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9 **DC TO AC** **2KW INVERTERS**



There is only one way to run your mains-powered electrical items at sea and that's by installing an inverter.

Duncan Kent tested a group of 2kW models to see if they would cope with a selection of typical domestic AC devices.

In recent years there has been a rapid rise in the number of cruising yachts carrying mains-rated, AC electrical items powered either by shore power or by a DC to AC inverter. The desire to have all the comforts of home, including microwave ovens, hair dryers, kettles and a multitude of chargers for mobile devices, is too much to resist – especially when today's technology is offering such luxuries on a plate, at an ever-shrinking cost.

The DC to AC inverter has been around for many decades. At first they were huge devices that weighed almost as much as a rugby forward and so inefficient that you could cook on the giant heat-sinks that seemed to be specifically designed to dissipate much of the energy away into the surrounding atmosphere, heating the cabin

up unbearably at the same time as you were simply attempting to run a small drill.

Back in 1987 my boat had a revolutionary inverter from American company, Heart Interface, that could miraculously convert DC power from the battery and turn it into 700W of AC power. At the time it seemed an amazing feat of technology; that is until one stops to think that a modern microwave oven will typically consume 1.2kW, a kettle 2kW and a toaster 800W. Suddenly 700W isn't looking so useful!

Over the years the units shrank a little as their efficiency improved and transformers reduced in size, but then suddenly a decade ago the digital era arrived and everything became solid-state and switch-mode in operation.

Thanks to these advances and the

improvements in battery technology, modern cruisers are beginning to forfeit noisy generators and revert to the use of a larger battery bank and a hefty inverter.

QUASI (MODIFIED) SINE WAVE INVERTERS

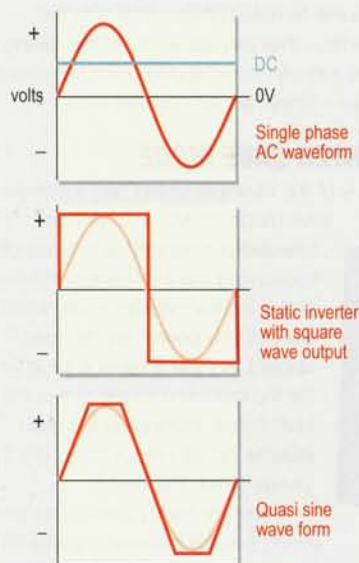
Many of the new model inverters built over the past two decades use what is termed 'quasi sine wave' (QSW) technology or, sometimes, 'modified sine wave'. Basically, the mains AC you receive in your home from the National Grid has a waveform that fluctuates smoothly between positive and negative (See pic opposite). The smooth curve is called a sine wave and recreating this pure wave form in an inverter is complicated and expensive.

Does it matter? Well it's hard to say for



The test bed – we ran a number of typical domestic items.

AC WAVE FORMS



sure, because it rather depends on what you want to use it for. Some domestic mains devices will only work properly when run on a pure sine wave supply – washing machines, microwaves, TVs and some chargers, to name a few. While they will often run on a QSW inverter, they are noticeably less efficient and can even sustain damage. The reason for this is that many of these devices – especially older models – contained thyristors in their power supplies. This is no longer a problem, however, with switch-mode devices, which are becoming increasingly common nowadays.

In my opinion, if you are long term cruising and want to ensure all your AC devices function normally at all times, without the risk of damaging them, you should opt for a pure sine wave (PSW) device – just in case. But if your needs are pretty basic and you only want AC to run a few tools, or you know for sure that all your AC devices contain switch-mode power supplies, then a QSW inverter would probably suffice and will save you quite a lot of money in the process.

WHAT SIZE WILL I NEED?

If you want to save money and reduce installation costs then you need to get a rough idea of what you want to run off the inverter and when. I say when, because if you are careful about what devices you run simultaneously and don't mind unplugging one thing to plug in another, you won't need such a hefty unit. For instance – running a microwave, kettle and toaster together

would require some 4kW of AC power – that's around a 350A current draw from the batteries – and would need a huge inverter or two piggy-backed together. By alternating use of the power-hungry devices, however, you can keep the inverter size down to 2kW, but still be able to run most things – albeit in sequence rather than together.

