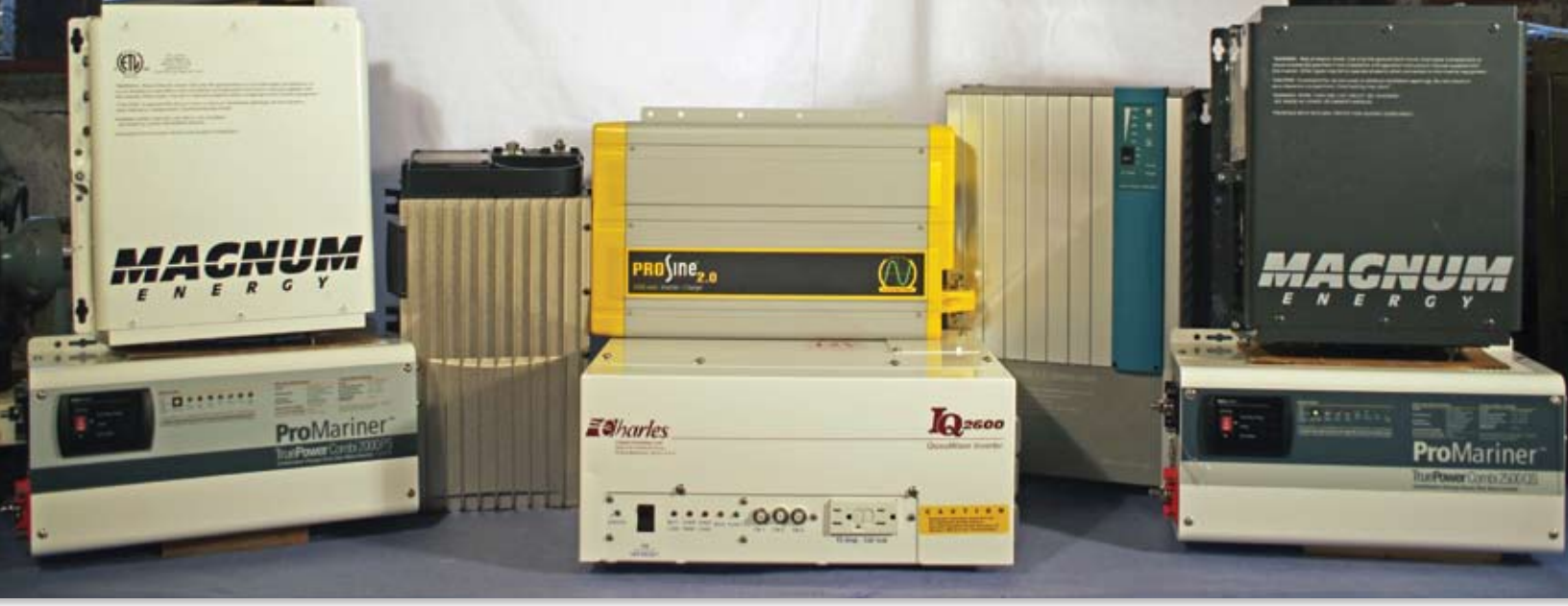


The test field (clockwise from left): Magnum MS2000, Tripp Lite MRV2012, Xantrex Prosine 2.0, Mastervolt Combi, Magnum ME2012, ProMariner Combi 2500QS, Charles IQ-2600, and ProMariner Combi 2000PS.

Inverter-Chargers Roundup

PS tests 8 products' charger functions and taps 2 as top picks for double duty.

The February issue launched our evaluation of marine inverter-chargers with a look at the inverter capabilities of devices from six manufacturers. This month, we compared the battery charger functions of the multi-tasking tools.

In *Practical Sailor*'s Oct. 15, 2002 review of dedicated battery chargers, we discussed the advantages of "smart charger" technology. Without question, the constant rate, Ferro-resonant transformer-based battery chargers of the past are rapidly fading into history—as well they should. Those early chargers were problematic and lacked sophistication, which led to the destruction of many a battery. That is certainly not the case with today's "smart" chargers.

WHY THE NEED?

Battery technology has seen some major shifts in the last decade. These days, it's difficult to find a battery with serviceable cells. Whether it's a flooded cell, gel cell, or AGM battery, increasingly the cell caps are fixed, meaning that periodic checking of electrolyte levels and replenishment of dry cells is becoming a thing of the past.

