

# RSP5

## Solar Panel Instructions



**General Information**

General Information ..... Page 3  
Features ..... Page 3  
Specifications ..... Page 3  
Battery Selection ..... Page 4  
Location ..... Page 4

**Installation and Maintenance**

Installation ..... Page 5  
Wiring Diagram ..... Page 6  
Maintenance ..... Page 6

**Appendix A: Solar & Battery Power Guidelines**

Power Requirements for Seametrics Products ..... Page 7  
The Solar Panel ..... Page 8  
The Solar Charge Controller ..... Page 8  
The Battery ..... Page 8  
The Load ..... Page 9  
Wiring and Installation ..... Page 9  
Maintenance ..... Page 9  
Checklist ..... Page 10

**Appendix B: Estimating Minimum Needed Amp-Hour Capacity**

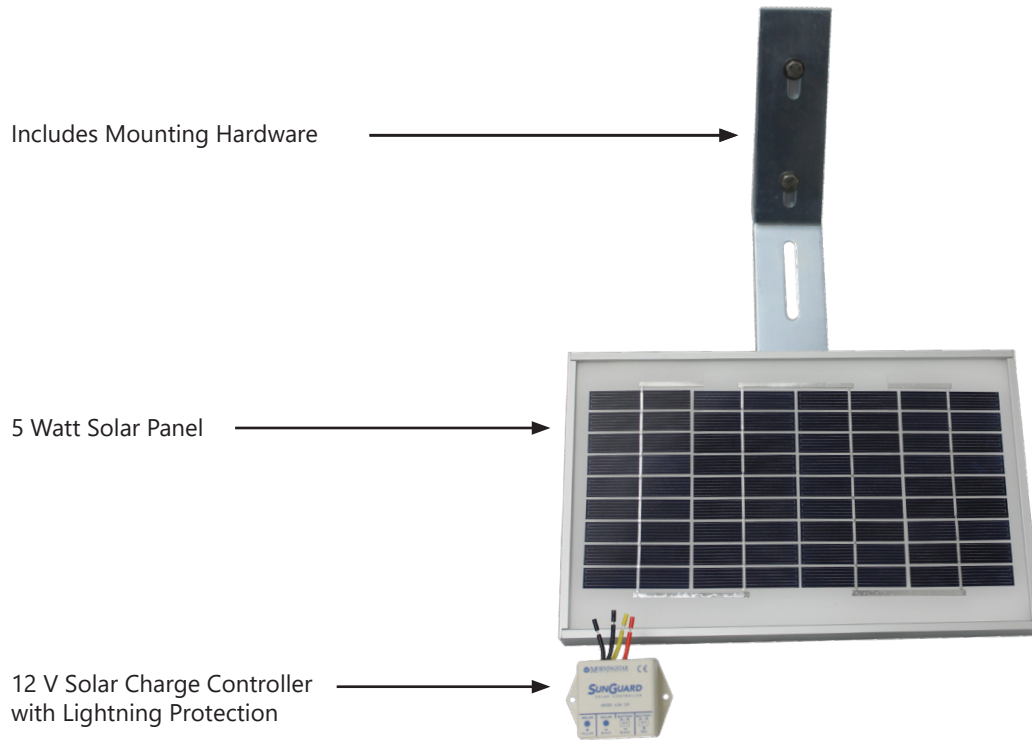
Estimating Minimum Capacity for a Given Climate ..... Page 11  
Example Calculation ..... Page 11

**Warranty**

Seametrics Limited Warranty ..... Page 7

The RSP5 solar panel makes it possible to use Seametrics flow meters in remote applications where a reliable source of electricity is not available or practical. The RSP5 is intended for use with a standard 12 V, 22–33 Amp-hour Sealed Lead Acid battery (not included). It comes standard with a charge controller and corrosion-resistant mounting hardware. The RSP5 can also be used to provide up to a 40-day back-up power supply for periods of darkness.

**Features**



**Specifications\***

<b>Electrical</b>	<b>Current</b>	290 mA (typical at design operating point)
	<b>Voltage</b>	17 V (typical at design operating point)
<b>Dimensions</b>	<b>Height</b>	14.2" (36.07 cm)
	<b>Width</b>	8.5" (21.59 cm)
	<b>Weight</b>	4 lb (1.814 kg) (solar panel and mounting bracket)
<b>Mounting</b>	Bracket, band clamps, and mounting hardware for 1 1/2 or 2 inch vertical pipe	
<b>Operating Temperature Range</b>	-40° F to +158° F (-40° C to +70° C)	
<b>Charge Controller</b>	High efficiency series PWM regulator with temperature compensation and built-in lightning protection	

\*Specifications subject to change • Please consult our website for current data ([seametrics.com](http://seametrics.com)).