Also, it will save you a considerable sum on heavy duty cabling and extra batteries. The 12V/2kW models we have tested here draw a maximum of 220A, which keeps the battery cables to a more sensible size and will mean you can get away with a smaller battery bank (around 350-400Ah) and less powerful charging devices.

One thing to remember in your calculations is the extra start-up demand of any device with an electric motor. This can often be five times its stated running power, so a small 500W drill might need 2.5kW for the first few seconds, dropping down to a constant 500W once up to speed. This is the same for refrigerators with electric compressors and other similar devices.

The good thing is that all the inverters we tested appeared to be able to accept a surge load of 3-4kW for at least five seconds before tripping out the overload breaker.

12V OR 24V?

Those with small or mid-range coastal cruisers will most likely have a 12Vdc ship's power system running off one or maybe two deep-cycle batteries for domestic power. However, many offshore and bluewater cruising yachtsmen prefer to use 24Vdc for the large, power hungrier devices, such as windlasses, water makers etc, because if you double the volts you halve the current (Ohm's law). This in turn allows you to use smaller cables, which in the case of long runs like the windlass, bowthruster etc, could save a considerable amount of space and money and makes them a lot easier to handle and

terminate etc.

These 2kW inverters are probably on the cusp of where one might start thinking of going to 24Vdc for the DC input and indeed many are available in a 24V version.

The 12Vdc models we have tested here require around 350-400Ah of battery power and 70-90mm² cable (around 16mm in diameter), which is expensive to buy and awkward to run and terminate, whereas if you use 24V the current draw drops to around 100A and the cable can be reduced to 50mm².

Bear in mind, though, that just because the inverter is consuming half the current, you won't be cutting your energy consumption by 50 per cent as well – it will stay the same, I'm afraid. If you parallel-connect two 12V/100Ah batteries together you double the effective capacity (200Ah), but still only get 12V. If you join them in series, as you must to get 24V, the total capacity remains the same as it would for one battery – 100Ah.

CABLE SIZE

One vitally important factor to remember about any heavy current device is that the smaller the cable, the greater the resistance to current flow. It might be tempting to use cable a size or two under the recommended specification, but this will create a voltage drop, which might well stop the device from functioning effectively. In the case of an inverter, it will simply switch off if the voltage drops too low – usually 10.5V – to prevent damage to the batteries.

However, a much more important factor is the risk created by cables that are too small overheating and melting their insulation, which more often than not leads to a fire.

BATTERIES

One other important consideration is the issue of battery bank capacity. You will probably have worked out just how much



battery power you need for your day to day DC use and with luck reduced this as much as possible by replacing filament bulbs with LEDs, but if the inverter is a new device that you're just introducing to the boat, then it's pretty inevitable that you'll need to increase your battery capacity to cope with the extra demand.

Given that you shouldn't discharge a battery below 50 per cent capacity, if you want it to last a reasonable time, and that any inverter is only around 90 per cent efficient, it's wise to do some accurate calculations

and add whatever extra battery power you'll need to cover the heavy drain the inverter will introduce.

Furthermore, I wouldn't fit an inverter without some sort of intelligent battery monitor to let you know the actual state of your batteries. Yes, the inverter will shut down if your battery voltage drops below 10.5V, but it might be too late by then to prevent lasting damage to the batteries.

it imperative to fit a remote panel so you can see/hear any alarms and switch the device on and off when required, without grovelling about in a locker.

Some remote panels come with the inverter – they just detach from the casing itself and can be extended using the supplied cable – others are an optional extra.

POWER SAVE MODE

Many of the inverters tested had a power save mode (PSM), which when selected put the device into standby, consuming mere milliamps. However, unlike the normal idle mode, which will instantly power any AC load applied, in PSM it takes a short while for the detection circuit to see the load before starting up the main inverter circuitry ready to supply the power to run the load.

