

9 Multi-stage battery chargers



Along with the ever increasing need for electrical power and the installation of larger battery banks on today's average cruising yacht, comes the need to replace this energy within the shortest possible time. Duncan Kent took nine of the latest shore power 12-volt battery chargers and put them to work.

Charger types

To maintain a typical modern cruising boat's battery banks properly requires a charger that is not only powerful enough to carry out the task within a sensible time span, but also to do it in a manner that is kind to the batteries. In addition to discharging too deeply, not fully re-charging is the principal cause of reduced lifespan in service batteries.

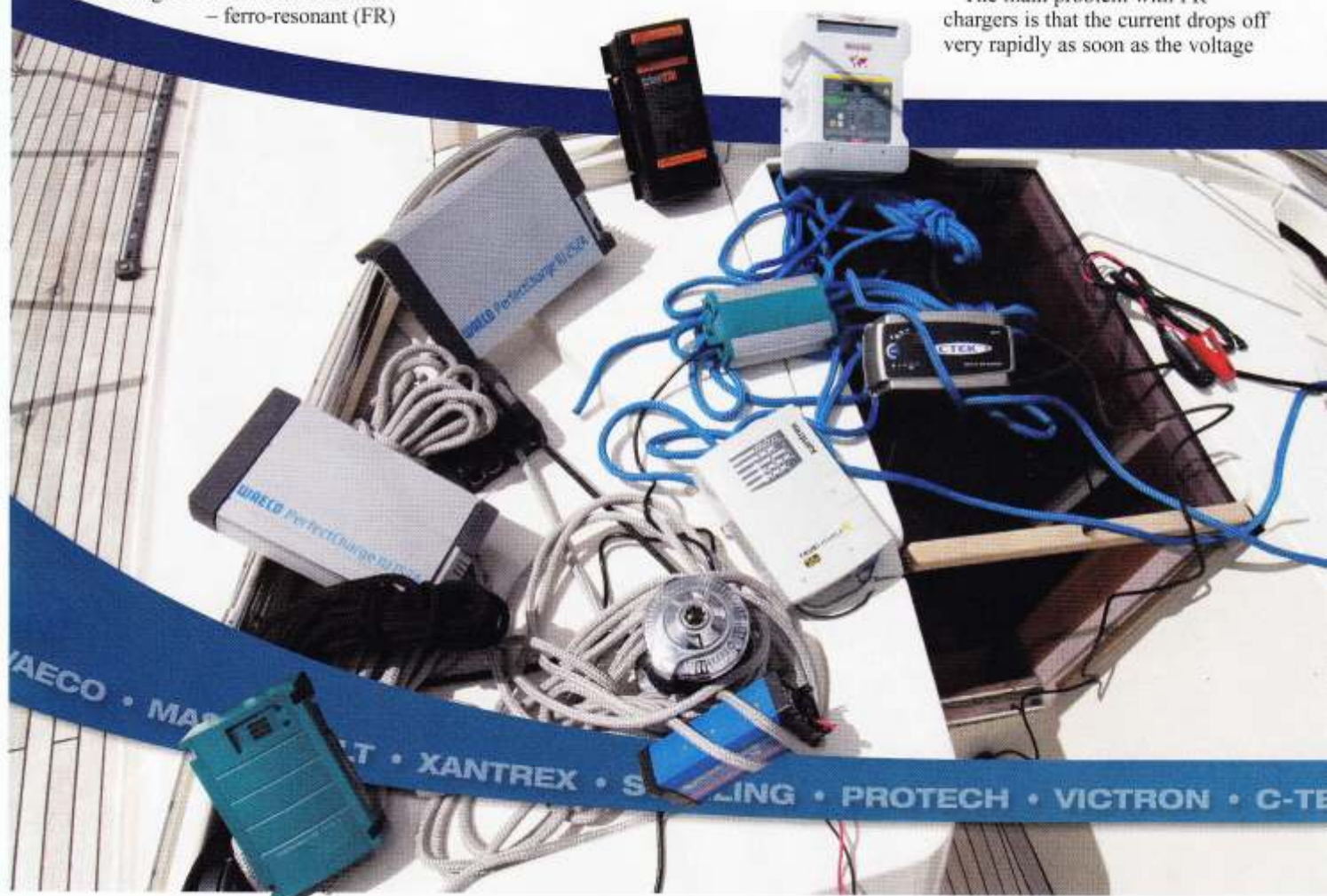
There are two distinct types of battery charger for lead-acid batteries – ferro-resonant (FR)

transformer-based chargers and switch-mode (SM) devices.