On the surface, this is a wonderful evolution that eliminates at least one periodic maintenance hassle, but it puts some important burdens on the charging system used to reverse the electro-chemical reaction that occurs as part of battery discharge. The chemical reaction that occurs during charging is quite violent and still produces some gassing inside the battery. Plate chemistry has brought gassing down to a minimum under normal charging circumstances, but gas is still generated as a part of the process.

Contrary to popular belief, today's "sealed" batteries are not totally sealed. They are properly referred to as "SVR," or sealed valve regulated. Under normal charging conditions, they are sealed, but if cell pressure exceeds 1.5 PSI, a check valve will open, and the excess pressure will be relieved. If this condition, which is caused by an over-charging situation, continues, the cell will eventually dry out, increasing the risk of a battery explosion. Remember that in spite of all the chemical "tweaking" that's occurred over the last 10 years with battery technology, they still can generate explosive hydrogen gas in an overcharging situation.

The bottom line is that modern batteries must be re-charged by properly calibrated, multi-stage chargers, preferably those with temperature monitoring.

WHAT WE TESTED

The chargers in this test group are all very sophisticated—they have to be to accommodate modern onboard battery demands and technologies. In the last five years, battery chargers have consistently gotten smarter as charging-regimen algorithms have gotten more precise and in general, the needs of modern battery technology are easier to meet than ever.

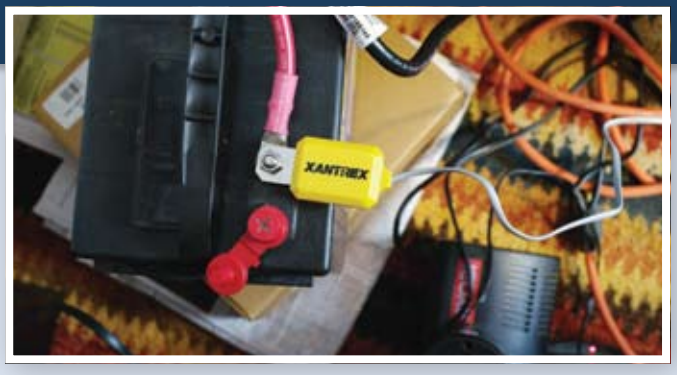
We tested marine inverter-chargers from Charles Industries, Magnum Energy, Mastervolt, ProMariner, Tripp Lite, and Xantrex. Newmar and Xantrex recently released new units that were not yet available when this test began; we plan to test these in a follow-up report.

CHARLES IQ-2600

The Charles IQ-2600 is not a new design. In fact, it was included in our 2005 inverter test group. Although it did have the highest maximum rated output of our group this time around, it was also the most expensive test product.

If you add in the optional remote monitoring panel—which we categorically recommend for all battery chargers and inverters—it's priced at over

Photos by Ed Sherman



The Xantrex ProSine 2.0 was one of the test products featuring a built-in sensor to measure battery temperature.

Gauging Performance

PS *bench tests marine chargers for function and features.*

Temperature dramatically affects battery performance. At higher temperatures, the chemical activity inside a battery is amplified considerably. In the long term, this higher level chemical activity will reduce the life of a battery.

The best chargers incorporate a temperature sensor that mounts on the battery or one of its posts. The sensor adjusts voltage outputs from the battery charger based on real-time data input.

Many chargers available have a temperature compensation adjustment mounted on their case, and although this is better than nothing, it's still a compromise because all that's being accomplished is that the installer is making a judgment call on the average ambient temperature in the location the charger is mounted. So, one of the things *Practical Sailor* testers considered in our comparison was the availability of a temperature sensor. All but the ProMariner units in our test group have an optional sensor available; the Mastervolt, Magnum, and Xantrex sensors are included.

VOLTAGE AND AMPERAGE CALIBRATION

When studying battery manufacturer's recommendations for ideal charge regimens, you learn quickly that the actual numbers are all over the map. We're talking here about very subtle differences, in the 10th-of-a-volt range. Keep in mind that the voltage difference between a fully charged battery and one that's discharged to 0 percent is only approximately 0.9 volts, and you can begin to understand why these subtle differences are significant.

For testing purposes, amperage is the determining factor in how long it takes to achieve a certain state of charge. It's interesting to note that with any sealed battery, it takes approximately 60 percent of the total charge time to get the battery from a 0 percent state of charge to 90 percent. The remaining 10 percent will take 40 percent of the total time required.