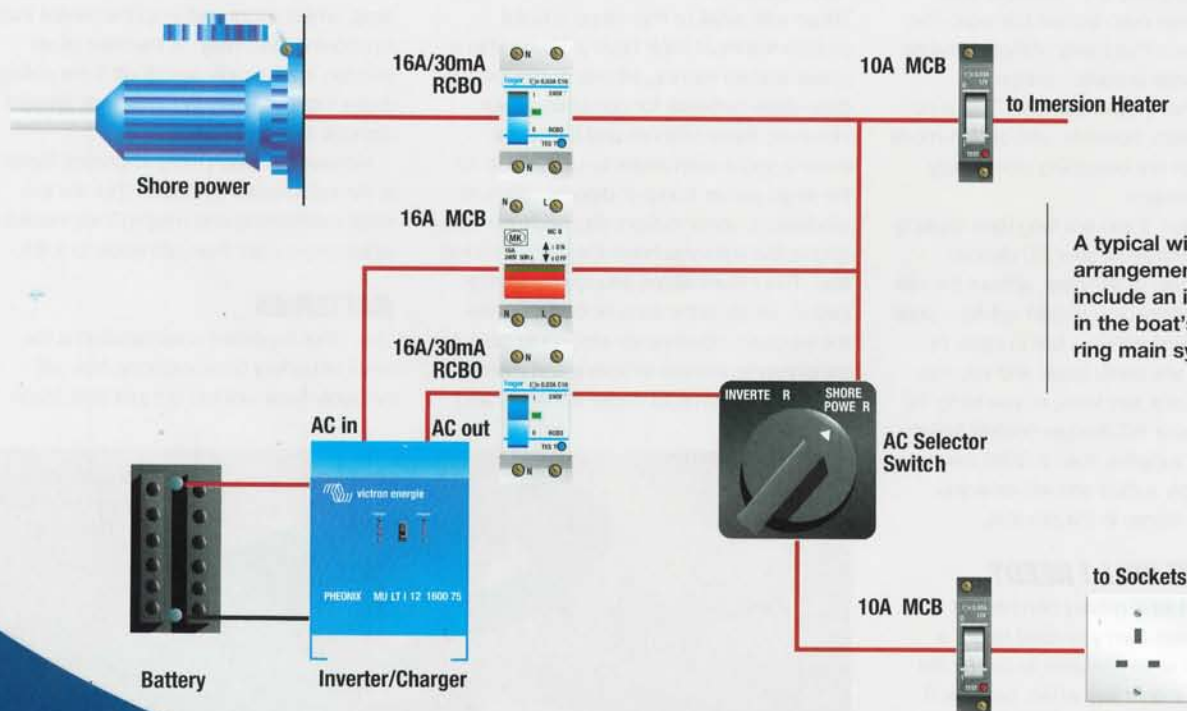
If you are happy to wait this short period (usually between 10 and 15 seconds) then you will save considerable energy in the long run when the inverter is not actually doing anything.

Clearly, if you have constant loads on the inverter, such as a fridge, you wouldn't want to activate this function.



REMOTE CONTROLS

An inverter of this size will most likely be installed out of the way in a locker somewhere, so lights and switches on the casing itself will be inaccessible. This makes



A typical wiring arrangement to include an inverter in the boat's AC ring main system.

All non-battery circuits include live, neutral and earth

ALARMS

The most commonly found alarms on inverters of this calibre are:

Overload: Activated when the AC load applied exceeds the stated continuous rating.

Temperature: All had fans fitted that cut in when under heavy load, but even then the units can get quite hot when loaded to maximum for a long period – especially if they are installed inside a poorly vented locker.

Low battery: If your battery bank voltage drops below a pre-set level (commonly 11.0V) this alarm will sound to warn you.



CIRCUIT PROTECTION

All modern marine electrical equipment should be properly protected against circuit damage and these inverters are no exception. However, having both AC and DC sides, the protection has to be even more extensive. All of these units require a large fuse on the incoming positive side of the DC circuit, rated between 250-300A. Some have them fitted inside, but if not please do ensure you fit one, because a short circuit at these current levels can easily (and often does) cause a fire.

As with any shore power circuit, the AC side of an inverter must be protected by a Residual Current Device. If you're not very knowledgeable or qualified in electrical installations, I would highly recommend (some suppliers insist) calling in a professionally qualified electrician to install it for you; preferably one who is familiar with marine installations.

