MP-20
EMP Hardened MPPT Controller

A truly unique EMP hardened MPPT charge controller featuring both buck (voltage downshifting) and boost (up shifting) of input signals to squeeze out the highest potential your alternate energy source has to offer.

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- High efficiency buck/boost MPPT charge controller.
- Capable of boosting small input voltages up to 60 volts.
- Works seamlessly with Solar, Wind and Hydro inputs up to 100 volts.
- Fully digital remote user interface can be located in another room.
- Continuously streams CSV data via USB port, which can be viewed or stored.
- EMP Hardened. NEMA 3R, outdoor enclosure.
- Perfect for small systems mounted on RV's, Campers and Trucks.
- No jumpers or potentiometers need to be set.
- Included Remote Menu Module, with 2 x 16 back-lit LCD display.
- Both manual and automatic equalize modes are available..
- Automatic nominal battery voltage detection, no setup required.
- Nearly all charge parameters can be managed through the user interface.
- Supports voltage and amperage calibration to fine tune performance.
- Optional high battery SSR module can be used to engage diversion loads.
- Automatic LCD back light dimming to save energy.
- One year standard warranty against manufacturer defects.
- 12, 24 or 48-volt battery systems.
- Lockable cover, with standard conduit openings on bottom of box.

Quick Start:

All user settable parameters as well as additional information are accessible via the included remote menu module which consists of a LCD screen and three buttons located on a flush mountable panel.

Pressing any key during the normal operation of the unit will cause the main menu to be displayed. Using the right/left buttons will scroll through the menu options. Pressing the "Enter" button will cause that menu option or value to be selected. Use of the up/down menu increases and decreases the current menu value. Pressing the up button exits the menu (unless you are currently modifying a value, in which case it will increase the value. First press "Enter" to select the current value, and then press the up button to exit the menu).

The Red LED on the remote panel indicates an error. The exact cause of the error will be shown on the LCD screen (unless you have activated one of the menu options).

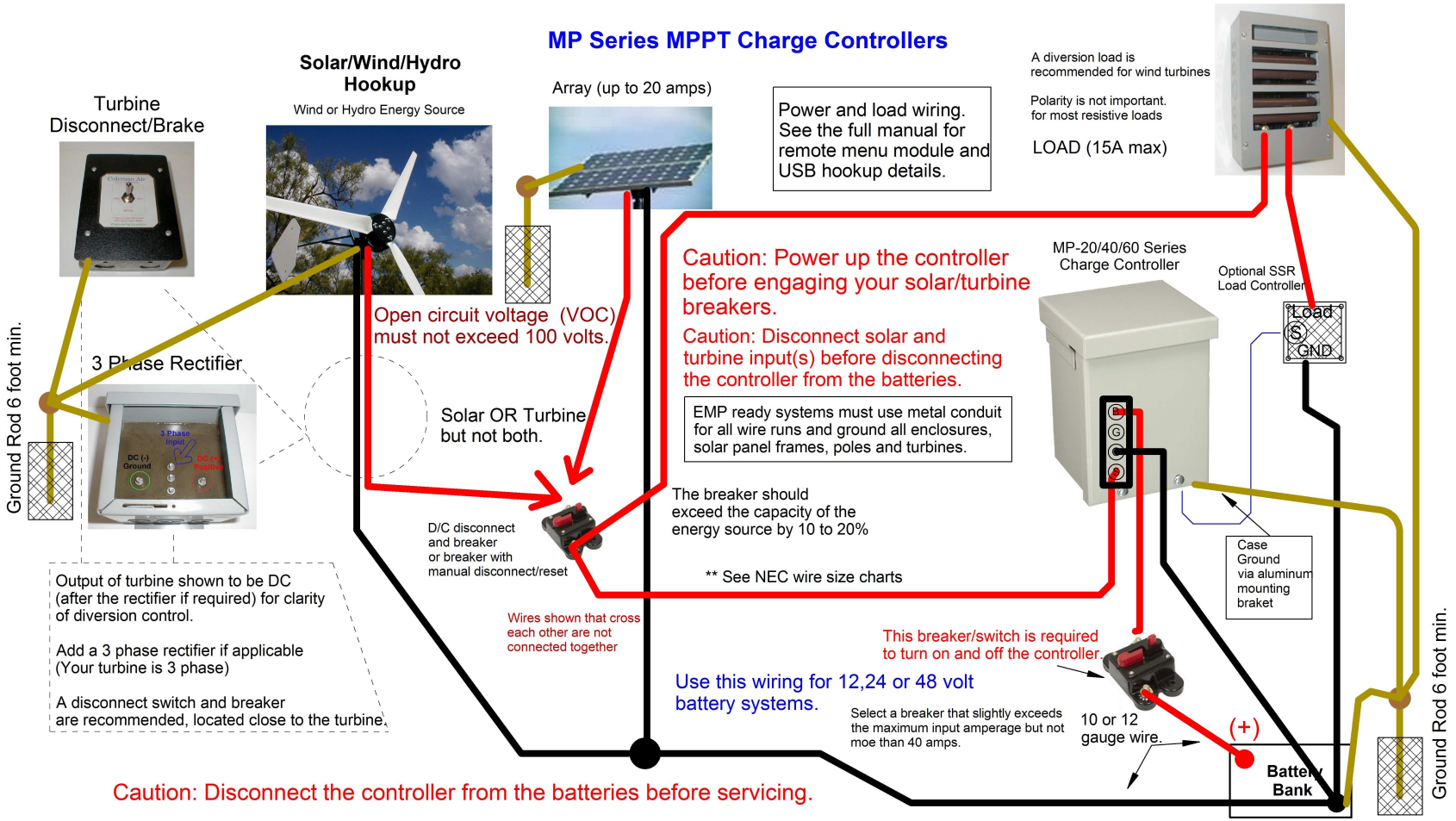
The Green LED on the remote panel is illuminated when the unit is first turned on and also any time the charge performance is considered high enough to complete the current charge cycle. If the solar/turbine power is not adequate to complete the charge cycle, the cycle will be extended and the mode timer will not count down. When this green LED is lighted, the charger is able to pass enough current to the batteries to complete a full charge of the batteries.

The red LED on the small daughter board inside the main controller is illuminated when there has been an over-voltage detected. **To clear an over-voltage condition, all power to the unit must be disconnected for at least 30 seconds**. Once power is re-applied, the unit should clear the fault. **Over-voltage conditions should be addressed by ensuring your wind turbine and/or solar inputs never exceed 100 volts** and both wind/hydro and solar are never enabled without first ensuring the controller is powered up and running from the batteries.

The MP-20 has been designed to handle 20 amps of continuous current. Short-term charge currents in excess of 25 amps are allowed providing the internal temperature does not rise beyond the automatic throttle back protection region. If this occurs, the charging current will be automatically reduced until the temperature stabilizes.

The main controller is housed in a NEMA 3R rain tight enclosure. Is may be mounted outdoors providing it is not subjected to rising water, salt mist or condensating humidly. **The enclosure will not protect the contents from wind driven salt mist**. The remote menu module must be mounted indoors or fully protected from the elements.

