# Beginner's Guide to ElectroDacus

**DRAFT VERSION 0.2 – 2021/03/11**

**MAY CONTAIN ERRORS**

By Oberon Robinson, with awesome contributions from Dacian Todea & FilterGuy


## 1 Overview

The ElectroDacus system takes care of solar charging, lithium battery monitoring, and optionally, diverting excess solar power for other uses. Its modular components can function as a BMS, a charge controller, and a thermal controller. It was designed for DIY systems, and is highly customizable – which gives it a bit of a learning curve, but a very worthwhile one.

There are a number of concepts that the ElectroDacus design uniquely brings together:

1. **Non-current-carrying**. Most battery monitoring systems (BMS) have the full current of the battery running through them, and when the battery gets to its charge limits, they switch the current off using large solid-state switches (MOSFETs). This limits the amount of current that the BMS can handle, and can also create excess heat.

   The ElectroDacus SBMS0 takes a different approach, by providing on/off signals to the battery's inputs and loads. When the battery gets full, it switches off the charging sources, and if the battery gets low, it switches off any draws. The switching function is customizable, with multiple input/output ports, and programmable set-points.

2. **Simplified charge control**. Most charge controllers work either with maximum power point tracking (MPPT) or pulse-width modulation (PWM). The ElectroDacus approach is that neither of these technologies is necessary for lithium batteries. Instead, the solar panels are matched to the battery voltage.

   This works because lithium batteries have very low internal resistance, and will draw as much current as the panels can produce. This prevents the panel output voltage from ever rising above the battery voltage – at least until the battery is full, at which point the power is switched off or diverted. So the battery inherently charges at the available power output of the panel.

   In situations where it isn't practical to match the panel voltage to the battery, such as with very large solar arrays or very long cable runs, the SBMS0 can still work with a separate charge controller using remote switching.

3. **Excess power diversion**. Solar arrays are usually sized for the power output that's needed for the worst conditions. That means that at all other times, there is more solar power available than the battery's capacity. The ElectroDacus system gives you the option to divert that excess power for other purposes – such as heating, hot water, pumping, or cooling. This option can be built in to the same switch that disconnects solar charging from the battery. And for whole-home heating, there is an additional thermal controller module available for maximum heating efficiency.

4. **Active cell balancing**. Any time there is a charge current of at least 300mA, the cells will be actively balanced via the same wires that are used for cell voltage sensing. ElectroDacus uses the exact same type of balancing as commercial EV's (Tesla, Nissan Leaf, etc).

5. **Maximizing battery cycle life**. Many inexpensive BMS's protect a battery from failure, but don't do much to extend its cycle life. ElectroDacus incorporates numerous methods to maximize cycle life, using safe default parameters, and all of those parameters can be customized via the built-in display.

6. **Display included**. There is a built-in colour display and controls, which allow for monitoring and adjustment, with no additional hardware. This eliminates the need for a smart shunt or external battery monitor.

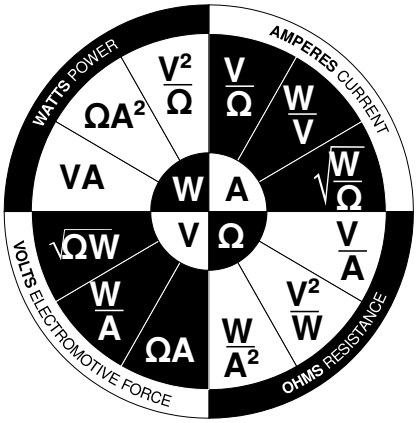
7. **Data logging**. Up to a year of logs are stored internally, and can be downloaded for analysis or record-keeping. The logs include individual cell voltages, charge percentage, temperature, load current, solar charge current, and other data, each recorded at 2-minute intervals.

8. **External interface**. You can connect an external device via WiFi, USB, or UART – such as a phone, laptop, Raspberry Pi, or Arduino – for additional monitoring and control.

9. **Dual solar array**. You can set up your solar array in two parts, ideally with one part being twice as large as the other, and the best combination of parts for the current conditions will be automatically connected for optimum charging.