DANGER OF DEATH

While I don't wish to 'nanny' our readers, I really do want to emphasise the dangers that can be encountered fitting and using an inverter. For some reason a few folk think that, because they use the fairly harmless DC battery to create 230Vac, inverted mains power isn't as lethal as the mains in your home. Well it is every bit as lethal, if not more so, considering you're surrounded by water and an earth on a boat is not the same as that on the terrestrial grid.

As with the shore power, the 230Vac output from the inverter should be protected by an RCD, unless the output is linked into the shore power input on the shore side of the breaker box (consumer unit).

Finally, do please take care with the output from an inverter and treat it with the same respect as you do your mains at home, or it could kill you. Nag over!

TRIALS

We powered up each inverter using two 110Ah deep-cycle lead-acid batteries and monitored the current flow and voltage at the terminals with a Merlin Powergauge battery monitor. The batteries were kept constantly charged by a Sterling ProCharge mains battery charger between tests and added to the available current during the trials.

TEST EQUIPMENT

- 2 x 110Ah PowerMax deep-cycle lead-acid batteries
- 20A Sterling ProCharge mains battery charger
- 300A battery fuse
- Merlin Powergauge Lite battery monitor



LOADS

- 1kW/2kW fan heater
- 3kW kettle
- 800W toaster
- 1.2kW microwave
- Digital TV
- Laptop charger
- 500W electric drill



PURE SINE WAVE INVERTERS

MASTERVOLT MASS SINE 12/2000

£1,842.00

This unit is not too bulky or heavy and its connections and controls straightforward. The DC and AC cables feed through watertight grommets with the DC wires terminating on large bolts and the AC via a screw-terminal block.

The switch panel is also simple to understand with an on/off/remote rocker switch, an on/off LED and alarm LEDs for overload, low voltage and high temperature. Unfortunately, the optional remote panel has only a switch and one alarm LED, so you would need to look at the casing panel to identify the type of alarm that's been triggered.

The unit has a low energy mode, in which it can supply 208Vac up to 30W. Drawing more power switches it back into normal mode. Alternatively, you can activate a power save mode by moving a jumper on the main case. In this mode current draw is reduced to just 50mA and the inverter checks for a power draw every two seconds.

The unit operated by the book and was one of the quietest, despite having two large cooling fans. We were, however, slightly surprised that it didn't have a shore power sensor circuit.





MERLIN M-POWER 2000

£699.98

This unit is so small and light compared to some of the others tested that we wondered what they'd left out. At first this unit complained at the 2kW load, due to the battery voltage being too low (alarm pre-set to go off at 11.0V, unit shuts down at 10.5V), but this was solved by increasing the battery cable size to reduce the voltage drop (our fault). The panel has an on/off switch and a small LCD that indicates battery voltage, AC output power (kW) and a series of error message codes, which are listed in the operating manual.

A remote panel is optional and simply plugs into the existing front panel using the 7.6m-long RJ-type cable supplied. However, it doesn't offer a duplicate of the useful LCD – just an on/off button and associated status LED.

The unit had no trouble coping with the devices we tried on it and did exactly what it stated when overloaded or run on batteries that had too little charge.

Although it doesn't boast a UPS/shore power detection circuit or a power save mode, at nearly half the price and weight of some of the better known makes of pure sine wave inverters and seemingly well capable of supplying the stated power, this has to take our Best Buy award.



STERLING PROPOWER S

£1,199.90

An uncomplicated, rugged inverter that did whatever we asked of it. It ran all types of load without a problem, the fan cutting in under serious loads only. Nothing seemed to phase it – not even when loaded with a 3kW kettle for several seconds before the overload alarm came on.

The unit has a simple but smart monitor that detaches for mounting remotely by attaching the 5m RJ-type network cable supplied, so there's no need to buy a separate remote panel or switch. The panel contains an on/off switch, supply and overload indicators.

The inverter has a Power Save mode, which is activated by setting a small DIP switch through the side panel. Once activated, the inverter goes into a sleep mode, drastically reducing power consumption to just 0.1A. However, should you then apply a load you have to wait for 15 seconds or so for the unit to 'wake up' and supply the demand in full.