In terms of battery technology, the driving factor is a given battery's internal resistance. This is a huge variable among the different technologies and different manufacturers.

The battery's internal resistance affects what is known as its charge acceptance rate. We know, for example, that a typical AGM battery has a much higher acceptance rate than a traditional flooded-cell battery, but again, the actual acceptance rate will be a controlling factor in how quickly a given battery can be recharged and what the actual charge regimen, in terms of voltage and amperage, should look like.

So with these thoughts in mind, *PS* testers compared manufacturers' methods to deal with this fine-tune calibration, as well as the specific course settings they provide for the different battery technologies.

Many chargers available five or 10 years ago provided only two course settings: one for flooded cells and one for gel cells. Times have changed, and these two settings are simply not ideal with the battery technologies available today.

This may seem like nit-picking—and it would be with smaller installations of only one or two batteries. However, improper settings will reduce battery life expectancy, and our assumption is that since we are talking about inverter-charger units, the battery bank being charged may easily consist of at least two batteries—more likely three or four because of the demand

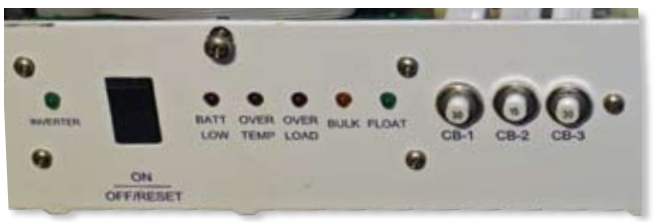
$3,700, more than $1000 over the closest price competitor in the test field. It also has the shortest warranty period at 1 year.

The IQ-2600's programmability is quite limited as well, using fixed-value dip switch settings with course settings only available for gel-cell and flooded-cell batteries. There is no fine tuning voltage outputs on this unit.

The IQ-2600 had the second highest AC ripple reading at 0.347 volts AC.

Although its heavy weight, almost twice that of its competitors, may account for its historic reliability and higher output, we think its time for a new design with more consideration for where we are technologically.

Bottom line: If you're still using conventional flooded-cell batteries with removable caps and serviceability, this may be a good choice.



An LED panel on the Charles IQ-2600's case allows users to monitor the battery charging through its multiple phases.

MAGNUM MS2000

Relatively new to the marine market, the Magnum MS2000 has some strong attributes on the battery charger side. Testers really liked the single-knob programming on the remote panel as it allows infinite programming capability and precise adjustment of the charging

load on the inverter side. This represents a significant financial investment in batteries, one worth maximizing the return on. At the end of the day, it really is all about individual cost/benefit analysis.

Fine tuning of the charging regimen based on the battery vendor's specific recommendations will be the best way to ensure the maximum cycle life of the batteries and an acceptable return on your battery investment.

AC RIPPLE AND ITS IMPACT

AC ripple, simply put, is the amount of AC leakage past the rectifier set, and there is usually some (electronic filtering) as it converts generator or shorepower voltage to a usable form of DC current to charge a battery. Excessive AC ripple from any battery charging source can cause battery overheating, and in the case of sealed batteries, excessive gassing and ultimately premature cell dry out (loss of electrolyte).

AC ripple is a very heady topic that goes well beyond what we have space to explain here, but suffice to say, it varies depending upon the charge phase and the internal resistance of the battery being charged. For that reason, all of our comparative AC ripple tests were conducted with the chargers connected to the same battery during the final float phase of the charging cycle.

To keep things simple, a generally accepted industry standard for AC ripple from a battery charger is a maximum of 0.4 volts AC. Generally speaking, chargers using a high-frequency converting transformer perform extremely well in this regard. Our tests bear that out, but we also found that several of our traditional low-frequency units did extremely well in this area.

You can see the test results in the Value Guide on page 16.

EMI/RFI EMISSIONS

As we did in the evaluation of these devices' inverter function (February 2010), testers measured the amount of electromagnetic interference (EMI) and radio frequency interference

The Tripp Lite MRV2012-UL measured considerable AC ripple leakage during our tests. Excessive ripple can result in a battery overheating.

produced by each of the units during charging (in the bulk phase). We established a "safe zone of separation," a minimum safe distance for mounting the inverter-chargers away from other equipment that may be either magnetically or noise sensitive.