The former, which are cheaper and more commonly sold as automotive, rather than marine battery chargers, contain a simple transformer that steps 220-240VAC mains power down to around 14-15VAC. Two, or more often four, diodes are then used to rectify this output to DC. This is all you will get if you buy a cheap car battery charger, maybe with a moderately

accurate analogue ammeter or LED charge indicator thrown in. Slightly more expensive models will incorporate two charge levels, high and low, for rapid and/or trickle charging respectively and most modern units now switch between these charge rates automatically once a certain voltage is reached. However, this is not done very scientifically and takes no account of the battery temperature – only voltage.

The main problem with FR chargers is that the current drops off very rapidly as soon as the voltage



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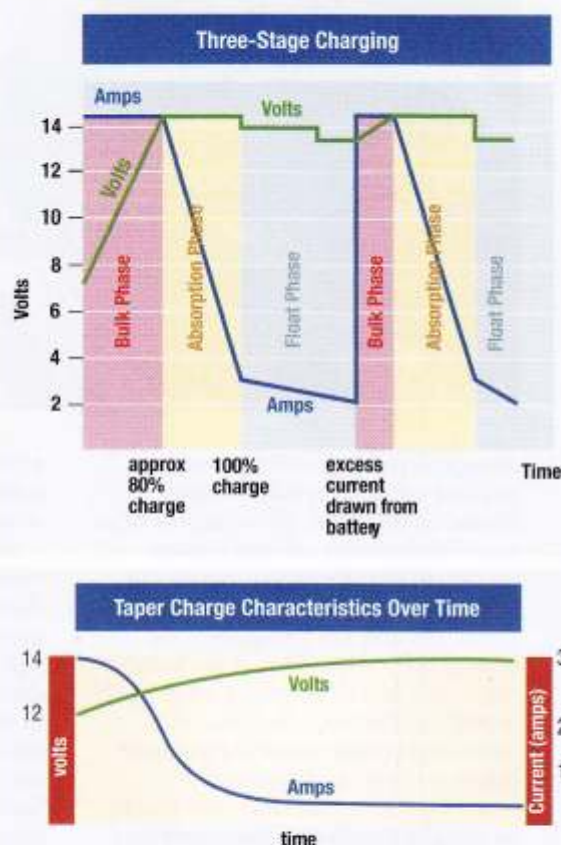
risers, so after an hour or so a 10A unit might only be putting some 2A-3A into the battery, even though it could still be at just 60 per cent of charge capacity. The only answer to this is to use the biggest charger you can find, but then you stand a very good chance of boiling the battery and buckling the plates, especially if the charger is left on for long periods. Lead acid cells prefer to have a more delicate regime of three-stage or four-stage charging to avoid excess gassing and plate damage.

Some boat owners swear they have only ever used a car charger and never had problems, however they usually end up throwing away their batteries a lot sooner than they would need to with an intelligent SM charger, due to them rarely ever achieving better than 80 per cent of the battery's total charge capacity.

Solid state switch-mode chargers use the same principle as the car charger, but the AC voltage is 'switched' on and off at very high frequencies using high efficiency Field Effect Transistors (FETs), before being fed into a transformer. This high frequency input is simpler to step down and requires a considerably smaller and lighter transformer to produce the same output as a ferro-resonant charger. It also enables greater control over the pulse bandwidth – ie the amount of RMS output voltage produced in each cycle – which helps in keeping the voltage at a predetermined level throughout each charge phase.

Dry or gel cell batteries

Gel and other non-liquid electrolyte batteries have very different requirements to wet, lead-acid models and any charger must be designed specifically to cope with these specifications. Although they too benefit from three-stage charging, the voltage levels during charging are far more critical. For gel cells this is 14.1V for the bulk phase and 13.7V for the absorption and float phases. Equalisation regimes should never be used on gel batteries; they can explode when



overcharged.

Before purchasing a charger make sure the supplier is informed of the type of batteries you have, so that the charger you buy is capable of handling them.

If you have gel service batteries, but a lead acid engine start battery, you will need a charger with two independent outputs, the output voltages of which can each be adjusted to suit the different battery types.

