As an Amazon Associate, this site earns commissions from qualifying purchases. For more details, click here. When a solar panel charges a battery, you need a charge controller to prevent overloading. If you have a 500W solar panel for instance, the charge controller must be the right size to match the current coming into the system and provide protect for the panels and the battery. A 500W solar panel needs a 30A charge controller. Divide the watts by the battery voltage and add 25%. In this case, 500 watts / 24V battery voltage + 25% = 26 amps. Round it off to 30A and you have the ideal charge controller size. In the following examples we will use 500 watt solar panels. But these calculations work with any solar panel size. To calculate charge controller size, divide the solar panel watt output by the battery voltage. Add 20-25% to the result and you have the charge controller size you need in amps. In our example we will add 25%. It looks like this: Watts / battery voltage +25% = charge controller size in amps. Charge controller sizes are measured in amps (A). The most common are 10A, 20A, 30A, 40A, 50A, 60A, 80A and 100A. Round off the figure you get to the next largest size available. Suppose you have the AC POWER 500W Solar Panel Kit , which is optimized for RV, home and other off grid applications. Now you just need to figure out what battery voltage to use. The most commonly used are 12v and 24V. If you pair a 500W solar panel with a 12V battery, you will need a 60A charge controller. 500 / 12 + 25%= 52 Round off 52 amps to 60, and that is your charge controller. If you use a 24V battery with your 500W solar panel, you can use a 30A charge controller. 500 / 24 + 25% = 26 Rounded off that would be 30 amps. In this case, you can use a 24V battery like the Ampere Time or connect two 12V batteries in a series to get 24V.You can use this approach for any solar panel or battery size. Once you know the charge controller size, the nest step is to decide what controller type to use. This is what we discuss below. An MPPT charge controller is the best for a 500 watt solar panel system. It is up to 30% more efficient than a PWM and offers greater flexibility. A PWM charge controller is only suitable for small solar panels. To understand this, we need to explain the difference between nominal and actual voltage. Solar panels and batteries are classified as 12V or 24V, but these are nominal voltages. A 12V solar panel can charge up to 18 volts, while a 12V battery charges from 12.5 to 14.4 volts. Suppose you have a 100 watt solar panel, a 12V battery and a PWM charge controller. A PWM charge controller pulls the power up to the maximum battery charge limit, which is 14.4 volts. Most of the time, 12V batteries charge at 13V. To find out how much solar power is being charged, multiply volts x amps. Assuming the solar panel lmp LNK is 5.7 amps: 13 x 5.7 = 74.1 Only 74.1 watts out of the possible 100 watts goes into the battery. Solar panels rarely draw up to maximum power, but even at 90 watts, that is 16 watts an hour wasted. Multiply that by 5 hours and 80 watts is wasted per day. Now imagine if you have 5 x 100 watt solar panels hooked to a PWM controller. Using the same calculations the battery will get only up to 370 watts out of a possible 500 watts per hour. An MPPT charge controller like the Victron 30A is better optimized for these situations. Using the same system specs, more power goes into the battery. Assume the battery charges at 13 volts. With a PWM controller the rest goes to waste. But an MPPT turns them into amps. With an 18 volt solar panel charge: 18 / 13 = 1 .38 Now we multiply the lmp by 1.38: 5.7 x 1.38 = 7.8 Now we have 7.8 amps. Multiply this by the battery volt charge: 13 x 7.8 = 101.4 That is 101.4 watts. It is higher than the solar panel maximum output, but since panels are not perfect the result will be less than 100 watts. But this goes to show why MPPT controllers are superior to PWM. For small systems, a PWM is fine, but for a 500 watt solar system and larger, MPPT is a must. You typically need just one charge controller for a solar system. Large solar arrays benefit from multiple controllers, but for a 500 watt system, one is enough to handle the batteries. Recall that you have to divide the solar panel watts by the battery voltage to get the charge controller size. In our example we used 12V or 24V batteries. But you are not limited to one 24V battery. You can connect two 12V batteries in a series and get 24V. Two or more batteries can be joined together in a series or parallel connection. Batteries connected in parallel will add up their amps, but not the voltage. If you have 2 x 100ah 12V batteries in parallel, you will get 200ah capacity but the voltage will remain at 12V. Batteries connected in a series will add their voltage but not the amps. If you have 2 x 100ah 12V batteries in a series, you get 100 ah capacity at 24V. To configure batteries in parallel, connect the positive terminal of one battery to the positive terminal of another battery. Repeat this with their negative terminals. To configure the batteries in a series, connect the positive terminal of a battery to the negative terminal of another battery. Repeat with the rest. Going back to our example: you can use several batteries with your solar panel without exceeding the capacity of your charge controller. If you have 2 x 12V batteries connected in a series, you get 24V, which means you need a 30A charge controller. But if you add another 12V battery, the minimum charge controller size goes down to 20A. Most of the time though we configure batteries in parallel to increase capacity. In this case the voltage does not get added up so you can use several. With an MPPT charge controller, you can use parallel or series configurations and get maximum output. If you are going to run AC appliances you will need an inverter too. The inverter size will depend on how much power load it has to carry so keep that in mind. If you are still thinking of setting up your solar system without a charge controller, don't. There are a lot of reasons why you should always have one installed. Automatic Low Voltage Disconnection. Your charge controller, as the name makes clear, controls the amount of current and power going into the battery. A solar panel and battery setup without a charge controller can result in an overload and destroy the components. Overload Prevention. Solar panels continuously receive energy from the sun. There is no off button here. If you don't have a charge controller installed, the panel will keep transmitting current into the battery. This can overload the system and cause serious problems. Reverse Current. Solar panel current normally flows into the battery. But sometimes the opposite can happen whereby the battery current flows back into the solar panel. Reverse current is also the reason why some charge controllers appear to drain batteries at night. This can be prevented with a charge controller installed between the solar panels and battery. I am an advocate of solar power. Through portablesolarexpert.com I want to share with all of you what I have learned and cotinue to learn about renewable energy. How can financial brands set themselves apart through visual storytelling? Our experts explain how.Learn MoreThe Motorsport Images Collections captures events from 1895 to today's most recent coverage.Discover The CollectionCurated, compelling, and worth your time. Explore our latest gallery of Editors' Picks.Browse Editors' FavoritesHow can financial brands set themselves apart through visual storytelling? Our experts explain how.Learn MoreThe Motorsport Images Collections captures events from 1895 to today's most recent coverage.Discover The CollectionCurated, compelling, and worth your time. Explore our latest gallery of Editors' Picks.Browse Editors' FavoritesHow can financial brands set themselves apart through visual storytelling? Our experts explain how.Learn MoreThe Motorsport Images Collections captures events from 1895 to today's most recent coverage.Discover The CollectionCurated, compelling, and worth your time. Explore our latest gallery of Editors' Picks.Browse Editors' Favorites Planning to install a solar panel system this new year, then you must have made the list of things you would require. Well, have you included charge controllers in the list? If not, then it is recommended to add them right away, as they are one of the essential elements in a PV system. Depending on the wattage of your solar panels, you have to decide the size of controllers. Let's calculate what size of charge controller will be needed for 100W, 500W and 1000W solar panels. The wattage and voltage of your solar panel must be considered while finding what size charge controller for 100W 500W and 1000W solar pane is needed. There are two kinds of charge controllers: PWM and MPPT. When choosing the size of a PWM controller for your solar panel system, consider the following factors: PWM charge controller is important for solar panel systems to maintain constant voltage. Check panel specs, and multiply the current output by a safety factor to choose the right controller. Moreover, consider max power current and short circuit current too because a higher capacity controller should be selected when expanding the system, as it is necessary to match battery type with the PWM controller. When choosing the size of an MPPT controller for your solar panel system, consider the following factors: The main factor is the amp reading, which determines the amps used by the MPPT charge controller. The second factor is the voltage rating for MPPT controllers, as they can adjust voltage levels. It's crucial to ensure that the rating of the MPPT controller exceeds that of the solar panel. Lastly, consider the solar input voltage. The MPPT controller guarantees efficient voltage adjustments based on the solar panel's specific