To test for EMI, we scanned each unit under load with an A.W. Sperry EMF-200A Electromagnetic Field Radiation Tester. For our radiated noise tests, we used a Grundig G2000A AM / FM shortwave radio (frequency spectrums from 540-1700 kHz, 88-108 MHz and 2.3-26.1 MHz) and a Standard Horizon handheld VHF radio (160 MHz).

The results—and our suggested minimum distance for mounting these away from sensitive electronics—appear in the Value Guide on page 16.

THE PHASES OF CHARGING

The 2005 report on dedicated battery chargers provided a comprehensive description of what should happen during each phase of battery recharging. (That archive article is posted online along with this review, and subscribers will find it at *www.practical-sailor.com*.)

There is one point highlighted in that article that we want to reiterate. Some new chargers offer a manually selectable "equalization" phase. This phase is essentially a controlled overcharge. As mentioned in the 2005 article, PS feels that if we wanted to boil our batteries to death, we'd simply connect them to a traditional constant-rate battery charger. We want to re-emphasize this point today.

It's getting harder to even find non-sealed batteries for marine use. The equalization phase should never be used on sealed batteries. It is a sure fire way to destroy the best of new technology batteries.

regimen for flooded, gel, or AGM battery technologies.

Testers would prefer that the $230 optional remote panel was standard, but we do understand that in some applications, it may not be needed. Having optional add-ons allows consumers to customize a package based on their needs.

Our AC ripple test demonstrated that the unit has some excellent filtering in its output.

Bottom line: With a three-year warranty and its true-sine wave inverter output, the MS2000 is a good option for an inverter-charger in this power and charging range.

MAGNUM ME2012

In terms of its charging capability and functionality, the ME2012 is totally on par with its MS2000 sibling. We did notice, however, that the AC ripple test showed one of the lowest levels of AC leakage in our grouping at 0.023 volts AC—compared to the MS2000's 0.147 volts AC leakage. They both perform beautifully and are quite acceptable for anything out in the field today, in our opinion.

Bottom line: The ME2012 is only $120 less than the MS2000, so between the two, we'd opt for the additional functionality of the true-sine wave version.

MASTERVOLT COMBI 12/200-100

The Mastervolt Combi 12/200 impressed us in many ways. It was the lightest unit, which can be attributed to its high-frequency transformer design, which the Xantrex ProSine 2.0 also uses. It was also one of the quietest in terms of EMI and RFI emissions, again, partially attributable to the high-frequency transformer at the heart of the unit.

The Combi 12/200 includes a standard remote panel and offers an optional deluxe panel for more advanced systems utilizing power sharing and to monitor AC loads when in inverter mode. It also includes a standard battery temperature