The controller is fully wrapped in a metal enclosure, providing full EMP protection as long as the case is properly grounded via a 6-gauge or heavier copper ground wire direct to a copper ground rod(s) buried at least 6 feet into the soil. Metal (flex or rigid) conduit must be used or the EMP protection will be defeated.

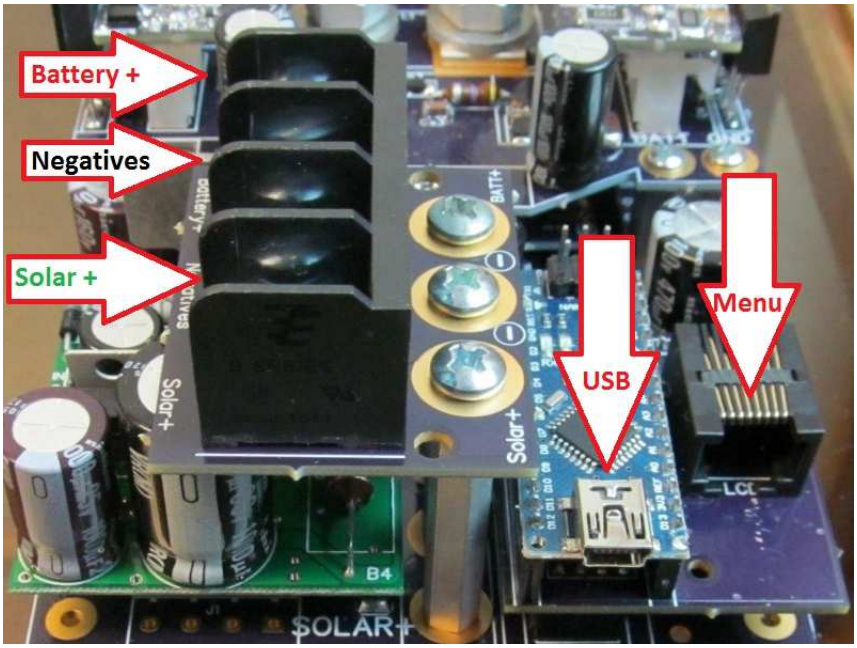


The MP series controllers are EMP hardened, MPPT controllers capable of boosting or bucking input voltages as low as 10 volts and as high as 100 volts, to charge a battery based system of 12, 24 or 48 volts. High speed MPPT processing supports solar, wind and hydro inputs. **Multiple solar panels and or wind turbines may be hooked up as long as you do not exceed the total capacity of the unit.** It is not recommended to mix and match input types, as each of these energy sources require different processing for best MPPT performance.

Ensure you have selected adequate sized wire for the amperage you will be controlling. Undersized wire can result in very high heat in the wire and connections possibly leading to a fire. Always use a fuse or DC disconnect! Hooking up an energy source or diversion load without a fuse or disconnect can result in serious injury or death!

EMP Ready systems, MUST be fully grounded or the EMP Hardening of the controller will be defeated. All solar panel frames must be grounded, use aluminum straps between panels. Each vertical row should be grounded with a 6 or 8 gauge wire direct to a ground rod. All turbine masts/poles must be grounded. There can be no exposed system wiring. Only metal conduit (rigid or flexible) should be used. The negative side of the battery bank must also be grounded. Use 6 or 8' copper ground rods with copper wire only. Keep ground runs short and use large radius bends if at all possible. DO NOT put ground wires inside the conduit.

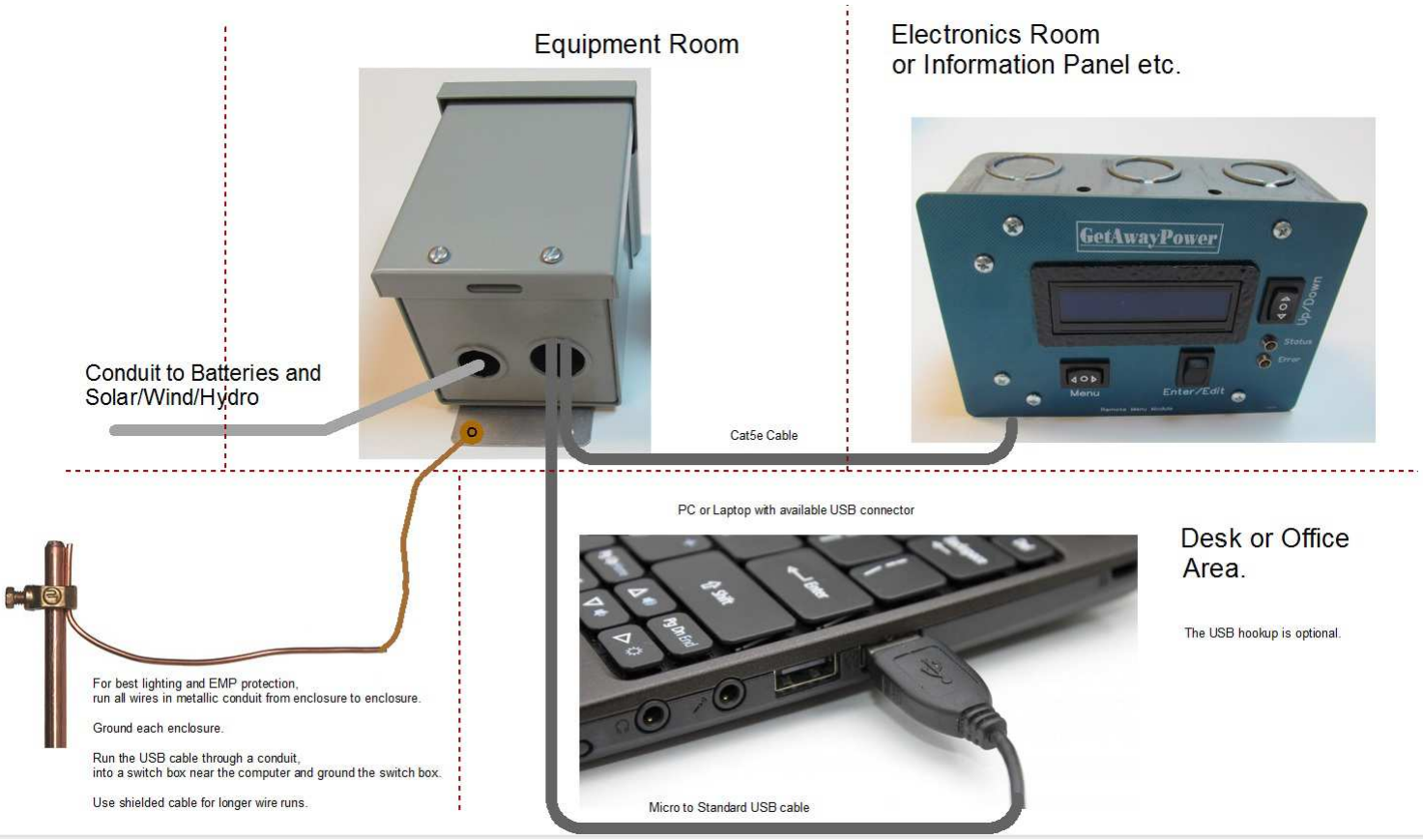
Use extreme caution when installing or servicing this controller. High amperages and voltages can KILL you. – Always disconnect the controller before servicing



The MP-20 uses a four position terminal block located inside the unit for the power wire hookup. The top position is for the battery positive. This wire should be run directly to your battery positive post (or positive buss bar) via a breaker or fuse. A breaker or fuse is required for all wires leaving an energy source.