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**Battery Selection**

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For powering Seametrics mechanical meters along with display electronics, use a 12V Sealed Lead Acid (SLA) deep-cycle battery with a minimum capacity of 22 Amp-hours. This should provide a conservative 40 day backup with maximum battery service life. Marine/RV grade deep-cycle batteries or automotive batteries may be used but must be upsized in Amp-hour capacity by two times and four times respectively to achieve the same battery service life in most applications.

For powering Seametrics low power (<50mA) magnetic flow meters (**AG3000, iMAG 4700, AG90, EX90, WMP and low power EX 100/200/800 series meters**, etc.) use only deep-cycle SLA batteries (not marine/RV or automotive grade batteries) with a minimum capacity of 33 Amp-hours. In climates where meters are operating in full pipe mode much of the time with extended periods of cloudy days, operating continuously through the year, or in latitudes above 50 degrees, the required battery Amp-hour capacity should be reviewed before selection. To learn more, consult Appendix B later in these instructions.

In summary, the minimum recommended battery capacity, as described above, will be adequate in most climates and applications. However, under marginal conditions, a larger capacity battery may provide superior reliability, better battery service life and lower life-cycle costs.

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**Location**

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The solar panel should be oriented as much as possible toward the midday sun. Locate where there is no significant shading of the solar panel. The Solar Charge Controller and Sealed Lead Acid (SLA) battery should be located in close physical and thermal proximity. Both must be shaded from direct sunlight to minimize temperature differences between them which will greatly diminish the battery service life. Also insulate the bottom of the battery if heat could be absorbed from the surface (concrete, metal etc.) on which the battery is resting. Also take measures to prevent accumulation of moisture (rain, snow, ice, flooding) between the battery terminals which could discharge the battery.

If the battery and Solar Charge Controller are housed in an enclosure, the outside must be white or shiny metallic to minimize solar heat build up inside that is seriously detrimental to the service life of the battery. Even light colors (such as the standard ANSI 61 Gray) can elevate the interior of the enclosure by 40 F (22 C.) If other colors are used, the enclosure must be shaded from direct sunlight or painted glossy white. In addition, because even sealed batteries could vent if the Solar Charge Controller fails, for safety reasons the enclosure should be vented, particularly if it contains other electrical equipment, to prevent ignition of the venting gas.

**INSTALLATION**

The solar panel is designed to mount to a 1-1/2 to 2 inch diameter vertical pipe. First, locate and record the product code (either 'D' or 'R') on the box label.

To install product code 'D' panels, attach the 45 degree angle bracket to the panel with the two M6 bolts, flat washers and nuts provided as shown. **Before tightening the bolts. Be sure to position the bracket to the side of the black cable cover rather than over it to avoid stressing the panel.**