10. **Open source design**. The hardware and firmware are released under an open source license, so if you want to, you can build your own, and/or customize the design and coding.

This guide is intended for DIY enthusiasts who are comfortable building electrical circuits and taking multimeter readings. Knowing Ohm's law is also helpful. And you will need to source some additional components, such as shunts and resistors, which will be fully explained later in this guide.



The way the guide is structured is to first look at all the different system components, and how they interact with ElectroDacus. After that, it goes through the actual process of connecting and configuring everything together.

This is not intended to be a substitute to the ElectroDacus manuals, which are written by their inventor, Dacian Todea. Reading the manuals thoroughly is essential. This is just a different way of presenting some of that information, to help make everything as clear as possible.

# 2 Battery design with SBMS0

SBMS0 is short for Solar Battery Monitoring System Zero – the zero refers to the battery charging & load currents that pass directly through the unit. (They don't.) The SBMS0 is the heart of the ElectroDacus system. It will work with any lithium battery chemistry, or a supercapacitor.

Currently, the most cost-effective cell chemistry is lithium iron phosphate ($LiFePO_4$), so this guide will assume that's what you're using, but it's just as easy to set up other cell types if you prefer.

At the time of writing, the best values in $LiFePO_4$ cells on the market are EVE and Lishen cells. CALB, Fortune, and other cells are also commonly used. Just make sure to use a reputable supplier, which you can find by looking for suggestions and feedback in online solar forums.

## 2.1 Choosing a battery voltage

The SBMS0 can monitor 3 to 8 cells, at a total battery voltage of 8 to 32 volts. Each of the monitored cells can be made up of more than one physical cell in parallel, to create a larger effective cell and more total battery capacity.

$LiFePO_4$ cells have a nominal voltage of 3.2V, so in practice you will most likely use multiples of 4 cells for a 12V battery, or multiples of 8 cells for a 24V battery.

It is suggested to build a 24V battery if possible, as the currents in your system will be half what they would be with a 12V battery. This will give you multiple savings in your wire sizes and other components. Even if some parts of your system require 12V, it is likely still more cost-effective to run on 24V and add a DC-DC converter for your 12V loads.

However if you only have space for 4 cells, or if that is enough capacity for you, then go with a 12V system.

If you want to build a 48V system, unfortunately ElectroDacus is not designed for that. You could build two 24V batteries in series, controlled by two SBMS0's – but they don't have the ability to communicate with each other about their battery states, so the two batteries would gradually drift apart in charge, and only one of the batteries would be able to get its daily state-of-charge calibration.

## 2.2 Battery capacity & configuration

To calculate your battery capacity, you'll need to calculate your total daily power needs, and figure out how many cells are required to handle that load. There are other resources that cover this in detail.

Say, for example, you're using 280Ah $LiFePO_4$ cells, and you need a 14kWh battery, which would require 16 cells.

You could parallel your 16 cells in groups of four, then put four of those groups in series, to make a 12V battery.

Or you could parallel them in groups of two, then put eight of those groups in series, to make a 24V battery.

Both will have the same capacity of 14kWh, but the 24V battery will only need to put out half the current of the 12V battery for an equal level of power output.

The paralleled cells are functionally identical to a single larger cell of that capacity.

What is not recommended is to build 4 separate 12V batteries and connect them in parallel, or build two 24V batteries and connect those in parallel. Each of those paralleled batteries would require its own BMS, and those BMS's should be interconnected. This is not a function that's built in to ElectroDacus.

If you are using a large number of smaller cells, and you're willing to spend the time to measure their individual capacities, then a useful online resource to configure your battery pack is rePackr. It was designed for 18650 lithium-ion cells, but works equally well for $LiFePO_4$ or other battery chemistries.

# 3 Solar panels

The choice of the total size of your solar array depends on many factors, including insolation, available space, battery charge rate, and total daily loads. Once you know what your overall array size needs to be, you can choose the specific panels you're going to build it with.