VETUS IV200012

£1,229.00

Quite a heavy and 'boxy' unit, the Vetus inverter will need to be mounted securely. That said, it looks quite smart and has a useful load gauge on the front of the casing. It has an unusual way of connecting the DC cables,

which actually we quite liked. Blade-type terminals are supplied, which, once attached to the battery cables, are simply pushed into the plug casings provided. This protects them and helps prevent a short-circuit. It also means they can be removed easily for maintenance. Two plugs are provided, so that you can double up on the cables. This means you can run two 35mm dia cables, which are easier to handle than one large 70mm cable, but you must ensure both are connected before you run heavy loads.

The unit ran everything perfectly with a quietish fan cutting in on heavy loads. The two multi-pin AC sockets on the casing are very useful and I would like to see them on all inverters, because often you find you have some 2-pin and some 3-pin connectors amongst all your chargers etc. The output power gauge is also handy for judging at a quick glance whether you're overdoing it a little and the Vetus remote panel has an LCD as well as buttons for all the most commonly used functions and alarms.

Power save and UPS (shore power detection) modes are selected by DIP switches on the casing.



VICTRON PHOENIX COMPACT 2000 **£1,040.40**

Known for their top-quality marine electronics systems, Victron gear is well liked by boat owners for its reliability and well respected in the trade for its flexibility and ruggedness.



The Phoenix, like its various sisters large and small, is a hefty unit compared with some of the others. Its blue powder-coated aluminium casing is easily recognisable, but I'm not so keen on the way it is connected up. All the other inverters we tested have an external connection for the batteries – usually chunky terminal studs with an insulated cover – but on the Victron they connect directly to the main circuit board, meaning you have to open it up to install it. Okay, given that this item is most likely to be installed by a professional, well trained Victron engineer, problems are unlikely to occur, but in the hands of a DIY sparky somewhere in the nautical outback this could be asking for trouble.

Otherwise, the machine worked faultlessly – well able to take all its stated loads without a murmur and well over these limits for short periods with no effect.

By its looks it's tempting to think this inverter is old technology, but far from it. Unlike the others, this inverter can be piggybacked with others to increase the available AC power should you find the need to. It can also self-synchronise with another AC source, such as shore power or a generator, turning off if required when shore power is on, or boosting the power from a small portable generator for heavy start-up loads.

A rather basic remote panel is available that has an on/off switch and alarm indicators, but no eco-mode control, but a better specified remote is also available.



WAECO MSP2012 **£1,498.80**

Much larger and heavier than the Quasi-sine wave version we also tried, this smart looking unit comes with AC cables and plugs, but annoyingly you have to remove the end cap to access the battery terminals – a great opportunity for losing the bolts in the bilge. The unit has a shore power detection circuit, which is simply activated by plugging the supplied lead into a socket on the front panel. The AC output is a computer-style socket that takes an extension lead supplied and has a normal UK 3-pin socket at the other end. If you want to connect this directly into the boat's ring main you'll need to cut off the socket.

As with most of the other units, it has a three-way rocker switch to select between on/off/remote on the front and a remote control panel is an option, although it can be wired to a simple switch somewhere if you prefer.

Power save/standby mode can be selected by DIP switches, which cuts the battery consumption when sitting idle. This mode allows up to 40W (approx) 3A to be supplied before it needs to boot up the main inverter circuitry, which obviously takes a few seconds.

The inverter had no trouble powering up all our devices and stood up to its rated output without a murmur. A load level LED changes colour and flashes to indicate the power being consumed, culminating in a flashing red for maximum or overload.

The unit can be mounted vertically or horizontally, using the bracket provided, and mounts to install a separate ducted fan vent are also supplied.