The middle two positions are shared negatives. Please use either one of these positions to run one wire to the negative post of your battery bank. The other position may be used to terminate the negative wire of your solar/wind/hydro if you are unable to wire those negatives directly to the battery bank. The bottom position is used to terminate the positive wire from your solar panel (or wind/hydro turbine).

Please use fine stranded wire. 10 or 12 gauge is recommended. Larger, solid or heavy stranded wire may be very difficult to terminate in the space provided inside the unit. The USB port is used to send log and status data to any computer that supports USB serial communications. The RJ45 connector is used to hookup the main MP-20 to the remote menu module. Both USB and CAT5E cables are provided. Longer cable runs are possible, however, you may need to use shielded cabling for runs over 10 feet. Please note, the RJ45 connection is not the Ethernet protocol.



Connecting the remote menu module:

The remote menu module consists of a LCD display and 3 buttons that allow you to configure the controller as well as view its performance and current status. The display can be located several feet away from the controller in a different room. The Cat5e cable supplied is 10 feet long. If you wish to mount the display further away, shielded cable may be necessary to ensure proper signal transmission.

Please note, this connection uses a standard Ethernet cable and RJ45 connectors but it does NOT use the Ethernet protocol. The unit will not work by connecting to an Ethernet router or switch etc. The cable must be run directly from the MP-20 to the remote. Splices and connecting jacks may be used if the terminations are solid and secure.

Of note, it can be difficult to remove the cable from the unit once it clips into place. If you need to disconnect it, then use a bended paper clip or similar to get up under the wire clip to unlatch the RJ45 connector.

In order to provide EMP protection to the MP-20, it is necessary that this cable is run in a metal conduit and both enclosures are grounded. If you are not concerned with this level of protection, it is still necessary to ground the MP-20 enclosure. The remote module need not be grounded.

Connecting the Laptop or PC:

The MP-20 outputs steaming log data via USB Serial. The supplied cable is a standard male USB to mini USB. The data can be retrieved via any computer that has a standard USB connection available. Nearly all recent laptops and computers have some type of USB connection. Smaller laptops use micro or mini USB cables. If this is the case, you will need to obtain a USB micro-to-mini or mini to mini cable to complete the hookup to your computer.

The serial data from the MP-20 steams at all times, regardless if there is a connection to a computer or not. This log data is in CSV format and therefore can be easily imported into a spreadsheet program.

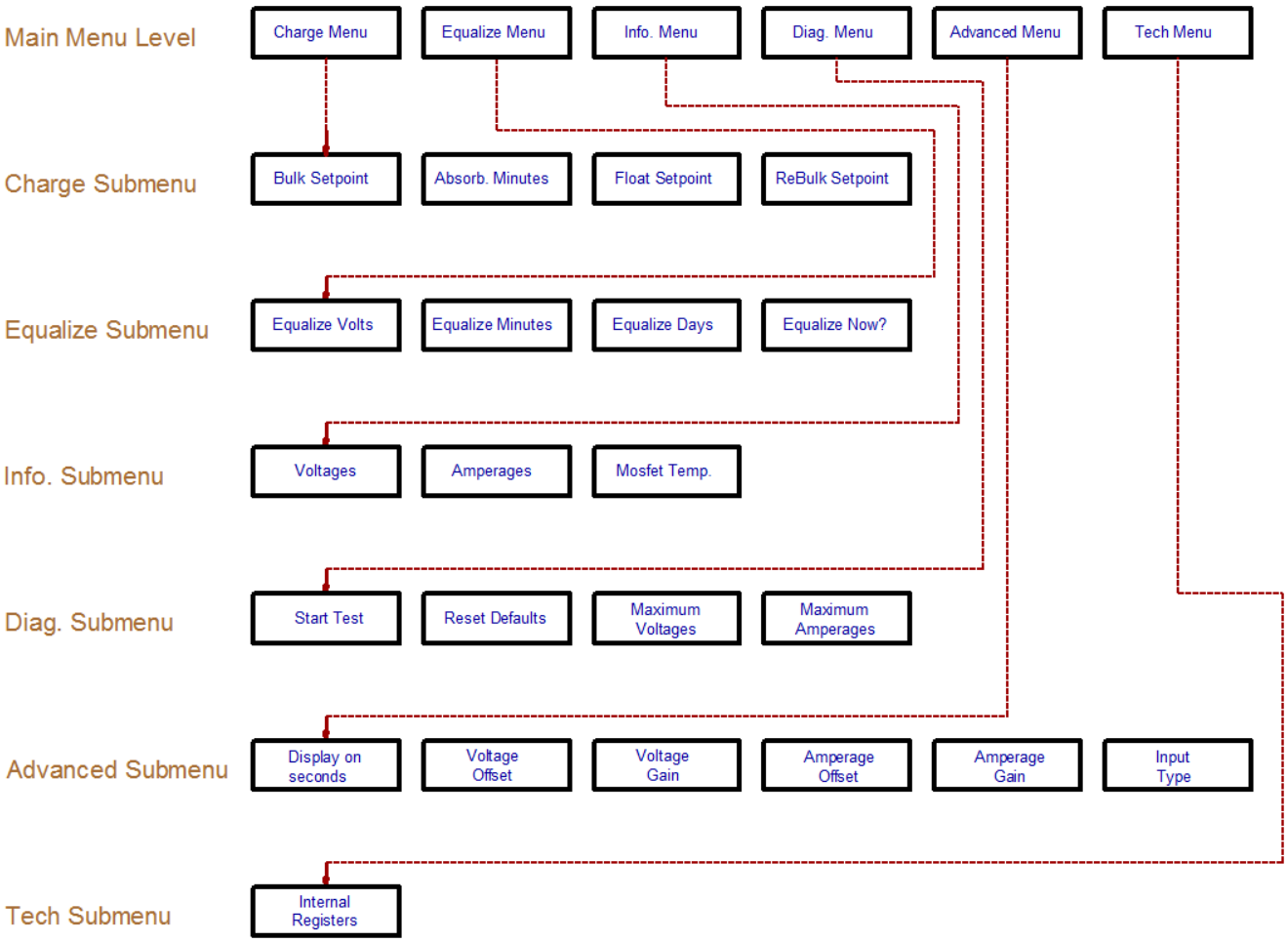
When you plug the MP-20 USB cable into your computer, the new serial port will be automatically installed and configured. You will however need to obtain an interactive serial communications program to communicate with the newly configured serial port. There are many such programs available for free download via the Internet. A very useful and easy to use one can be downloaded at:

https://freeserialanalyzer.com/

Once you install your software, then follow the instructions provided by the software manufacturer to complete the setup. When fully installed and configured, you should begin to receive steaming data from the MP-20.

