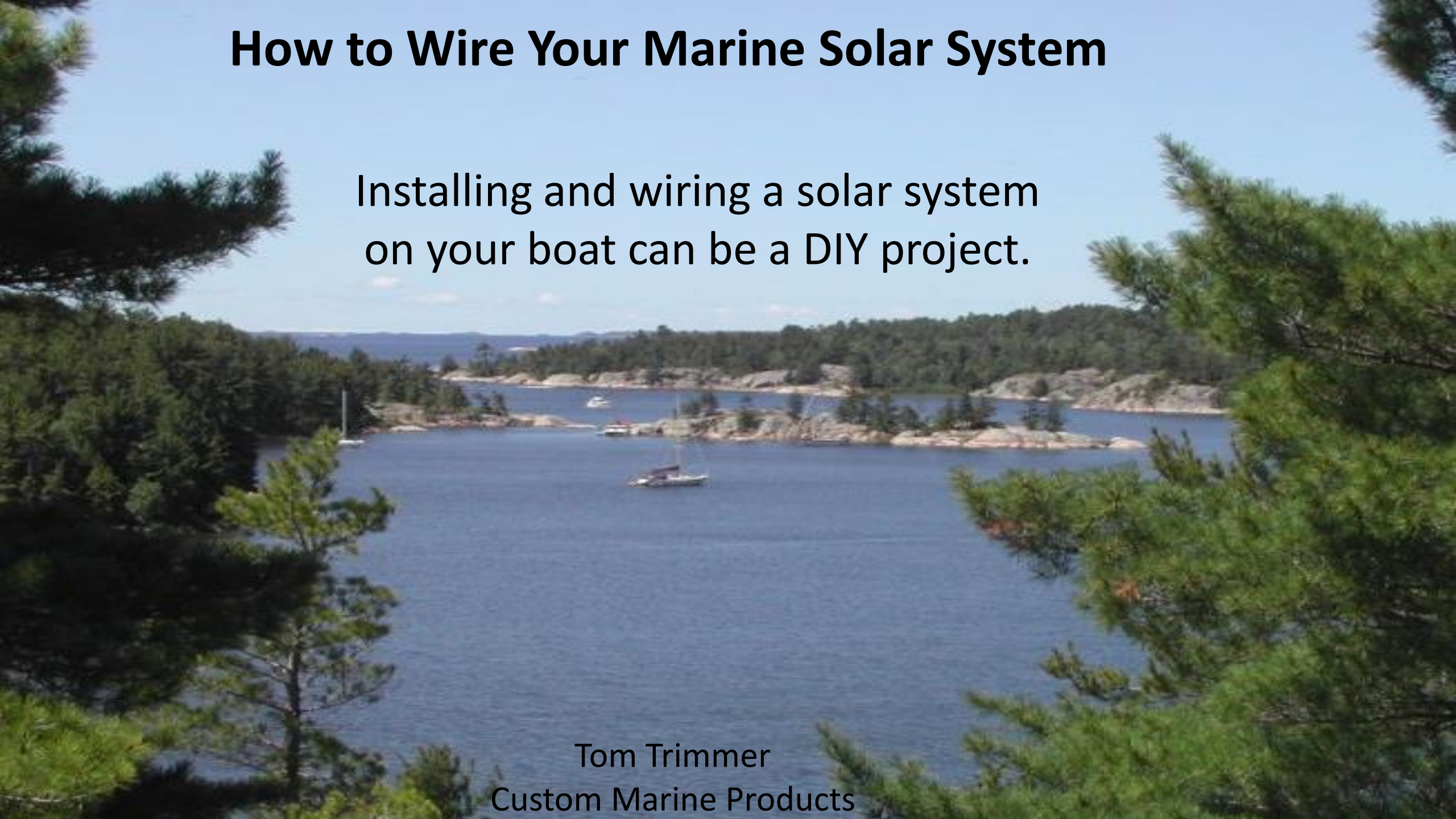
How to Wire Your Marine Solar System



Installing and wiring a solar system
on your boat can be a DIY project.

Tom Trimmer
Custom Marine Products

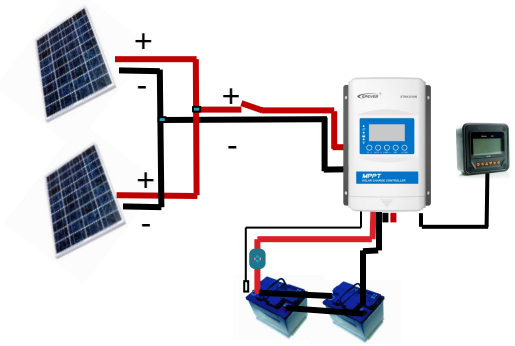
If you are just getting started with solar, here are some introductory videos you might find helpful.

- Selecting the Proper Marine Solar System
- What to Know About LiFePO4 Batteries
- Flexible Solar Panel Mounting Techniques

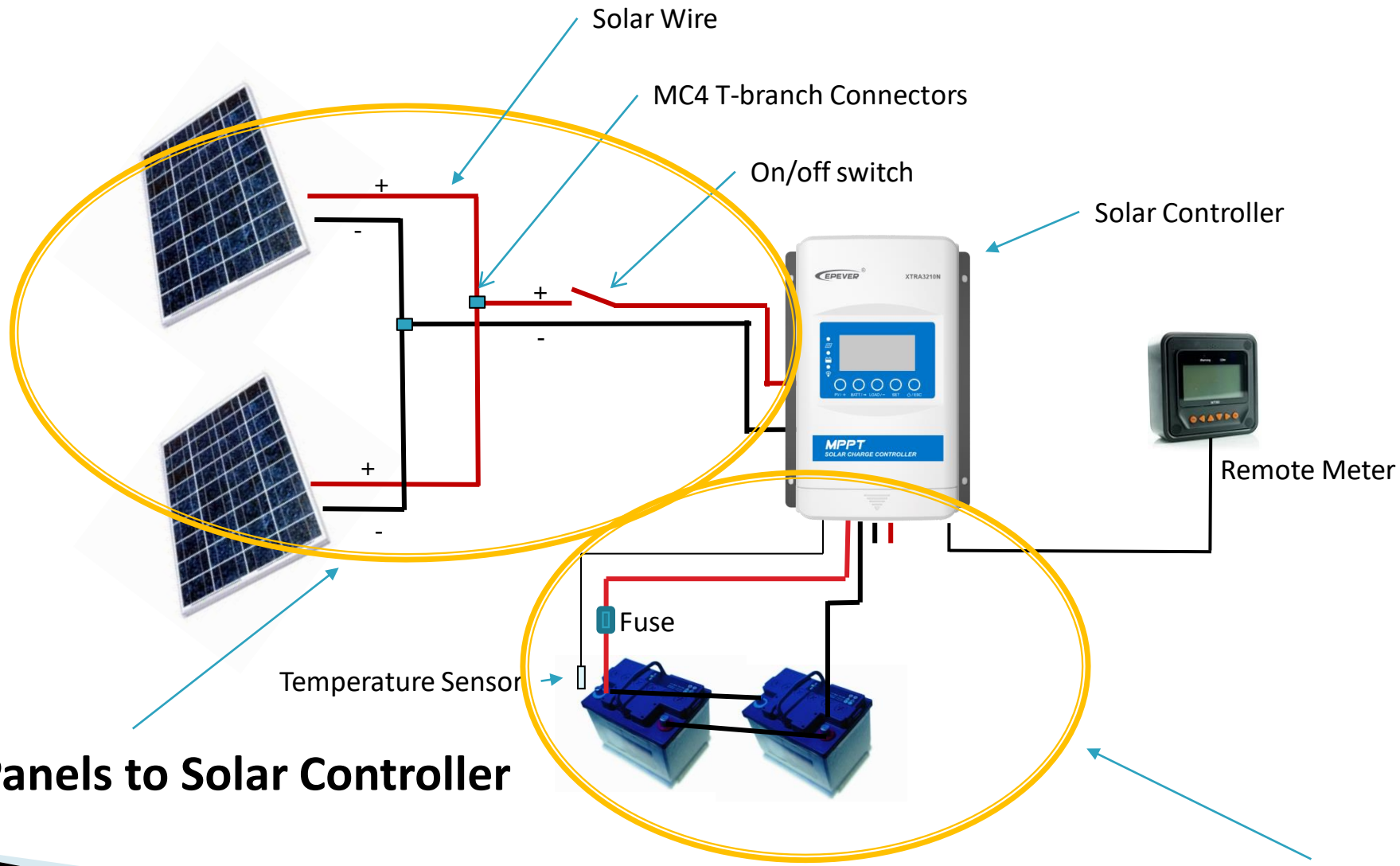
Videos are available at custommarineproducts.com under *Support*, *Manuals & Info*

How to Wire Your Marine Solar System

- **Solar Panels to Solar Controller**
  - Marine Solar Wire and Connectors
  - Wiring Solar Panels to the Controller
- **Solar Controller to Battery Bank**
  - Background on Solar Controllers
  - Wiring Solar Controller to the Battery
- Trouble shooting
- Wiring Diagrams for Various Applications



Two Wiring Components of a Marine Solar System



Solar Panels to Solar Controller

Solar Controller to Battery Bank

Solar Wire Specifications

We recommend using marine solar wire to connect the solar panels to the solar controller.

- Like all marine grade wire, solar wire should be tinned to prevent corrosion.
- High strand count is important. It should be >50 strands
  - More flexible
  - Won’t fracture from boat vibration
  - Less resistance – lower voltage drop
- Most solar wire is single conductor with two layers of insulation.
- AWG #10 solar wire is ¼” (6mm) in diameter and adequate for most marine installations.

Wire Size

Number 10 or 8 gauge high strand count tinned solar wire is generally adequate for most marine solar systems.

2% Voltage Drop Chart For 12 volt Systems

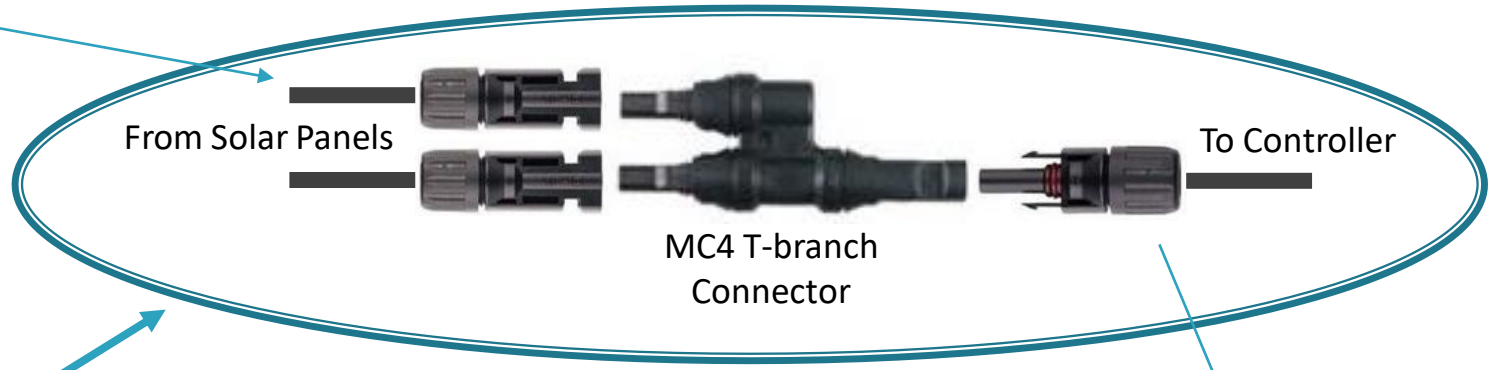
Maximum distance in feet of various gauge two conductor copper wire from power source to load for 2% voltage drop in a 12 volt system. Do not exceed the 2% drop for wire between PV modules and batteries. A 4 to 5% loss is acceptable between batteries and lighting circuits in most cases, however the cost of the next larger wire size is usually insignificant and increases efficiency.