Battery imbalance and multiple outlets

At one time most cruising boats had a single battery, so you only had the one to worry about. Fortunately, most changed this to two some years ago, because owners soon became fed up with not being able to start the engine, having flattened the battery with high electrical demands such as lights.

Nowadays cruising boats are commonly fitted with much larger, heavy duty service batteries to cope with the increased power demands of modern living, which creates a new problem. A single output charger that is powerful enough to restore

charge in a comparatively large service bank, would 'cook' the considerably smaller, thin plated engine start battery in no time if connected in parallel with a heavily discharged service bank, either through a mechanical switch or a diode-based isolator. The best option is to install a multi-outlet charger that has two independently controlled charge circuits, especially if you have different types of battery for start and domestic power such as a lead-acid starter battery and gel or AGM domestic.

Several makes of battery charger offer multiple DC outlets, which, though it sounds useful, isn't always what the salesman makes it sound like. Some outlets are isolated by diodes, so there is no cross-feed between batteries, while others require you to link any unused outputs to the one you're using with jumper leads.

It would be really useful if each outlet could be set to different

battery types or different charging regimes, but otherwise I can't see the point, apart from to isolate the start and domestic batteries in the isolated output models. All share the total charging power available between all the outputs, so if the start battery is full, say, the bulk of the power will go to the domestic bank automatically. Some prioritise one output for the start battery, or give it a different charge rate, so make sure you get your connections correct.

The alternative to fitting a multi-outlet charger is to fit a switch to isolate the starter battery from the bank immediately it becomes fully charged. This can be a manual switch, but then there is the danger you will forget to switch over in time. Better to fit a Voltage Sensitive Relay (VSR), which will sense when the start battery has reached a fully charged level and isolate it automatically. A VSR has the added benefit of ensuring your engine battery will be charged first.

Alternatively, you could simply fit two chargers – smallish one for the engine start battery and a larger, more powerful one for the domestic bank.

Multi-stage charging and equalisation

Proper thick plated, deep cycle marine batteries will last longer and accept charge more readily if they are recharged in three distinct phases, with the charge voltage being very carefully monitored for each stage. These stages are commonly called the 'bulk', 'absorption' and 'float' modes. Some more powerful units will also supply most of your domestic power requirements, in addition to keeping the battery bank topped up in float mode, so that you're not actually using any stored energy when you're connected to shore power. This is sometimes referred to as a fourth stage, but it isn't really.

During the first bulk charge stage, the charger supplies between 14.1-14.8V to the batteries until the voltage reaches its nominal figure, after which time the current will decrease slowly. The nominal voltage varies according to the type of battery used – for instance a flooded cell lead-acid battery should be bulk charged at 14.7-14.8V, whereas an AGM requires 14.4V and a gel battery 14.1V. Stage 1 charges the batteries up to between 80 and 90 per cent of their full capacity. Stage 2 is commonly activated when the current reaches around 80 per cent of its nominal value – ie 16A for a 20A charger. At the start of Stage 2 the charging voltage drops to between 13.3V-13.8V, again depending on battery type, which allows the last 10-20 per cent of charge to be slowly absorbed without vigorous gassing.

Finally, on reaching maximum capacity (usually defined as when the current the battery will accept drops to around 2 per cent of maximum capacity (eg 1.6A for an 80Ah battery), the charger will revert to Stage 3, when a float voltage of some 13.4V-13.8V is applied in order to overcome the batteries' self-discharge properties and ensure full charge is maintained in the batteries.

Some of the more sophisticated chargers briefly drop back into Stage 2 once a week to ensure the batteries are at their maximum capacity, before returning to Stage 3.

Most good quality chargers also offer an 'equalisation' or 'de-sulphation' mode whereby a higher voltage charge of around 16.0V is briefly applied after the



absorption phase in order to dissolve any lead sulphate crystals that have formed on the plates. This vital, but often overlooked, feature can add years to the overall life of a battery and should be carried out once every 20-30 charge cycles. Because the voltage over the battery terminals, and hence the switch panel, will be well above the usual 12.8V during equalisation, it is advisable to disconnect voltage sensitive equipment before carrying out this procedure.

One final important factor that should be taken into account is the temperature of the batteries during charging. The colder the battery, the greater the voltage required to bring it up to full charge, so most modern marine chargers have a temperature sense option whereby a small thermal sensor is placed on or near the battery itself and the voltage varied accordingly. The sensor will also act as a further protection against the battery overheating and boiling dry, because it will reduce the charge or switch off the charger completely if it reaches too high a temperature – usually around 50°C.