needs. The size of charge controllers is measured in terms of their amperage. The most widely used sizes of charge controllers are 10A, 20A, 30A, 40A, 50A, 60A, 80A and 100A. The size of the charge controller required for the solar panel is determined by dividing the solar panel watt output by the battery voltage and adding 20 – 25% to the result. To find what size charge controller for 100W, 500W and 1000W solar panel is required, you need to round off the figure you get to the next largest size of the charge controller available. For a 100W solar panel, you will need a charge controller of approximately 1.2 kW, with a maximum current of up to 12A, and the ability to handle a maximum current of up to 1.2 amps. You can determine the size of the charge controller required for your unique 100-watt solar panel array by using the formula power = voltage x current. If we know the power and voltage, we can find the current using the equation, current = power/voltage. In this scenario, 100W divided by 12 equals 8.33 amps, but after adding a safety margin of 25% to this total, it rounds it up to 10 amps. In the example above, a 10-amp charge controller is needed for a 100W solar panel to achieve the best performance and efficiency. It's important to purchase a charge controller with a slightly higher amp rating than necessary to handle the full output of the solar panel. This should clarify any doubts about the appropriate size charge controller for a 100W solar panel. Size of PWM Controller for 100W Solar Panels Let us assume that you are using a 12V battery. In this case, a 100-watt solar panel can somewhere produce 8.3 amps of current. Accordingly, a 10-amp PWM controller would be suitable in this case. Size of MPPT Controller for 100W Solar Panels Different factors have been considered to decide that a 10-amp MPPT charge controller is the most optimal solution for a 100W solar panel system with a 12V battery. Moreover, MPPT controllers are more efficient and better suited for larger solar systems while PWM controllers are a cost-effective option Also See: How much Power does 100W, 500W and 1000W Solar Panel Produce? Since we are discussing what size charge controller for 100W, 500W and 1000W solar panel is needed, you must wonder the right size 400W solar panel. When connected to solar panels, a charge controller limits the amount of charge that gets into the battery and avoids overcharging. When a 400W solar panel saves energy in a battery, the controller ensures that everything runs smoothly. For this to happen, you must have the right charge controller size for your 400W solar panel. If you have a 400W solar panel and a 200Ah 12V battery, you can do the following to calculate what size charge controller for 400W solar panel is required: Watts / Volts = Amps 400 / 12 = 33.3 Now add a safety margin of 25% to this total: 33.3 + 25% = 41.6 For a 400W 12V solar panel with a 200ah 12V battery, a 50A charge controller is required. Nevertheless, some might recommend adding a 20% safety margin to the total, but 25% gives greater safety and reserve capacity. Furthermore, you would be offered the option of using MPPT or PWM. A problem with PWM controllers is that they reduce solar panel voltage in accordance with the battery. However, an MPPT charge controller will set the voltage required by your battery at a better efficiency level. Size of PWM Controller for 400W Solar Panel For a 400-watt solar panel setup with a 12V rating and short circuit current rating of 11 amps, the output current rating of a PWM controller can be calculated by multiplying the short circuit rating by 1.25. In this case, it would be 11 multiplied by 1.25 equalling 13.75. Therefore, the size of PWM Controller for a 400Watt solar panel system should be rated 15 amps with 12V nominal voltage for both the solar panel and the battery. Size of MPPT Controller for 400W Solar Panel In the case of a 400-watt charger with a 12V battery, the output current rating of the MPPT controller can be calculated by dividing the power rating of the solar panel by the lowest charging voltage. So, considering that the battery bank is empty, and its voltage is 10 volts, then the MPPT charge controller will produce an output of 10.5 volts. This means dividing 400 watts by 10.5 volts which gives us 38.09 amps of output current rating. Therefore, the size of an MPPT Controller for a 400Watt solar panel system should be 40 amp with a 12V battery. Also Read: 30 Amp PWM Solar Charge Controller Manual: Comprehensive User Guide A 500W solar panel will require a 30A charge controller as it can handle most solar panel systems operating at peak capacities. Dividing 500 watts by 24V battery voltage and adding 25% will give 26 amps. This figure will be rounded off, and it is 30A. Size of PWM Controller for 500W Solar Panel Typically, the size of PWM controller for a 500Watt solar panel system should be 40A/60A. Size of MPPT Controller for 500W Solar Panel The size of an MPPT controller for a 500Watt solar panel system is around 30A. It is calculated by dividing the solar panel watt output by the voltage of the battery. Don't forget to add a 20%-25% extra margin ratio to the result. Also Read: What Size Charge Controller For 600W Solar Panel? If you have an 800W solar panel connected to a 24V battery, the most suitable option would be a 60A controller. This is because the current produced is calculated as 800/24, resulting in about 33.33 amps. Since 33.33 amps is less than 60A, it is perfectly safe and within a reasonable range. Thus, solar charge controllers ranging between 60A to 100A are suitable to effectively reduce the risk of any damage. Size of PWM Controller for 800W Solar Panel An 800W solar panel could have an Isc rating of around 21 amps, but with a 25% safety margin, the adjusted Isc value would be about 26.25 amps. So, a 30 or more-amp PWM charge controller would be enough for this panel. The higher amps requirements are based on the increase in battery size. Size of MPPT Controller for 800W Solar Panel The size of an MPPT controller for an 800Watt solar panel system should be at least 33A to 40A. It depends on the voltage of the battery bank and the voltage input of the charge controller. A 1000W solar panel with 24-volt battery will require a 40-41-amp charge controller. Similarly, for a 48-volt battery bank, a 20-amp charge controller would be suitable. For a 48V battery bank, the required current can be calculated by dividing 1000W by 48V and adding a 25% safety margin. A 30A solar charge controller is a good choice for a 1000W solar panel with a 48V battery system. Size of PWM Controller for 1000W Solar Panel A 1000W solar panel's Isc is about 26.5A, and with a 25% safety margin, it becomes around 33.13A. Therefore, a 40A PWM charge controller is suitable for the panel. Size of MPPT Controller for 1000W Solar Panel If you are using a 12V battery bank in a 1000W solar panel system, you will need an MPPT controller with a capacity of at least 100 amps. For a 24V battery bank, you will need an MPPT controller with a capacity of at least 24V and 40 amps or 60 amps. Well, today we learned what size PWM and MPPT charge controllers are suitable for 100W, 500W, and 1000W solar panels. While this blog gave you an estimated idea of what and how to choose, it is still highly recommended that a professional technician should be referred. Recommended: How Many Batteries are Needed for a 100W, 500W and 1000W Solar Panel? There are two types of charge controllers available in the market. Depending on the number and power of the solar panels to be paired with the number and voltage of the battery bank, a selection of the best size charge controller can be made. Charge controllers are rated according to amperage. Charge controllers are sized to cope with the input voltage and current from the solar panels and how this power is most efficiently transferred to the battery bank. A safety factor of 25% is added to the solar array amperage to compensate for environmental factors. Additional factors to consider when selecting the type and size of a charge controller are: Budget Design lifespan of the system Climate conditions (cold temperatures, marine) How many solar panels do you have to meet your energy needs The number, size, and type of batteries in your battery bank Let's look at selecting the correct type and size charge controller for your system? What Type And Size Charge Controller To Select 1. Pulse Width Modulation (PWM) charge controllers For solar systems where the output voltage of the solar panels must match the input voltage of the battery bank, the Pulse Width Modulation (PWM) charge controllers are ideal. They are less expensive and ideal for smaller simple solar systems for recreational vehicles, tiny homes, or vans. The PWM charge controller charges the battery bank with short current pulses at the same charge voltage as the solar panel output voltage. PWM charge controllers are unable to limit their current output. Suppose the solar panel array has 30A (amp) output current. In that case, the charge controller selected will have to cope with a minimum of 30 A. To compensate for solar array performance in cold weather when the panels operate more efficiently, a safety factor of 25% must be added to the 30 A output current. The PWM charge controller size must be 30 A x 1.25 = 37.5 A for such a system. We need to consider both the amperage and the voltage when matching the correct size charge controller to the system. See also: What A Solar Charge Controller Does (Explained) Ideal For Simple Systems PWM charge controllers are available in 10 A, 20 A, and 30 A capacities and are ideally suited for simple systems to charge 12 V and 24 V battery banks. A 10A PWM charge controller can support a 120 W solar array to charge a 12 V battery bank (120W/12V = 10A) or it can support a 240 W solar array to charge a 24 V battery bank (240W/24V = 10A). For a 240W 12 V solar array to charge a 12V battery bank (240W/12V = 20A) a 20 amp PWM Charge controller is required. It is imperative that the voltage of the solar array matches the charge voltage of the battery bank with PWM-type controllers. PWM controllers are not as complex or expensive as MPPT controllers. They work best in small PV systems where operational efficiency is not critical. They are best for sunny and warm conditions and have a long lifespan due to the simplicity of the design. On the negative side, PMW controllers are less efficient and can only be deployed in systems where the solar array and the battery bank have matching voltage requirements. 