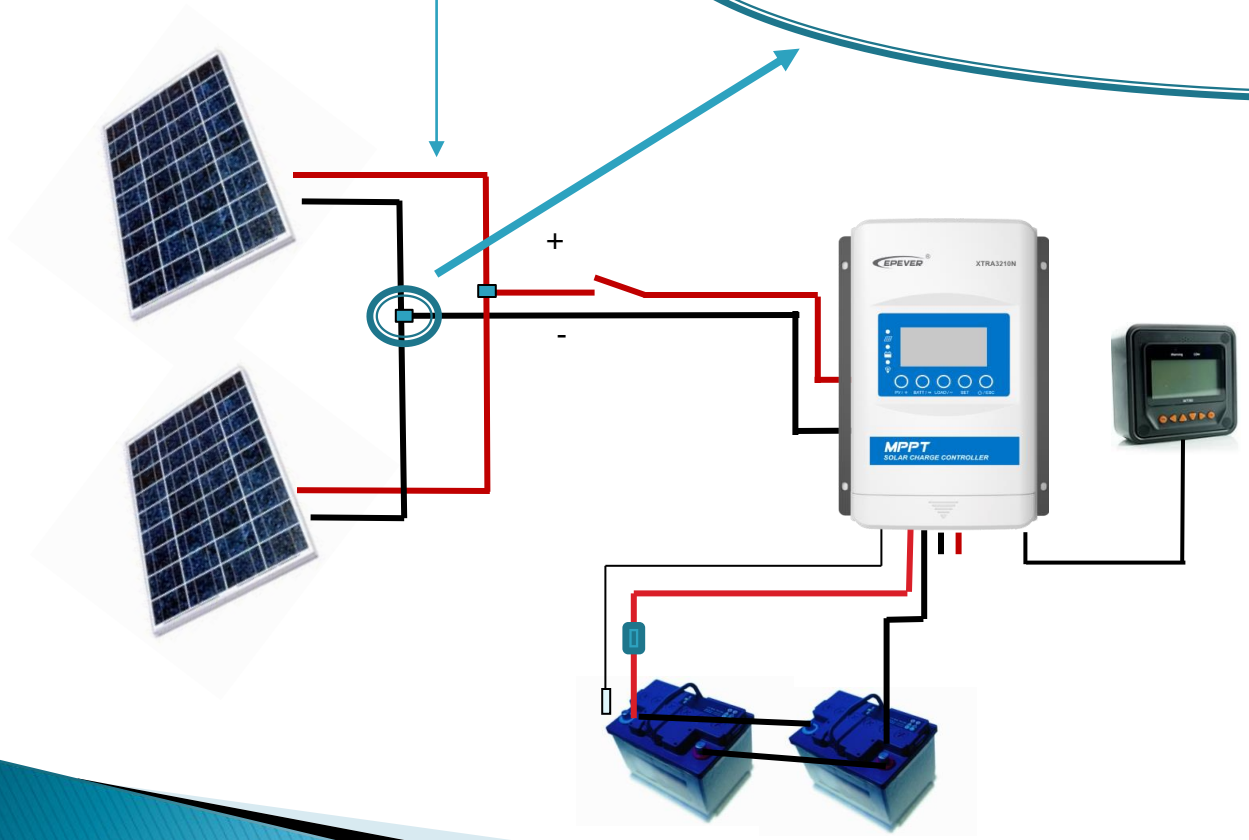
Amps	#14	#12	#10	#8	#6	#4	#2	#1/0	#2/0	#4/0
1	45	70	115	180	290	456	720			
2	22.5	35	57.5	90	145	228	360	580	720	1060
4	10	17.5	27.5	45	72.5	114	180	290	360	580
6	7.5	12	17.5	30	47.5	75	120	193	243	380
8	5.5	8.5	11.5	22.5	35.5	57	90	145	180	290
10	4.5	7	11.5	18	28.5	45.5	72.5	115	145	230
15	3	4.5	7	12	19	30	48	76.5	96	150
20	2	3.5	5.5	9	14.5	22.5	36	57.5	72.5	116
25	1.8	2.8	4.5	7	11.5	18	29	46	58	92
30	1.5	2.4	3.5	6	9.5	15	24	38.5	48.5	77
40			2.8	4.5	7	11.5	18	29	36	56
50			2.3	3.6	5.5	9	14.5	23	29	46
100					2.9	4.6	7.2	11.5	14.5	23
150							4.8	7.7	9.7	15
200							3.6	5.8	7.3	11

Available at custommarineproducts.com under *Support*

MC4 Solar Connectors

Most *CMPower* solar panels include three foot pigtails with MC4 connectors pre-installed.





Note: *CMPower* wire coil provided in a solar kit includes a male and female MC4 connector pre-installed on each wire end. Coils are typically 50 or 60 feet in length.

Cut the coil in half and there are two 25 or 30 foot lengths to run from the solar panels to the solar controller. Thus, no crimping tool is required. Excess wire can be used to connect the solar controller to the battery bank.

MC4 Solar Connectors

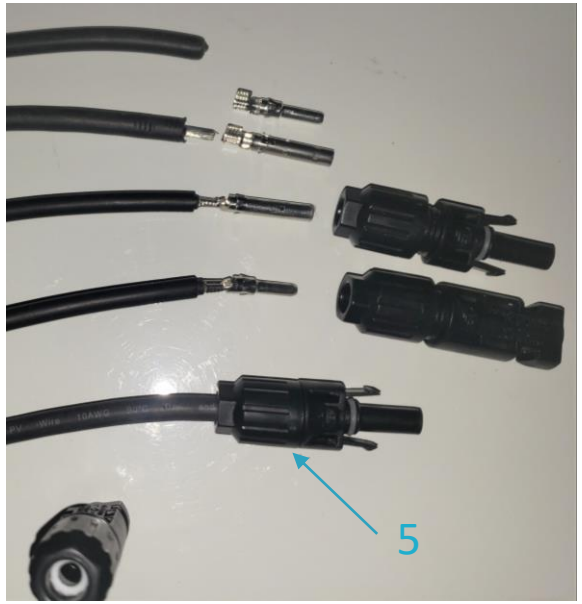
- MC4 connectors are waterproof.
- MC4 connectors seal around solar wire.
- MC4 connectors enable easy connecting and disconnecting of solar panels.
- MC4 T-branch connectors are used to wire solar panels in parallel.
- A special crimping tool is required to install connectors.

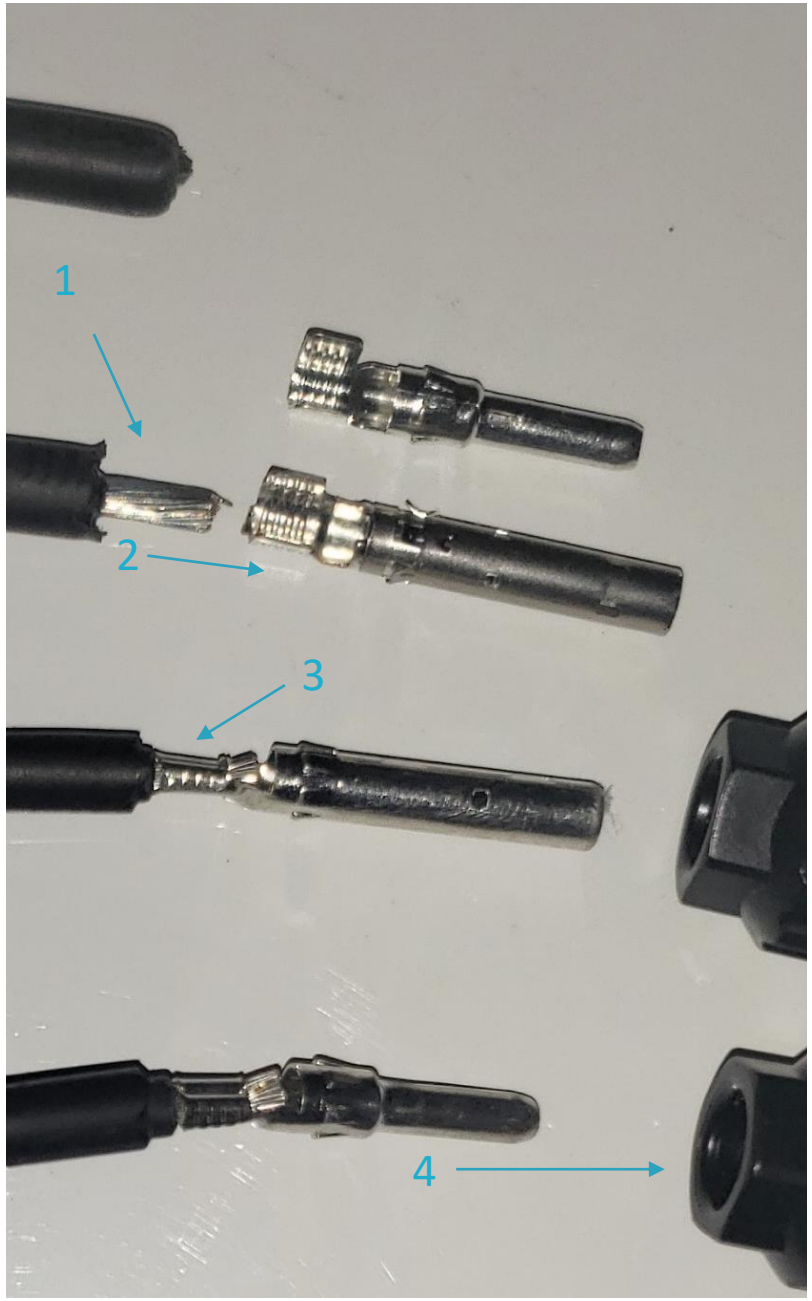
MC4 Male & Female Connectors

MC4 Male & Female T-branch Connectors are Used to Wire Multiple Solar Panels in Parallel

Installing MC4 Connectors

1. Strip wire back 3/8 “ or 1 cm.
2. Place the wire in the metal insert between the two tabs.
3. Use an MC4 crimping tool to fold the tabs onto the bare wire.
4. Insert the metal insert into the MC4 connector until the insert tabs lock into the MC4 connector. Note which insert to place into which connector.
5. Use spanners or wrenches to tighten the barrel onto the connector making a waterproof seal.





About *CMPower* Marine Solar Panels

- *CMPower* semi-flexible and rigid solar panels come with 3 foot pigtails with MC4 connectors pre-installed.
  - *CMPower* semi-rigid solar panels come with 6 foot pigtail only.
- *CMPower* solar panels have built in diodes in the junction box to optimize performance especially with shading.
- *CMPower* solar panels have junction boxes filled with inert silicone to prevent corrosion of electronic components.

Other considerations

- Most *CMPower* marine solar panels use premium SunPower solar cells that have the highest efficiency available at 23.7%.
- *CMPower* semi-flexible and semi-rigid solar panels are built with ETFE laminates that are rugged and won't deteriorate from UV.
- *CMPower* semi-rigid solar panels are designed to be walked on.