Matching chargers to batteries

The ideal current for the bulk charging phase is around 10 per cent of the battery bank's total capacity when charged – eg 20A for a 200Ah battery bank. There is no actual harm in using a less powerful charger, say a 10A unit, but the downside is the extra time it will take to charge. When you're cruising and maybe only want to visit a marina with shore power once every few days, you will want to be able to recharge overnight and not have to wait around all day or run the engine unnecessarily. Over 20 per cent and you'll not risk damaging the batteries, but just be paying more for unnecessary charger

power capacity, although this is always handy should you decide you need to add another battery in the future.

Your total battery capacity should have been calculated to ensure you need never discharge the batteries below 50 per cent over a discharge/charge cycle. Any lower will permanently damage the cells and drastically shorten the life of the batteries. In simple terms, the less you discharge a battery the more charge cycles you'll get out of it. So say you have a 200Ah battery bank that you discharge to 50 per cent capacity over a few days' cruising. You will require 100Ah, plus a further 10 per cent (lost in heat overcoming the batteries' internal resistance) to restore it to full capacity. Using a 20A three-stage charger, the bulk charging phase will take it to 90 per cent capacity (180Ah), ie it replaces the first 80Ah of the total 100Ah required, in just four hours or so. For the remaining 10 per cent (20Ah) the charger will output at absorption level, probably around 5A, taking a further four hours. This means the charger needs to be on for at least eight hours to recharge the batteries fully.

A simple 10A ferro-resonant car charger would probably average just 2A over the whole unregulated charge cycle, thus taking at least 50 hours to do the same job. In other words, to do it in the same eight hours as the three-stage charger you would need something in the region of a massive 60A FR charger.

Moreover, these calculations don't take into account the oft forgotten DC demand throughout the charging period. As already mentioned, good quality chargers will supply the bulk of your domestic needs as well as charging the batteries, so you can still use your DC lights, shower pumps etc during this period without discharging the batteries. Whereas with a simple FR

charger the charging time will increase when you add extra DC loads during charging. In order to get a clearer picture of just how long a 50 per cent recharge would take in this case you would need to enter your demand for that charging period into the equation, which would add a considerable number of extra hours to the overall charge cycle.

Power factor correction

Recent EU emission control directives concerning the efficiency of electrical equipment have meant that a great number of electrical items have had to be redesigned to include power factor correction circuitry.

Basically, power factor (PF) is the ratio of the usable power of an inductive electrical device to the total power consumed by it. Not only does it make the equipment more efficient, thereby costing less to run, it also means it can be smaller, lighter, cooler and more powerful. It also has the added benefit of enabling the device to accept a much wider and less stable range of input from the mains AC supply. In marine battery chargers this means you can run a PF-corrected charger

from any 90V-270VAC supply, including poorly regulated AC generators.

Monitoring the battery condition

For those whose boats are left all week in a marina with access to shore power, precise monitoring of the batteries may not be too important. Merely purchasing a reasonably powerful ferro-resonant charger with an automatic switch to drop the charge to float level would most likely suffice. The addition of a simple digital voltmeter would ensure that things were all okay at a quick glance, working on the widely accepted presumption that 12.2V is 50 per cent, 12.5V is 75 per cent and 12.8V is fully charged.

Those who spend lengthy periods at anchor or leave the boat on a swinging mooring, would be advised to have a better regime of battery maintenance – especially if the boat has a fair amount of high power electrical kit on board or an inverter to power AC devices. In

these situations it is essential to fit a good quality battery monitor – such as the BTM-III from Mastervolt shown in the photo above – that can automatically calculate and display the remaining capacity available and whether it has been fully recharged.

An ammeter will offer you an insight into how much current is being drawn from the batteries at any one time, but requires a tedious number of manual calculations to derive your average daily consumption and then work out the exact amount of charging time required to replace it.



PRODUCTS TESTED

PROMARINER PROTECH 1225i £250

A smart and compact unit with just a couple of rows of LEDs on the front panel showing charge stage and battery type, no on/off switch and no remote display option. Two DIP switches inside the cover set the type of battery you are charging (Flooded, AGM or Gel), so, like all the others tested, you can't mix battery types with this charger despite having three outputs. Another switch adjusts the length of the absorption stage of charge, from 1-4 hours (default 3hr). This is usually automatic for multi-stage chargers and means you need to have some idea about how long your particular batteries prefer for this stage of charging.