2. Maximum Power Point Tracking Controllers (MPPT) MPPT charge controllers are best suited for large solar arrays and battery banks in domestic off-grid or marine applications where solar power is one source of power input only. These controllers are highly efficient and best for getting the best power conversion from solar to a battery. The MPPT controller will convert the maximum power voltage from the solar array to the voltage required to optimally charge the battery bank. The voltage of the solar array does not have to match the battery bank's voltage. Automatic Adjustment An MPPT controller will monitor the state of charge of the battery bank and adjust the charge voltage and current accordingly, protecting the battery chemistry and longevity of the battery bank. In cloudy conditions, the MPPT will decrease the amount of charge current while maintaining the optimal charge voltage to the battery bank. As the clouds disappear and the stronger sunlight increases the output, the MPPT will increase the charge current but maintain the optimal charge voltage. MPPT charge controllers can be sized to suit the size of the solar array and the voltage requirements to charge the battery bank optimally. Select Correct MPPT Amp Large solar arrays can generate power, but the MPPT controller will limit the output. It would be inefficient to have panels delivering 80 A of current to an MPPT controller with a 40 A output current rating. In this example, it would be better to have two 40 A MPPT controllers controlling the 80 A input current from the solar panels. The input voltage rating of the solar array can be much higher than the charge voltage requirement of the batteries. MPPT Voltage If the MPPT charge controller is rated to accept 100 V input from the solar array, it would need to step this voltage down to 12V or 24V depending on the battery system voltage. Example: If we have 4 x 100 W panels in series at 5 A, each panel will have an open-circuit voltage of 22.5 V. The 4 panels will each deliver 22.5 V for a total of 90 V, which is within the 100 V rating for the controller. MPPT charge controllers are highly efficient and ideal for more complex solar systems where energy efficiency is critical. These controllers are well suited for cold climates and to govern the input voltage from a large array of solar panels. MPPT controllers are significantly more expensive than PWM controllers and do not have long life cycles due to the component complexity. Typical MPPT Amperage Sizes A 20A MPPT charge controller can support up to 260W input for a 12V battery bank. (260W / 20A = 13 A) or 520W solar input for a 24V battery bank. (520W / 24V = 21.67 A) A 30A MPPT charge controller can support up to 400W solar input for a 12V battery bank. (400W / 12V = 33.33 A) or 800W solar input on a 24V battery bank. (800W / 24V = 33.33A) A 40A MPPT charge controller can support 520W solar input for a 12V battery bank. (520W / 12V = 43.33A) or 1040W for a 24V battery bank. (1040W / 24V = 43.33A) A 60A MPPT charge controller can support 800W on 12V (66.67A), 1600W on a 24V (66.67A), 2400W on 36V (66.67A) or 3200W on 48V battery bank (66.67A) A 100A MPPT charge controller can support 1300W solar input for a 12V battery bank (108.33A) or 2600W on a 24V battery bank (108.33A) or 3900W on a 36V battery bank or 5200W on a 48V battery bank (108.33A). References: Authors Note: This has been updated on Feb 23, 2022 with updated information, links, and resources. Solar charge controllers are a critical component in every solar installation. They protect your battery storage components, and they ensure everything runs efficiently and safely throughout the lifespan of your system.WHAT ARE SOLAR CHARGE CONTROLLERS? The charge controller in your solar installation sits between the energy source (solar panels) and storage (batteries). Charge controllers prevent your batteries from being overcharged by limiting the amount and rate of charge to your batteries. They also prevent battery drainage by shutting down the system if stored power falls below 50 percent capacity and charge the batteries at the correct voltage level. This helps preserve the life and health of the batteries. Charge Controllers DemystifiedHOW DO SOLAR CHARGE CONTROLLERS WORK? Regarding "what does a solar charge controller do", most charge controllers has a charge current passing through a semiconductor which acts like a valve a to control the current. Charge controllers also prevent your batteries from being overcharged by reducing the flow of energy to the battery once it reaches a specific voltage. Overcharging batteries can be particularly damaging to the battery itself so charge controllers are especially crucial. Charge controllers also offer some other important functions, including overload protection, low voltage disconnects, and blockage of reverse currents. Overload protection: Charge controllers provide the important function of overload protection. If the current flowing into your batteries is much higher than what the circuit can deal with, your system may overload. This can lead to overheating or even fires. Charge controllers prevent these overloads from occurring. In larger systems, we also recommend a double safety protection with circuit breakers or fuses. Low voltage disconnects: This works as an automatic disconnect of non-critical loads from the battery when the voltage falls below a defined threshold. It will automatically reconnect to the battery when it is being charged. This will prevent an over-discharge. Block Reverse Currents: Solar panels pump current through your battery in one direction. At night, panels may naturally pass some of that current in the reverse direction. This can cause a slight discharge from the battery. Charge controllers prevent this from happening by acting as a valve.DO YOU ALWAYS NEED A SOLAR CHARGE CONTROLLER? Typically, yes. You don't need a charge controller with small 1 to 5 watt panels that you might use to charge a mobile device or to power a single light. If a panel puts out 2 watts or less for each 50 battery amp-hours, you probably don't need a charge controller. Anything beyond that, and you do. Solar charge controllers play an integral role in solar power systems, making them safe and effective. You can't simply connect your solar panels to a battery directly and expect it to work. Solar panels output more than their nominal voltage. For example, a 12v solar panel might put out up to 19 volts. While a 12v battery can take up to 14 or 15 volts when charging, 19 volts is simply too much and could lead to damage from overcharging. Solar charge controllers aren't an optional component that delivers increased efficiency. They're an absolute necessity that makes solar power battery charging possible. What will affect my decision-making when selecting a charge controller? The following factors should be considered when buying a charge controller: • Your budget • Lifespan of the technology • Climate where your system will be installed: Certain charge controllers operate better in colder climates. • How many solar panels you have and how high your energy needs are • Size, number, and type of batteries you're using in your system These factors all interact in complex ways that can be challenging to implement effectively. However, there is a clear process for determining which charge controller is right for your application. Read More: • Factors to Consider When Deciding to Purchase a Charge ControllerDIFFERENT TYPES OF SOLAR CHARGE CONTROLLERS There are two main types of charge controllers to consider: the cheaper, but less efficient Pulse Width Modulation (PWM) charge controllers and the highly efficient Maximum Power Point Tracking (MPPT) charge controllers. Both technologies are used widely, protect the battery, and typically have a lifespan of around 15 years, although that may vary from product to product. Each of the two main types has certain cases where they are the clear choice. However, there's more to choosing a charge controller than simply choosing the right type — in addition to this, you must consider additional features in terms of both safety and convenience. The quality of these products can vary widely, even within the two main categories. Pulse Width Modulation Charge Controllers: Best for those with small-scale systems Cost: \$20-\$60 Best for: Those with smaller systems (vans, RVs, tiny homes), those living in warmer climates Pulse Width Modulation charge controllers have been around longer and are simpler and less expensive than MPPT controllers. PWM controllers regulate the flow of energy to the battery by reducing the current gradually, called "pulse width modulation." In contrast to providing a steady output, pulse width modulation charge controllers provide a series of short charging pulses to the battery. While effective, this pulse width modulation results in a loss of power between your solar panels and your batteries. This type of charge controller can't adjust voltages, only switch off intermittently to prevent excessive voltage to the batteries. The voltage and current put out by your solar panels are always shifting, so this inevitably leads to some waste when using a PWM solar charge controller. When batteries are full, PWM charge