Semi-flexible

Semi-rigid

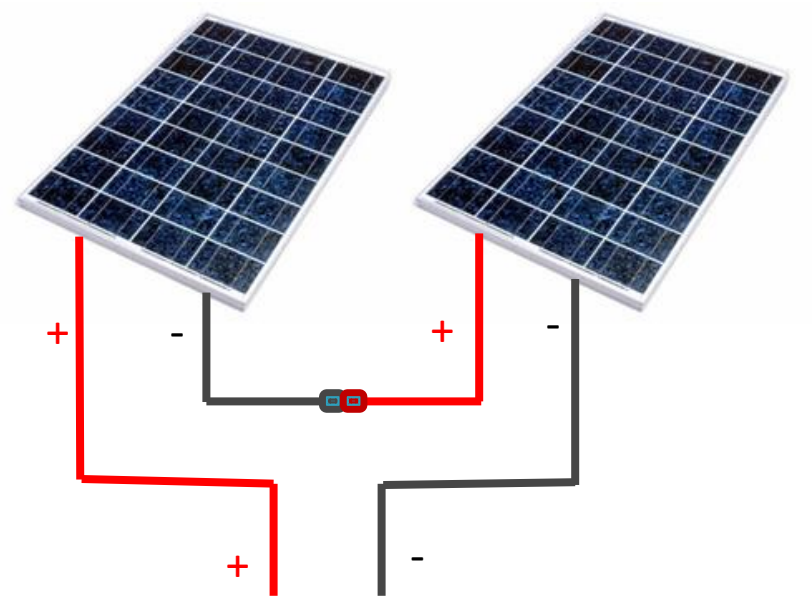
Rigid

Wiring Multiple Solar Panels

Example - 100 Watt, 18 Volt, 5.6 Amp

Generally Recommended

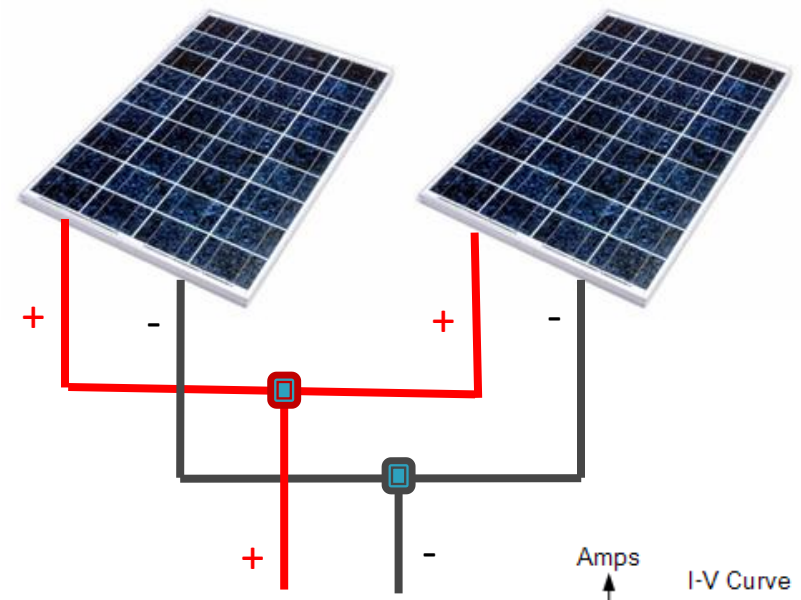
Series



36 Volts

5.6 Amps

Parallel

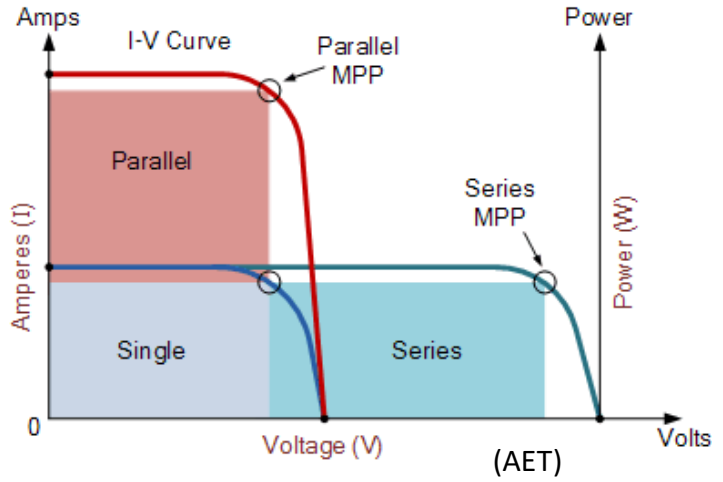


18 Volts

11.1 Amps

Same Watts

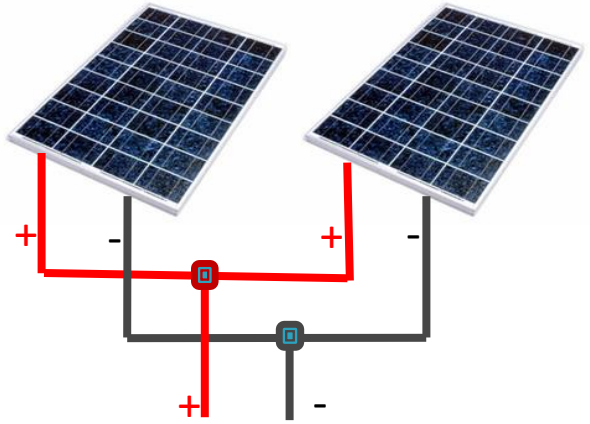
Amps x Volts = Watts



Wiring Solar Panels in Parallel

We generally recommend solar panels be wired in parallel on a boat.
Here is why:

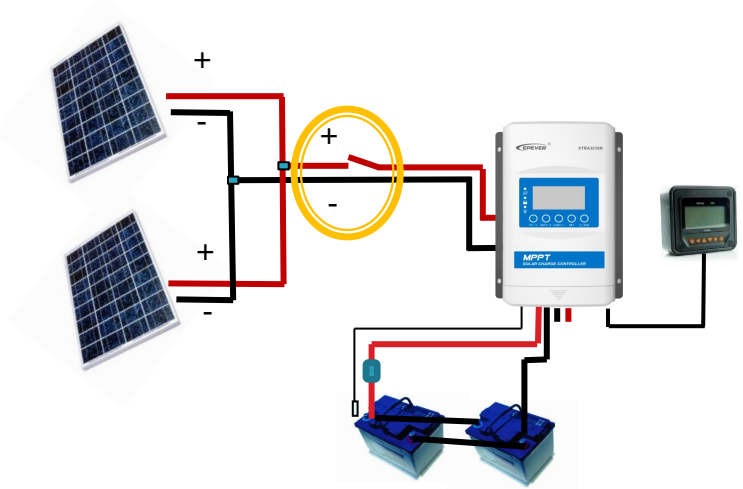
- *CMPower* panels have built in diodes so if one panel is shaded, the higher output of the other panels is not hindered.
  - If the panels are wired in series and one panel is shaded, the output of the entire solar array is reduced.
- The total voltage output of an array wired in parallel is lower than if wired in series so the reduction of solar array voltage to battery charge voltage is more efficient resulting in more power being stored in the battery.



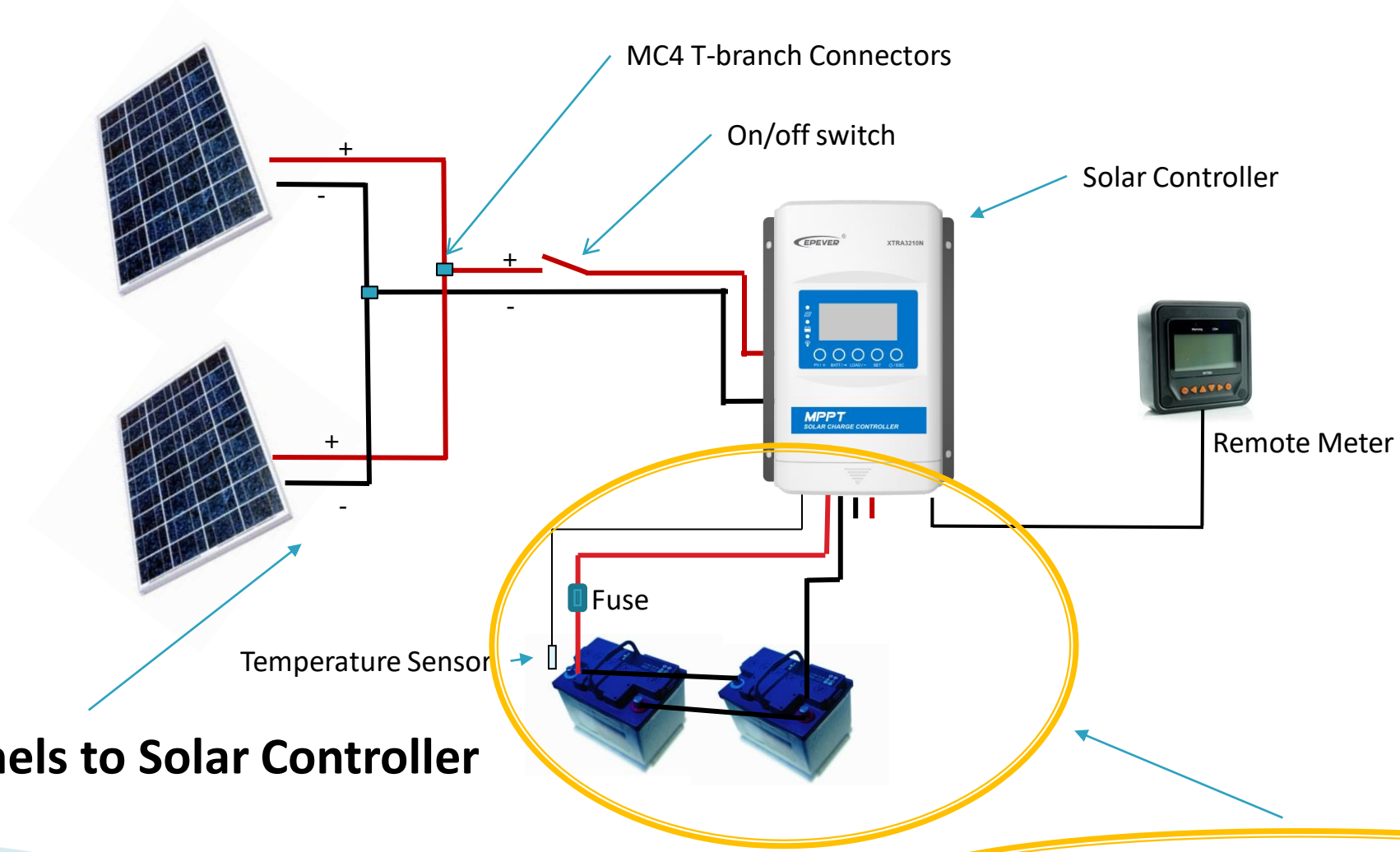
Turning a Solar System On and Off

- We recommend inserting a switch in the positive wire between the solar array and the controller to turn the solar system on and off.
- Why? To prevent the alternator and shore power charge controller from prematurely going into float mode.
- The alternator may sense the battery voltage plus the solar controller voltage and thus sense the battery bank is in a higher state of charge and prematurely go into float mode reducing the output of the alternator.
  - If this occurs, use the switch to shut down the solar system and gain the full output power from the alternator or shore charger.
  - This only occurs with some charging devices.

Note: Any on/off switch with sufficient rated capacity will do.