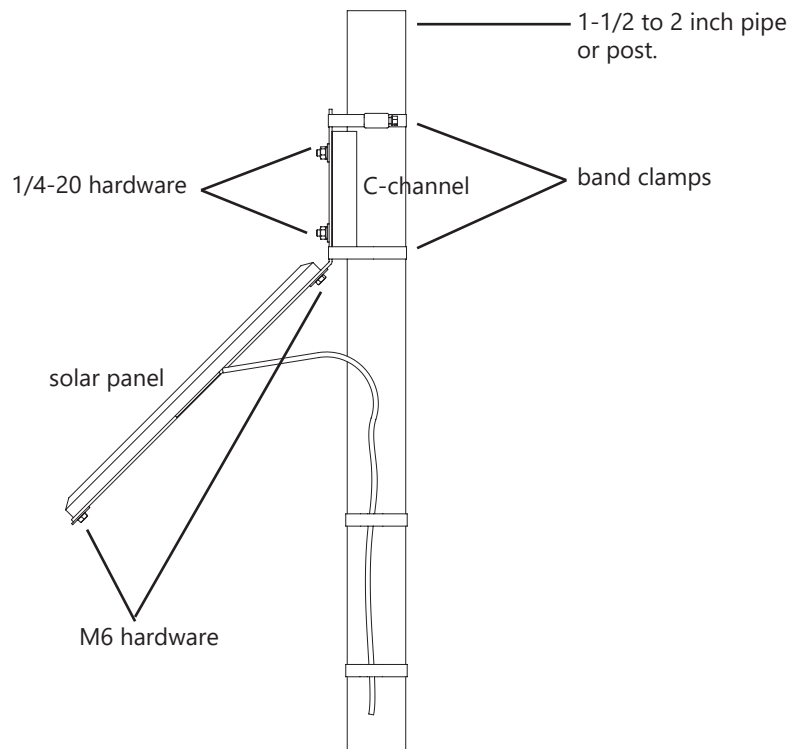
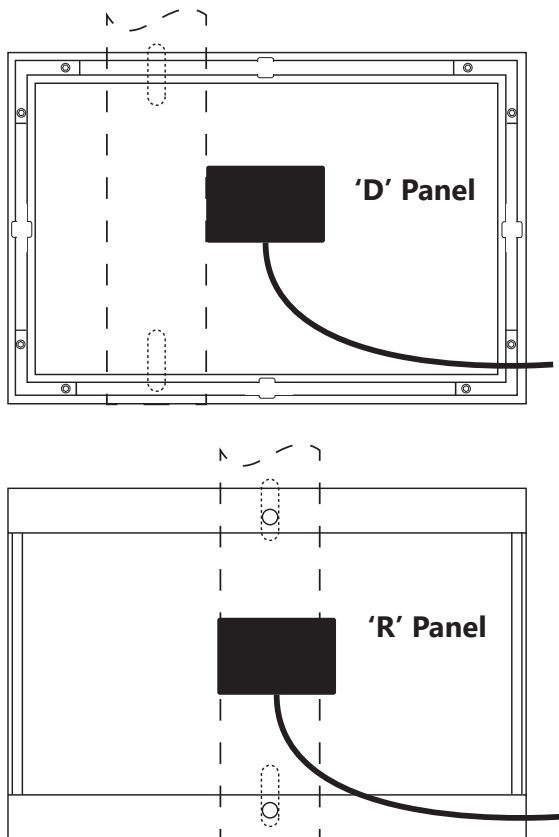
To install product code 'R' panels, the 45 degree angle bracket is mounted to the two center holes on the rear of the panel with the two M6 bolts, flat washers and nuts provided as shown. Cut off and discard the ring lugs on the panel wires.

At latitudes above 50 degrees performance may be improved by bending the angle bracket so that the angle of the panel to the horizontal is increased to approximately the local latitude plus 15 degrees. **To avoid damage to the panel, do this before bolting the bracket to the panel.**

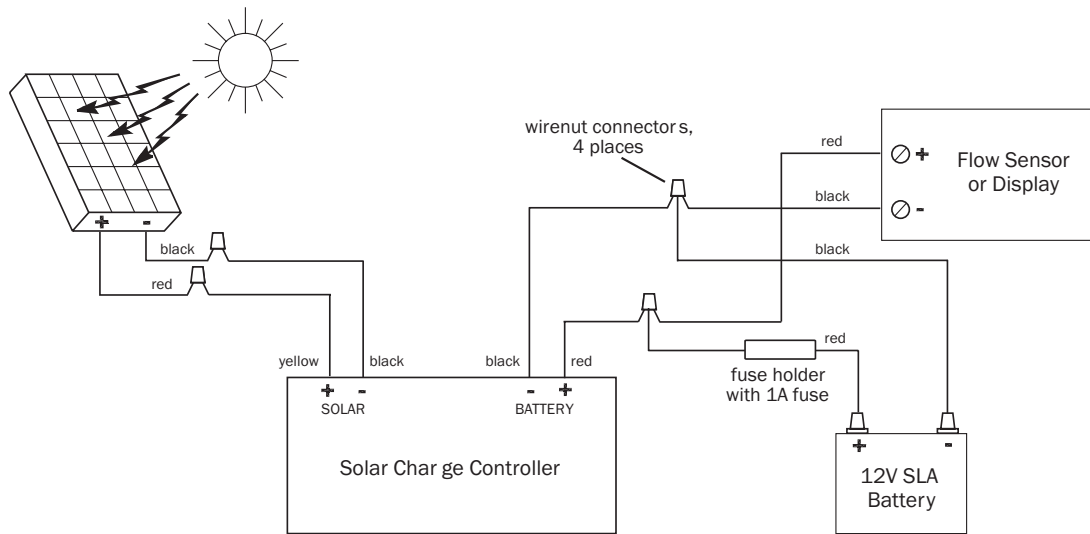
Next use the two sets of 1/4-20 bolts, nuts, flat and lock washers to attach the angle bracket to the pipe mount C-channel. Then attach the entire assembly to the pipe using the two band clamps as shown. Turn the panel to face true (not magnetic) south in the northern hemisphere or north in the southern hemisphere before tightening the clamps securely.