Although the unit is 'marinised' and weatherproof, a drip shield is provided for mounting above the unit just in case of any water falling from above.

The charger doesn't come with any cables or mounting screws, which is a little annoying and connecting the leads is somewhat fiddly.

Its performance is good, although it pays to remember to add jumpers from the unused DC outputs to the used ones – we forgot at first and the current trailed off quicker in the absorption stage than with them connected. The fan cut in after five minutes' full charge and it stayed on, and was very noisy, throughout – despite the cover remaining quite cool.

VERDICT

Does a perfectly good job of basic charging, but is arguably the least refined of the chargers on test and was a bit short on the bells and whistles such as remote display and temperature sensor which you might expect for a charger within this price bracket.



C-TEK MULTI XS25000

£197

While this looks more like a car battery charger with its large crocodile battery connectors, it is in fact waterproof and suitable for flooded deep-cycle, AGM or gel batteries. Commonly available in chandlers for marine use, this is the largest (25A) in the C-Tek range and boasts a power supply mode as well as a de-sulphation regime. It comes supplied with a UK 3-pin mains plug and it also has an integral temperature sensor in the battery cables to adjust the charge current to suit battery temperature and avoid gassing by overcharging.

The unit pumps out the maximum current with no problem, although it gets

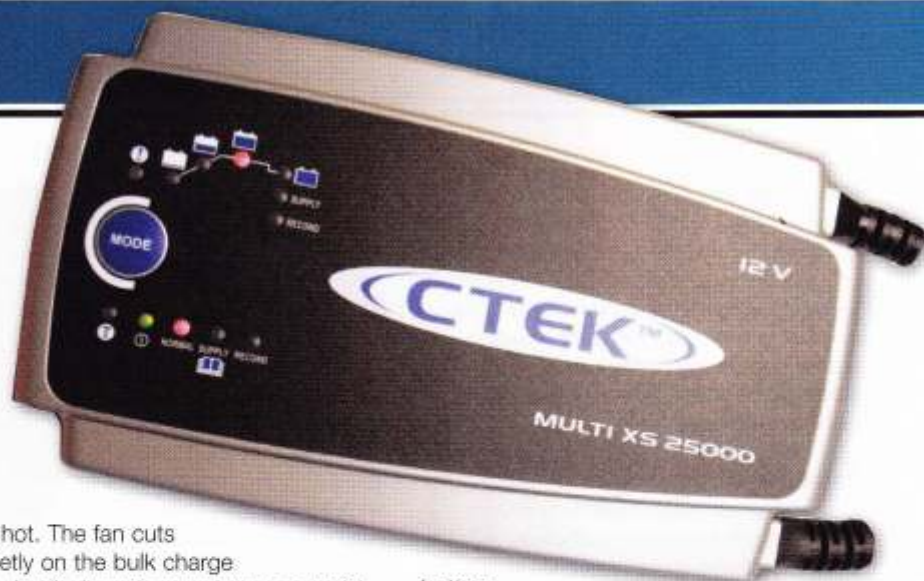
quite hot. The fan cuts in quietly on the bulk charge stage, but it doesn't sound very powerful – I would certainly want to ensure any locker it might be installed in was well ventilated.

The two rows of LED indicators are straightforward – one shows the charging stage, including the supply and desulphation modes, the other shows the mode, which is set by pressing the mode

button until the desired setting is indicated – normal, supply or desulphation.

VERDICT

Good value for money, does what it says on the tin but nothing more.



STERLING PRO CHARGE ULTRA £299



This is a serious marine battery charger that has a plethora of functions built in and an impressive control panel that includes a digital voltmeter and ammeter as well as an impressive number of LED indicators showing the battery settings, charge stage, system settings and alarms.

It is easy to wire up thanks to its simple screw terminals – all of which are neatly protected by a smart cover. A battery temperature sensor is included, but no supply cables. The unit came pre-programmed for sealed lead-acid flooded batteries, but it's a fairly simple process to change this to any one of 11 alternative settings – including your own custom one should you wish (and actually understand what

you're doing).

This has to be the most flexible marine battery charger on the market today and its display panel is fantastically comprehensive, but as a fixed-mount charger it is most likely to be mounted out of sight and it just seems a shame that the panel doesn't detach to mount remotely, which means that you have to buy the optional remote as well.