Important note: If you hookup your USB cable before hooking your MP-20 to a battery bank, then the MP-20 will power up via the USB supplied power. **This will cause it to configure itself as a 12-volt battery bank (which is dead).** It is therefore best to ensure the MP-20 is properly connected to the battery bank, before connecting the USB cable. Should this not be possible, you will need to use the "Reset Defaults" option via the diagnostics menu once the MP-20 is powered up to the system battery bank.

The MP-20 Menu System Layout



The MP-20 Menu is selected by pressing any button on the front panel. Pressing the right/left buttons will scroll through the menu options at the current level. Pressing the "Enter" button will cause that menu option or value to be selected and/or displayed. Use of the up/down menu increases and decreases the current menu value. Pressing the up button exits the menu (unless you are currently modifying a value, in which case it will increase the value. First press "Enter" to select the current value, and then press the up button to exit the menu).

For example: To change the float set point of the controller. Press the "Enter", "Up/Down" or "Scroll" button on the front panel. The Charge submenu will then be displayed. Press the "Enter" or "Down" button to enter the submenu.

Press the "Scroll" button towards the right two times. This will display the float set point menu along with the current value of the set point. Press the "Up/Down" button to alter this value to the desired voltage. Press the "Enter" button to save this value. Press the "Up/Down" button upwards to exit the menu system. You could also of course continue to alter more values and/or view other settings.

The MP-20 is a Maximum Power Point Tracking (MPPT) controller that incorporates both buck and boost algorithms to perfectly match the charging source (Solar/Wind/Hydro) to the battery (and/or load). The default charge logic incorporates a standard three-stage charge cycle. Additional charging logic has also been added including such features as re-bulking, an absorb mode that allows for automatic adjustments due to changes in solar illumination (low current) as well as offering both a manual and automatic equalize modes.

MPPT Controllers: Maximum Power Point Tracking controllers.

MPPT controllers are the most advanced controllers available on the market today and may offer 10 to 50 percent more efficiency over PWM and mechanical controllers when used in installations where there is a mismatch between the charging source and battery (load). For instance, if your solar panels are putting out 40 volts on a cold day, and they are connected to a 12-volt battery bank, having a bulk voltage of 14.7 volts, then there is a large difference in panel voltage vs. battery voltage. This excess voltage is un-harvestable by a PWM controller, yet very usable by a MPPT controller.

So how do MPPT controllers work? In order to charge a battery (any battery), the charge voltage must exceed the battery voltage. If the charge voltage is equal to or less than the battery voltage, there will be no positive current flow and the battery will either not charge or be slowly drained (if no blocking diode is present). Since a standard 12 volt battery (lead acid), requires a charge voltage of around 15 volts (to finish the charge process), the solar panel must have an output of least 15 volts.

There are a couple of factors however, that must also be considered.

1. The rated output of a solar panel is generally measured at 25 degrees Celsius. All solar panels are more efficient when it is cooler, therefore on cold sunny days, the panel will put out more power (watts) than on a hot sunny day. Due to this fact, solar panels must be designed to output even higher voltages to counter-act lower performance during hot days.
2. There are multiple losses that are suffered from the solar panel to the battery. These include resistance in the wire, as well as voltage drops across any diodes and connectors.
3. Semi-cloudy or hazy days can reduce voltage output dramatically. This is also considered to some degree to allow charging in less than perfect sun.

All of these factors require that “12” volt solar panels start out with an open circuit voltage of at least 18 volts, and perhaps as high as 24 volts, with a maximum power voltage generally in the range of 17 to 18 volts. This assures that after any and all voltage drops, there will still be a high enough voltage at the battery to allow for a positive charge current. The maximum power point of a panel is measured in watts; (remember watts = volts x amps), this point is where product of the voltage and amperage of the solar panel is at the highest point (producing the most amount of useable power). The problem is that as soon as you hook up the solar panel to the battery, the battery "Drags down" the voltage at the solar panel, immediately; the solar panel is below its maximum power point (unless it is a very hot day, there is considerable voltage loss in the copper and connections, and/or the battery is mostly charged.). More often than not, the solar panels are operating below their maximum capability. This is especially exasperated when the batteries are low or under a large load (perhaps measuring 12 volts or lower), this drags the solar panel voltage down even lower, causing a great deal of power to be lost due to the mismatch of the battery voltage and the solar panels maximum power point.

The solution which is well provided for by MPPT controllers, is to prevent the solar panel output voltage from dropping so dramatically though the use of very sophisticated electronics which include transformers and/or inductors and highly intelligent tracking algorithms that monitor both the solar panel voltage as well as the battery voltage. The MPPT controller basically downshifts (and/or up-shifts as in the case of the MP-20) the incoming voltage from the solar panel by converting the D/C current into an A/C current (or pulsed D/C), transforming the voltage level via a

buck or boost circuit, and finally rectifying it back to a steady D/C voltage at a level that properly matches the best charge voltage for the battery.

Basically, the MPPT controller converts excess voltage to amperage. The point that allows the most amount of charge current is determined by the microprocessor in the controller and is continuously updated (tracked). The controller constantly tracks this point and responds as required, thus the name, Maximum Power Point Tracking.

MPPT controllers are recommended for solar systems in cold climates as well as where there is a large difference between the VOC of the charging source and the battery bank. The greater the disparity between the battery voltage and the solar panel's maximum power point, the more useful a MPPT controller is.

MPPT controllers were generally not available until recently for wind based systems as the MPPT processing for wind based systems required very fast and very complex computations to match the dynamic properties associated with a wind turbine. In addition, in order for a MPPT controller to work fully with a wind-based system, it must also be able to "boost" lower voltage inputs (low wind conditions) up to higher voltages to allow current to flow to the batteries as much as possible, regardless of the RPM of the turbine. The MP-20 incorporates these high-speed processing techniques and is fully capable of working with most small wind systems. Simply choose "Wind" under the input type within the advanced menu.

The MP-20 is capable of providing 3-stage charging for Lead acid, AGM and Lithium based battery systems.

A three stage charge cycle consist of:

- Bulk Charge
- Absorption Charge
- Float Charge

The 1st stage in a 3 stage charging mode is the Bulk Charge: In this mode, most (if not all) of the available current is sent to the batteries to raise the battery voltage up to the bulk set point. This mode brings the battery to about 80% of its capacity. Generally the bulk charge voltage is set to between 14 and 15 volts, with 14.4 volts often used as a standard. There is really no perfect voltage setting as there are many factors involved. The ambient temperature, the size of the energy sources vs. the battery bank size, the desired length of time in this mode, the cost of the energy (if it is supplemented by the grid or generator, etc.). Simply stated, the bulk charge gets the battery up to a mostly full state at a quick but healthy rate.