Two Wiring Components of a Marine Solar System



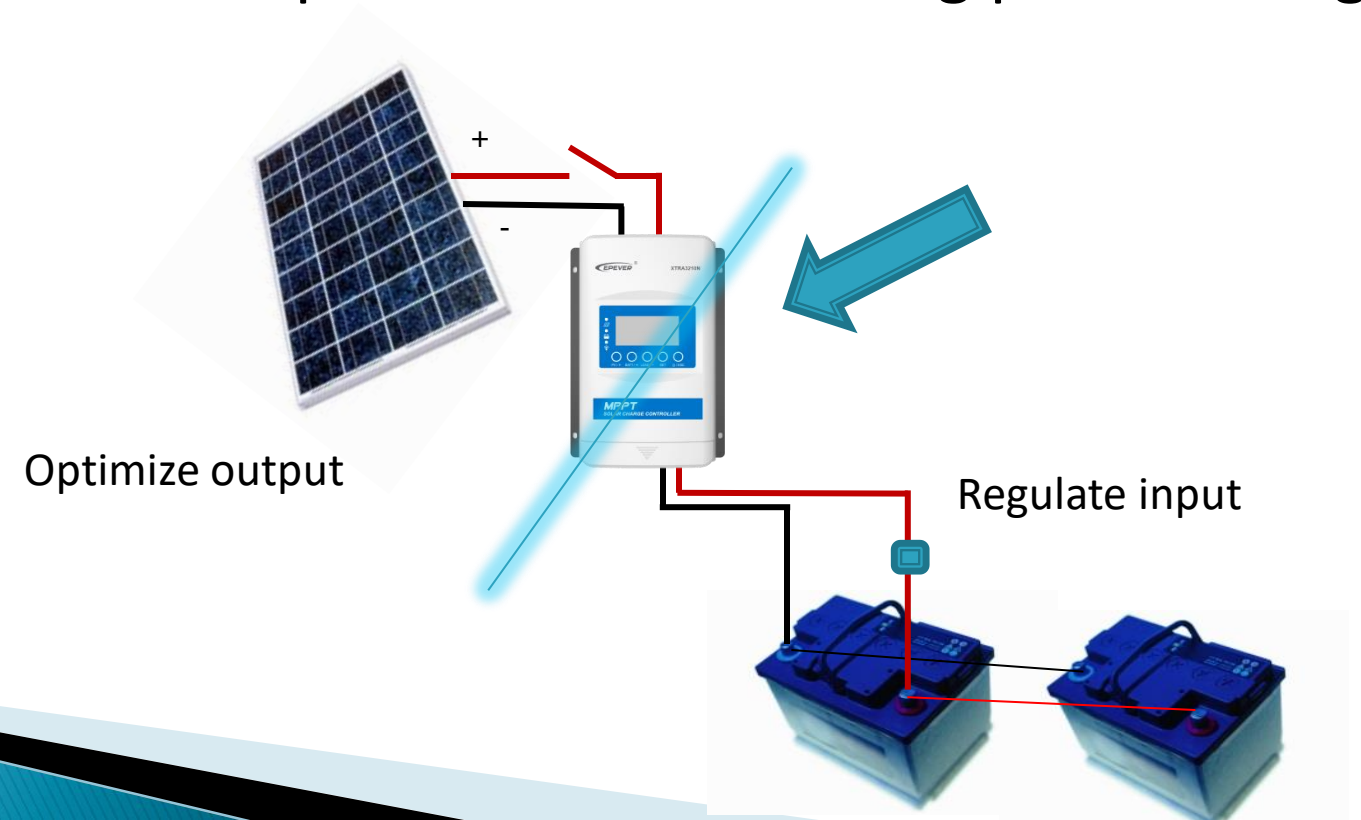
Solar Panels to Solar Controller

Solar Controller to Battery Bank

A Few Things to Know About Solar Controllers

The purpose of a solar controller is to:

- Optimize the power output of the solar array
- Regulate the amount of power going to the battery bank
- Prevent battery bank overcharging and overheating
- Prevent solar panels from absorbing power at night



There Are Two Types of Solar Controllers

(PWM) Pulse Width Modulation

- Pulse width modulation provides efficient battery charging
- Streams full power to battery bank when bank is low
- Useful if panel voltage is similar to battery voltage
- Less expensive than MPPT controllers

(MPPT) Maximum Power Point Tracking

- Essential to use with commercial solar panels
  (usually above 30 volts)
- Optimizes power from the solar array
- Reduces voltage to 14 volts and increases amperage
  Pw = V * I (Watts = Volts x Amps)
- Of little value for panels rated under 20 volts and for small solar arrays (under 200 watts).
- More expensive than PWM controllers

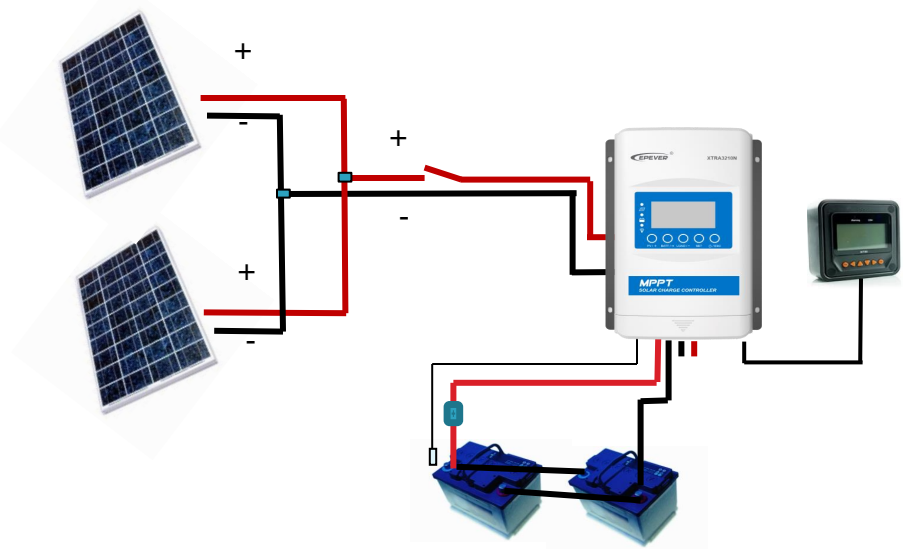
Wiring the Solar Controller to the Battery Bank

- **Wiring** - Unless there is a battery monitor, the negative wire from the controller should attach to the negative buss or the negative terminal on the battery. The positive wire should go directly to the battery.

- **Controller connection** - Bare wire goes directly into the receiver ports on the controller. No special plug is necessary.

- **Fuse** - Per ABYC standards, the positive wire leading to the battery bank should be fused roughly 10 amps above the maximum solar controller output.

- **Always check to be sure the + and – wires are the correct polarity before inserting into the controller.**

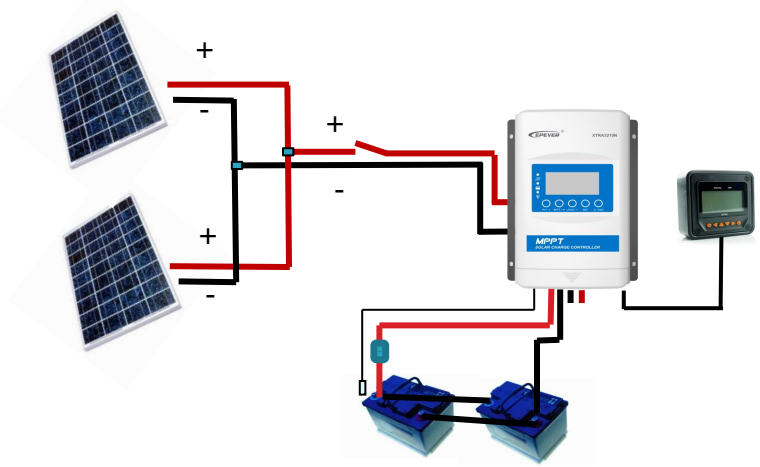


Wiring the Solar Controller to the Battery Bank

- **Load function** - The LOAD function available on some controllers is not used for marine applications. Ignore it. LOAD is used to control lighting systems.

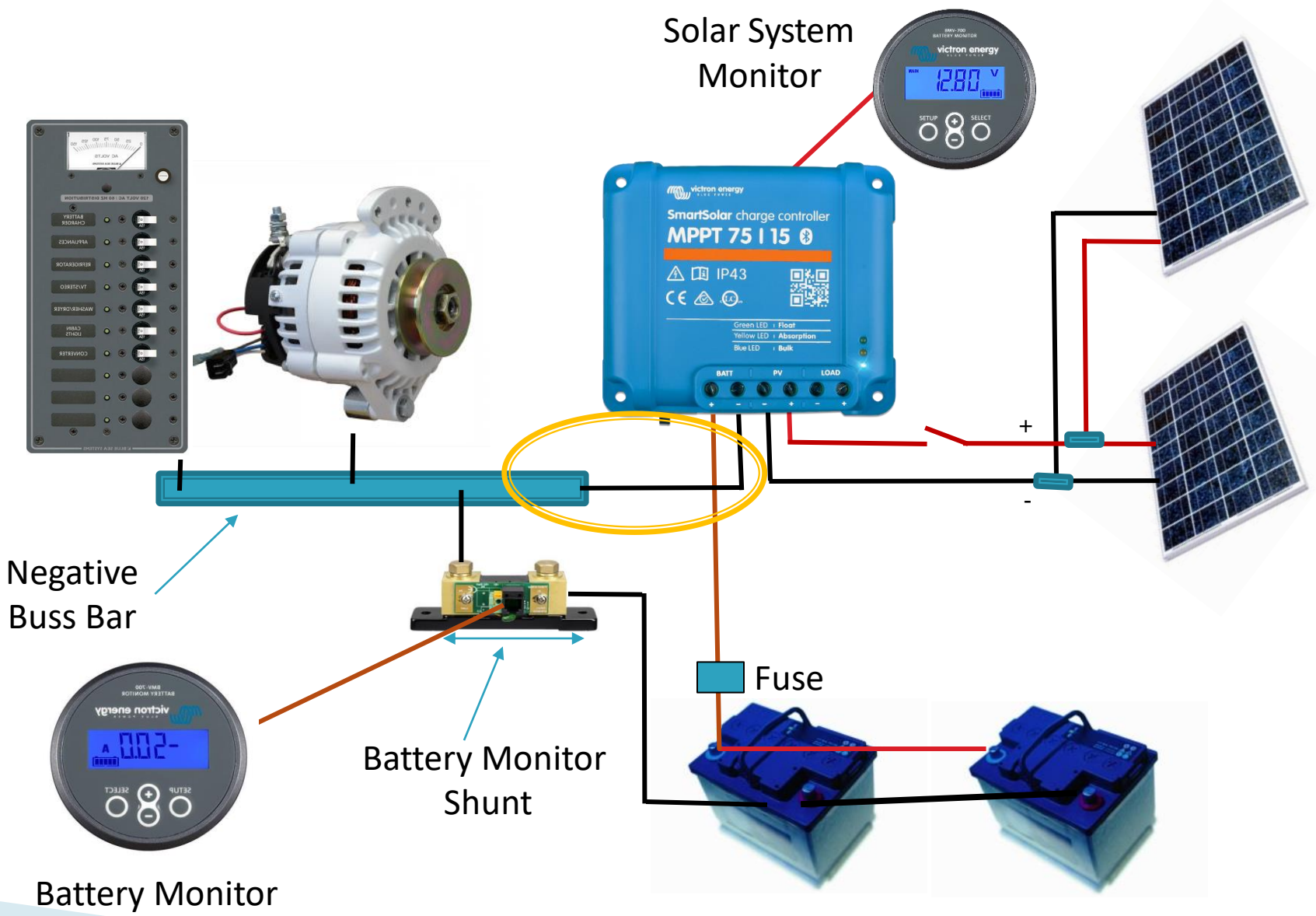
- **Temperature sensor** - The temperature sensor should be attached to the side or top of a battery. If the battery heats up, the controller cuts back on the power supplied. A temperature sensor is not needed for LiFePO4 batteries or for small systems with solar arrays under 150 watts.

- **Connection sequence** - The solar controller is powered by the battery bank, not the solar panels. Thus, **the solar controller should be attached to the battery bank first and then to the solar panel array.**



Wiring a Solar Controller with a Battery Monitor

- Most battery monitors require a shunt.
- The negative wire from the controller is attached to the house/charging side of the shunt.
- The positive wire from the controller is attached to the positive battery bank terminal and fused.