If you're using an MPPT or PWM solar charge controller, you'll need to follow its specifications to select and wire your panels – they can usually work with a wide variety of panel sizes.

The rest of this section is for information about using the ElectroDacus DSSR20 controllers, which can manage solar arrays of up to a maximum of 18kW.

DSSR20 stands for (Ideal) Diode Solid State Relay 20 - the 20 refers to the 20 amps of current that each of these units can carry & switch. They are designed to work with panels that are matched to the battery voltage...so they simply turn the charging circuit on and off.

If you choose the DSSR20 units with diversion, then when battery charging is turned off, your solar power is diverted to a different use of your choice. More on this in Section 4.

## 3.1 Choosing your panels

Each individual cell in a panel produces up to 0.5-0.6V, so you'll need to select a panel with the number of cells that add up to the right charging voltage for your battery. There are always some voltage losses in a system, and less-than-ideal sun conditions, so you also need some extra cells to make up for them.

Part of the ElectroDacus philosophy is that because solar panels have become so inexpensive relative to other system components, it is often more cost-effective to add more panel capacity than to design your system to be as perfectly efficient as possible.

Most panels are sold by watts, not by number of cells, so to select your panels, you may need to count the number of cells across & down, and multiply.

For a 12V system, you will generally use 32-cell solar panels – or 36-cell panels if you have longer than a ~20m (65') cable run between your panels and battery. Look for nominal 12V panels, and choose the price-per-watt that gives you the quality and warranty that you are looking for.

For a 24V system, you will generally use 60-cell solar panels – or 72-cell panels if you have longer than a ~20m (65') cable run between your panels and battery. If you get half-cut cells, they will have 120 or 144 half-cells respectively. Look for nominal 24V panels, and choose the price-per-watt that gives you the quality and warranty that you are looking for.

## 3.2 Arranging your panels

Each DSSR20 has a capacity of 20 amps, and up to 51 volts, of photovoltaic input. To see how many panels one of them can control in parallel, divide 20A by your panels' short-circuit current ($I_{sc}$). For example, if your $I_{sc}$ is 10A or less, you can have two of them in parallel per DSSR20. If your $I_{sc}$ is 6.6A or less, you can parallel three of them per DSSR20 – although with more than two panels in parallel, you will need to fuse each panel.

It's also possible to use smaller panels, and for example have two parallel pairs of two panels in series, all being controlled by one DSSR20, as long as the total maximum current they produce is 20A or less.

You will need as many DSSR20's as you have sets of 20A parallel panels. For example, if you have a 10-panel array, and 2 panels paralleled per DSSR20, you'll need 5 DSSR20's.

The SBMS0 can control up to 30 DSSR20's, with a maximum array size of 18kW. For such large arrays, this may not be the most cost-effective option, so you may want to compare it with the cost of using a single large solar controller, with fewer wires to your array.

## 3.3 Dual arrays

If your weather and seasons give you a large variation in solar output, it can be difficult to design a solar array that always fulfills your needs. Having dual arrays can help solve that issue.

You can set up dual arrays if you have at least two DSSR20's. Ideally, one array will be half the size of the other, and the SBMS0 can charge your battery with the smaller, larger, or both arrays. This allows you to set a maximum charge rate for the health of your battery, and more panels will automatically be connected in cloudy conditions to try to maintain that charge rate.

For example, say you have 3× DSSR20's, and each of them is connected to a pair of panels that can supply 20A. So you have a maximum solar output of 60A, but say you want to keep your battery charging rate at a maximum of 20A to maximize its cycle life. You could set up two of your DSSR20's as your large array, and the other one as your small array.

That way, when there's full summer sun, just the small array will be connected, and when it's a cloudy day in winter, both will be connected. The SBMS0 can automatically select charging at 1/3, 2/3, or all of your full solar power output, based on your actual charge current and your maximum setting.

More details of how this is set up are explained in Section 5.5, Type 6.