The 2nd stage of the 3-stage charging mode is the Absorption Charge: Once the bulk mode set point is reached, the charger attempts to hold and track this value. The absorption mode uses the same set point as the bulk mode with the difference being that the battery voltage is no longer rising up to the set point; but instead, it is being maintained at that set point. Due to the chemical nature of the battery, this constant voltage causes the charge current to drop as the battery reaches a "full" state of charge. The factory default for the absorption mode is set to 120 minutes, which under sufficient solar/turbine energy input is ample to charge most battery banks.

The final stage is the Float Charge: This mode is the charge mode that the battery is under most of the time for a properly designed system. Once the batteries are brought to a full state of charge, the float charge mode maintains the batteries at a voltage level of around 13.2 to 13.7 volts (for a flooded, 12 volt lead acid battery). By applying the required amount of charge current to offset any load the battery might be powering, as well as overcoming the batteries natural self-discharge, the batteries longevity is greatly increased.

Another charge mode incorporated by many chargers (and the MP-20) is the equalize charge. This mode is not a part of the normal charge cycle, but is instead initiated (either manually or automatically based on a timer) to help mix the electrolytes of the battery. During normal use, the battery's chemical mix becomes stratified. (Separated from top to bottom). An equalize charge uses approximately 10 percent higher voltage to help mix these elements in the battery.

Equalize charging also helps bring all of the batteries in a multi-battery bank to an equal state. Most people agree that an equalize charge should be run once every 10 to 40 days, for 2 to 16 hours for lead acid batteries. During this charge cycle quite a lot of gassing will occur, which causes the fluids to be mixed and the plates to be "cleaned". An equalize charge is not recommended for sealed batteries or lithium batteries. Be sure your battery room has good ventilation before running an equalize charge.

The MP-20 also incorporates a “ReBulk” set point. Should the battery voltage drop to the “Re-bulk” set point for more than a few seconds, the controller will exit the current charge mode and start a new bulk mode. If the Bulk mode is already active, then the controller will restart the countdown timer to force a new full-length bulk mode charge.

Fine tuning your system:

As introduced above, the MP-20 is fully configurable through the front panel buttons and display. There are no jumpers that need to be set or potentiometers that need to be adjusted. All configurable options are reachable via the menu system. This menu system is comprised of a main menu and several submenus as depicted above in the menu layout graphic (page 6). Each submenu allows you to either set a particular value, view information, or perform specific actions like running a test or starting the equalize mode. Most of these menu items are self-explanatory and will not be discussed in detail; however, there are some features and settings that deserve greater explanation.

First and foremost, **you generally do not need to change anything.** When the controller is first powered up, it analyzes the current battery voltage to determine whether the battery bank is a 12, 24 or 48-volt bank. If your battery bank nominal voltage has changed since the last time the unit was powered up, then the microprocessor will reset all values to the factory defaults and store the new information. These factory defaults are normally perfectly adequate for a lead acid battery bank used with most solar and wind installations. Changes to the settings are therefore only required when your requirements are different in one manner or another from what has been set by the factory. The controller is basically plug-and-play! Factory defaults can be viewed in the technical specifications page at the end this manual.

- **Setting up the charge parameters**. See the technical specifications pages for the factory defaults. If you need to alter any charge settings, simply select the charge menu choice from the main menu and scroll though the submenu to select and alter the values. There are very few limits placed on the values you set, other than you cannot set a float set point higher than the bulk, or the bulk higher than double the battery system voltage etc. Once you set or reset these settings, you should monitor the controller and see that these settings are working to achieve the results you require.

  The factory time setting for the absorption is 120 minutes. This value can be changed as required. This timer is performance based. The microprocessor uses multiple algorithms to determine if during the last minute the batteries actually realized a certain level of charging. The main consideration is whether the controller was able to reach and hold the upper set point. If the performance during the last minute for the absorb mode is considered adequate, the timer will be decremented by one minute. If on the other hand, the performance is below the standard, the timer will not be decremented, which can result in a charge cycle that lasts much longer to ensure the batteries actually receive the best charge possible even in less than optimal charging conditions.

  The green LED on the remote panel will be illuminated when the processor determines the performance is high enough and off when the performance is not high enough to properly charge the batteries. This allows you to quickly visualize the real time charging performance that the controller is detecting. Often the green LED will blink on and off randomly and rapidly as the solar/wind energy fluctuates.

- **Turning on or off the Equalize mode**. By default, the equalize mode is not enabled. To start a manual equalize, select the Equalize submenu, scroll right or left to the "Equalize Now?". When this submenu is displayed, press the "Up/Down" button to select "YES" and then press the "Enter" button to request this mode. The equalize mode will then be queued. The controller will not actually start the equalize mode until the bulk set point has been reached. Once the mode is started, the countdown timer will start and the mode will stay in affect until the timer expires. The length of time in this mode is controlled by the "Equalize Minutes" submenu option. The equalize mode is not performance based and will not be restarted automatically due to low current conditions.

  The automatic equalize: Changing the Equalize days from "0" to any number up to 90 will enable this feature. The equalize function will then run once the day timer has been triggered and the bulk set point has been achieved. The equalize will not actually start if the bulk set point is not achievable via the solar/turbine charge inputs.

- **The Advanced Menu:** The advanced menu allows you to change the LCD backlight options, voltage and amperage calibration adjustments as well as let the system know which type of energy source is hooked up to it.

  By default, the LCD backlight will be turned off after 120 seconds of no activity. If you would like to extend this, to say 5 minutes, then simply raise the seconds on time to 300. If you do not want the backlight to be turned off, set this value to zero.

  There are 4 submenu locations that allow you to fine tune both the voltage and amperage calibration. This should only be necessary if you notice that the unit is displaying a voltage or amperage, which you believe to be incorrect and wish to calibrate in order to correct the measurement error.

  The voltage and amperage "offsets" allow you to raise or lower the displayed values by a set amount across the entire measurement range equally. Setting the offset to .2, causes the voltage displayed (and used internally) to be raised by .2 volts at both the low end as well as the upper end of the input range. 10V becomes 10.2V and 49.5V becomes 49.7V.

  The voltage and amperage "gain" allows you to raise or lower the upper end of the range by more than the lower end. This is used when you notice that the lower end measurements seem to be pretty close, but the upper end is off a tenth or more. Setting the gain does alter both the upper and lower end, but the upper end is affected more than the lower. A gain of .1 = .1% gain, which is not a lot of change on the lower end, but about a tenth of a volt at the maximum input of 100 volts. This same logic applies to the amperage offsets and gains.

  Input type: The input type submenu lets the system know which type of alternate energy source has been hooked up to it. This feature allows it to perform MPPT processing and diversion processing more specific to a particular energy source. This setting is optional for fine-tuning only and not a requirement, as the system has a self-learning capability, which will often be fully sufficient. Of note however, this option also changes the menu display and log data outputs from the default "Solar" to "Wind" or "Hydro". If you have a wind or hydro based system and have purchased the optional SSR diversion control module, then use this menu option to let the system know you have a wind/hydro unit so it will properly engage/disengage the SSR.

- **The View Submenu:** The view menu allows you to view the real time voltage and amperage of the connected solar and or turbine energy sources. The controller incorporates two shunts, allowing it to measure both input and battery amperages simultaneously.