PS VALUE GUIDE MARINE INVERTER-CHARGERS

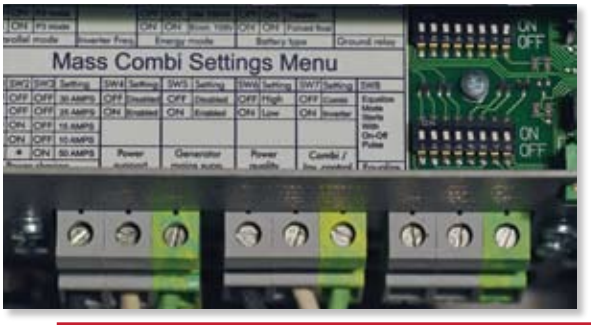
MAKER	CHARLES	MAGNUM		MASTERVOLT	PROMARINER		XANTREX	TRIPP LITE
MODEL	IQ-2600	MS2000	ME2012	Combi 12/ 2000-100 ★	Combi 2500QS	Combi 2000PS	Prosine 2.0 $	MRV 2012
PRICE / WARRANTY	$3,745* / 1 year	$1,750 / 3 years	$1,630 / 3 years	$2,599 / 2 years	$1,300 / 2 years	$1,400 / 2 years	$1,900 / 2 years	$1,144* / 2.5 years
WEIGHT	79 lbs.	43 lbs.	35 lbs.	24 lbs.	42 lbs.	42 lbs.	24 lbs.	43 lbs.
DIMENSIONS	17.5 x 14 x 8.25 in.	15 x 13 x 6.75 in.	15 x 13 x 8 in.	18.5 x 12.5 x 6.5 in.	18 x 11.5 x 6 in.	18 x 11.5 x 6 in.	18 x 11.5 x 6 in.	17 x 10.5 x 7.75 in.
CHARGER RATED CURRENT (MAX)	120 amps	100 amps	100 amps	100 amps	50 amps	70 amps	100 amps	100 amps
INVERTER TYPE	Modified sine wave	True sine wave	Modified sine wave	True sine wave	Modified sine wave	True sine wave	True sine wave	Modified sine wave
LISTING / CERTIFICATION	UL Listed	ETL Listed	ETL Listed	Self-certified CE, meets UL	Self Certified CE Mark	Self Certified CE Mark	CSA Certified	UL Listed
INVERTER RATING		✓		✓			✓	$
TEMPERATURE SENSOR	Optional	Included	Included	Included	No	No	Included	Optional
BATTERY SETTINGS	Flooded, Gel	Flooded, Gel, AGM	Flooded, Gel, AGM	Flooded, Gel, AGM, AGM Spiral, Traction	Flooded, Gel, AGM, Pb/Ca (Calcium)	Flooded, Gel, AGM, Pb/Ca	Flooded, Gel, AGM, Pb/Ca	Flooded, Gel
CHARGE PHASE CALIBRATION	Fixed value, Dip switch inputting	Infinite capability, One-knob inputting	Infinite Capability, 1-Knob inputting	Fixed value, dip switch inputting or software	Fixed value, one-switch inputting	Fixed value, one-switch inputting	Infinite capability, panel inputting	Fixed value, Dip switch inputting
CHARGER TEST RESULTS								
AC RIPPLE VOLTAGE	0.347 vAC	0.147 vAC	0.023 vAC	0.013 vAC	0.125 vAC	0.070 vAC	0.174 vAC	0.368 vAC
EMI EMISSIONS** / SUGGESTED SAFE ZONE	200+ mG / 36 inches	182 mG / 36 inches	200+ mG / 36 inches	54 mG / 18 inches	200+ mG / 36 inches	200+ mG / 36 inches	7 mG / 12 inches	36 inches
RFI EMISSIONS	Very loud, kHZ	Noticeable, all but VHF	Loud, KhZ and 2mHZ	Very low, all frequencies	Very loud, all frequencies	Very loud, all frequencies	Very low, all freq.	Moderate, all freq.

★ Best Choice $ Budget Buy * With recommended optional remote panel **Measured in milliGauss

sensor, an important feature.

At $2,599, it was the second most expensive in our test group, but that includes the remote panel, temperature sensor, and its handy paralleling capabilities in inverter mode.

Because of this unit's European heritage, many of its dip-switch settings deal with issues related to global power differences and frequency variations. The course settings for battery technologies identify gel, AGM and AGM spiral, flooded, and what Mastervolt describes as a "traction battery." To most Americans, this is what we generally refer to as a deep-cycle battery. Fine tuning for battery maker-specific voltage requirements can over-ride the dip switch settings and can be achieved from the remote panel or via the free "MasterAdjust" software and built-in computer link port. Adding this software to a boat already equipped with a PC will enable the operator to monitor charging and inverter functions from the PC.



The Mastervolt Combi uses two sets of dip switches for charger calibration and inverter functions.

Our AC ripple tests put the Mastervolt Combi at a mere 0.013 VAC ripple. Exceptionally clean, this level of ripple won't affect even the most finicky of batteries.

Bottom line: The Mastervolt Combi 12/200-100 is the most sophisticated inverter-charger in our test. It performed flawlessly and gets the *PS* Best Choice pick for an inverter-charger in this range.

PROMARINER COMBI 2500QS

The ProMariner 2500QS had the lowest maximum current rating of the chargers we compared at 50 amps, which will increase charge time. It does have remote-panel capability as the on-case panel can be removed and mounted remotely, a cost-saving feature that we liked. A remote battery temperature sensor is not available, a serious drawback, in our opinion.

It measured very low AC ripple in our tests, which is a plus. The 2500QS offers only fixed-value programming for the

The ProMariner 2500QS uses a single switch for charge calibration. Its monitoring panel can be removed and mounted remotely, a bonus feature testers liked.

charging regimen, but it does offer some unique features in this area.

The above photo of the unit shows settings for two gel-cell, two AGM, sealed flooded, traditional flooded, and Calcium batteries. (Lead and calcium apply to many sealed battery types and have specialized voltage requirements.) These are fixed values, but based on our survey of the various battery manufacturer recommendations for voltage settings, careful selection here should get you what you need to maximize battery cycle life.