# 4 Diversion

So you've sized your panel array to give you enough power in the worst possible conditions. But what happens when conditions are great? Your battery will be fully charged by noon, and all the rest of your solar power is now wasted. Or is it? Not if you have a system that can automatically divert that extra power to other uses.

You could heat your house, or a hot water tank. You could power an air conditioner. Or you could run a pump to fill your pond. The possibilities are limited only by your imagination.

To enable diversion in your system, you only need to have DSSR20's with the extra diversion components installed, and one or more DEXT16 units to manage your diversion circuits.

DEXT16 stands for DSSR20 Extender 16, because it can connect up to 16× DSSR20's with diversion. It is an inexpensive add-on component that works with the SBMS0 to provide the necessary signals to control both solar charging and diversion.

If your diverted power needs to have on/off control – such as a thermostat or float switch – that can be done at low voltage, by switching the control wire to the DEXT16.

# 5 Controlling inputs and loads

Besides a number of other ports which we'll cover later, the SBMS0 has 4 external input/output ports, labelled EXTIO3 through EXTIO6. The + and – polarity on these ports actually doesn't matter, but it did on earlier versions of the SBMS0, so it is kept for backwards compatibility.

By default, EXTIO3 turns on and off the system's electrical loads, and EXTIO4 turns on and off the charging inputs. However, each of the 4 EXTIO ports can be configured for any of 6 different switching modes.


The way each of the EXTIO ports works is like an on/off switch. They do not provide any power by themselves.

The actual switching within the SBMS0 is done with a photorelay, which has a maximum current capacity of 50mA. As the system designer, you will need to put together the trigger circuits for all of your charging inputs and loads, and make sure that the current in each of those circuits stays below 50mA. If you aren't familiar with circuit design, this may seem intimidating, but it's really quite easy.

You will need to know the remote on/off circuit current for each device you are controlling. You may be able to find a specification for it, or simply measure it: connect the device to power, remove the jumper (if any) from the remote terminals, and connect your multimeter (set to amps) across them. You will either get a reading in amps, or nothing will happen – in which case it's likely that it needs an external voltage applied (see Section 5.3).

## 5.1 Switched trigger circuits: 50mA or below

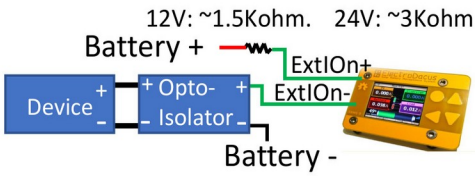
In the simplest case, the EXTIO-switched devices will have an external trigger circuit that is closed (shorted) for on, and open for off. Most Victron products, for example, are controlled this way – and they, like the DSSR20, have a switching current that may be as low as 2mA. Most remote on/off circuits are well below 10mA.

As long as the total of the remote switching currents being controlled by an EXTIO port is 50mA or less, they can simply all be connected to one EXTIO in parallel.

## 5.2 Switched trigger circuits: above 50mA

If your devices are on/off triggered, and the total switching current needed on one EXTIO port is above 50mA, then you will need a relay – ideally, an optically-isolated solid-state relay (SSR). The CPC1706 is a good choice for many applications, and has a maximum load current of 4A.

In order to power the relay, you will need to connect the EXTIO+ to your positive busbar via a resistor, and the EXTIO– to the SSR input positive. Then connect the SSR input negative to your negative busbar.



Your device(s) can now be switched by the SSR load terminals.

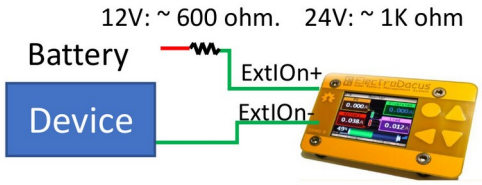
The size of the resistor depends on the minimum switching current that's required by the SSR. For example, the CPC1706 mentioned above requires 5mA to activate, so for a 24V battery, the resistor can be a maximum of 24V ÷ 0.005A = 4,800Ω. To give a safety margin, you may want to size it around 3,000Ω. Then to check the power rating for the resistor, $V^2/R = 24^2 \div 3000 \approx 0.2W$, so with a healthy safety margin, a 0.5W resistor will be good.