controllers keep supplying a tiny amount of power to keep your batteries full. This two-stage regulation is the perfect fit for a system that may experience little energy use. PWM controllers are best for small scale applications because the solar panel system and batteries must have matching voltages. The current is drawn out of the panel at just above the battery voltage. Many PWM charge controllers come with a diverse set of extra features. Renogy's Wanderer 10A PWM charge controller can be used with a 12V or 24V battery or battery bank and comes equipped with self-diagnostics and electronic protection functions to prevent damage from installation mistakes or system faults. Pros: • Cheaper than MPPT controllers • Best for smaller systems where the efficiency is not as critical • Best for warm sunny weather • Typically longer lifespan due to less components that may break • Performs best when the battery is near the full state of charge Cons: • Less Efficient than MPPT controllers • Because solar panels and batteries have to have matching voltages with these controllers, they are not ideal for larger, complex systems Maximum Power Point Tracking Controllers: Best for those wanting a highly efficient system Cost: \$100-\$729 Best for: Those with larger systems (cabins, homes, cottages), those living in colder climates Maximum Power Point Tracking charge controllers are efficient at using the full power of your solar panels to charge your batteries. With MPPT controllers, the current is drawn out of the panel at the maximum power voltage, but they also limit their output to ensure batteries don't get overcharged. MPPT charge controllers will monitor and adjust their input to regulate the current from your solar system. The overall power output will increase as a result and you can expect efficiency ratings of 90% or higher. As the power output of your solar panels varies with changing conditions, there will always be a particular voltage that will provide the most optimal results. This voltage is the maximum power point that your MPPT charge controller follows. In doing so, it ensures that you maintain optimal power output every moment that your solar panel is in operation. For example, if it becomes cloudy, your MPPT charge controller will decrease the amount of current drawn in order to maintain a desirable voltage at the output of the panel. When it becomes sunny again, the MPPT controller will allow more current from the solar panel once again. MPPT charge controllers are highly recommended for most large solar power systems. PWM charge controllers are typically only a viable option for portable applications such as for RV trips or possibly for a small off-grid cottage. MPPT charge controllers deliver superior performance, with the only real downside being the additional cost compared to more basic options. Pros: • Highly efficient • Best for larger systems where the additional energy production is valuable • Best in colder, cloudier environments • Ideal for situations where the solar array voltage is higher than the battery voltage • Performs best when the battery is in a low state of charge Cons: • More expensive than PWM controllers • Typically shorter lifespan due to more components Read More: • Charge Controller Types • What To Know About MPPT Solar Charge Controllers • What is the Difference Between MPPT and PWM Charge Controllers?HOW TO SIZE YOUR CHARGE CONTROLLER When it comes to charge controller sizing, you have to take into consideration whether you're using a PWM or MPPT controller. An improperly selected charge controller may result in up to a 50% loss of the solar generated power. Charge controllers are sized depending on your solar array's current and the solar system's voltage. You typically want to make sure you have a charge controller that is large enough to handle the amount of power and current produced by your panels. Typically, charge controllers come in 12, 24 and 48 volts. Amperage ratings can be between one and 60 amps and voltage ratings from six to 60 volts. If you haven't sized your system yet or calculated your energy needs, we recommend using the Renogy solar power calculator. This will help you size your solar panels, as well as all of the other components in your system. When it comes to sizing your system properly, the amps are the value you'll have to pay the most attention to for your charge controller. You need the right voltage as well, but that's as simple as matching the system and charge controller nominal voltages. The amperage is instead based on your energy use and battery capacity, which can be much more challenging to determine. If your solar system's volts were 12 and your amps were 14, you would need a solar charge controller that had at least 14 amps. However due to environmental factors, you need to factor in an additional 25% bringing the minimum amps that this charger controller must have to 17.5 amps. So in this case, you would need a 12 volt, 20 amp charge controller. Here's some more specifics based on the type of charge controller you have installed in your system. PWM Charge Controller Sizing: PWM controllers are unable to limit their current output. They simply use the array current. Therefore, if the solar array can produce 40 amps of current and the charge controller you're using is only rated to 30 amps, then the controller could be damaged. It's crucial to ensure your charge controller is matched, compatible with, and properly sized for your panels. When looking at a charge controller, there are a range of things to examine on its list of specifications or label. A PWM controller will have an amp reading for it, for example 30 amp PWM controller. This represents how many amps the controller can handle, in the case above, 30 amps. Generally the two things you want to look at in a PWM controller is the amperage and voltage rating. Firstly, we want to look at the nominal system voltage. This will tell us what voltage battery banks the controller is compatible with. In this case, you can use 12V or 24V battery banks. Anything higher, such as a 48V battery bank, the controller will not be able to work on. Secondly, we look at the rated battery current. Let's say in this example you have a 30 amp rating charge controller. We recommended a factor of safety of at least 1.25, meaning you would multiply the current from your panels by 1.25 and then compare that to the 30 amps. For example, five 100 watt panels in parallel would be 5.29 x 5 = 26.45 Amps. 26.45 Amps x 1.25 = 33 amps and would be too much for the controller. This is because the panel can experience more current than what it is rated for when exposure to sun rays is above 1000 Watts/m^2 or tilted. Thirdly, we can look at the maximum solar input. This tells you how many volts you can have going into the controller. This controller cannot accept more than 50 volts in. Let's look at having 2 x 100 Watt panels in series for a total of 22.5V (open-circuit voltage) x 2 = 45 volts. In this case, it will be ok to wire these two panels in series. Fourthly, we can look at the terminals. Each controller will usually have a maximum gauge size for the terminal. This is important when purchasing wiring for your system. Finally, look at battery type. This tells us what batteries are compatible with the charge controller. This is important to check as you don't want to have batteries that cannot be charged by the controller unit. MPPT Charge Controller Sizing: Because MPPT controllers limit their output, you can make an array as large as you want and a controller will limit that output. However, this means your system isn't as efficient as it could be since you have panels that aren't being properly utilized. MPPT controllers will have an amp reading for it, for example a 40 amp MPPT controller. Even if your panels have the potential to produce 80A of current, an MPPT charge controller will only produce 40A of current, no matter what. MPPT controllers will have an amp reading for it, for example a 40 amp MPPT controller. They will also have a voltage rating, but unlike PWM, the input voltage rating is much higher than the battery banks it will charge. This is due to the special ability of the MPPT controller to lower the voltage to the battery bank voltage and then increase the current to make up for lost power. You do not have to utilize the high input voltage if you want to avoid series connections in small systems, but it is very beneficial in larger systems. Let's say a controller's label shows that it can handle 12V or 24V battery banks. Look for the Rov value. For example, if it is Rov-40, this means it is rated for 40 amps of current. Thirdly, we can look at the maximum solar input voltage. For example, if an MPPT Controller can accept 100 volts of input, it will then take this (up to) 100 volts and step it down to your 12V or 24V battery. Let's say you have 4 x 100 Watt panels in series, each with an open-circuit voltage of 22.5V. Those 4 in series will be 4 x 22.5 V = 90 Volts, which the controller can accept. Being able to accept higher voltages makes MPPT controllers particularly suited to some specific applications. Higher voltages lead to less power loss across a length of wire, which is why long-distance transmission lines have such high voltages. If your battery banks are some distance from your panels, running the system at higher voltage and relying on MPPT solar charge controllers is the best way to cut down transmission loss. CAN YOU USE MORE THAN ONE CHARGE CONTROLLER? You can use multiple charge controllers with one battery bank in situations where a single charge controller is not large enough to handle the output of your solar panel array. In fact, for MPPT charge controllers, this can be the best way to connect your system as arrays have different maximum power points. Having two controllers can optimize the total power output. In many cases, individuals who install