  The current reading (amperage) of the solar and turbine inputs will be zero (or very close to zero), if there is no active input from the energy source.

  The voltage shown for the Solar or Wind turbine is affected by the MPPT processing for the input. For example, if the system is boosting a 12 solar panel up to meet the charging voltage of a 24-volt battery bank, then the solar input voltage may actually show to be even lower than 12 volts. This "over-boost" phenomenon can be result of a cloudy or hot day, which causes the solar panel's MPP to drop below the normal VOC. The MPPT processor will constantly reset itself when it notices a condition that is somewhat out of the normal base of operation.

Other Menus and Submenus:

In addition to changing the charging parameters, the diagnostics menu system can be used to view the maximum voltages and amperages reached during the active charge cycle. These values are reset each time the charge mode is changed (a change from the bulk mode to the absorb mode for example). They are also reset when the controller is powered up. These values can be helpful in determining the performance of the charging sources.

Another diagnostics submenu option is the **"Start Test?"**. To select this feature, press any button on the front panel, scroll right or left to the Diagnostics menu, press the down button to select the "Start Test?" feature. Press the "Up/Down" button UP until "YES" is displayed, then press "Enter". The controller will now enable and disable the MPPT processing at full output, 5 times, using two-second intervals. During this time, the battery voltage, solar voltage, solar amperage and turbine amperage will be displayed in an alternating and repeating pattern that allows you to see each of these values during both the fully enabled and fully disabled state.

During the test, all LEDs on the remote menu will be illuminated when the processor is enabled and off when it is disabled. Generally, this test will only be run when you suspect problems and are working with a factory technician to diagnose the issue.

Resetting to factory defaults:

If for any reason you wish to start over with all configuration settings and parameters, then simply select the "Reset Defaults?" submenu, choose "YES", then press "Enter". All configuration settings will be reset to the factory defaults. This reset is also performed anytime the batteries nominal voltage (12, 24 or 48-volt) changes from the last time the unit was powered up. This means if you change your battery bank from a 12-volt system to a 48-volt system, then the microprocessor will automatically initiate a reset to factory defaults for the currently detected battery bank.

Using the controller with a wind or hydro turbine:

The MP-20 is a MPPT controller that is designed for both Solar and Turbine based systems. In order to work fully with a turbine based system, the optional SSR (solid state relay) module and a diversion load are recommended. The basic operating philosophy of diversion control is quite simple. Monitor the battery voltage, and if it should rise to a predetermined level, connect a diversion load or "dummy load", of sufficient size, to the battery or energy source to prevent the battery voltage from increasing any further. This is a very simple, yet very effective way of preventing battery overcharging, while keeping a load on the input source.

The MP-20 excels when used in conjunction with a wind/hydro turbine to run diversion loads, via the optional SSR diversion module.

As detailed earlier, the MP-20 is a MPPT based controller that is capable of bucking or boosting the input voltage as well as reducing the current flow as the batteries are charged. Yet, a wind turbine by its nature needs the controller to keep the turbine loaded. This of course is not possible if the battery is full, unless there is a means to shed some of the excess energy to a "dummy" or diversion load. The MP-20 is capable of doing just that, by both reducing the current flow to the battery as required, yet at the same time energizing a SSR to enable a diversion load to keep the turbine loaded. When you select "Wind" or "Hydro" as the input source, the controller outputs a 5V signal that can be connected to the SSR (Connection details can be found in the SSR hookup document), which in turn energizes the diversion load, which then loads the turbine to prevent it from spinning too rapidly. This signal is turned on and off as the charging set point is reached and missed.

For example, if the charger is currently in the bulk mode, charging a 48-volt battery bank, with a bulk set point of 57.6 volts, and the set point (57.6v) is being predominately reached, then the controller will enable the diversion load for the turbine. This will cause the output voltage of the turbine to decrease (possibly below 57.6v), which will cause the MPPT to boost the turbine's inputs voltage as required, more and more, which extracts yet more power from the turbine, while at the same time, placing a larger load on the turbine, which of course slows the turbine even more. Eventually, the bulk set point is no longer attainable, resulting in the disabling of the diversion load. This cycle of course then repeats, endlessly, as long as there is more wind energy then the batteries can absorb. This cycle of on and offs can be as fast as many times per second, to a slow as a few times per minute, depending on the all of the input forces and loads. It is therefore very important to have a diversion load that can be cycled on and off many times per second and many times in its lifetime without failure.

A few points of interest here:

1) The controller will not engage the SSR if it notices that the input energy source is not what is causing the batteries to be charged (or the set point to be reached). This prevents the wind turbines diversion load from being engaged, simply because the batteries are charged. This also allows multiple charge sources to work in conjunction with each other, while using different input sources, yet hooked up to the same battery bank. For example: If the battery bank is being predominately charged by a solar system, and there is very little wind, then the MP-20 hooked up to the wind controller on the same battery bank, will not engage the diversion load, since it will notice the wind energy is not what is bringing the battery voltage up to the set point. This logic is not perfect, since wind energy is very dynamic, small bursts of energy may be sent to the diversion load when the wind energy increases and the batteries are nearly full and the solar panels have not fully reduced the current flow.

2) When there is a great deal of wind energy, but the batteries are not full. The controller will still automatically apply the diversion load if the:

    a) Input voltage of the turbine rises beyond twice the level of the battery bank or the:
    b) Current from the wind turbine begins to overheat the MP-20 internal mosfets.

FAQ: But do I really need a diversion load for a wind turbine?

Generally Yes. A solar panel may be safely disconnected from the batteries, but an active wind turbine should never be disconnected from its load (battery/diversion load). When a wind turbine is not loaded, it can easily spin out of control during high wind events, which can lead to catastrophic failure of the turbine as well as the possibility of damage and injury to other property and people. **Unless your wind turbine has a built in braking or furling system, it is very important that your turbine has a very reliable load at all times.**

Please see our FAQs located on our website http://GetAwaypower.com for more information on this subject and many others.

Diversion Load Types

A diversion load needs to be larger (by at least 10-20%), than wind/hydro charge source that is hooked up to the controller. When the diversion load is too small, turbine RPM may continue to rise even when the diversion is active. It is also important to use a load that is not likely to fail. Light bulbs and similar such loads are very poor diversion (dummy) loads, since they will fail and you may be left with no method to dump the excess energy coming from your turbine

It is commonly thought that a standard 120vac, 2000 watt heating element (readily available from your local hardware store), would make a good load; however, in reality, they are not well suited, as it takes several of these elements to actually be effective in lower voltage systems. A 2000 watt, 120VAC element will not dissipate 2000 watts at lower voltages. You would need to install multiple elements in parallel to achieve the desired load specifications.

Please use the following chart as a quick guide in using a 2000-watt, 120 VAC heating elements.

60Vdc dump (48Vdc system) -- 500 Watts -- 8.3 amps
30Vdc dump (24Vdc system) -- 125 Watts -- 4.2 amps
15Vdc dump (12Vdc system) -- 35 Watts – 2.1 amps
120Vac -- 2000 Watts, at 16.7 amps

Basically, a standard 2000-watt, 120 VAC element, in a 12-volt system will only dissipate 35 watts!