See Section 9 for more information about sourcing resistors.

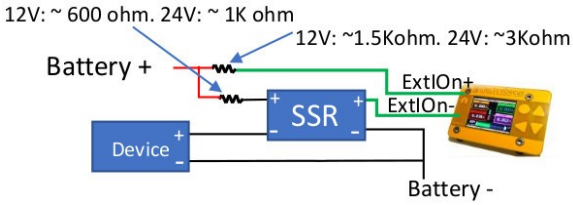
## 5.3 Trigger circuits that require external voltage

Some devices require an external voltage to be applied in order to turn them on and off. In this case, you'll need to dedicate one of your EXTIO ports for this purpose.

If the switching current that's required is 50mA or less, you can simply connect EXTIO+ to your positive busbar via an appropriately-sized resistor, and connect EXTIO– to your load.




If the required switching current is more than 50mA, you'll need to use an SSR. In this case, to wire it in, you'll also need a resistor for both the input circuit and the load circuit.




## 5.4 Other control cases

- For the SBMS0 to disconnect DC loads in a low battery charge event, you will need a large relay that can handle your maximum DC load current. Many people use a Victron Battery Protect for this purpose – they come in multiple current ratings – and set it to Li-ion ('L') mode.

- There are inverters that don't have a remote trigger circuit, but do have a physical on/off switch. In this case, you can simply solder an EXTIO circuit across its on/off switch, which will allow the SBMS0 to turn the inverter on and off. You may want to remove or otherwise lock-out the original switch, because if it gets accidentally left on, the SBMS0 won't be able to turn off the inverter at low battery charge.

- Some inverters turn on and off using a momentary switch. This is more difficult to control automatically, however Ross Freeman came up with a circuit that can do it, for at least some inverters, if you're comfortable building a small circuit board.

## 5.5 EXTIO types

Each of the four EXTIO ports can be configured as one of six possible types:

**Type 1: Charge disconnect** – switches off (open circuit) when the battery reaches its upper set-point for state of charge (SOC). This is the default type for EXTIO4, and is used for controlling any charging source: DSSR20, MPPT charge controller, grid charger, or battery-to-battery charger. It is recommended to use EXTIO4 as this type in case your SBMS0 is ever reset, so it will stay the same.

**Type 2: Load disconnect** – switches off (open circuit) if the battery drops to its lower SOC set-point. This is the default type for EXTIO3, and is used to control any loads: inverter, DC loads, etc. It is recommended to use EXTIO3 as this type in case of a reset.

**Type 3: High voltage alarm** – switches on (closed circuit) when the battery goes above its upper voltage set-point. This can be used to set an alarm in case the charge disconnect fails for some reason and the battery gets to a higher voltage than it normally should. This type can also be used creatively, for example to turn on extra loads when the battery is getting close to full.

**Type 4: Low voltage alarm** – switches on (closed circuit) when the battery falls below its lower voltage set-point. This can be used to set up an alarm, similar to Type 3. Or it could also be used to connect a backup charging source.

**Type 5: Fault condition** – switches on (closed circuit) if the battery reaches an outer limit of high or low voltage, which are set in the 'Voltage Lock' parameter settings. This is intended to trip a remote-triggered breaker in the unlikely event that all of the other safeguards have failed.

**Type 6: Charge disconnect for dual array** – switches on or off as needed to control the charging rate from a dual solar panel array. Connect your smaller array to a Type 1 EXTIO, and your larger array to a Type 6 EXTIO, and the SBMS0 will automatically connect one or both arrays to optimize the charging rate. Note that a PV shunt is required for this function (See 6.2). Set your charging current as the 'Max Charge Limit' in the DMPPT settings menu.

# 6 Using current shunts

The SBMS0 keeps track of your battery's state of charge (SOC) by monitoring the current flow into and out of the battery. It does this by measuring the voltage drop across a shunt at the battery positive terminal. Optionally, you can add another shunt on your solar circuit to measure your solar power generation.