solar power systems will later go on to expand these systems. It isn't uncommon for the capacity of the expansion to go well over what the existing charge controller can handle. However, we do recommend using the same type of charge controllers if you are using more than one. So if you have one MPPT charge controller, all of your charge controllers should be MPPT. Additionally, you'll want to make sure all your controllers have the same battery setting input.WHAT IS THE UPPER VOLTAGE LIMIT? All charge controllers have an upper voltage limit. This refers to the maximum amount of voltage the controllers can safely handle. Make sure you know what the upper voltage limit of your controllers is. Otherwise you may end up burning out your solar charge controller or creating other safety risks. While there are many other factors at play to determine whether you're choosing the right size charge controller, there is very little wiggle room when it comes to the upper voltage limit. Choosing the wrong size in terms of amperage can leave you without the capacity you need from your charge controller, but an insufficient upper voltage limit will lead to your system not functioning at all. You need to make sure that your charge controller is able to handle the maximum voltage that's put out by your solar power system. In general, this is a serious concern if you're running solar panels in series. When connected in series, the voltage adds up with each panel. So your two 12v panels are now putting out 24v, which will surely fry your 12v charge controller.COMMON CHARGE CONTROLLER MISTAKES AND ERRORS Because of all the different components of a solar installation, it can be easy to make a misstep in the installation process. Here are a few commonly made mistakes when it comes to solar charge controllers. • Do not connect AC loads to the charge controller. Only DC loads should be connected to the charge controller's output. • Certain low-voltage appliances must be connected directly to the battery. • The charge controller should always be mounted close to the battery since precise measurement of the battery voltage is an important part of the functions of a solar charge controller. During operation, there are a few potential issues that can arise with your charge controller. You could find yourself with no power at all from your solar power system. This situation could be the result of either disconnected or improperly connected wires. Check to see if all connections have been made and verify that none are reversed. The temperature of various components is of serious concern when it comes to your charge controller. The worst-case scenario is the core of your battery overheating, which could lead to significant damage. The controller itself can also overheat, which should happen before the battery does, in order to prevent further damage. For the highest level of safety from your solar power system, you should look into a battery temperature sensor. This simple device can monitor your battery temperature to prevent disastrous overheating.WHAT ARE THE DIFFERENCES BETWEEN RENOGY CHARGE CONTROLLERS? Renogy produces three main models of charge controllers: the Wanderer, Voyager, and Rover. Wanderer Model (PWM Charge Controller) The Wanderer models are designed for small and simpler solar systems. They can be used with many types of battery banks, including flooded, gel, sealed, or lithium iron phosphate. Both models are compatible with 12V or 24V systems. Wanderer 10A: Can support up to 120W on a 12V or 240W on a 24V system. The controller also features integrated 5V 2A USB ports to charge USB devices, an LCD screen, and multiple LED indicators for displaying system operation information. There is no Bluetooth port, so this unit is not compatible with the optional Bluetooth module. Wanderer 30A: Can support up to 400W on 12V systems. The Wanderer 30A does not have built-in USB ports or an LCD screen, but offers multiple LED indicators for displaying system operation information. This model also features a bluetooth port. Voyager Model (PWM Charge Controller) The Voyager is Renogy's only waterproof charge controller and is perfect for outdoor applications. Voyager 20A: Can support up to 240W on a 12V system. It features an LCD screen and multiple LED indicators for displaying system operation information, is compatible with seven different battery types, including lithium ion, lithium iron phosphate, LTO, gel, AGM, flooded, and calcium, on a 12V system, and offers 5-stage charging. There is no bluetooth port on the Voyager. An optional temperature sensor is also available to monitor the temperature at the battery. When the battery is located a moderate distance away from the charge controller, a temperature sensor is highly recommended. Rover Model (MPPT Charge Controller) The Rover was designed for the most efficient and advanced solar power system. It can be used with flooded, gel, sealed, or lithium iron phosphate batteries. The 20A, 30A, and 40A models are compatible with 12V or 24V systems. The 60A and 100A models can support 36V or 48V systems. Each of the Rover models has an LCD screen and multiple LED indicators, customizable parameters, and error codes, as well as 4-stage charging, and temperature compensation to increase your battery life and improve your system's performance. All of the Rovers also have a Bluetooth port. Rover 20A: Can support up to 260W on 12V or 520W on 24V systems. Rover 30A: Can support up to 400W on 12V or 800W on 24V systems. Rover 40A: Can support up to 520W on 12V or 1040W on 24V systems. Rover 60A: Can support up to 800W on 12V, 1600W on 24V, 2400W on 36V, or 3200W on 48V systems. Rover 100A: Can support up to 1300W on 12V, 2600 watts on 24V, 3900 watts on 36V, or 5200 watts on 48V systems.HOW CAN YOU REMOTELY MONITOR MY CHARGE CONTROLLER? As mentioned above, certain charge controller models have LCD screens and LED indicators for monitoring the system from the unit. If you'd like to remotely monitor your system from wherever you may be, you're in luck. Remotely monitoring your charge controller has never been easier, thanks to the data module for Renogy charge controllers. The Renogy DM-1 4G LTE module is capable of connecting to select Renogy charge controllers through an RS232 port and can be paired with Renogy's 4G monitoring app. Available for smartphones and tablets, the app allows you to conveniently monitor your system and change system parameters remotely using your device anywhere the 4G LTE network service is available. Renogy's Data Module is available with a year of prepaid service powered by T-Mobile's 4G LTE network. You may also opt to purchase your module without prepaid service and add it to an existing cell phone plan through your mobile provider. The app is currently only available on T-Mobile and AT&T networks. In addition to LTE options, Renogy also provides a selection of Bluetooth modules for short-range remote monitoring. These simple and affordable modules allow you to monitor the conditions of your charge controller when in use at your home, cottage, RV, or another off-grid site. The various models can offer a range of up to 82 feet. These Bluetooth devices are powered directly through your charge controller's RJ12 or RS485 communication port. Monitoring couldn't be more straightforward when you can easily connect your charge controller to our Renogy DC Home app. Our Bluetooth modules can be configured to work with a variety of solar components beyond your solar charge controller. With these convenient modules, you can monitor and control smart lithium batteries, pure sine wave inverters, battery chargers, and more.CONCLUSION Whether you're in an RV or an off-grid cabin, charge controllers are an essential part of your solar installation. Doing the research and weighing your options before making that investment will ensure you select the controller that's right for you and your system. See other related articles to learn more about off-grid solar knowledge: Solar Panels 101: A Beginner's Guide How many watts to run a house Do solar panels increase home value how efficient are solar panels How long do solar panels last How Many Solar Panels Do I Need Charge controllers are rated based on how much current they can handle, measured in amps (A). The current produced by your solar panels is determined by their total power and the voltage of your battery bank. You can calculate the current using the formula: Current (A) = Power (W) / Voltage (V) This means, 500W of solar panels using a 12V battery needs a solar charge controller of 40 amps. 500W/12V=41.6A If you have a 24V battery, you can halve this, and your charge controller will be cheaper too. 500W/24V=20,8A We will talk about this more later in the article. Undersize or Oversize? A solar charge controller has a limit on the current output. If your solar array is bigger than the current output of the charge controller it will limit it's output. For example, a 500W solar array has a charging current to the battery of 41.6A (500W/12V=41.6A) you can use a 30A charge controller without damaging it. You will damage a solar charge controller if you go over the maximum input voltage. oversize or undersize You can also choose to have multiple charge controllers charging the same battery. Read more about it in my detailed guide here. Undersize Undersizing means having your solar charge controller working at 100% most of the time. In my recent guide, I talked about overpaneling your solar charge controller. It discusses why you should have more panels on your charge controller than it can handle. For example, using a 30A charge controller with 500W of solar. You will lose some power during the best times of the day, but it will be more cost-efficient on cloudy and winter days. Read more about overpaneling your solar system here. Advantages: Cheaper charge controller Disadvantages: You will lose some power on most sunny days Might reduce lifespan of charge controller Oversize Oversizing means having your charge controller work at 80% most of the time. Some guides on the internet say you should calculate a 20% safety margin, meaning that you never load the charge controller to its maximum output. For 500W solar and a 12V battery, this would become: 500W/12V = 41.6A 41.6A * 1.2 = 50A Here you will be using a 50A charge controller. Advantages: You can harvest all the energy Charge controller may last longer Disadvantages: My recommendation If you are limited by space for solar panels in an RV or boat, oversize your solar charge controller. If you don't have space limitations, undersize your solar charge controller. The Effect of Battery Voltage on the Charge Controller If you increase your battery voltage to 24 or 48V, then your charge controller will be cheaper. Let's explore this with an example. 