Programming the Solar Controller

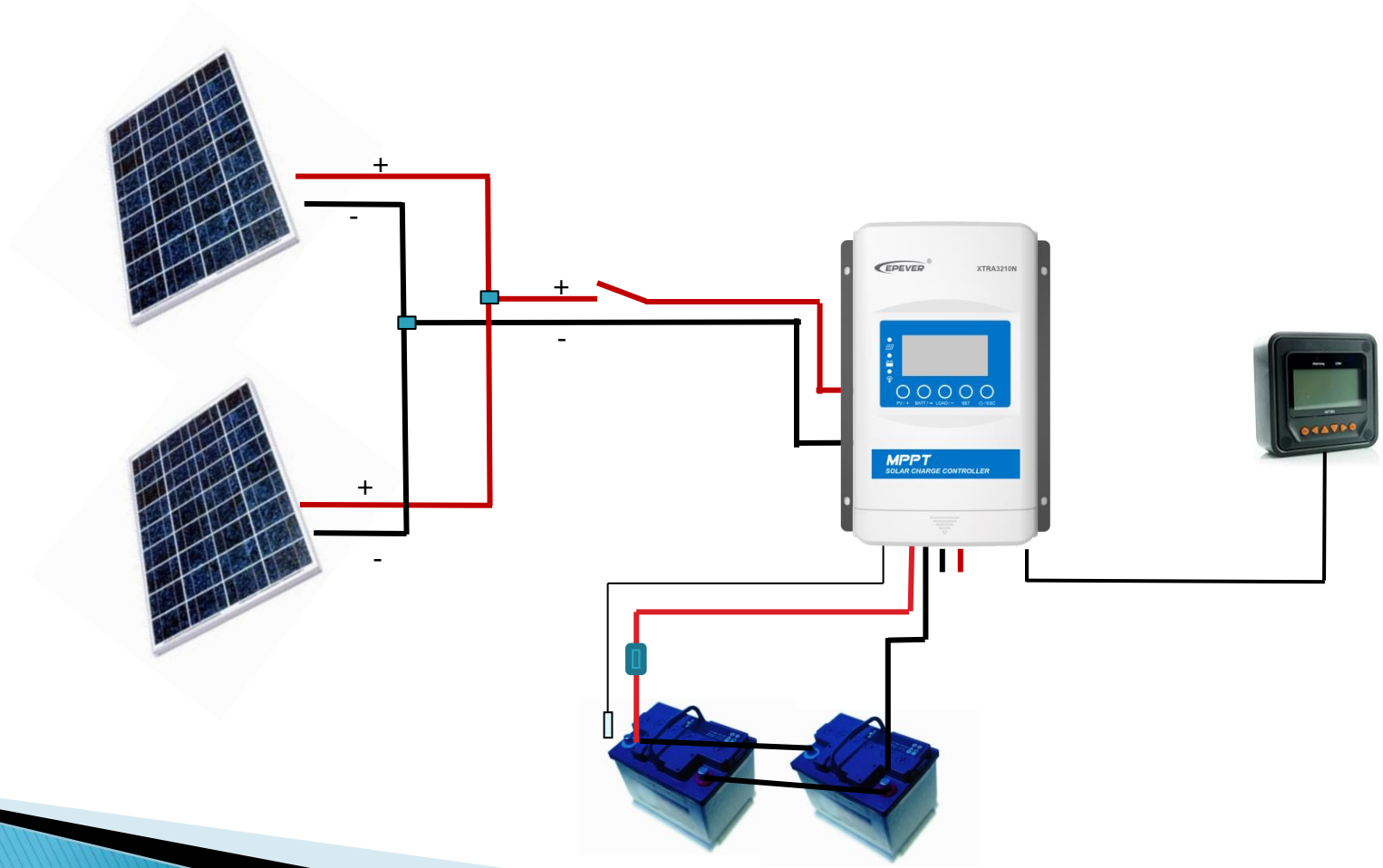
- Once the solar controller is powered and operational, setting the operating parameters can be completed. Key parameters typically include: size of the battery bank, battery type, and time and date. Some battery types, like LiFePO4, may require using the ‘USER’ battery type to set parameters specific to that battery.

- The solar controller parameters can be set using the meter or the Bluetooth app.
  - The Bluetooth app for EP controllers is available at Google Play or the Apple Store. Search for ‘Epever’.
  - The Bluetooth app for Victron controllers is titled ‘victronconnect’.

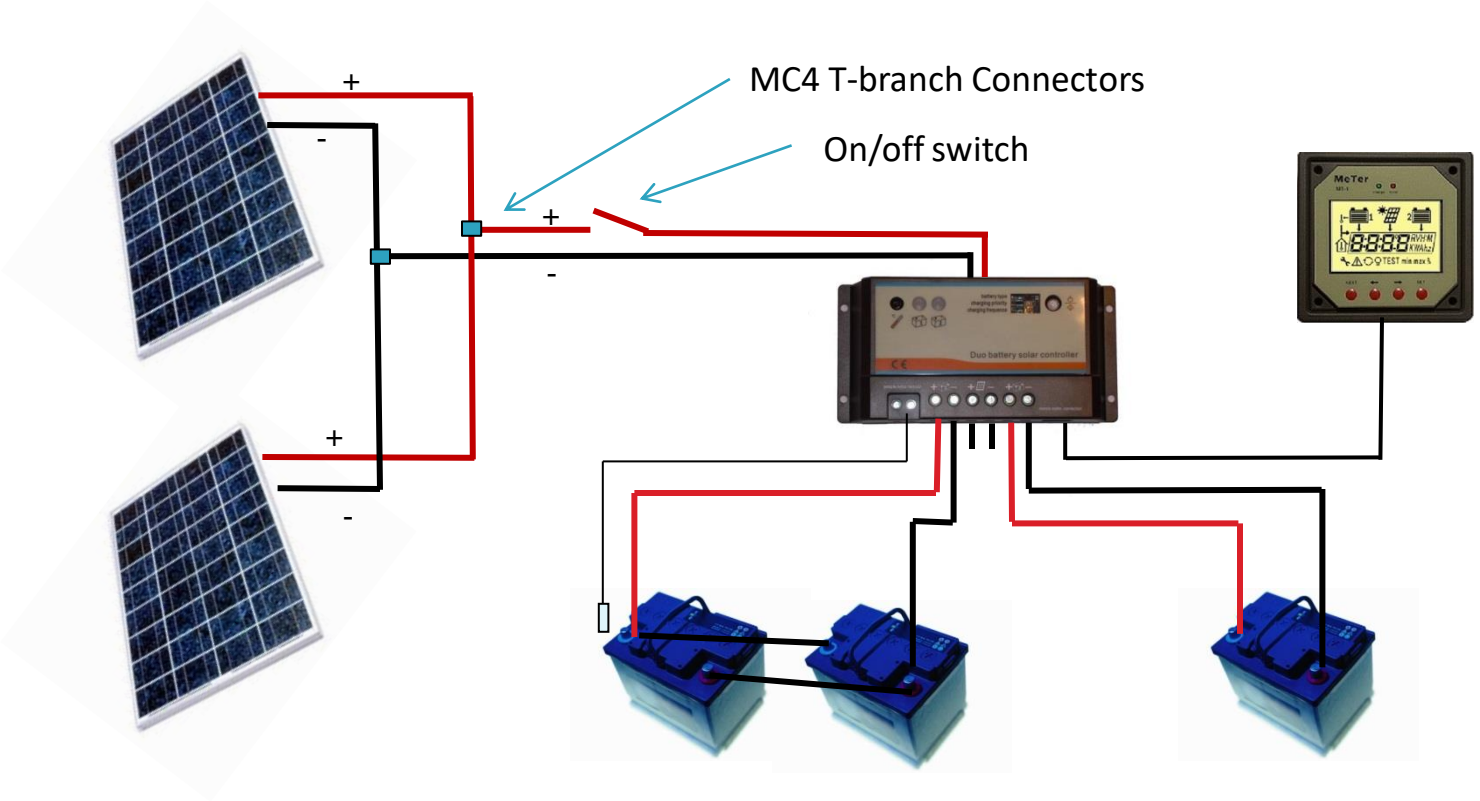
- Check out the ‘Quick Tips for Programming Controllers’ under *Support, Manuals & Info* at custommarineproducts.com for easy instructions for programming EP controllers.

Variations in Wiring

Wiring will vary depending on the configuration and quantity of solar panels and the type of controller(s) used. The following slides provide wiring diagrams for the most common solar system configurations.

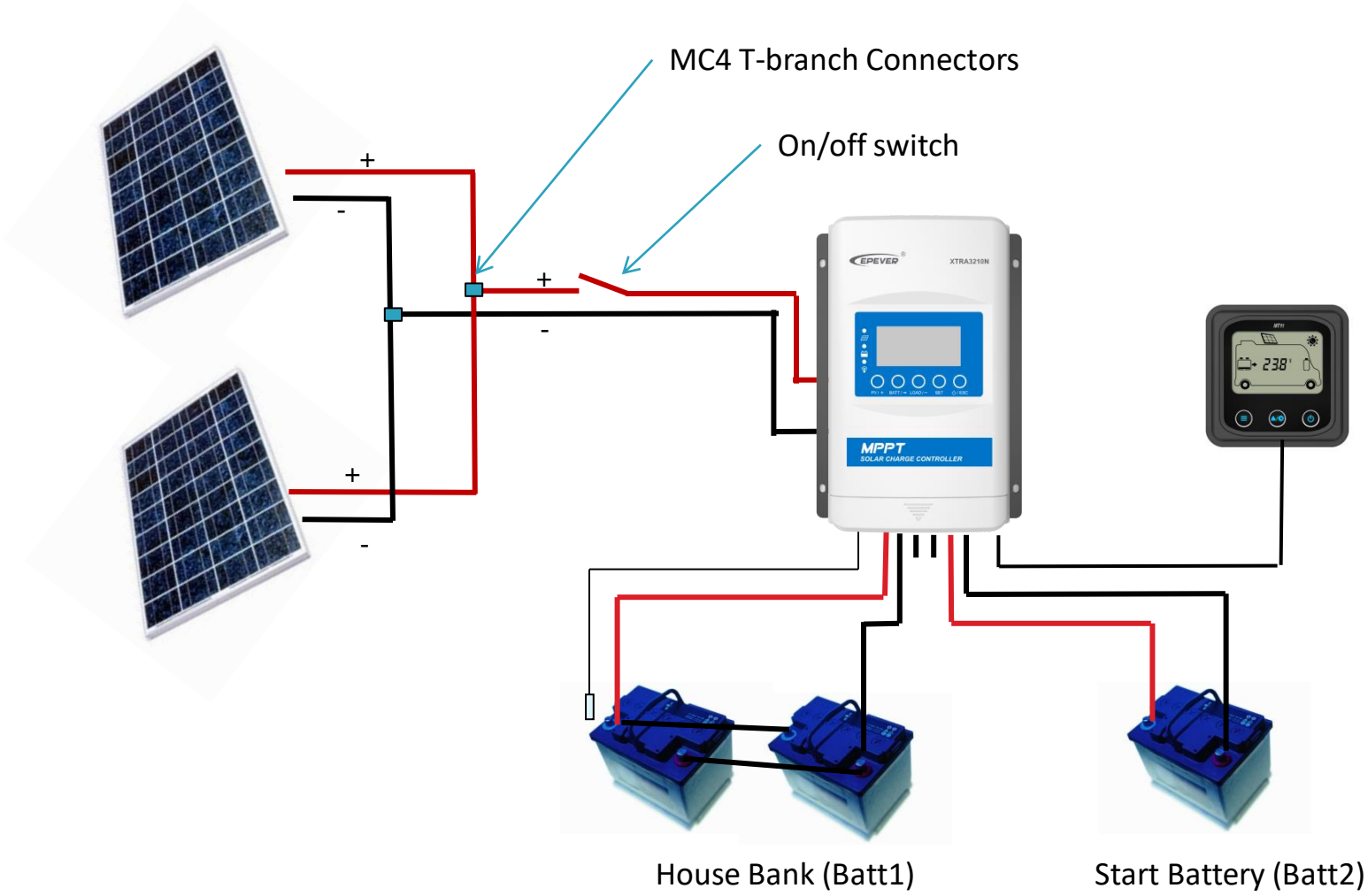


Two Solar Panels Wired in Parallel with PWM Dual Output Controller Charging Two Battery Banks