A shunt is a resistor with a low but accurately-known resistance, that is able to handle high currents. Some shunts can be expensive, but have a look at Riedon or Murata for shunts that are high quality and reasonably priced. You can also order inexpensive shunts from China – they won't be very accurate, but it's possible to calibrate for the error.

Shunts are usually rated by current and voltage drop. For example, a Riedon RSB-300-50 is rated for 300A and 50mV. If you see a shunt rated by current and resistance, you can calculate its voltage drop as V=IR (voltage = current × resistance).

The current rating is the maximum current a shunt can carry. However the maximum continuous current through your shunts should be no more than 2/3 of their rated current.

A shunt's rated voltage drop is quoted at the rated current. The SBMS0 has a shunt voltage reading scale of 90mV, so a 75mV or 100mV shunt will give you the most accurate readings. On the other hand, if you want to minimize any heat created by your shunt, you could go with a 50mV shunt – the accuracy of the readings will still be very good.

## 6.1 Battery current shunt

The battery current shunt is a required component, and lets the SBMS0 keep track of your battery's state of charge (SOC). It must be connected directly to the battery positive terminal – with no breaker, fuse, load, or disconnect in between.

To size your battery current shunt, calculate the maximum continuous total load current that your system may ever have. Then add 50% more, and round up to the next available shunt current rating. Then choose a shunt with a voltage drop of 75mV or 100mV for maximum accuracy, or 50mV for minimum heat dissipation.

You will need to enter the resistance of your shunt into the SBMS0 settings (Section 8). If it is not quoted, you can calculate it as R=V/I, for example 0.075V÷200A=0.375mOhms.

## 6.2 PV current shunt

Installing a photovoltaic current shunt is optional but highly recommended. It measures your solar charging current, which is useful to know by itself. And it also allows the SBMS0 to calculate and log other data, such as load current, total solar energy, and total power draw – none of which can be known without it.

To size your PV current shunt, first calculate your system's maximum solar output current. If, for example, you have 3× DSSR20's, that would be 3×20=60A. Then add 50% more, and round up to the next available shunt current rating. For the same example, 60×1.5=90A, so choose a 100A shunt. Then follow the same recommendations for voltage drop as above.

If you are using dual arrays (see Sections 3.3 and 5.5) then a PV current shunt is a required component.

# 7 Circuit protection

The main reason why it's important to have a fuse or breaker on each circuit in your system is to prevent smoke and fire in the event of a fault.

When you think about how much energy is stored in your battery, and then imagine all of that energy getting immediately released if one of your cables accidentally makes contact in the wrong place, it makes sense to have safety measures in place to provide an emergency disconnect.

Generally, breakers are priced a lot higher than fuses. It's up to you whether you want to invest more for breakers which can be reset, or keep spare fuses so they can be replaced. In a well-designed system, that should never be needed, but it's the real world and sometimes interesting things happen.

Fuses and breakers shouldn't be run at more than 80% of their rated value. That means that each circuit should be protected at 1.25× the maximum continuous current the circuit will see, and the fuse or breaker needs to be DC rated for at least the highest voltage across the circuit.

At the same time, the fuse or breaker should always disconnect the circuit at less than the rated ampacity of that circuit's smallest wire – including the negative. So:

**Wire ampacity > Fuse rating > Maximum current in that circuit**

Another factor to consider is that if your fuses or breakers will be operating at ambient temperatures above 40°C (104°F), they will need to be derated – you should be able to get temperature-dependent ratings from the manufacturer.

See Section 10.2 for more in-depth resources about DC circuit protection.

## 7.1 Solar panel protection

Each solar panel is rated with a short-circuit current, $I_{sc}$, which is the maximum current the panel produces at the standardized testing conditions. But in other conditions, the actual maximum current may be as much as 1.25 times that. And the circuit protection should be rated at 1.25 times the actual maximum current. So a fuse or breaker for a solar panel should have a rating of $1.25 \times 1.25 \times I_{sc} = 1.56 \times I_{sc}$.