Connect the solar charge controller, flow meter, and battery as shown in the wiring diagram. Clean battery terminals and secure connections to the battery using grease or other means of preventing corrosion. For safety, the in-line fuse holder should be installed at the positive battery connection with a 1 Amp time lag (slow-blow) fuse. In unprotected locations the included weatherproof fuse holder and outdoor-rated wire nuts should be used. The sealed lead-acid battery should have an ampere-hour (Ah) rating sufficient to maintain the battery charge level above 50% at all times. Automotive or marine deep-cycle batteries are not recommended due to short life times in most climates.

See Appendix A for more detailed information.



Wiring Diagram



Maintenance

Periodic cleaning of the solar panel glass is recommended to remove dust accumulation. Snow and ice may need removal if it remains more than 2 weeks. Installing the panel at a steeper than 45 degree angle may make

this unnecessary in most areas. Battery service life for good quality SLA batteries should be 4-6 years. Actual maintenance replacement interval will depend on local conditions and criticality of data.

*"I bought an expensive deep-cycle battery for my solar system and it only lasted a year."*

*"The battery went dead after an unusually long period of gray overcast weather and power was lost just when it was needed."*

*"Lightning struck nearby and now the battery doesn't recharge."*

*"I just discovered that my current solar panel has a bullet hole through it and a year ago my previous one was stolen."*

Fortunately the above occurrences are rare, and in most cases they are easily preventable by proper component selection, installation, and maintenance based on an understanding of solar power principles and practice.

This appendix explains the causes of solar power problems and provides simple installation and maintenance precautions that will assure that your Seametrics solar powered system will be reliable, trouble-free, and achieve low lifetime cost. For most small 12 V solar systems, such problems are preventable if you follow the recommendations as described in detail below.

To begin, a solar system consists of the following:

- The solar panel, which is the power source, and its mounting hardware
- The solar charge controller which charges the battery
- The battery, the power storage element
- The device being powered, or load, which for this discussion is a flow sensor or meter and any associated accessories such as remote display
- And, of course, the wiring between these parts

Each of these will be discussed in turn. But first, a precautionary note. Although much of what is discussed below also applies to large solar systems, a large system is far more complex, and what applies to one does not necessarily apply to the other. So this discussion will be limited to systems with small solar panels (5 or 10 Watts) and small loads (less than 50 milliamps average current drain.) Unlike large RV or residential systems no specialized design calculations are needed for Seametrics solar components when used with low or medium power Seametrics products (less than 50 milliamp current requirement)—see Table 1.

The Seametrics RSP5 components are not intended to power the high power products listed in Table 1. For these products, solar panel and battery sizes are much larger and must be specifically calculated using local meteorological data. Solar panel requirements typically increase to 10 or 25 Watts. Battery size can be estimated using the procedure outlined in Appendix B. However, in all but the sunniest climates, cost may rule out using solar power for these products. Consult a solar system distributor/designer for feasibility.

**Table 1: Power Requirements for Seametrics Products**

Power Requirement	Meter Type	Average Empty Pipe Current (Amps)	Average Full Pipe Current (Amps)	Average Full Pipe Current with Flow (Amps)
<b>Low</b>	Mechanical Meter with Electronic Rate/Total Indicator*	0.010	0.010	0.010
	AG3000-BX/iMAG 4700-BX	0.0002	0.0003	0.0003
	EX90/AG90	0.00025	0.00035	0.00035
<b>Medium</b>	AG3000-BX/iMAG 4700-BX with MODBUS	0.0014	0.0014	0.0014
	AG3000/iMAG 4700 external power with no output options	0.0006	0.0008	0.0008
	AG3000/ iMAG 4700 with optional outputs (except BX Modbus)	0.01	0.015	0.03
	EX100/200/800 (low power option) with electronic Rate/Total Indicator*	0.016	0.044	0.044
	WMP101	0.0002	0.018	0.018
<b>High</b>	EX100/200/800 (Standard)	0.016	0.250	0.250
	PE202	0.150	0.150	0.150

\* FT430/440 with analog disabled



### The Solar Panel

A 5 Watt solar panel is sufficient for powering the low- and medium-power Seametrics products listed in Table 1 in nearly all cases. In the case of medium-power meters installed at high latitudes, with continuous flow measurement through the winter, long periods of overcast weather or short days, a 10 Watt panel may be required.

Remember that solar panels are fragile and especially vulnerable to damage during installation. If located near a road, where possible mount them where other structures will hide the panel or make it less noticeable.

During installation the most important adjustment is to make sure the panel faces true south (not magnetic) in the northern hemisphere or true north in the southern hemisphere for maximum solar exposure with minimal shading. Solar panel shading should be avoided for at least the four hours before and after noon. For this type of application at locations below 50 degrees latitude it is not necessary to set the panel angle with respect to horizontal to other than the fixed 45-degree angle provided by the Seametrics RSP5 mounting bracket. (If the flow meter is to be powered through the winter at higher latitudes, system performance may be increased somewhat by pre-bending the bracket (before bolting it to the panel) so the angle to the horizontal equals approximately the latitude plus 15 degrees.)