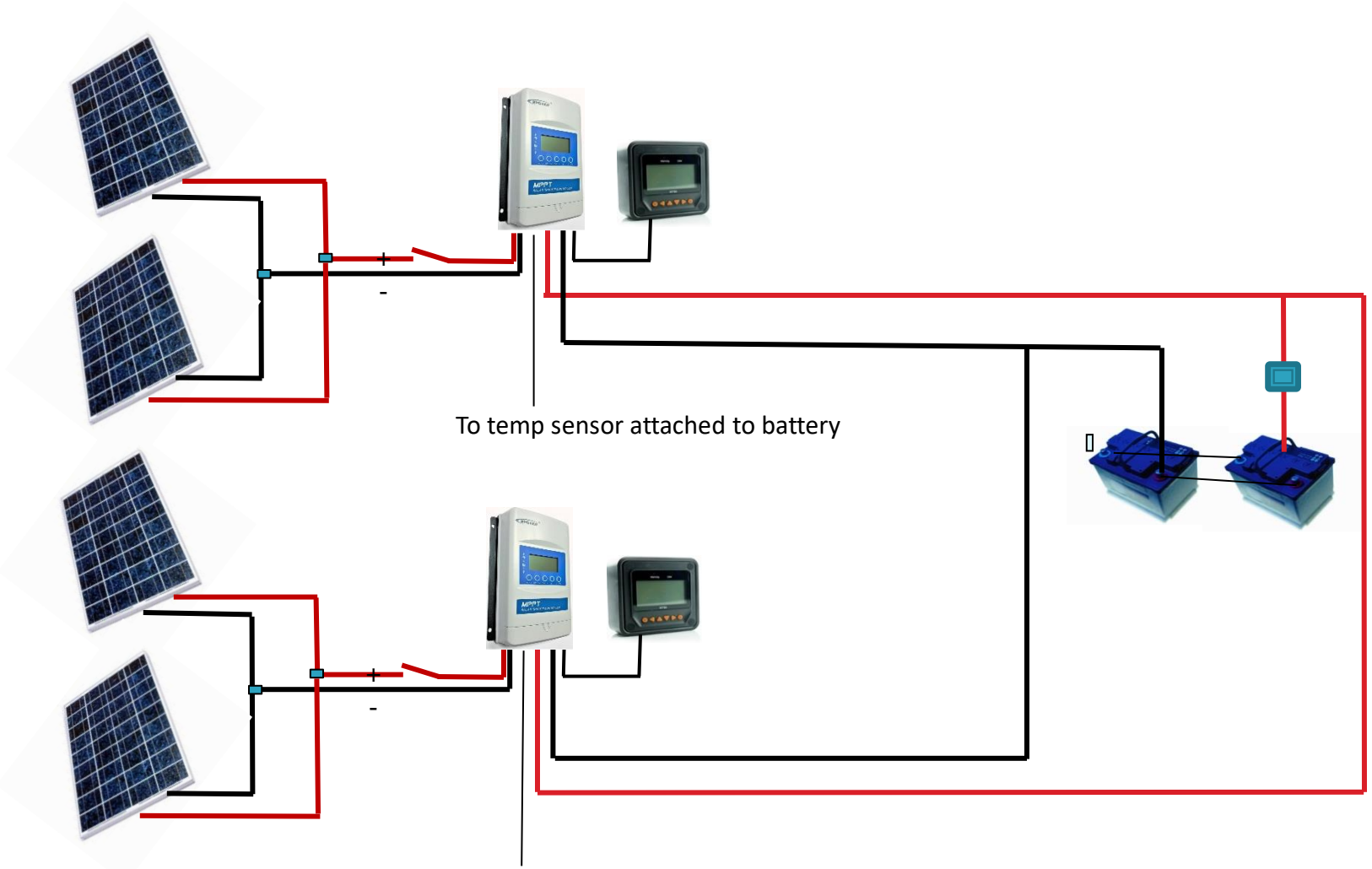


Attach controller to battery banks first and to solar panels second.

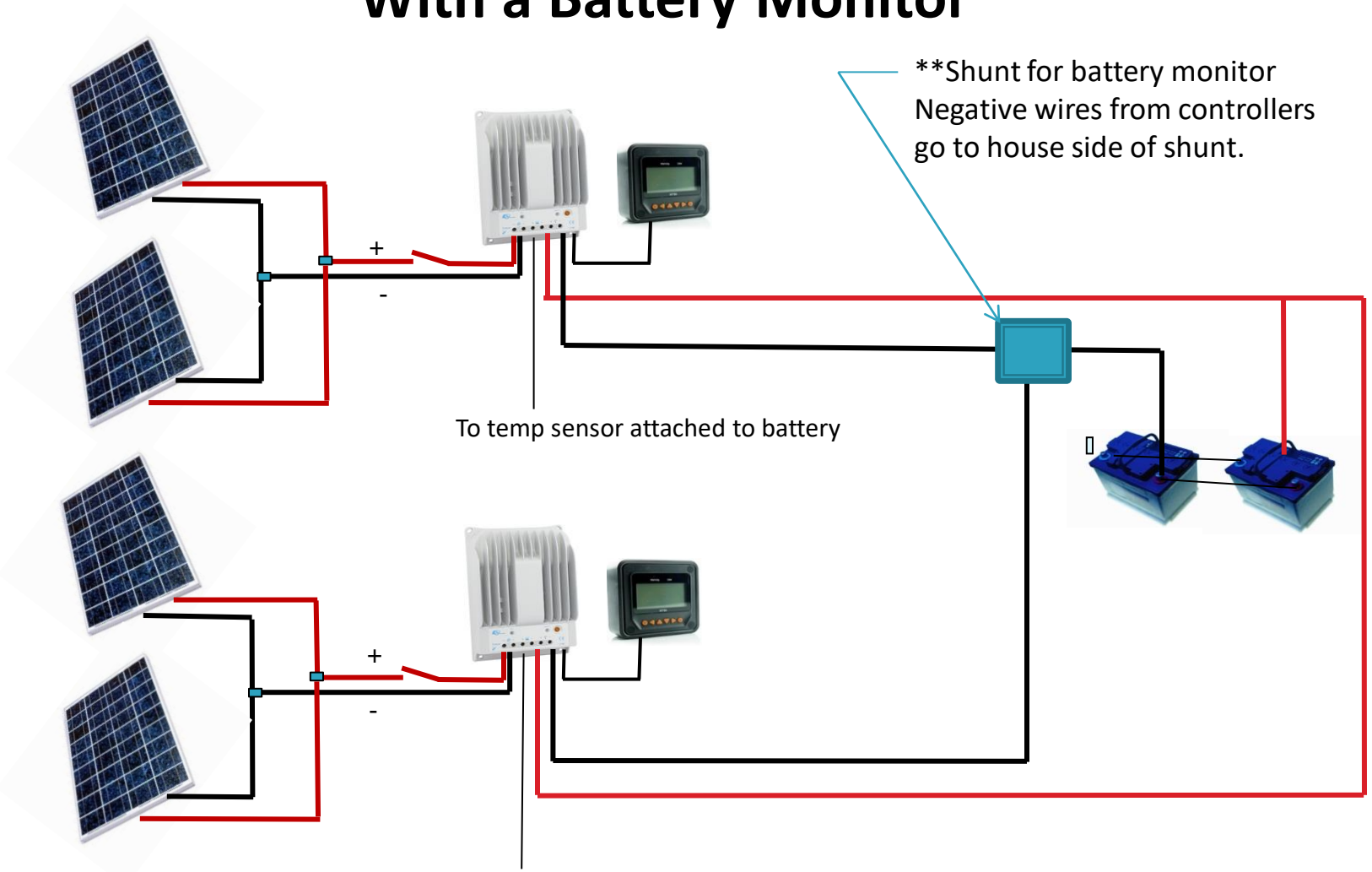
Two Solar Panels Wired in Parallel with MPPT DuoRacer Dual Output Controller Charging Two Battery Banks



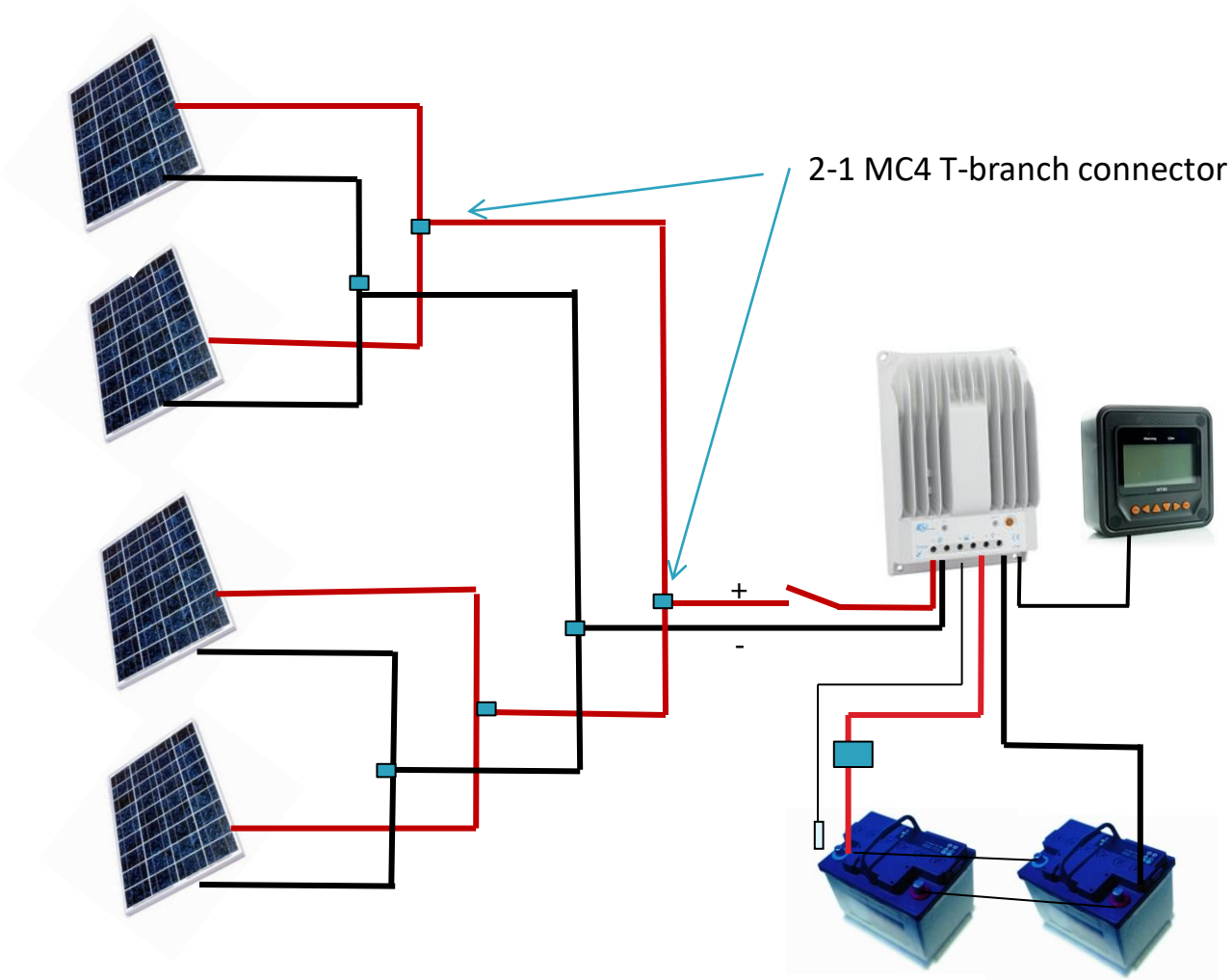
Two Sets of Solar Panels Wired in Parallel with Two MPPT Controllers