Its output was exactly what it said and it seemed to have no trouble keeping up the power and current during the first two stages. The automatic fan is 3-speed, but on the second setting – during bulk charge mode – it was pretty noisy.

VERDICT

A very comprehensive, professional charger that looks the part and does the job effortlessly.

WAECO PERFECTCHARGE IU152A £200

This is a large unit for the output, but thanks to its large aluminium heat sinks on the casing it never got hot enough during our trials to require the fan, which is a

bonus for those who want to leave it on at night when on board. The only noticeable difference is that it only has two positive battery outputs, one of which is a simple start battery circuit that charges at a constant 13.8V/1.0A and is given priority over the domestic output until the start battery reaches 13.8V, when it then starts charging the

domestic bank.

The unit is supplied with a plug-in temperature sensor and two plug-in mains cables (2-pin and 3-pin). Wiring it up is quite tedious, due to the need to remove the end plate (four long allen bolts) before gaining access to the DC terminal screws and DIP switches, which must be set to battery type and absorption charge time

(8 or 16 hours).

It operated faultlessly and can take an optional, plug-in remote panel.

VERDICT

This felt well engineered and easily capable of producing maximum power all day without overheating. Having to remove the end panel to insert the DC cables is tedious and it wasn't immediately obvious as to which was on and which was off on the DIP switches.



WAECO PERFECT CHARGE IU252A £270

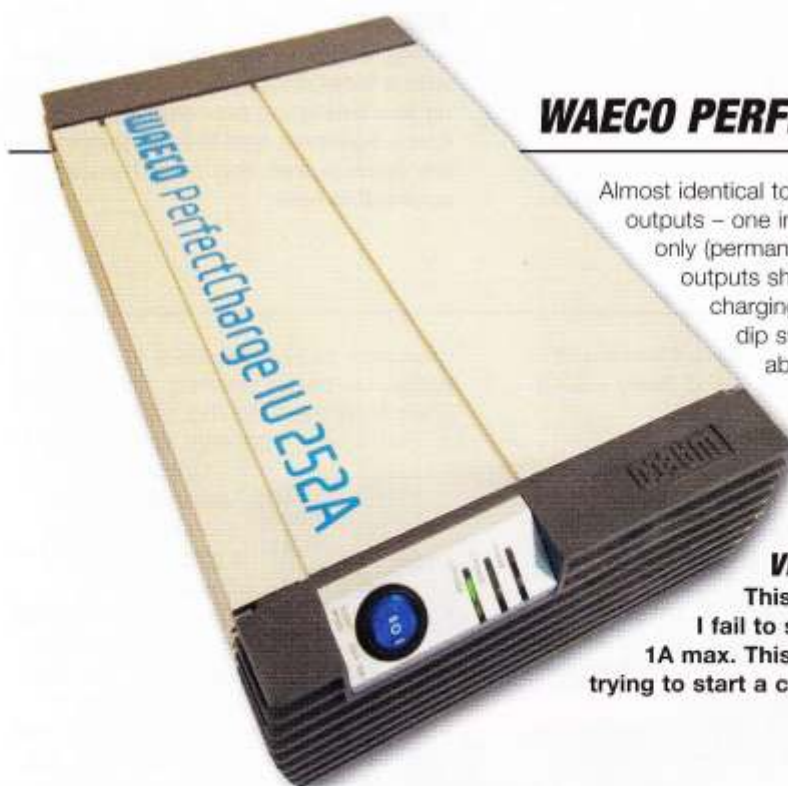
Almost identical to the 152A, this has an even larger casing with three DC outputs – one independent output dedicated to the engine start battery only (permanent 13.8V/1.0A) as with the 152A, the other two DC outputs sharing the 25A maximum DC output. As with the 152A, charging voltages and other characteristics must be preset using dip switches inside the cover, including the time period for the absorption phase.

Yet again this was completely silent, because it never became hot enough for the fan – despite them including an exhaust fitting for the case in the box.

At £270, this wasn't the cheapest charger on test, but it was a more beefy alternative to the 152A

VERDICT

This unit operated as well as the smaller 152A, however, I fail to see why the start battery can only be supplied with 1A max. This could be tedious if you've run it down low trying to start a cold engine.