24-VOLT INVERTER

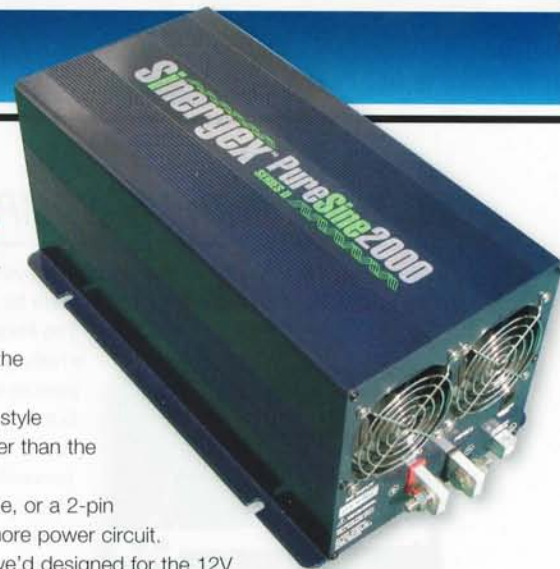
SINERGEX PURESINE2 2000 (24V) £1,108.63

One of a series of ruggedly built inverters, the PureSine 2000 is neat looking, powerful and quiet – although compared to the M-Power unit, it appears massive. We were only able to get hold of a 24V version for our trials (same size and weight), but this did give us a good view on the difference between 12V and 24V inverters.

The unit has stout terminals with bolts for the battery connections and the now common RJ-style connector for a remote panel, which is supplied. Two big fans keep it cool, but they're no noisier than the others we tried.

The unit only has one AC outlet socket on the front, which can be ordered as a 3-pin UK type, or a 2-pin Continental version, but there are also terminals inside for direct connection, for those with a shore power circuit.

As expected with a 24V model, the current draw was effectively halved, so the cabling that we'd designed for the 12V inverter now induced very little voltage drop – even on full power. It did seem slightly less tolerant of overloading than the Victron or Mastervolt models, but it never became hot and simply cut out after five seconds of bleeping when we connected up a 2kw heater and a 1.2kw microwave together. At its continuous rating it was absolutely fine and ran all the devices faultlessly.



QUASI SINE WAVE INVERTERS

WAECO PP2002 £402.00

A very neat package that is smaller and lighter than most of the pure sine wave inverters we tested. It is no less sophisticated, however. This unit can not only supply nearly twice its output over the short term, but will also accept an AC input from the grid/shore power so that it will automatically disconnect from the batteries when mains is available.



SPECIFICATIONS

Make	Waeco	Mastervolt	Merlin	Sinergex	Sterling	Vetus
Model	MSP2012	Mass Sine	M-Power	Pure Sine2-2000	ProPower S	IV200012
Type	PSW	PSW	PSW	PSW	PSW	PSW
Rated continuous power	2kW	2kW	2kW	2kW	2kW	2kW
Rated surge power	4kW	4kW	4kW	4kw	4kW	2.6kW/30mins?
Rated input voltage (Vdc)	10.5-15.0V	12.0-16.0V	10.5-15.5V	21.0-30.0V	10.0-16.0V	10.0-16.0V
Tested continuous current @ 2kW	186A	194A	175A	100A	206A	204A
Rated AC output (Vac)	230V	230V ± 5%	230V ± 10%	220/230/240V	230V (200-240V)	200/220/230/240
Tested idle DC load	2.2A	500mA	1.0A	1.1A	1.7A	2.5A
Power save current	600mA	50mA	n/a	250mA	100mA	250mA
Rated efficiency (Max)	90%	92%	90%	94%	90%	85%
Shore power/UPS detection	Y	N	N	N	N	Y
AC connection	3-pin lead	Hard wire	3-pin skt	3-pin skt/hard wire	3-pin + 2-pin skts	2 multi-pin skts
Overload alarm	Y	Y	Y	Y	Y	Y
Low voltage alarm	Y//10.6V	Y/11.0V	Y/11.0V	Y/22.0V	Y/10.5V	Y/10.0V
Low voltage disconnect	Y/10.5V	Y/10.0V	Y/10.5V	Y/20.3V	Y/10.0V	Y/10.0V
Remote panel	Option £65.34	Option £80	Option £29.99	Supplied	Supplied	Option £86.50
Size (H x W x L mm)	116 x 349 x 516mm	130 x 318 x 420mm	115 x 240 x 418mm	160 x 208 x 422mm	102 x 278 x 413mm	185 x 285 x 420mm
Weight	15.5kg	9.7kg	5.4kg	9.0kg	7.2kg	11.0kg
Warranty	1yr	2yrs	1yr	2yrs	2yrs	3yrs
Price	£1,498.80	£1,842.00	£699.98	£1,108.63	£1,199.90	£1,229.00

WAECO • SINERGEX • STERLING • VETUS • VICTRON • V

Surprisingly, the DC battery terminals are quite small compared to most. After all, it is still capable of drawing 150A or more, so it needs to use 50mm² cable, which is pretty bulky and requires quite a chunky cable terminal.