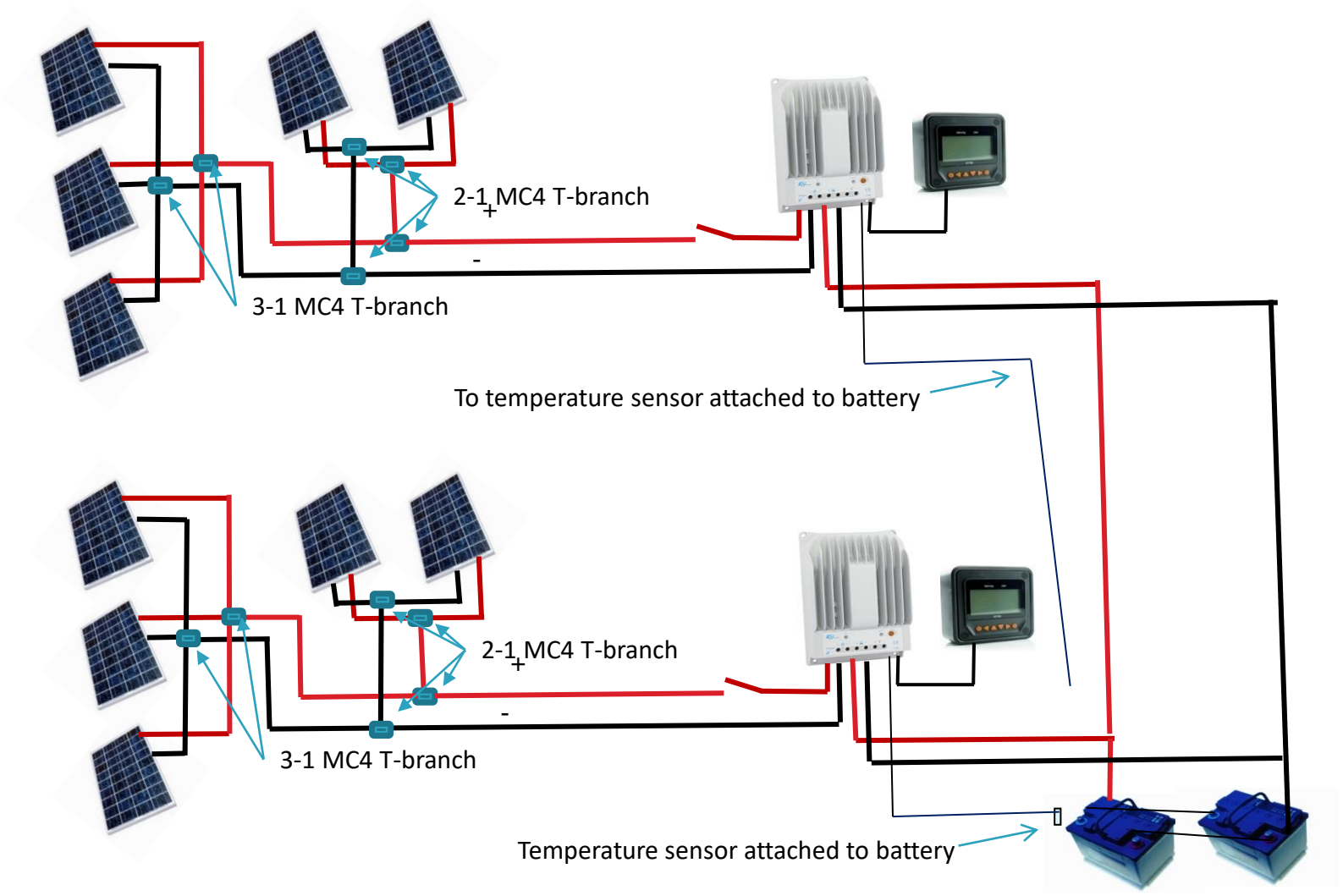
Two Sets of Solar Panels Wired in Parallel with Two Controllers With a Battery Monitor



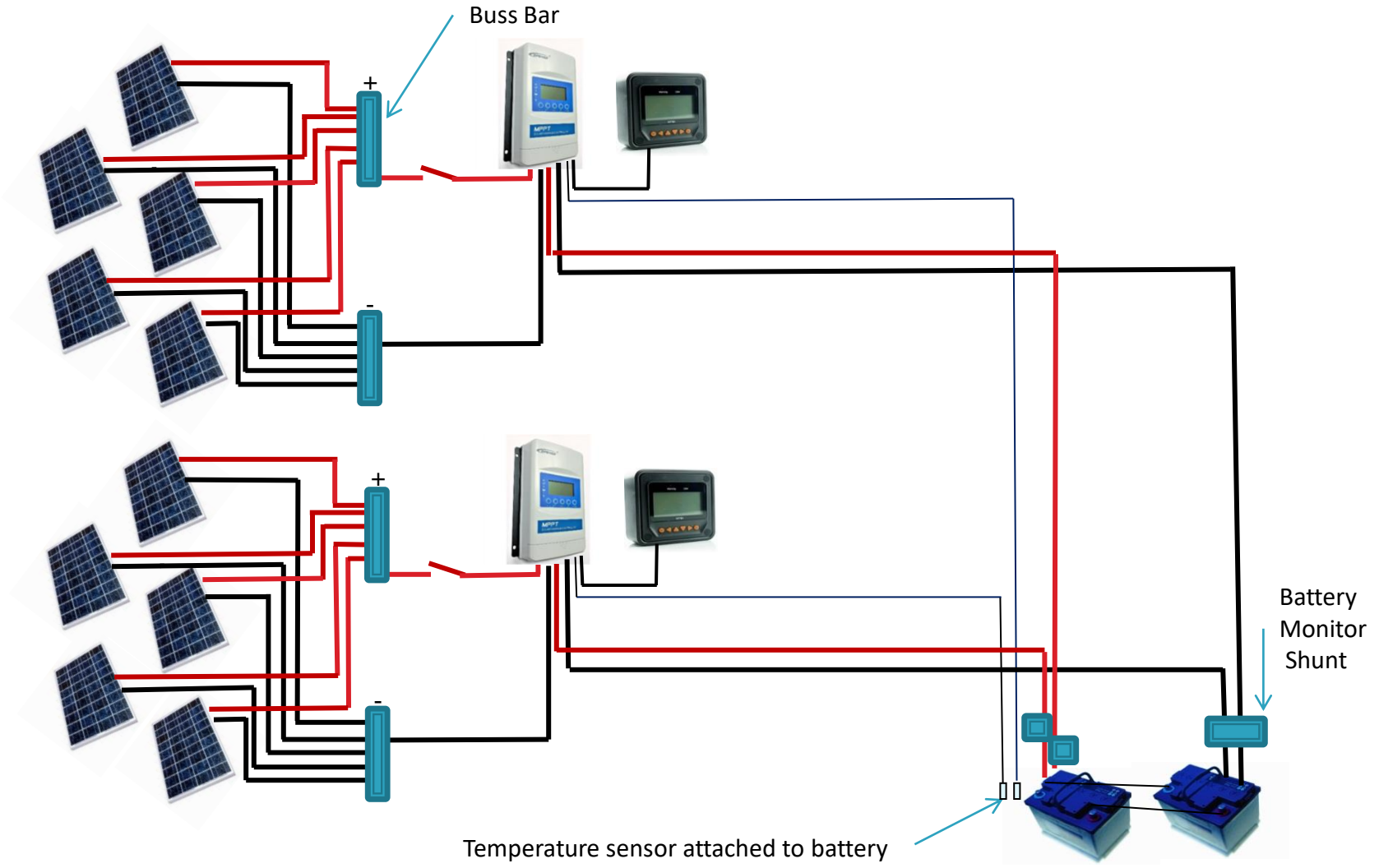
Four Solar Panels Wired in Parallel with One MPPT Controller



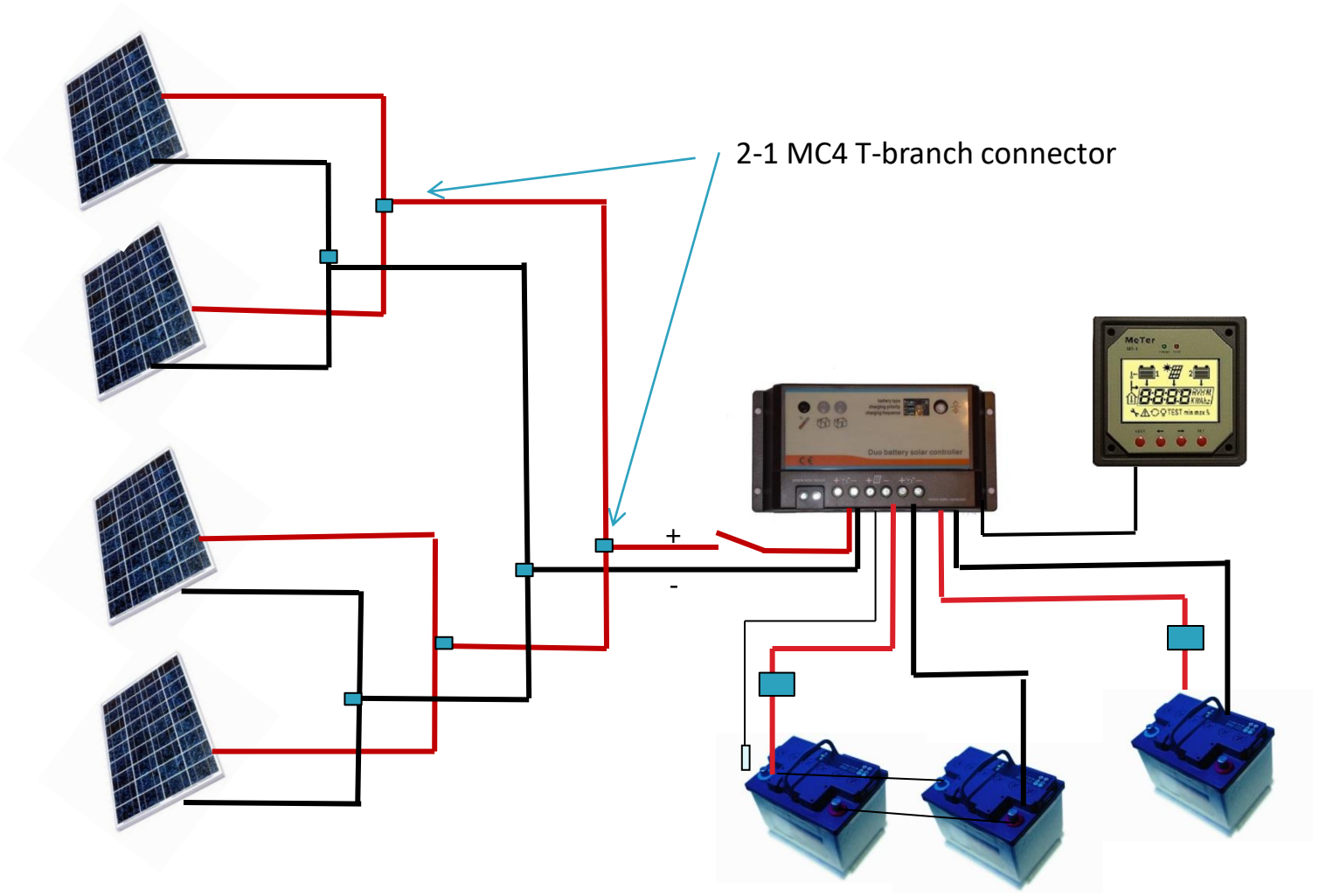
Ten Solar Panels Wired in Parallel with Two MPPT Controllers