Similarly, the highest rated voltage for a solar panel is the open-circuit voltage, $V_{oc}$. That is measured when the cell is at 25°C (77°F) – and panel voltage increases as temperature decreases. So in a cold climate, the actual maximum voltage may be up to 1.25 times the rated $V_{oc}$. All of the over-current protection devices on your solar circuits should be voltage-rated with that in mind.

When solar panels are connected in series, their voltages add together, but the current does not. Any number of panels can be connected in series without needing extra fuses or breakers.

When panels are connected in parallel, the currents add together, but the voltage does not. Up to 2 panels can be connected in parallel without individual fuses or breakers, but 3 or more panels connected in parallel need to each have individual circuit protection, rated for a current of $1.56 \times I_{sc}$, and a voltage of up to $1.25 \times V_{oc}$ for cold climates.

If you are using the standard configuration of 2 panels per DSSR20, then you'll need one fuse or breaker for each DSSR20, rated for 32A to 40A. It should be wired in at the DSSR20 end of the cable that runs to the battery positive. You might consider Langir DC breakers for this.

## 7.2 Battery protection

A lithium battery can easily put out thousands of amps in a short circuit, and a regular fuse is definitely not designed for that kind of excitement. So there should be a Class-T fuse at the battery positive, rated for at least 1.25× the maximum continuous current draw that you expect to have on your battery.

Since the SBMS0 requires the current shunt to be the first thing connected to the battery positive, your Class-T fuse should be connected immediately after that, and before the cable running to your positive busbar and your loads.

## 7.3 Load circuit protection

For DC loads, most people add an automotive fuse block. Automotive fuses are generally rated for up to 32V DC, but they are not specifically rated for lithium batteries, so use them at your own risk. If you have both 12V and 24V loads with a DC-DC converter, you will need two fuse blocks, one for each voltage.

Your inverter will need its own DC fuse on the supply side, and an AC breaker box on its load side. The DC fuse should be sized according to your inverter's rated maximum wattage, divided by nominal battery voltage, and multiplied by 1.25. Since there can be very high current running to your inverter, you may want to consider making this a Class-T fuse as well. And always make sure that both its positive and negative wires have a larger ampacity than the fuse.

## 7.4 SBMS0 control-wire protection

If you are running powered control wires through your SMBS0 EXTIO ports, each of them should have a resistor at the positive busbar end of the control wire.

If you are supplying power to the load side of any solid-state relays that are being controlled by EXTIO ports, those should also be protected by a resistor or a fuse.

# 8 Connecting everything up

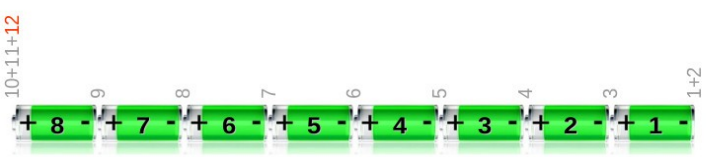
Finally, after all that background, we can talk about connecting all of your components together.

The first thing to take care of, before anything else, is to top-balance your battery cells. If you aren't familiar with this process, there is a resource linked in Section 10.2 that covers it well.

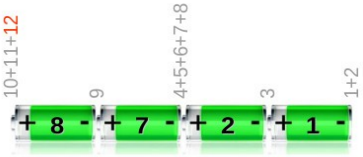
Next, follow the steps in the SBMS0 manual to connect it to your battery. The manual explains everything clearly, but this section gives you a summary of the important points.

## 8.1 Battery sense wires

Connect the ribbon cable sense wires to your battery – you might want to get something like the Wirefy 3/8" Red ring terminal connectors. The ribbon cable can be cut shorter, but make sure to keep all of its wires the same length as each other. Leave the SBMS0 end disconnected until you are 100% sure you have the battery cell wires hooked up correctly. Start with the red wire, which is wire #12, and number them sequentially down from there.