Resistive heating elements designed specifically for 12, 24 and 48-volt systems are by far a better choice.

A very acceptable diversion load is a power resistor. These can be obtained via http://getawaypower.com/. Various wattages are available as either completed load centers or individual power resistors.

A diversion load is not required for solar only systems.

Please visit our online store for a selection of diversion loads, diodes and rectifiers.

Installing and hooking up your MP-20 Controller:

To help prevent over-voltage, always hookup the controller to the batteries (and power it up) before enabling your turbine or solar energy sources. The controller cannot engage its protective circuits if there is no connection to the battery bank.

A free spinning turbine can instantly generate very high voltages, which can damage many of the components within the controller if the controller is not first powered up.

Inspect the unit when it first arrives. Please contact your dealer immediately if any problems are found.

The controller should be connected as close to the battery bank as possible, using finely stranded, insulated copper wire.

A common installation method is to mount the controller on the wall, often reinforced with plywood or similar material, in a room specifically built for your alternate energy equipment. A garage or similar room is also fine. **Installation of the main controller in your living area is not recommended!** Large currents and voltages are passed through the unit and there can be a noise emitted during the normal cycling of the controller. The remote menu module can and often is mounted in a living area, such as the electronics area in your house, RV, Motor home etc. The remote menu module will not emit any noise, nor does it contain any high voltages. Of note, the LED's can be disruptive to sleeping if the remote module is located in a sleeping area.

Do not install the controller in a small area that does not allow for proper ventilation. **Absolutely do not install the controller in a small "battery box" without substantial ventilation.** Lead acid batteries expel hydrogen into the air as they charge, which can be ignited by the controller during normal operation. It is perfectly fine to mount the controller in the crawl space of a camper or generator compartment etc, providing there is adequate ventilation for it to cool itself during normal use.

The controller has four holes on the mounting plate of the unit that accommodate up to ¼" screws or similar to be used to securely fasten the unit to the wall or panel. The unit may be installed on a flat horizontal surface as well. When mounting, ensure there is adequate space above the unit for any heat to be expelled.

Use only 10 or 12 gauge finely stranded wire. Solid wire is not recommended, as it is difficult to terminate inside the controller.

Again, do not install under sized wire, it is utterly dangerous! See the NEC wire charts to determine your minimum safe wire gauge for the amperage of your system and energy sources.

Any wire that leaves an energy source MUST have a breaker or fuse. Do not run a wire from your battery bank that is not protected against over current. This means you need a breaker or fuse between the battery bank and controller.

Inspectors generally insist that a breaker or disconnect be located as close to the energy source as possible and may also insist on a 2nd breaker or disconnect near its final termination point. Please consult NEC regulations and your local inspector to determine the requirements in your area. These subjects are outside of the scope of this manual; however, it is your responsibility to ensure your unit is installed safely!

Solar panels and Wind/Hydro turbines are energy sources. A breaker or fuse is required between these devices and any other components (including the MP-20). **Do not hook up a wire from any energy source into the MP-20 without the ability to quickly and safely disconnect the input. All inputs need fuses or breakers!**

EMP Protection:

The MP-20 has been built to withstand an EMP burst; lightning and/or any other high-energy surge providing you properly install it.

The MP-20 is fully enclosed in a NEMA 3R enclosure that provides protection against rain, snow, wind and falling debris etc. This enclosure is also the perfect faraday cage, which fully protects the internal electronics from high-energy air-born bursts. In addition, all controls and displays are designed to be mounted remotely and therefore do not impede upon the EMP hardening of the controller … when everything is properly installed and GROUNDED! If you do not ground EVERYTHING as described below, then NO EMP protection is possible.

Grounding your MP-20 and alternate energy system.

A properly grounded system is extremely important, for both safety and reliability. An ungrounded system is significantly more likely to be damaged during an electrical storm than a properly grounded system. It stands no chance against an EMP burst.

Solar panels and wind turbines act as lighting antennas or "magnets" as they are always mounted in manner that opens then up and elevates them in some manner or another which often makes them the most likely target for a lightning strike.

It is important to note, that due to the relationship between the earth's ground and the electrically charged sky during an electrical storm, the lighting bolt does not actually seek the highest object, but the highest object actually attracts the lighting bolt to it, with an initial burst of conductivity that starts from the ground up, not the sky down. So, putting it simply, if you put a wind turbine up in the air and that tower is not grounded, then you can fully expect it to be hit by a lighting strike, which will result in equipment failure. This is a "not if, but when" scenario and then "how often".

When a lighting bolt hits an ungrounded tower, the entire voltage/current spike will travel down the wires that lead directly to your MP-20 controller, looking for a ground. On the way through, untold damage can be done. The MP-20 incorporates multiple over-voltage surge protection devices and circuits, but they may be no competition to a direct lighting hit. Many of our controllers have survived direct lighting hits due to the internal protective circuits yet the connected equipment like meters, inverters, etc. are damaged beyond repair. Proper grounding is paramount! Damage due to lightning strikes and high voltage surges are not protected under the warranty.

To make matters worse, the lighting strike does NOT have to be direct. Highly charged atmosphere may be present for many miles around an active lighting area. This super charged air is more than sufficient to damage the sensitive equipment used in an alternate energy systems where the solar panels and towers act as antennas for this energy.

Additionally, indirect electrical charges can be present at other times, including a stand-storm, high wind event, very low humidity conditions etc., that are more than sufficient to generate static electricity that far exceeds hundreds or even thousands of volts. Without grounding, this static electricity alone can damage any piece of equipment used in your system.

A properly grounded system is comprised of (at the very minimum) 6' ground rounds and large (6 to 8 gauge) bare copper wire that ties the enclosures and system negatives directly to the ground rod. Ground rods (plural) should be placed as close to turbine towers and solar panel installation as possible. The towers and panels should be tied directly to the ground rods, with few or no splices. The battery bank's negative (or buss) should also be tied to a grounding rod.

Grounding details:

Solar Panels:

There is a great deal of discussion on how to protect solar panels from EMP (both solar and atomic), but in the long run there is really very little true knowledge of the subject, since there is no effective way to test the theories. That said, all authorities agree, that grounding is paramount and proper grounding requires carefully thinking about how high energy burst of energy from externally (i.e., grid) connected wires and/or the atmosphere to the earth are likely to travel. Ground wires need to be as short of possible and as numerous as required to ensure each and every panel is grounded.

Each vertical row of solar panels requires a separate ground wire running vertically down to the ground. Multiple ground wires may be combined into a single ground rod. Generally a new ground rod should be driven for every 8 to 12 feet of lateral ground distance, driven (6' or 8' deep) the more the better, the deeper the better.

Use an aluminum grounding strap between each solar panel frame (even if you have mounted the panels to an aluminum rack). Alternatively, you may tie each and every solar panel frame directly to the grounding wire via a ground lug or bolt. This is often the best and easiest method.