MASTERVOLT IVO SMART 12/15 £325.48

This very neat little unit is capable of charging up to a 200Ah battery bank and can be programmed (via a laptop) to suit flooded, AGM or gel batteries. Three models are available with 10A, 15A and 25A outputs. It comes with a fixed mains lead (albeit with a 2-pin EU-style plug) and, unlike some other models, came with output leads with pre-attached terminals.

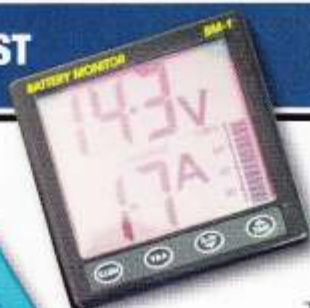
These chargers are designed to be fixed or free standing and there is no need to open the casing to access the output terminals or PC port.

VERDICT

A good little unit that is ruggedly built and simple to install, set up and operate. A handy spare to carry even if it's not your main charger.



GROUP TEST



MASTERVOLT CHARGE MASTER 12/25-3 £399.50

This is the bigger (in power not size) version from Mastervolt, which is designed to be permanently installed. It has three isolated outputs that share the overall charge power and a simple, plug-in temperature sensor.

It is easy enough to install – a fixed mains cable is provided and there are screw terminals for the battery connections. The unit had no problem putting out a near maximum 23A almost continuously during the bulk charge stage. The fan appears to run noisily throughout this phase, but then again it is cooler to touch than most.

The front panel has a 5-bar LED indicator showing the battery charge

capacity, which is also used for setting up battery type and number of stages you require (you can set it to flooded or AGM/gel and two or three stages). The unit also has three backlit keys named BULK, ABS and FLOAT to show the mode it is operating in. An optional remote monitor can be connected via the Masterbus data port on the end of the unit.

VERDICT

A tidy, compact and powerful charger with a lucid display and easy set up and operating procedures. A bit noisy, however, and the DC terminals are unprotected. Has no externally accessible fuse.

VICTRON BLUE POWER 12/15 £165

The smallest of the 15A chargers, the Victron Blue Power comes with 2-pin mains lead and plug and battery cables with crocodile clips. Operation is in four stages, rather than the more usual three, but the principle is the same, it just holds the battery to 14.0V for 24-hours of float charge, before dropping to what it calls a 'storage'

voltage of 13.2V, where it remains. If unused, every week it

goes back into charge mode to top the battery up, before returning to storage. There is no facility for monitoring the battery's temperature.

Operation is extremely simple – it has two LEDs, a green one for on/off and yellow for stage indicator. Quick flash – bulk, slow flash – absorption, on – float (14.0V), and off – storage (effectively float 13.2V). In this last, the device drops back into



Make	Model	Size LxWxD	Weight	Max output	No. of outputs	Charge stages	Power supply mode	Flooded o/p (V) Blk/Abs/Flt
		(mm)	(kg)	(A)				
Xantrex	Truecharge2.20	250 x 170 x 70	2.2	20	3	2 or 3	Yes	14.4/14.4/13.5
Sterling	ProCharge Ultra	260 x 215 x 90	2.4	20	3	3	Yes	14.8/14.8/13.3
C-Tek	Multi XS25000	233 x 128 x 64	1.9	25	1	3	Yes	14.4/14.4/13.6
Mastervolt	IVO 12/15	206 x 121 x 50	1.0	15	2	3	Yes	14.25/14.25/13.25
Mastervolt	IVO 12/25	210 x 130 x 60	1.0	25	3	3	Yes	14.40/14.25/13.25
Victron	Blue Power 12/15	200 x 85 x 50	1.3	15	1	3	No	14.4/14.4/13.2
Promariner	Protech 1225i	254 x 157 x 74	2.1	25	3	3	Yes	14.7/14.7/13.5
Waco	PerfectCharge IU252A	332 x 208 x 96	3.8	25	2 + 1	3	Yes	14.4/14.4/13.8
Waco	PerfectCharge IU152A	310 x 175 x 91	3.1	15	1 + 1	3	Yes	14.4/14.4/13.8

absorption mode once a week, just to keep the battery in top condition, before reverting to storage mode. The unit has no on/off switch and a quiet fan cuts in during the bulk charge phase.

It had no trouble outputting the maximum 15A and it stayed high for a

considerable time, but the voltage took a while to rise.

VERDICT

Not the bells and whistles one usually associates Victron with, but a low cost, simple,

fit and forget charger that is fine for the small cruiser or sports boat.