500W/12V=41.6A 500W/24V=20.8A 500W/48V= 10.4A If we double the battery voltage, we can see that the current gets halved. I recommend getting as high of a battery voltage as possible. You will also save on wires because they need to be less thick. Conclusion the size of the charge controller for a 500W solar panel system depends on the voltage of your battery bank and whether you choose to undersize or oversize your charge controller. Increasing your battery voltage can make your charge controller and wiring cheaper. Always consider your space limitations and the specific needs of your solar system when choosing a charge controller. [custom-related-posts title="Related Posts" none_text="None found" order_by="title" order="ASC"] Solar charge controllers are a vital part of any solar installation. They secure your battery storage components and ensure that it runs smoothly and reliably over the life of your device. In the following article, we will discuss an Introduction to DC-DC power converters, Charge controllers, and MPPT in a Solar PV system. What are Solar Charge Controllers? The charge controller in your solar installation is present between the energy source (solar panels) and the storage room (batteries). Charge controllers keep your batteries from being overcharged by limiting the volume and charge intensity of them. They often avoid the battery from being depleted by shutting down the device if the storage power dropped below 50 percent capacity. The batteries are getting charged at the right voltage level. It helps to protect the life and health of the batteries. Related Posts: DC-DC Converters: DC-DC converters are widely used to convert unregulated or uncontrolled DC voltage to a regulated or controlled DC voltage level as shown in figure 1. Fig 1: DC-DC converter Other than the uncontrolled voltage to controlled voltage these converters convert the voltage from one level to another level (high or low). For example, we have a PV system that produces 24 V dc output voltage but the inverter AC output needs to be 230 V, so we require a higher input dc voltage at the inverter's input. So, to obtain that we connect a dc-dc converter in between the PV array and the inverter. These dc-dc converters play a very significant role in our solar PV system. They are used as charge controllers, maximum power point trackers, and acts as an interface along with PV source for different types of loads. Their application also includes power bus regulation, Current boosting, and noise isolation. In the DC to DC converter both the input and the output side have a DC flow. It is possible to determine input DC power if we know the input voltage and current, similarly, we can determine the output power if we know the output voltage and current. Once we know the input and output power the efficiency of the power converter can be easily determined. Let us take an example of a DC-DC converter where a battery of 50 V is connected, supplying an input current of 8 A. At the output of the converter the voltage measurement shows a voltage of 100 V and current measurement shows a current of 3.6 A. Determine the input and output power, power loss in the converter, and efficiency of the converter. Input voltage = 50 V Input current = 8 A Output voltage = 100 V Output current = 3.6 A Thus, Input power = Input voltage × Input current Input power = 50 × 8 = 400 W Similarly, the output power can be determined as follows; Output power = Output voltage × Output current Output power = 100 × 3.6 = 360 W The power loss in the converter can be determined as follows; Power loss = Input power – Output power Power loss = 400 – 360 = 40 W Efficiency of the converter is determined as follows; Efficiency % = (output power/input power) × 100 Efficiency % = (360/400) × 100 = 90 % Related Posts: Working & Function of Charge Controllers: In layman's terms, you can consider a solar charge controller as a normal regulator which prolongs the life of solar batteries. In most solar charge controllers, the current passes through a semiconductor that serves as a valve to regulate the current. Charge controllers often keep the batteries from being overcharged by reducing the battery's flow to exceed a specific voltage. The over-charging of batteries can be especially harmful to the battery itself, so the charging controllers are particularly critical. It is the controller that helps to control the charge flow from and to the battery. It maintains the long battery life and performance by preventing deep discharge and overcharge of the battery. When a PV module is connected to a battery through a charge controller, the charge controller would disconnect the PV from the battery to avoid overcharging. Similarly, when a battery is connected to a load through a charge controller, the controller will disconnect the load from the battery if it detects over-discharge. Such an ability of the charge controller helps in prolonging the life and performance of the battery. Overcharge and deep discharge of the battery are detected by measuring the voltage level of the connected battery. In overcharge, the battery voltage increases above a certain voltage level similarly in case of deep discharge the battery voltage decreases below a certain voltage level. The charge controller can disconnect the battery in both these above-mentioned conditions. The charge controller also reconnects the battery when the voltage level has reached within the normal operating level. Due to overcharge the voltage level of the battery reaches high and the charge controller disconnects the battery from the PV module (or charging DC source), but when the level of the voltage falls due to utilization of the battery by the load the charge controller detects this voltage drop and reconnects the PV module (or charging DC source) to charge the battery. Such a similar thing can also observe in case of deep discharge when the battery gets cut-off (from load) due to a drop in voltage below a certain level. Now if the battery is an undercharging condition, the terminal voltage level will rise after a while due to the charging process. This rise in voltage level is detected and if it is above a low cut-off voltage level the controller will reconnect the battery to the load so that the load can utilize the energy stored in the battery. Solar charge controllers also provide several other essential features, including overload safety, low voltage disconnect, and reverse current blockage. Overload protection: Charge controllers have the essential role of protection against overload. If the current flowing into your battery is far higher than the circuit can handle, your device can overload. It can lead to overheating or even explosions. Charge controllers avoid the overload from happening. In larger systems, double safety protection with circuit breakers or fuses is also essential. Low voltage disconnects: This acts as an automatic disconnection of non-critical loads from the battery when the voltage drops below the defined threshold. When it is powered, it will immediately reconnect to the battery. It is going to avoid over-discharge. Blocks the flow of Reverse Currents: Solar panels send the current through the battery in single direction. At night, panels can, of course, transfer some of the charges in reverse order. It can trigger a minor discharge of the battery. Load controls avoid this from occurring by serving as a valve. Related Posts: Types of Charge Controllers: The following are the two widely used charge controllers; Maximum Power Point Tracking (MPPT) charge controllers Pulse Width Modulation (PWM) charge controllers In the case of MPPT charge controllers, the voltage across the battery bank and the PV array is different. This type of charge controller operates at the maximum power point of the PV array to deliver the maximum possible power available from the irradiance. The kind of charge controllers makes it possible to have PV array voltage higher than the voltage of the battery bank connected to our system. The advantage is that the higher the voltage lesser will be the current for the same flow of power. Thus, we can use the small gauge wire which reduces the cost of the wire in the system. On the other hand, the Pulse Width Modulation (PWM) charge controllers have identical voltage across the PV array and the battery bank connected to the system. Related Posts: The various voltage and current level of the charge controller can be defined as follows; Nominal system voltage: This voltage represents the voltage at which the charge controller and the battery operate in a solar PV system. Nominal Load current: This represents the maximum load current that a charge controller should handle. Nominal PV array current: This represents the maximum PV array current that the charge controller should be able to handle. It is the short-circuit current of the entire PV array. While designing a safety factor of 1.25 is considered for variation in determined short-circuit current under non-STC (Standard