In areas where there may be dust accumulation it may be necessary to periodically clean the glass surface of the panel if the dust becomes thick enough to reduce incident solar radiation. Likewise, snow and ice build-up may need to be removed if present for more than a few weeks.

The solar panel is best mounted on an electrically grounded metal pole or other structure whose highest point is at least 3 feet above the solar panel. There should be an eight-foot ground rod driven at the base of the structure and electrically bonded to it if there is risk of a lightning strike.

### The Solar Charge Controller

The purpose of the solar charge controller is (1) to charge the battery using the electrical energy coming from the solar panel with the most efficiency (least loss of solar energy) and (2) to maximize the useful life of the battery.<sup>1</sup> It cannot be overstated that the wrong choice of solar charge controller for a particular type of application will result in an unreliable system requiring much more frequent replacement of your expensive battery. With

*1. The solar charge controller's ability to extend battery life is contingent on its ability to prevent both overcharging, undercharging and "deep cycling" the battery, all of which degrade battery life. In this application the requirements for the solar charge controller are that it (1) be temperature compensated for outdoor use with lead acid batteries, (2) has the correct "float" or finish charge voltage for the type of battery, and (3) is designed for the correct charge/discharge cycling regimen for the load. The charge controller currently sold by Seametrics is temperature compensated at -4.7 mV/degree C/cell, a value acceptable for all types of lead acid batteries in this application. The float voltage is 14.1 V. Exceeding this voltage as in some controllers will shorten battery life by overcharging. Overcharging will also occur with multi-step controllers designed for cyclic service, so our controller is specified for standby service to extend battery life for our low power meters. It will work with solar panels up to 50 Watts. It employs series regulation for better efficiency, helping to prevent undercharging, is designed for outdoor applications, has an operating temperature range of -40 to +85 degrees C and is fully lightning protected. The solar charge controller must also consume as little power as possible for its own use (< 2% of the solar panel's full power output) and cause negligible drain on the battery after dark (leakage current.) Many charge controllers will not be close enough to meeting these requirements to the degree necessary for flow meter applications.*

a properly selected solar charge controller, you should get five years of useful life from a correctly sized battery except in very hot climates. The only installation requirement is that the charge controller be located so that its temperature matches the battery temperature under all weather conditions to within  $\pm 5$  degrees C ( $\pm 9$  degrees F) during daylight hours. The most reliable means of accomplishing this is to mount the controller close to the battery and have both shaded from the sun to prevent unequal solar temperature gains. The cooler the battery is kept the longer its life. The solar charger supplied by Seametrics is lightning protected for severe lightning environments.

### The Battery

In nearly all solar installations, Lead-Acid batteries provide the lowest life-cycle cost. Good reliability is achievable under all but the hottest climatic conditions. Long battery life, however, requires proper selection, installation and maintenance of the battery.

Battery capacity (the amount of energy a battery can store) is measured in Amp-hours. Under typical conditions, a 20 Amp-hour battery will power a device requiring 1 Amp for 20 hours or 0.5 A for 40 hours. As a good approximation, the Amp-hour capacity is the product of the battery discharge current in Amps (consumed by the flow meter) and the number of hours it takes to fully discharge the battery. That is, Amps x hours = Amp-hours. (This relationship is nominally true for specified conditions but capacity will decrease at higher discharge currents and lower temperatures.) The battery capacity then determines how long the flow meter will operate under dark and heavy overcast conditions when the solar panel is unable to recharge the battery. For example a 20 Amp-hour battery could power a Seametrics low power mechanical meter consuming 0.010 Amps for 2000 hours (~3 months) with little or no sunlight (since 0.010 Amps x 2000 hours = 20 Amp-hours.)

There are three types of lead-acid batteries from which we may choose. They are differentiated by their engine starting capability (obviously unimportant for flow meter solar applications), depth-of-discharge (DOD) capability and cost. (Depth-of-discharge is defined as the ratio of the number of Amp-hours a battery has been discharged to its full capacity and is generally expressed as a percent.) Because names for these different battery types are inconsistently used, for our purposes we will refer to them as automotive, Marine/RV and VRSLA (for Valve Regulated Sealed Lead Acid<sup>2</sup>.) Their differences are due to variations in the lead plate material and construction to accommodate the battery's primary application. Automotive batteries use porous lead plates to maximize cranking amperes for starting engines and VRSLAs use solid lead (or lead-calcium) to get the best DOD. Marine/RV batteries, a compromise between the other two, have a better DOD than automotive batteries but poorer engine starting ability for the same size. They are often advertised as "deep-cycle" batteries due to their improved DOD, but this can be misleading since their DOD is not nearly as good as VRSLA batteries.