STERLING PROPOWER Q

£339.90

This was the only inverter we tried under 2kW, but we wanted to see how it fared against the big boys and whether it could be considered a good enough item of kit for a cruising yacht.

This inverter is pretty rugged, light and dead easy to connect, because it comes with battery leads and a 3-pin/multi-fit and 2-pin socket in the front panel. It also comes with a remote panel – all for £339.90!

It seemed to present no problems with any of the loads applied and happily coped with 2kW without a grumble. It also drew slightly less current from the batteries than some of the larger ones – both under load and at idle.

Charles Sterling himself states that if you just want a basic, but rugged and reliable inverter that will run most modern devices without a problem – this is it. There's certainly a degree of sense in what he says, given that devices using thyristor-controlled power supplies are diminishing rapidly and, should you have to buy a new microwave to suit the modified sine wave output – at between £35-75 you'll still have a lot of change left when compared with the extra you'd pay for a pure sine wave model.

The only problem we encountered – by chance – was that it interfered quite badly with our FM radio and TV, which might prove annoying on a long cruise.



CONCLUSION

Are pure sine wave inverters worth the extra cost? Well, if you want to guarantee to run any AC device – old or new – on it, then it would have to be the sine wave. They appear to be expensive, but one wonders how much you're paying for the pure sine wave output and how much is actually down to all the clever bits and pieces like shore power detection, power save, piggybacking etc. The low(ish) cost of Merlin's M-Power unit appears to prove the point, so maybe manufacturers should consider producing more economical, budget units without all the bells and whistles.

Most modern quasi (or modified) sine wave inverters are fine for basic items such as power tools etc, but they can make some items overheat with constant use and the output won't always suit more delicate electronics, such as stereos, DVD players, TVs etc. There are many to choose from, so we only tried a couple, so do read the sales blurb very carefully before you buy and if you want it for a specific purpose ask the salesman if it will run that device without a hitch. That way you can return it for a refund if it doesn't.

Finally, if you're carrying out a refit or building from scratch, do consider creating a 24V circuit on your boat, because it will supply all your heavy power consuming devices at half the current. This is safer and easier both to install and use in the long run.

CONTACTS

Merlin Equipment: 01202 697979 www.merlinequipment.com

Mastervolt: www.mastervolt.com for your nearest dealer

Sinergex: See Merlin Equipment

Sterling Power Products: 01905 771771 www.sterling-power.com

Vetus: 0800 9178 780 www.vetus-shop.com

Victron: see www.victronenergy.com for your nearest dealer

Waeo (Dometic): 0844 626 0130 www.waeo.co.uk

	Victron	Waeo	Sterling
	Phoenix	PP2002	ProPower Q
	PSW	MSW	MSW
	2kW	2kW	1.8kW
	3.5kW	4kW	3.0kW
	9.5-17.0V	11.0-15.0V	10-15V
	207A	156A	174A
	230V ± 2%	230V	230V ± 5%
	1.1A	1.4A	0.5A
	250mA	n/a	n/a
	93%	85%	90%
	Y	Y	N
	Hard wire	3-pin skt	3-pin + 2-pin skts
	Y	Y	Y
	Y/10.5-13.0 (adjustable)	Y/11.0V	10.0V
	Y/As above	Y/10.5V	9.5V
	Option - £55	Option £65.34	Supplied
	520 x 255 x 125mm	95 x 176 x 443mm	98 x 260 x 275mm
	12.0kg	5.0kg	4.2kg
	2yrs	1yr	2yrs
	£1,040.40	£402.00	£339.90