For EMP protection, the solar panel wires (MC-4 cables etc.), MUST be enclosed in metal conduit for the trip down to the controller, failure to do this will defeat the EMP Hardening of the controller. Enclosing the wires and junction box under the panels in a aluminum foil or tape, may help prevent energy from entering the wires, but for the most part, high energy gamma rays will travel easily through the solar panel into every wire, so the best solution is to always give this energy an easy way back to the earth ground it seeks by ensuring the wire ends up in a metal conduit and that conduit is grounded before it gets to any piece of electronics.

Grounding wind turbines:

As mentioned above, it is imperative that the wind turbine pole (tower) is grounded at its base. It is not enough that the pole is driven into the ground, you MUST provide a copper ground wire from the base to the top, and this wire must be tied to a ground rod(s) that are driven into the soil at least 6 feet.

The wind turbine housing itself should also be tied to this or another ground wire if at all possible.

The wires from the wind turbine must either be placed underground or run in metal conduit before it terminates at any piece of electronics, including the rectifier, break switch, or controller. Ground the conduit itself via a grounding strap directly to the ground rod before it gets to any enclosure. Do not run bare wires into an enclosure.

Grounding enclosures.

Each and every enclosure must be grounded directly via a copper ground wire. Each of these wires must make a separate run to the nearest ground rod or a grounded buss bar. Do not daisy chain copper ground wires, this does not work but instead can bring an otherwise unaffected enclosures into the direct path of the high-energy burst.

Grounding the battery bank.

The negative ground post or ground buss of the battery bank must also be grounded. This is one of the most important grounding places, yet often overlooked. If your battery bank is not grounded it can easily pass the high energy burst back into EVERY piece of equipment that is connected to it!

It is difficult to over ground, but it is actually possible. Please do an Internet search for solar system “ground loops” to ensure you are setting up a grounding system that is not subject to ground loops, which can introduce a new set of problems.

There is a great deal of information on these complex subjects including, grounding, EMP protection, and lighting strikes. There is also a great deal of misinformation, which can cost you a lot of money and hardship unless you take the time to research and then take the time to properly install and protect your system. This is knowledge you will be forced to garner, it’s really just a matter of being proactive or reactive and then how costly will such an education be.

An ungrounded system is also a safety hazard for a multitude of reasons that are outside of the scope of this manual. No safety conscience installer will ever design and/or install a system that fails to include grounding.

Please research “solar or wind systems grounding” on your favorite search engine for more information.

General Operating specifications	System Voltage		
MP-20 MPPT Controller	12V	24V	48V
Minimum operating voltage	10.5V	10.5V	10.5V
Maximum allowable intermittent/surge voltage (*1)	102V	102V	102V
Maximum input from energy source (VOC)	100V	100V	100V
Most efficient VOC	24V	48V	96V
Minimum voltage input (boost capability)	10.5V	10.5V	10.5V
Maximum continuous solar charge amperage (*2)	20A	20A	20A
Maximum surge charge amperage	25A	25A	25A
Energy consumed by the electronics (meters off, standby current)	< .1W	< .15W	< .3W
Energy consumed by the electronics (meters on, MPPT active. (*3)	< .75A	< .5A	< .5A
Minimum float setting (volts)	12.0	24	48
Maximum float setting (volts)	24	48	96
Factory default float setting (volts)	13.5	27	54
Minimum bulk setting (volts)	12	24	48
Maximum bulk setting (volts)	24	48	96
Factory default bulk setting (volts)	14.4	28.8	57.6
Time in absorption charge once bulk set point has been reached.	2 hours	2 hours	2 hours
Time in equalize charge once equalize set point has been reached.	2 hours	2 hours	2 hours

*1: Voltages spikes above 102v at the battery+ input terminal will trigger the over-voltage protection circuitry causing the isolation circuit to be engaged. The red over voltage LED will be lighted (on the small PCB board lower left inside of the unit). The controller must be un-powered for at least 30 seconds to clear this condition.

*2: Continuous power capabilities are determined by the internal mosfet temperatures. If the controller is not mounted where it can expel heat and/or does not have adequate ventilation, then these values will be reduced.

*3: Additional power is consumed when the MP-20 is boosting or bucking large currents with large differences between input to output voltage. The general MPPT operating efficiency is 96%, with buck (downshifting) efficiencies that can exceed 98%.

Install in a non-corrosive environment only.
External dimensions of the enclosure (Inches) 6.5 x 4.5 x 4.5

Minimum ambient air temperature	-20F
*2) Maximum ambient air temperature (20 Amps)	85F
*2) Maximum ambient air temperature (15 Amps)	110F

Operations above or below the maximum temperature range may result in loss of accuracy and/or a reduction in current handling capability

Designed for battery-based systems only.

These specifications and measurements are subject to periodic change without notice.

Automatic Nominal Battery Bank detection:

When power is first applied to the MP-20 controller, the voltage of the connected battery bank is measured to determine if the controller should operate in the 12, 24 or 48-volt mode. This process is automatic and eliminates the need for manual jumper settings or other user intervention. This process; can however, report the wrong value to the controller if the connected battery bank has been depleted beyond normal limits (A fully dead battery). For example, if a 24-volt battery has been allowed to deplete to perhaps 15 volts and the controller is restarted during this period, then the controller will assume it is connected to a 12-volt bank, not 24 volt. If this occurs, then simply increase the bulk charge point and let the battery bank recharge. Once the battery is recharged to a normal region; then via the menu system, select the “reset defaults” to set controller back to the factory defaults or simply restart your controller by removing power from it for 30 seconds or more.

Over-Voltage:

To help prevent over-voltages, always power up the controller (ensure it is running on the batteries) before enabling your turbine and/or solar panels. All solar panels and turbines must have a manual disconnect that allow you to safely power up the controller and then and only then, enable the energy sources.

The MP-20 use a specialized over-voltage sensing circuit that is MUCH faster than a fuse for detecting and protecting against over-voltage conditions such as a lighting strike or an over-voltage wind turbine, but damage can still ensue if the controller especially if not grounded and/or powered up. This protection circuit will be engaged should the input voltage rise above ~104 volts. If this occurs, the Red O.V. LED will illuminate (inside the controller) indicating the O.V. condition. **You must remove all power from the controller for at least 30 seconds to reset the O.V. circuit.**

General Information:

The internal negative power plane of the MP-20 is inter-tied to the enclosure; it is therefore imperative that the enclosure is grounded directly to a ground rod via a copper ground wire, to prevent damage to the unit in the event of lighting strike or EMP bursts.

The MP-20 uses a high frequency buck/boost circuit running at 104kHZ, this frequency creates harmonics in the GHz range that is fully shielded via the enclosure. Again, if the enclosure is not grounded, then this high frequency signal may cause interference with close by radio signals and receivers.

This main control unit is designed for mounting outdoors, but **the enclosure will not protect the contents from high moisture areas such as beach houses, sail boats etc**. Salt air will quickly oxidize the electronic components and connections, eventually resulting in failure of the unit. This type of failure is not covered under warranty and may preclude repair.

Note: Some of the photos of circuit boards may be from earlier version of this controller.

Modified 2/12/2019.