XANTREX TRUECHARGE 2 12/20 £305

Another fairly sophisticated charger with all the features you might ever need in a marine battery charger. The display is comprehensive, but not cluttered – I like the way it looks and how easy it is both to see which mode you're in and the status of the charge, as well as to be able to change the settings easily by pressing buttons on the front panel – not on DIP switches hidden away inside. There is also a remote monitor option that is almost a clone of the standard front panel – once again it's a shame manufacturers don't design the panel containing monitors to be removable to save money.

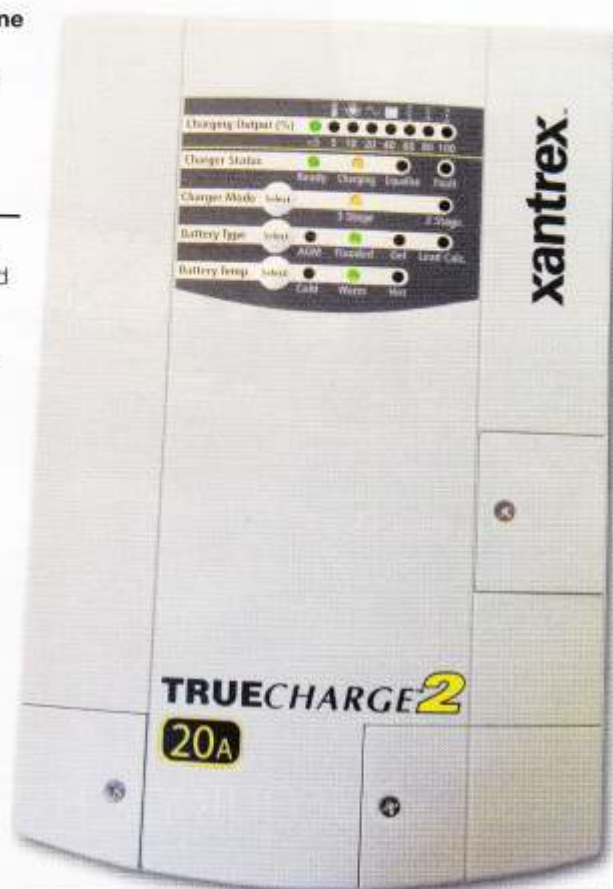
The TrueCharge has the ability to select four battery types and 2- or 3-stage charging regimes, while a battery temperature sensor is optional. Wiring it

up is an easy job – it has three isolated outputs that don't need jumpers but, as with all the other multi-output chargers tested, they still only share the total output power available and you can't mix several different battery types.

It performed well with the fan running reasonably quietly during the first two stages

VERDICT

This looks like a particularly smart piece of kit and performs well. I like the display panel and the ability to change settings with ease.



CONTACT

Waeeco – Dometic UK 01305 854000 www.waeeco.co.uk

Mastervolt UK – see website for local dealer www.mastervolt.com

Xantrex TrueCharge – Merlin Equipment 01202 697979
www.merlinequipment.com

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

ProTech – Promariner see www.pmariner.com for dealers

Victron – On Board Energy 0845 4566572 www.onboardenergy.com

Victron – Adverc Battery Management 01902 380494 www.adverc.co.uk

C-Tek – C-Tek UK 01353 789800 www.ctekchargers.co.uk

	Gel o/p (V) Blk/Abs/Flt	AGM o/p (V) Blk/Abs/Flt	AC Input (V)	Temp sensor	Power factor correction	Desulphation mode	Remote monitor
	14.2/14.2/13.8	14.3/14.3/13.4	90-265	Supplied	Yes	Yes	Optional
	14.0/14.0/13.7	14.35/14.35/13.35	90-270	Supplied	Yes	Yes	Optional
	14.4/14.4/13.6	14.4/14.4/13.6	220-240	Supplied	No	Yes	No
	14.4/14.25/13.8	14.4/14.25/13.8	180-250	No	No	No	No
	14.4/14.25/13.25	14.4/14.25/13.25	90-265	Optional	Yes	No	Optional
	n/a	n/a	90-265	No	Yes	No	No
	14.1/14.1/13.8	14.4/14.4/13.3	90-250	No	Yes	No	No
	14.4/14.4/13.8	14.8/14.8/13.8	207-253	Optional	No	No	Optional
	14.4/14.4/13.8	14.8/14.8/13.8	207-253	Optional	No	No	Optional