Selecting a battery with a higher DOD in most solar applications allows the use of a smaller battery. For example, for medium

*2. VRSLA batteries are also known as SLA (sealed lead acid) batteries but this confuses them with "maintenance free" automotive or Marine/RV batteries that are also sealed (no caps to add water.) VRSLA batteries are also referred to by the way the electrolyte is contained, such as non-flooded gelled or matted electrolyte ("dry") and flooded ("wet").*



power meters in Table 1, the required battery capacity using a VRSLA battery will be only one-fifth of that of an automotive battery for the same battery longevity. The reason is that the longevity of the battery depends on DOD (that is, how “deeply” you discharge it.) If you discharge an automotive battery by more than 10% of its capacity it will incrementally shorten its life each time you discharge more than 10%. How much its life is shortened depends on how much more than 10% you discharge it and how soon and how fast it is recharged after the 10% or greater discharge. For comparison, you can safely discharge a Marine/RV battery by up to 20% without significantly degrading it and for the VRSLA, up to 50%. Unfortunately, a VRSLA battery is much more expensive than the other two types for the same nameplate capacity. Essentially this means that the VRSLA has the most “usable” capacity for solar applications where you need to discharge the battery during extended cloudy periods without shortening its life due to excessive DOD. It also means that the battery choice that gives you the best lifetime cost depends on the DOD actually experienced with the model of meter you are installing in your particular climate.

You can make your own estimate of the optimum battery size (capacity) needed for each type of battery using the method in Appendix A. For most installations, some general battery selection recommendations can be made for the products listed in Table 1. For all but the cloudiest climates or for operation during high-latitude short winter days, a 20-25 Amp-hour VRSLA battery is a good choice for cost and longevity for the low power products in Table 1. In sunny climates a 40-50 Amp-hour automotive or preferably a Marine/RV battery may give the same longevity for less cost. For medium Power products use a 33-40 Amp-hour VRSLA. If you are uncertain, you should do the Appendix A calculation. (Do not substitute flooded deep-cycle marine/RV grade batteries as they will not perform much better than an automotive battery with medium power flow meters.)

A specialty battery or solar system distributor is a good source for VRSLA batteries. Good quality VRSLA brands include EnerSys, Hawker Energy, Panasonic, and Sonnenschein. Your distributor can recommend others besides these. Take advantage of their expertise and recommendations. With comparable batteries (having similar Amp-hour capacities) from the same distributor, a higher price generally means better quality and consequent longer life. Avoid the bottom end of the price range.

**NOTE: Use caution when selecting a battery for use with applications using the FT430/440. Evaluate the application over all anticipated operations and insure the battery voltage does not, at any time, drop below the minimum specified voltage, as this will lead to unreliable operation and possible damage to the unit.**

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### The Load

The load is the device using the power generated by solar panel, in this case, the flow meter or flow sensor and its display (if separate) and other accessories.

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### Wiring and Installation

Extreme temperatures are the enemy of lead-acid batteries. Extended periods of high temperatures (greater than 40 degrees C, 104 degrees F) can greatly shorten battery life. The battery should be installed in a location, which minimizes exposure

to extreme hot or cold since both significantly affect battery performance and service life. A ventilated, non-flooding, non-freezing underground location would be ideal, but as a minimum the battery should be shaded from direct sunlight with the solar charge controller mounted close enough to be at nearly the same temperature. Also take measures to prevent moisture from accumulating on the connector surface of the battery due to precipitation that creates a conductive path that could discharge the battery. Similarly, protect against submersion due to flooding for the same reason.

For safety reasons do not install the battery in an electrical equipment enclosure without ventilation since even a sealed battery is capable of venting hydrogen gas, which could ignite if an electrical fault should occur. Also beware of the added temperature rise inside enclosures. If the enclosure is not shaded it should be painted gloss white to reduce the temperature rise due to solar absorption. Even a moderately light color like the standard enclosure ANSI 61 gray can raise the inside temperature by an additional 40 degrees F (22 C) compared with only 10 F for a white enclosure. The temperature difference due to color alone can shorten battery life by several years, especially in hot climates.

Always fuse the battery as close to the positive terminal as practicable since in the event of short circuited wiring the battery can deliver enough energy to melt insulation and ignite surrounding flammable materials. Use a 1 A time-delay (slow-blow) fuse installed as close to the positive terminal as practicable. Protect the fuse connections from corrosion using a moisture resistant fuse holder or other means.