Test Condition). Charge regulator set points: The function of the charge controller is to charge and discharge the battery, it senses the terminal voltage (i.e. state of charge or commonly known as SOC) and decides either to disconnect it from the load to avoid the deep discharge or to disconnect it from its PV array source to avoid the overcharge of the battery. Such a controller has set points upon which it takes decisions either to connect or disconnect the load or charging source (i.e. PV array). Fig 2: Features of the Charge Controller Voltage regulation setpoint (VR): This represents the maximum voltage up to which a battery can be charged without getting overcharged. If this setpoint is reached then the controller will disconnect the battery bank from the PV source or it may regulate the current supplies to the batteries. Voltage regulation hysteresis (VRH): This represents the difference between the VR and the voltage at which the charge controller will reconnect the battery to the PV source for charging. If this difference is very small then the control will be oscillatory (connect and reconnect frequently) which will eventually result in deterioration in the performance and life of the battery. But having a difference might also lead to some overcharging in each cycle. So, a balance has to be made while stating the VRH. The VRH also helps us understand how effective is the charge controller at charging the battery. Low voltage disconnect (LVD): This represents the minimum voltage that up to which discharge of a battery is allowed without getting into the deep discharge. This is also known as the depth of discharge (DOD) of a battery. It is strongly recommended to avoid discharge below this level to avoid the deterioration of the life and performance of the battery. The charge controller can disconnect the battery from the load if it detects the LVD and avoids the deep discharge of the battery. Low voltage disconnect hysteresis (LVDH): This represents the difference between the LVD and the voltage at which the battery can be reconnected to the load. It is not kept too small, as this may result in frequent connection and disconnect. Which can further reduce the life of the battery. Related Posts: How to Select a Proper Rated Solar Charge Controller? The following two examples shows how to select a right size solar charge controller for solar panel and array system having the appropriate nominal current rating in amperes at given rated nominal voltage and load in watts. Example 1: Let us now take an example to understand the above parameters, a living room has the following DC loads which are rated at 24 V; Three 20 W lamps One 25 W fan All the above-mentioned loads are powered by two parallel connected PV modules, each PV module has a maximum power point current IMP of 5 A and short-circuit current ISC of 7 A. What will be the nominal system voltage, nominal PV array current, and Nominal load current of the charge controller? Total DC load = (No. of lamps × Wattage of each lamp) + (No. of fans × Wattage of each fan) Total DC load = (3 × 20) + (1 × 25) = 60 + 25 = 85 W The nominal system voltage of the charge controller is the same as the rated voltage of the load and the PV array (Nominal system voltage of the charge controller = 24 V) Nominal PV array current = 2 × 7 (short-circuit current of each PV module is 7 A and are connected in parallel) Nominal PV array current = 14 A A safety factor of 1.25 is considered for variation in determined short-circuit current under non-STC (Standard Test Condition). Considering the safety factor of 1.25 the Nominal PV array current is 1.25 × 14 = 17.5 A Nominal load current = Total DC load / Nominal system voltage = 85 / 24 Nominal load current = 3.5416 A Thus, the charge controller should be able to handle a current of about 3.5416 A at the output side. Example 2: Let us take another example to practice it; an auditorium has the following DC loads which are rated at 12 V; Three 30 W lamps One 20 W fan All the above-mentioned loads are powered by two parallel connect PV modules, each PV module has a maximum power point current IMP of 3 A and short-circuit current ISC of 5 A. What will be the nominal system voltage, nominal PV array current, and Nominal load current of the charge controller? Total DC load = (No. of lamps × Wattage of each lamp) + (No. of fans × Wattage of each fan) Total DC load = (3 × 30) + (1 × 20) = 90 + 20 = 110 W The nominal system voltage of the charge controller is the same as the rated voltage of the load and the PV array (Nominal system voltage of the charge controller = 12 V) Nominal PV array current = 2 × 5 (short-circuit current of each PV module is 5 A and are connected in parallel) Nominal PV array current = 10 A A safety factor of 1.25 is considered for variation in determined short-circuit current under non-STC (Standard Test Condition). Considering the safety factor of 1.25 the Nominal PV array current is 1.25 × 10A = 12.5 A Nominal load current = Total DC load / Nominal system voltage = 110W / 12V Nominal load current = 9.1666 A Thus, the charge controller should be able to handle a current of about 9.1666 A at the output side. Related Posts: Maximum Power Point Tracking (MPPT): The load connected to a PV module determines the power delivered by the module, take a look at the I-V and the P-V curve shown in figure 3 below. Fig 3: Characteristics of Maximum Power Point Tracking (MPPT) It can be observed from the above figure that at the short circuit condition i.e. at V = 0, maximum current is delivered by the module known as short circuit current ISC. But if we gradually increase the voltage across the load by varying the load the power delivered to the load also increases. So, the increase in the voltage causes the power to increase up to a certain point, the point beyond which the increase in voltage further causes a decrease in the power is called as Maximum Power Point (MPP). So, the I-V curve of a PV module has a point that corresponds to the maximum power known as Maximum PowerPoint or in short MPP. It is required that the load connected to the PV module should be operated at a voltage and current which corresponds to this maximum power point to obtain the maximum power from the PV modules. The operating point is the point of intersection of I-V characteristics of PV modules to a load. Manufacturers rated their PV modules for peak power output. But the output power of PV modules not only depends on the available solar irradiance but also on the combination of voltage and current. For example during mid-day when the sun is high the module will not deliver the power if it is in the open circuit or short circuit condition. So, there is an operating point on the I-V curve where the product of voltage and current will deliver the maximum power. But this maximum operating point changes with the change in the intensity of the radiation falling on the solar PV modules. Thus, to obtain that maximum power there are electronic devices that will ensure that the PV modules will operate at maximum power at all the level of irradiance throughout the day. This idea of operating the PV module at its maximum power is called Maximum Power Point Tracking (MPPT). Practically there are changes in the I-V curve of the PV module due to the change in the intensity of the radiation falling on the module. Thus, it is not possible to keep the PV operated at the MPP for a chosen load. The solar radiation is less at around 9 a.m. and it gradually increases till noon. This increase in the intensity of the radiation will cause the I-V curve of the module to change as shown in figure 4 below. Fig 4: I-V Curve of MPPT Solar Charge Controller This results in the change of the operating point for a given load. The operating points for 1 p.m., 11 a.m., and 9 a.m. are denoted by A, B, and C respectively. But the maximum operating points for 1 p.m., 11 a.m., and 9 a.m. are denoted by A', B', and C' respectively. Thus, if we need to obtain maximum power from the PV module the operating points A, B, and C should be brought closer to A', B', and C' respectively and this is done by an MPPT device. The MPPT device does the job of getting the operating point closer to the maximum power point at a different level of solar radiation. It helps in extracting the maximum power available from the PV module under any irradiance and temperature. It makes the use of an MPPT algorithm and an electronic circuit to get the job done. The idea is based on the principle of matching the impedance between the PV module and the connected load which is essential to transfer the maximum power. Thus, when the impedance of the PV source and the load matches maximum power is transferred from the PV source to the load. If the ratio of module voltage at maximum power to module current at maximum power matches the impedance of the connected load, maximum power transfer takes place. But practically it is not possible to have a matching of this ratio to the impedance of the load, hence the MPPT device does that operation of impedance matching to deliver the maximum power at available irradiance and temperature. Manufacturers combine the functions of the charge controller and MPPT into one device which is widely known as the MPPT charge controller. Both MPPT and the charge controller are two different and independent functions but are widely used as one device to serve two purposes. Related posts: Sun-tracking and MPPT for Maximizing the Power Output: The sun-tracking is not the same as the MPPT tracking, it is a mechanical tracking of a solar PV module in such a way that the sun ray's incident on the modules is always perpendicular. The module should mechanically face the sun to obtain maximum power during that time of the day. If the modules are not perpendicular to the sun rays falling on it most of the sunlight would be reflected from the modules. The solar module produces