The recondition setting is equivalent to the "equalization" phase discusses in "How We Tested" on pages 14-15, and we do not recommend its use on anything other than a traditional flooded battery, and even then only rarely.

Bottom line: With a $1,300 price tag, the 2500QS is one of the least expensive tested, but it also was one of the noisiest, in terms of RFI and EMI emissions.

PROMARINER COMBI 2000PS

For $100 more than the 2500QS, the ProMariner 2000PS offers pure-sine wave functionality and a 70-amp charger, but its peak output is 500 watts less than the 2500QS in inverter mode. So there are pluses and minuses in terms of specifications when comparing it to its ProMariner sibling.

The unit offers the identical charger functionality as the 2500QS in terms of programming. We also found the 2000PS to be quite noisy in our EMI and RFI emissions testing. AC ripple was extremely low at 0.070 volts AC, but it is in all other respects, identical to the Combi 2500QS already discussed.

Bottom line: The ProMariner Combi 2000PS is held back by its noisy performance in the emissions tests.

XANTREX PROSINE 2.0

The Xantrex ProSine 2.0 is not a new design, but it was a bit ahead of its time when it first came out, and it remains a solid contender today.

Like the Mastervolt Combi, the ProSine is lightweight compared to all the other units tested. It comes with a remote panel, and its $1,900 cost is in the middle of the pack. The unit has a maximum charger output of 100 amps and comes standard with a battery temperature sensor.

In terms of emissions, it is one quiet unit and needs only about 12 inches of separation from other electronics to eliminate magnetic field interference.

Like the ProMariner models, the ProSine also recognizes PbCa (Lead/Calcium) battery technology in its default programming modes for battery charging regimens. But unlike the ProMariner units, the ProSine offers a more detailed and infinite level of adjustment via its remote panel—a very useful feature for fine-tuning specifications to exact battery maker requirements.

Xantrex plans to slowly phase out the Prosine 2.0, starting in 2011. It will be replaced by the Freedom SW2000, which we plan to review once it's launched.

Bottom line: The ProSine 2.0 offers all of the features we consider desirable in an inverter-charger and does a great job delivering them. It's among the less expensive top performers we tested, and the fact it will be phased out means buyers can likely find a good deal on one in the upcoming year. It gets the *PS* Budget Buy nod.

TRIPP LITE MRV2012-UL

The least expensive of all the test units at just over $1,100 (with optional remote panel), the MRV2012 is also fairly unsophisticated compared to the others.

It does offer an available battery temperature sensor, but it only has default settings available for flooded-cell and gel-cell batteries.

We found the Tripp Lite to be a high emitter of EMI and RFI, so you'll want to keep this inverter-charger as far away from sensitive equipment as possible.

Using conventionally wound transformer technology, the MRV2012 is among the heavier units tested.

Testers measured considerable AC ripple leakage at 0.374 volts AC, the highest in the group.

Bottom line: We could only recommend this unit for those on a really tight budget with otherwise unsophisticated needs in terms of battery technology and AC equipment to be run from the inverter side.

CONCLUSIONS

So where do we stand in terms of overall recommendations for an inverter-charger combined unit? Depends on your needs.

For those with larger AGM or gel-cell batteries onboard who are planning to expand their systems down the road, we would definitely recommend the Mastervolt Combi 12/100. It has a steep price tag, but it also offers a high level of sophistication in terms of charger calibration and output for a reasonably large bank of batteries. On the inverter side, its clean, pure-sine wave output and low noise make it a winner for high-level audio and video power supply systems. Also, don't forget that as the boat's systems grow, an additional unit can be easily piggy-backed on to double the power capacity.

If no major expansion is planned for the future that would require doubling capacity, the ProSine 2.0 offers the best combination of price, features, and sophistication, in our opinion. It's the best value in our eyes, and gets the PS Budget Buy pick among these inverter-chargers.

CONTACTS

CHARLES INDUSTRIES
847/806-6300,
www.charlesindustries.com

MAGNUM ENERGY, 425/353-8833
www.magnumenergy.com

MASTERVOLT, www.mastervolt.com

PROMARINER, 603/433-4440
www.pmariner.com

XANTREX TECHNOLOGY,
604/422-8595, www.xantrex.com

TRIPP-LITE, 773/869-1234
www.tripplite.com