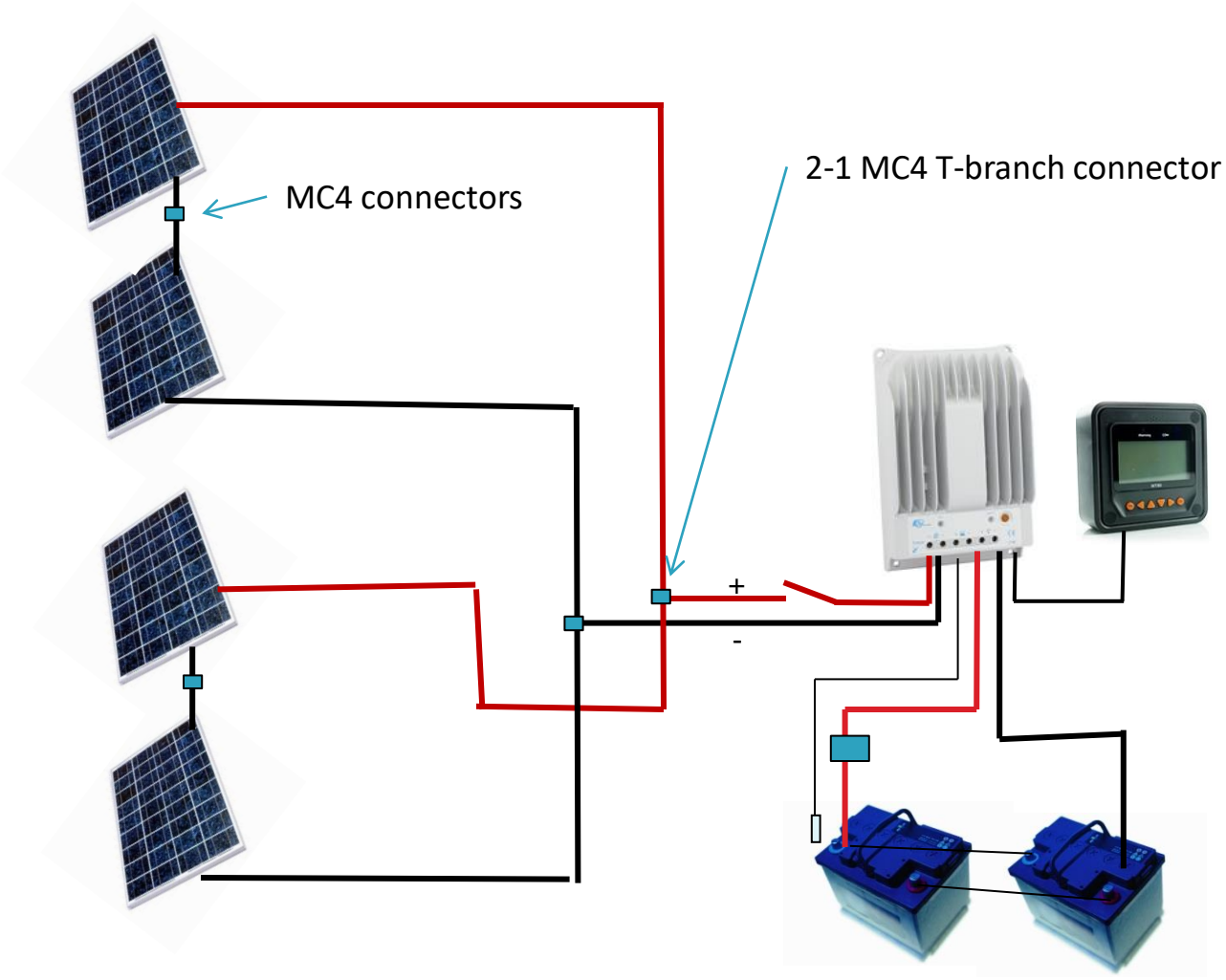
Ten Solar Panels Wired in Parallel with Two MPPT Controllers



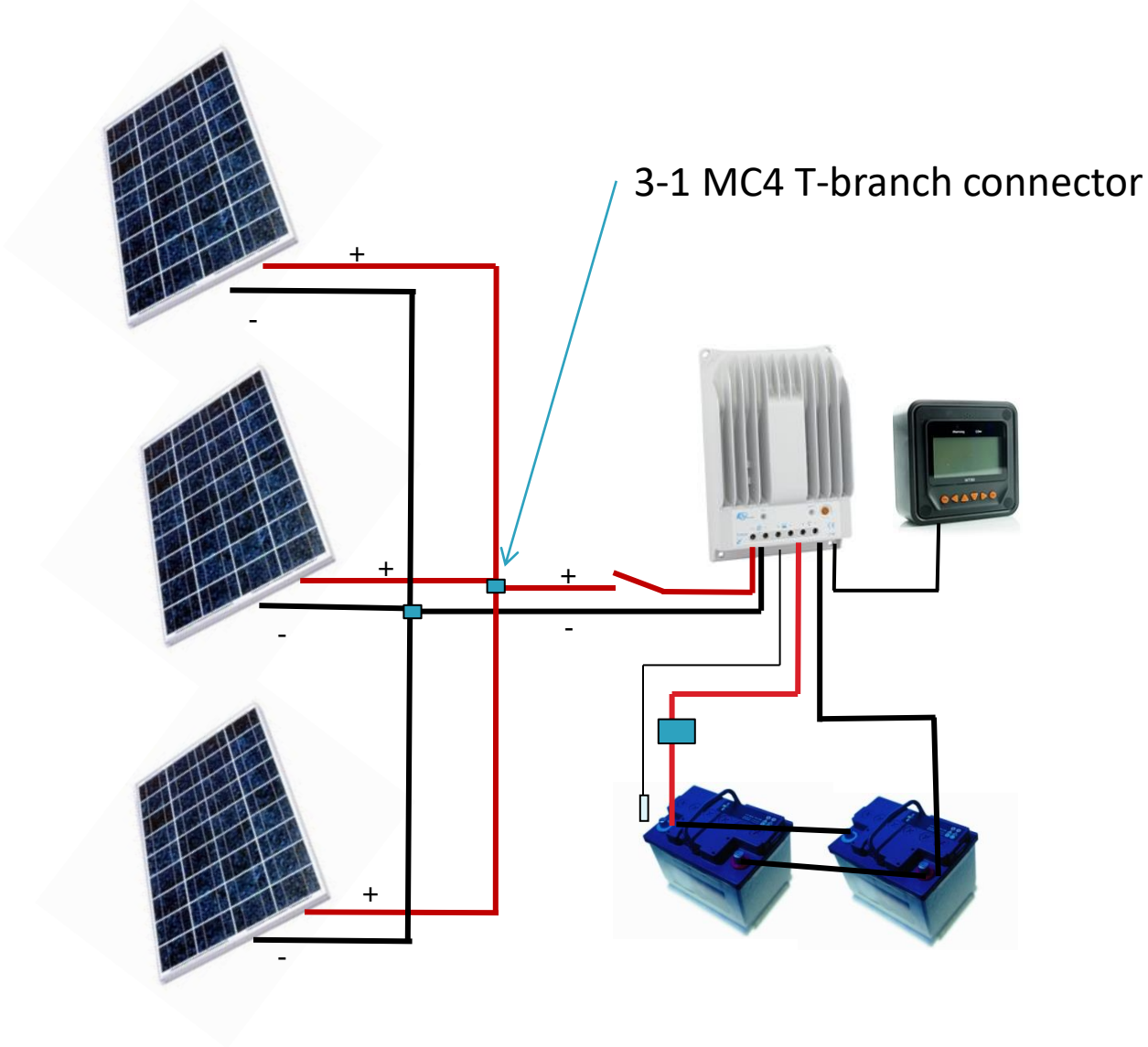
Four Solar Panels Wired in Parallel with One EP Dual Output Controller

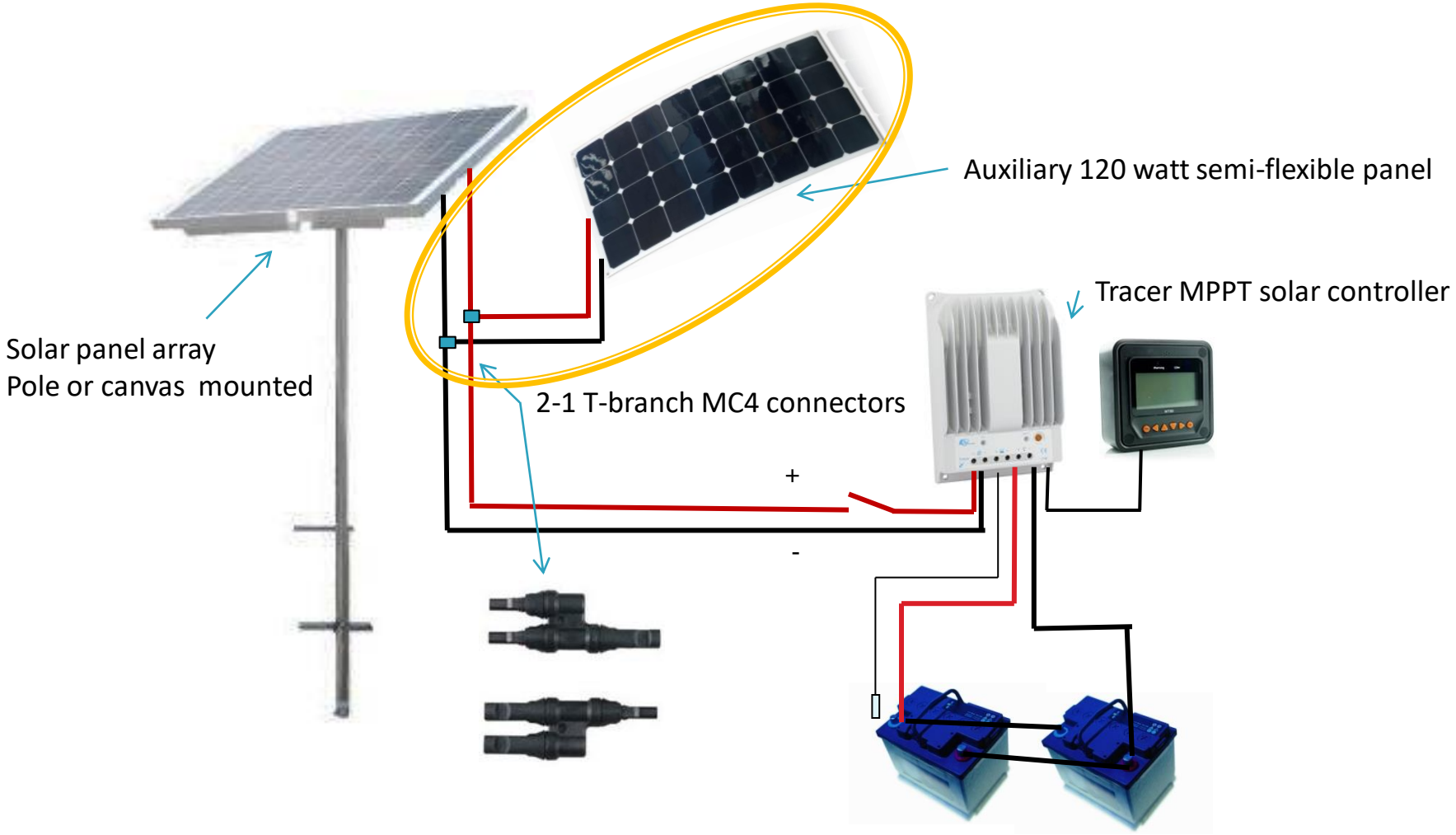


Four Solar Panels Wired Two in Series and Set in Parallel with MPPT Controller



Three Solar Panels Wired in Parallel with One MPPT Controller





Wiring diagram showing connection of an auxiliary 120 watt solar panel when extra power is needed.

Trouble Shooting

Meter shows voltage but zero amps from the solar panel –

- The controller is likely not getting power from the battery. It can display the panel voltage using power from the solar panel but not process the power to the battery. Check the battery connection and the fuse between the battery and the controller. Measure the voltage of the battery wires at the controller. If all looks good, measure the voltage and amperage at the panel pigtails. Check the on/off switch.

The solar panels are not producing the full amount of rated power –

- The power output of a solar panel decreases as the panel heats up. For every 20° above 77°F the panel performance is reduced by 3%. A panel in full sun operating at 140°F will decrease in performance 10%.
- If the batteries are fully charged or there are other charging sources active, the solar controller will reduce or even shut off power to the battery to prevent overcharging of the battery. This will be reflected in the meter. Turn off all other charging devices and put a load on the system with appliances. Check the meter.
- There may be a loose or defective connection in the MC4 connectors or the wiring between the solar panels and the solar controller. Starting at the controller, check the voltage and amperage in the wire. Take measurements at each MC4 connector all the way to the panels to find the faulty connection.

Below is contact information should you have questions or comments.

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