24V LiFePO$_4$




12V LiFePO$_4$

## 8.2 First boot up

Connect the 12-pin connector on the ribbon cable to the SBMS0. Once it boots up, go to the Parameter Settings menu, and select your type of cell, number of cells, and battery capacity. Then select Store Parameters to save your data, and reboot the SBMS0 by removing and reconnecting the 12-pin connector. This is the only time you need to reboot after saving your settings.

## 8.3 Control wire connections

Now the control wires can be connected. These should be in twisted pairs, which you can most easily get with a CAT5 or CAT6 Ethernet cable – solid wire is best, or you can add ferrules to stranded wire.


1. PVn & PVp – photovoltaic current shunt (see Section 6.2). PVp connects to the positive side of the shunt closest to your panels, and PVn connects to the negative side closest to your battery.

2. ADC1n & ADC1p – battery current shunt (see Section 6.1). The positive terminal is on the side of the shunt closest to your battery. The terminals are the other way around than the PV shunt terminals.

3. ADC2 & ADC3 – these are voltmeter inputs. They don't have any control function, but you can connect each of them to any wire or terminal whose voltage you would like to know, and their voltages will be logged. They have a range of 0-60V DC.

4. EXTIO3 to EXTIO6 – these are the switching control ports that are covered in Section 5. Because every system is unique, you will have to design your own control circuits, and make sure that the SBMS0 is able to turn off all of your charging sources and all of your loads.

5. XT1 – this is a battery temperature sensor circuit. It is optional but highly recommended that you connect a 10kΩ thermistor on this circuit, so the system can prevent damage to your battery if it is outside of a safe operating temperature. If your battery is in a conditioned living space or your climate never goes outside a safe range, you can leave this off. See Section 9 for thermistor sourcing info.

## 8.4 Settings

There are a number of settings that you'll need to adjust to make everything work the way you want it to. Most of the default settings for battery parameters should be left the way they are unless you really know what you're doing, and there are many advanced settings that we won't cover in this guide. Here are the basic ones that you'll need to set – and for many people, there won't be any need to change anything else.

Each of the settings will scroll when it is selected to give you more information.

**a)** Device Settings ➟ Time & Date – these need to be set to enable data logging.

**b)** Automation ➟ EXT IOx – set the Type for each of the EXTIO ports that you have hooked up, and the battery state of charge (SOC) at which you want them to act.

**c)** Automation ➟ EXT ADC – set your shunt resistances for your battery shunt (see Section 6.1) and your PV shunt (see Section 6.2). You can also fine-tune the calibration here over time if you are finding that the currents measured by the SBMS0 are not 100% accurate.

**d)** Make sure you select 'Device Settings ➟ Save Device Settings' when you're finished making any changes.

# 9 Sourcing circuit components

Note: this guide does not contain any affiliate links, and there is no sponsorship or affiliation with any of the products or companies mentioned – they are only given as examples to help you find the best options for your needs.

[To Do: add explanations and links to products]

- Control wire resistors
- Inverter capacitor charge resistor
- SSRs
- shunts
- thermistor
- crimp connectors
- Wirefy 3/8" Red ring terminal connectors
- ferrules 966066-3

# 10 Additional resources

## 10.1 ElectroDacus-specific info

ElectroDacus manuals – read them very carefully, with a fine-toothed comb, in as much detail as possible. Then read them a few more times because you definitely missed something important.

ElectroDacus Google Group for online support

ElectroDacus I/O Summary Chart by FilterGuy – another useful resource document. Free forum signup required to download.

Momentary switch inverter control circuit by Ross Freeman

[To Do] Adding a Raspberry Pi or Arduino

## 10.2 General solar info

Insolation map – average solar production for locations worldwide

rePackr – combine multiple smaller capacity cells into an optimized battery

MarineHowTo article on $LiFePO_4$ systems – intended for marine but applicable to everyone

Nordkyn Design series on lithium battery systems – also originally for marine but has excellent in-depth information about lithium and solar

Top-balancing lithium cells by FilterGuy

DC circuit protection by FilterGuy

## 10.3 Example system circuit diagrams

[To Do]