Use only wire rated for outdoor sunlight and weather exposure. Connections exposed to weather should use sealed wiring devices such as gel-filled wire nuts. Exposed wiring should be supported at regular intervals to prevent wind and animal damage. Battery connections should be clean and secure to prevent corrosion. Use an anti-corrosion inhibitor on battery terminal connections having dissimilar metals. Be careful to observe polarity when connecting solar panel, load and battery wires.

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### Maintenance

If the battery is removed for storage, be sure that it is fully charged. Unlike most other types of rechargeable batteries, a stored lead acid battery will deteriorate rapidly if it is left partially discharged. It will also self-discharge rapidly at higher temperatures. A disconnected battery stored in a hot or heated indoor location should be recharged every six months to prevent deterioration.

If the battery is discharged to less than 75% its capacity (25% DOD) it can be damaged by freezing electrolyte. At 50% DOD the battery electrolyte will freeze at -16F (-27C.) For this reason never disconnect the battery from a charging system during the winter unless the load is also disconnected and you assure that it is fully charged.

For automotive and Marine/RV batteries, unless they are of a sealed, “maintenance-free” type, check the electrolyte level at least once per/year.

Where necessary, remember to remove snow and clean dust from the solar panel.

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**Checklist**

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1. Is solar panel oriented for maximum solar exposure?
2. Has potential solar panel shading been checked, especially for low winter solar angles?
3. Have steps been taken to minimize vandalism (such as reducing panel visibility, raising it above easy reach if visible from road?)
4. Is the metallic structure supporting the solar panel properly earth grounded?
5. Is the solar panel support or other metallic structure sufficiently higher than panel to attract lightning away from solar panel?
6. Does the Solar Charge Controller provide the correct temperature-compensated charging voltage for "standby service"?
7. Is the Solar Charger Controller protected against lightning and overload?
8. Is the battery a recommended type and capacity for the load power requirement?
9. Are the battery and Solar Charge Controller co-located and shaded from the sun to minimize their temperature difference?
10. Have reasonable measures been taken to minimize the battery's exposure to extreme temperatures for longer life?
11. Are battery and wiring connections safely above high water level in areas that experience periodic flooding?
12. Is the battery terminal surface protected against moisture accumulation from precipitation or irrigation that could discharge the battery?
13. Is the battery properly fused and the fuse holder connections protected against corrosion?
14. If the battery and Solar Charge Controller are located in an enclosure, does the enclosure maximally reflect solar radiation to minimize the temperature rise inside?
15. If the battery and Solar Charge Controller are located in an enclosure, is the enclosure vented?
16. Are exposed wiring materials resistant to the effects of water, sunlight (UV resistance) and temperature extremes?
17. Is exposed wiring protected from animal and wind damage?
18. Are wiring connections protected against corrosion?
19. Are maintenance processes followed to check battery electrolyte for unsealed batteries (at least annually) and replace battery (every 3-6 years) at prescribed intervals as determined by climate?
20. Are processes in place to monitor and clear dust, ice and snow from solar panel glass as necessary?
21. If disconnected for seasonal storage, will the battery be stored fully charged to prevent battery deterioration or freeze damage?
22. If using with an FT430/440, has the application been evaluated over all anticipated operations and insured the battery voltage will not, at any time, drop below the minimum specified voltage?

For estimating the minimum Amp-hour capacity of the battery for a given climate you can use the following procedure:

- Estimate the maximum number of consecutive winter days (Dmax) for which it is overcast for most of the day (that is, more than half of the daylight hours.)
- During this length of time estimate the fraction of time the flow meter will experience empty pipe conditions and multiply this by the Average Empty Pipe Current (in Amps) for the meter of interest in Table 1.
- During the same length of time estimate the fraction of time the flow meter will experience full pipe, no flow condition and multiply this by the Average Full Pipe Current (in Amps) for the meter of interest in Table 1.
- During the same length of time estimate the fraction of time the flow meter will experience flow conditions and multiply this by the Average Full Pipe Current With Flow (in Amps) for the meter of interest in Table 1.
- Make sure the fractions in the three cases above add up to 1.00.
- Add the three products calculated above to get the Average Current (Iave) for this period.
- Multiply the result by the length of the period in days estimated above (Dmax)
- Multiply this by 24 (the number of hours in a day)
- Divide the result by the maximum allowable depth-of discharge (DODmax) (0.1 for automotive batteries, 0.2 for Marine/RV "deep-cycle" batteries, or 0.5 for non- flooded sealed lead acid batteries.) The result is the estimated minimum Amp- hour capacity for the battery.
- If the flow meter is in the empty pipe condition for more than half of the year (as in some irrigation applications), the above calculation should be repeated for summer, spring and fall and the highest of the four results used to determine battery size.
- The formula for each season is:  

$$\text{Battery capacity in Amp-hours} = (\text{Iave} * \text{Dmax} * 24) / \text{DODmax}$$

### EXAMPLE CALCULATION

An EX100/200/800 meter purchased with the low power option and a Seametrics FT430/440 remote display consumes 0.016A (from Table 1) when the pipe is empty, which for our example is 75% of the time in the winter. The other 25% of the time it is full pipe, and either flowing or not and using 0.044A. Therefore the average winter current is

$$(0.75 * 0.016) + (0.25 * 0.044) = 0.023\text{A}$$

The maximum duration of mostly cloudy days is estimated to be 14 and we wish to use a non-flooded SLA battery. Therefore:

$$\text{Battery capacity (winter)} = (0.023 * 14 * 24) / 0.5 = 15.4 \text{ Amp-hours}$$

Repeating the calculation for summer when the pipe is full all the time and we expect only seven consecutive cloudy days we get:

$$\text{Battery capacity (summer)} = (0.044 * 7 * 24) / 0.5 = 14.7 \text{ Amp-hours}$$

After also doing the spring and fall calculations (not shown), we conclude that winter requires the highest capacity. To be on the conservative side we size the battery up by 100% and order a 33 Amp-hour battery. One reason for this up-sizing is that many assumptions have been made. We haven't taken into account the worst case minimum number of sunny days between cloudy periods and whether the 5 Watt panel will have time to recharge the battery sufficiently in that many days before the next long cloudy period (Think SE Alaska, for example). We haven't accounted for the fact that the battery does not charge or discharge as efficiently in the winter at temperatures below freezing. Furthermore, we may need to leave a depth-of discharge margin so that freezing at very low temperatures doesn't damage the battery. Our calculations allow a maximum DOD of 0.5 (50% discharge) but at this DOD the battery could be damaged if the temperature drops below -16 F (-27C.) A calculation that takes all these factors into account with any accuracy is beyond the scope of this application note. If in doubt, consult Seametrics technical support.

The limited warranty set forth below is given by Seametrics, with respect to Seametrics brand products purchased in the United States of America.

Seametrics warrants that products manufactured by Seametrics, when delivered to you in new condition in their original containers and properly installed, shall be free from defects in material and workmanship. **Seametrics products are warranted against defects for a minimum period of two (2) years from date of installation, unless otherwise specified, with proof of install date. If no proof of install date can be provided, warranty period will be two (2) years from date of shipment from Seametrics, as defined on Seametrics' invoice.** Seametrics' obligation under this warranty shall be limited to replacing or repairing the part or parts, or, at Seametrics' option, the products, which prove defective in material or workmanship. The following are the terms of Seametrics' limited warranty:

- a. Buyer must give Seametrics prompt notice of any defect or failure and satisfactory proof thereof.
- b. Any defective part or parts must be returned to Seametrics' factory or to an authorized service center for inspection.
- c. Buyer will prepay all freight charges to return any products to Seametrics' factory, or another repair facility, as designated by Seametrics.
- d. Defective products, or parts thereof, which are returned to Seametrics and proved to be defective upon inspection, will be repaired to factory specifications.
- e. Seametrics will deliver repaired products or replacements for defective products to the buyer (ground freight prepaid) to the destination provided in the original order.
- f. Products returned to Seametrics for which Seametrics provides replacement under this warranty shall become the property of Seametrics.
- g. This limited warranty covers all defects encountered in normal use of Seametrics products, and does not apply to the following cases:
  - i. Loss of or damage to Seametrics product due to abuse, mishandling, or improper packaging by buyer
  - ii. Failure to follow operating, maintenance, or environmental instructions prescribed in Seametrics' instruction manual
  - iii. Products not used for their intended purpose
  - iv. Alterations to the product, purposeful or accidental
  - v. Electrical current fluctuations
  - vi. Corrosion due to aggressive materials not approved for your specific product
  - vii. Mishandling, or misapplication of Seametrics products
  - viii. Products or parts that are typically consumed during normal operation
  - ix. Use of parts or supplies (other than those sold by Seametrics) which cause damage to the products, or cause abnormally frequent service calls or service problems
- h. A new warranty period will be established for repaired products, or products replaced during the original warranty period.
- i. In the event that equipment is altered or repaired by the buyer without prior written approval by Seametrics, all warranties are void. Damage caused by equipment or accessories not manufactured by Seametrics may void the product's warranty.
- j. SOFTWARE: The Seller grants the user a non-exclusive license to use Seametrics' software, according to the following limitations and conditions:
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