maximum output power for given sunlight when the angle of the light and the module are perpendicular to each other (i.e. 90o) as shown in figure 5. When the angle of the incident of light is less than or greater than 90o as shown in figure 5 then it will produce output power lower than the maximum output power capability of the module. When the light falls on an angle greater or lesser than 90o some part of the light is reflected, and the light utilized by the module is less than the actual falling on it. This results in a reduction of the output power generated by the module. It is due to this reason that we must have mechanical sun-tracking to generate maximum possible electricity. Fig 5: Sun-tracking and MPPT for Maximizing the Power Output Specifications of the MPPT Charge Controller: PV Input Maximum input power: This represents the maximum power that the MPPT charge controller can handle from the connected PV array. Maximum open circuit voltage: This represents the maximum open-circuit voltage that the MPPT charge controller can handle. MPPT tracking voltage range: This represents the voltage level range that the MPPT charge controller can handle. DC Output to the Battery Nominal battery voltage: This represents the voltage at which the battery operates in a connected system. Voltage regulation setpoint (VR): It is the maximum level of voltage up to which we can charge a battery without causing the overcharge. Once this level has reached the charge controller will either disconnect the battery from the PV source or will regulate the current delivered to the connected battery. Low voltage disconnect (LVD): It represents the minimum voltage up to which the discharge of the battery is allowed without causing the deep discharge. Also known as Depth of discharge (DOD). When the battery level reaches the DOD level the MPPT charge controller disconnects to avoid overcharging. Maximum charging current: It represents the maximum current that an MPPT charge controller can handle from the PV array. It is a PV array short circuit current. While designing a safety factor of 1.25 is used due to variation at non-STC operations. DC Load Control Nominal voltage: This represents the charge controller's maximum load voltage which it should be able to handle. Maximum current: This represents the charge controller's maximum load current which it should be able to handle. Related Posts: How to Select the Right Size MPPT Charge Controller? Let us take some examples to understand the above-mentioned specifications numerically. Example 3: Consider a 500-watt PV array that operates at 24 V DC and has a battery bank of 12 V DC. Determine an MPPT charge controller rating s for this given system. Solar PV array wattage = 500 W Solar PV array operating voltage = 24 V Battery pack operating voltage = 12 V The input power to the MPPT controller is 500 W, the solar PV array is connected at the input side of the MPPT charge controller and the battery is connected at the output side of the MPPT charge controller. Thus, the battery acts as a load to the system. The data specifies the output voltage. Assuming 100 % efficiency we can determine the output current for its load. Power = Voltage × Current Current = Power / Voltage = 500W / 12V = 41.66 A Thus, we would require a 12 V, 41.66 A MPPT for the above system, we can increase the current value by 25 % considering some conditions that occur causing the panel to produce more power. Thus, we can take it as 52 A. So, 12 V, 52 A MPPT charge controller would be suitable for the above system. Note that the MPPT charge controller should be able to handle the open-circuit voltage and the voltage at the maximum power point of the connected PV array. Let us take another example where we have to design a 140 WP Solar home system with a PV module of 70 W having an open-circuit voltage of 20 V and voltage at maximum power point of 16 V. The voltage of the battery bank is at 12 V. Determine a suitable MPPT charge controller rating for this home solar design. Let us connect the available PV module in series. Thus, the open-circuit voltage of the system would become = 2 × 20 = 40 V Voltage at maximum power point would be = 2 × 16V = 32 V Peak power of the system would be = 2 × 70W = 140 W The input power to the MPPT charge controller is 140 W if we assume 100 % efficiency. And the available battery voltage at 12 V, then the current to the battery pack can be determined as follows; Power = Voltage × Current Current = Power / Voltage = 140W / 12V = 11.66 A Thus, we would require a 12 V, 11.66 A MPPT for the above system, we can increase the current value by 25 % considering some conditions that occur causing the panel to produce more power. Thus, we can take it as 15 A. So, 12 V, 15 A MPPT charge controller would be suitable for the above system. Again, it is important to note that the MPPT charge controller should be able to handle the open-circuit voltage and the voltage at the maximum power point of the connected PV array. Which Solar Charge Should I Select? PWM or MPPT? When it comes to deciding the controller size, you need to know whether you are using a PWM or an MPPT controller. Do you know that an incorrect selection of solar charge controllers can result in a loss of up to 50% of the solar system's energy? Solar Panel Battery Solar Charger 12V 12V PWM or MPPT 24V 24V PWM or MPPT 24V 12V MPPT (Recommended) Solar charge controllers are measured based on your solar array current and your solar system's voltage. Usually, you want to make sure that you have a charge controller that is big enough to accommodate the amount of power and current produced by your panels. Usually, charge controllers are present in 12, 24, and 48 volts. Amperage ratings can vary from one to 60 amps and voltage ratings from six to 60 volts. If you have not yet weighed your setup or estimated your energy requirements, we suggest using the solar panel calculator. It will allow you to scale your solar panels and all the other components of your device. If your solar system was 12 volts and your amps were 14, you will need a solar charge controller with at least 14 amps. However, you need to add 25% to the minimum amps that your solar charger controller would have at 17.5 amps due to environmental considerations. But you will require a solar charger controller with a rating of 12 volts and 20 in this situation. Here are few more details depending on the type of charge controller you have mounted on your device. Battery Condition @ 25 °C (77 °F) Nominal Battery Voltage 12V 24V 48V Battery during equalization charge Over 15 Over 30 Over 60 Battery near full charge while charging 14.4 to 15.0 28.8 to 30.0 57.6 to 60.0 Battery near full discharge while charging 12.3 to 13.2 24.6 to 26.4 49.2 to 52.8 Battery fully charge with light load 12.4 to 12.7 24.8 to 25.4 49.6 to 50.8 Battery fully charged with heavy load 11.5 to 12.5 23.0 to 25.0 46.0 to 50 No charge of discharge for 6 hours – 100% charged 12.7 25.4 50.8 No charge of discharge for 6 hours – 80% charged 12.5 25 50 No charge of discharge for 6 hours – 60% charged 12.2 24.4 48.8 No charge of discharge for 6 hours – 40% charged 11.9 23.8 47.6 No charge of discharge for 6 hours – 20% charged 11.6 23.2 46.4 No charge or discharge for 6 hours – fully discharged 11.4 22.8 45.6 Battery near full discharge while discharging 10.2 to 11.2 20.4 to 22.4 40.8 to 448 Related Posts: FAQ Do you need a controller for solar charges? Typically, yes. No charge controller necessary for small 1 to 5-watt screens. If the panel sets 2 watts or less for every 50 hours of battery life, you usually don't need a charge controller. It's far above that. What's going to influence my decision-making when I pick a charge controller? The following considerations should check out when purchasing a charge controller: The budget; The life of technology The temperature where the machine gets installed: specific charge controllers perform well in cooler climates. How much electricity is needed, and how many solar panels are available! The size, number, and type of batteries that you use on your device Can you use more than one charge controller? In cases where a single charge controller is not capable enough to handle the output of your solar panel array, you can use multiple charge controllers with one battery bank. Using an MPPT (Maximum Power Point Tracker) charge controller can be the safest way to connect the device as arrays have different maximum power points. However, it is recommended to use the same form of the charge controller if you use more than one. Meaning, if you are using a single MPPT charge controller, all your solar charge controllers should be of MPPT type. Make sure that all of your controllers have the same battery setting input as well. What is the upper voltage limit? Both charge controllers have a maximum voltage limit. It applies to the highest voltage that controllers can manage safely. Make sure you know what the upper voltage limit of your controller is. Otherwise, you could end up burning off your solar charge controller or causing other safety hazards. Common charge controller errors and mistakes Due to all the various components of a solar installation, it can be possible to make an error in the installation process. Here are some widely made mistakes when it comes to solar charge controllers. Do not attach AC loads to the load controller. Only DC loads can connect to the output of the charge controller. You should mount the charge controller next to the battery as the battery voltage's accurate calculation is an essential aspect of the solar charge controller's functions. Conclusion If you are in an RV (off-grid cabin), solar charge controllers are an integral part of your solar installation. Researching and weighing your choices before you make that investment helps mean choosing the right controller for you and your device and avoiding the hassle. Related Posts: