High Output Alternator

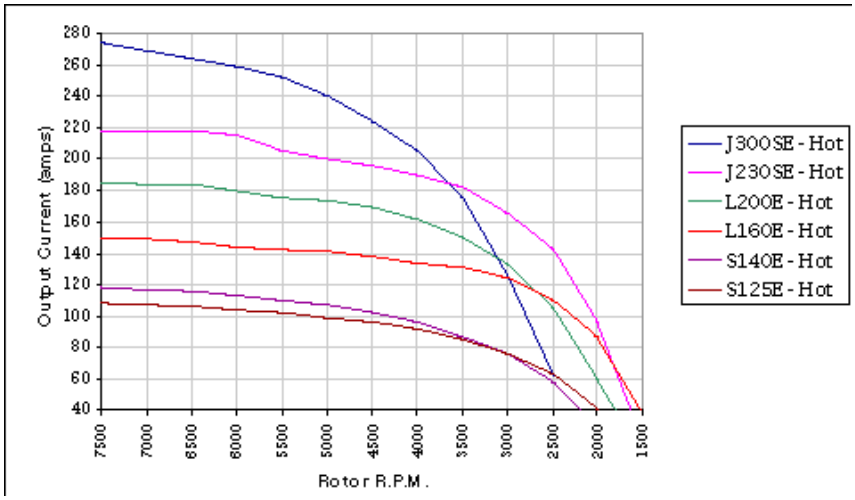
For many years, I have been investigating to find the best possible solution to install an High Output Alternator (HOA) onto the main engine. For engines under 70 hp, I believe it is better to have have a good charging facility on this, backed up with a wind/water generator, rather than investing in a diesel generator.

All "experts" I have spoken with regarding this matter have agreed on the fact that the crucial point is the installation of strong enough brackets, which can withstand the tension of a highly efficient alternator.

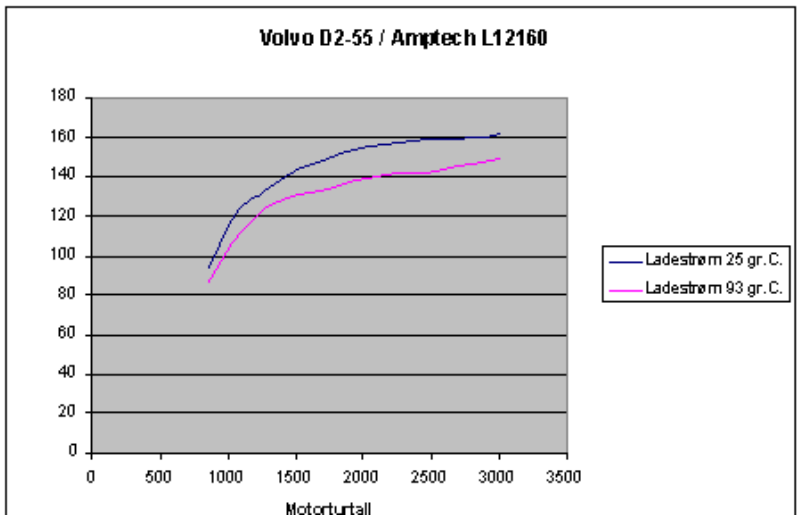
After discussions with several suppliers, I have finally chosen the Norwegian company Electromarine as to become our partner to supply our HOA. Ole Petter Hillestad at Electromarine knows what he is talking about and has many years of experience supplying pleasure boats as well as fishing vessels with required electrical power.

The chosen alternator is the Large Frame L12160E HOA by Amptech. The main reason for choosing this alternator is its good charging abilities at low revs. With some 1000 rpm on the engine, we can expect some 100A of charging, see below chart.

Please note that you should not charge wet batteries (Lead Acid) with more Amps than approx. 30% of its capacity in Ah. Our battery bank of 560 Ah would thus mean a maximum charging of 560 Ah x 30% = 168 A. We are here below this at any revs.



Charging characteristics for various Amptech alternators at different rotor rpm's. Hot means that the alternator is working in hot environment (as it usually does) and not in any perfect 25 deg. Our chosen 160A Amptech alternator is shown in orange.



Currents in Amps in obtained by a Amptech L12160 mounted on a Volvo Penta D2-55 as a function of the engine's rpm at two temperatures (25 deg C and 93 deg C). Chart supplied by Electromarine.

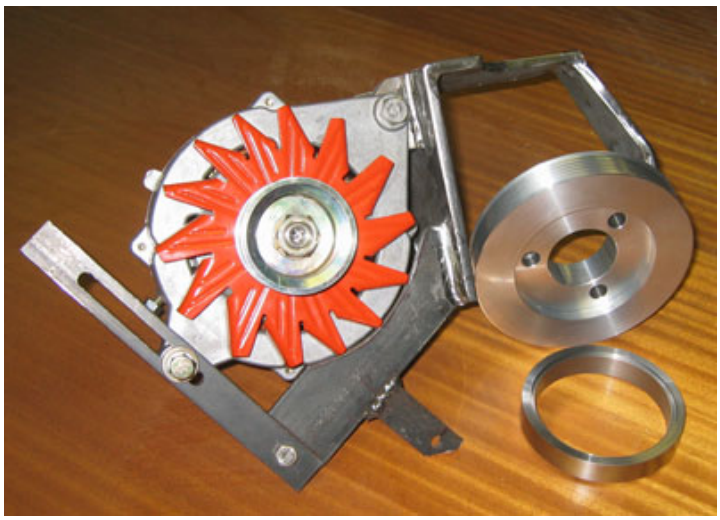
The HOA is being regulated by Mastervolt's Alpha Pro regulator. This intelligent regulator allows for "switch-off" meaning that in critical situations, such as maneuvering in harbours, the alternator can be switched off while full power is allowed for the propeller shaft. This switch is mounted on the steering wheel.

The old standard Volvo alternator is kept to charge the starting batteries and thus lives an easy life without too much load, except in case of a possible failure. If, for any reason, one of the alternators or regulators would break, it is still possible to charge both battery banks with the remaining alternator by connecting the two battery banks manually by the "Emergency Engine Start" switch. See illustration here.

By having two separate redundant charging circuits, the diodes are also becoming unnecessary, thus eliminating both the voltage drop at the diodes as well as eliminating another possible risk of failure.
The most important part - the brackets to hold the alternator firmly onto the engine- is designed and manufactured by Electromarine as. The brackets are of a "saddle type" giving support by strong bolts both from the rear side as well as the front side of the alternator.

The transmission belt is of an extra wide type with maximum friction consisting of 6 "V's".

In **January 2004**, the parts had been assembled and shortly thereafter were shipped from Norway as a fixed kit that is easily installed onto our Volvo Penta D2-55. In our case, the actual mounting will be done by Båtvårdsvarvet in Svineviken, Sweden, but I am sure it job could have been done by any handy person.



The first pictures of the AMPTECH 160A on the brackets for the Volvo D2-55 together with the new pulley. The V-belt is a standard Volvo belt, part No 3581460

The wiring of the Mastervolt Alpha Pro regulator can be seen here.
Not shown on this picture is the cable for the temperature sensor to be installed on the batteries and connected to the Alpha Pro regulator.

The installation of the HOA has now finally also been approved by Volvo Penta, Norway. This has been an embarrassing story, where Volvo at first did not want to approve the installation. I presume this is due to the fact that Volvo can not supply an own HOA solution and for some reason opposes a third party solution. Volvo expressed a worry that the extra force on the crankshaft was too large, without being able to give any specifications on the approved loads. There seem to be a lot of "opinions" going on inside as well as outside Volvo re the HOA-issue, where they still today (2004) claim that "Volvo only supplies a 60A alternator".

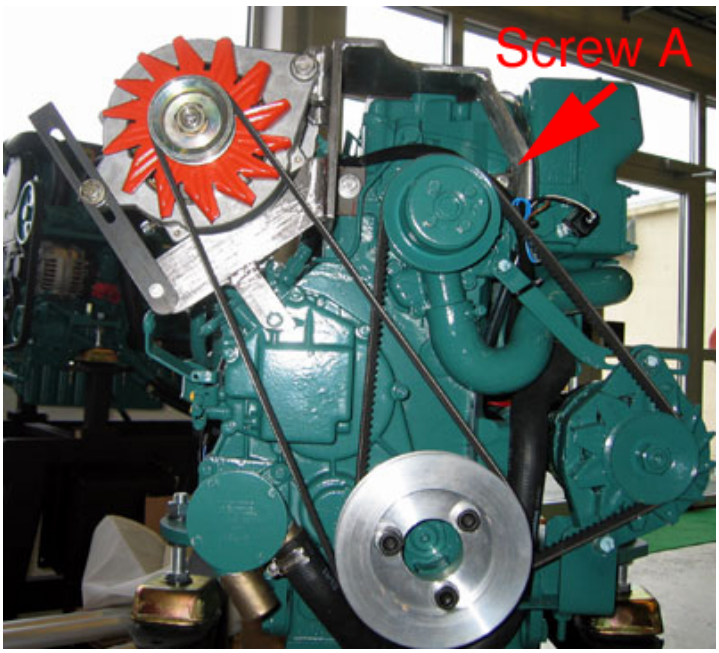
So, feeling like a David fighting Goliath, we had to do some investigations ourselves.

I was fortunate enough to get access to some internal Volvo material stating that the D2-55 engine can be loaded with 6.8 kW on three individual pulleys totalling 20.4 kW!

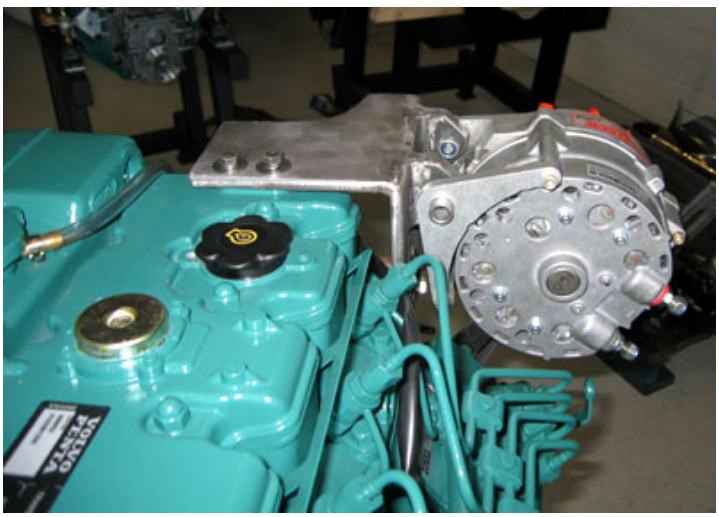
Our best triumph card, however, was the fact that Volvo themselves supply an optional 220V system for the D2-55 consisting of an alternator, similar to ours, and a regulator. According to Volvo's own brochure, this system delivers 220V with 10A = 2.2 kW. Even with an efficiency of 100%, the Volvo alternator for 220V must still deliver at least 2.2 kW, while our AMPTECH alternator delivers 150A x 14V = 2.1 kW.

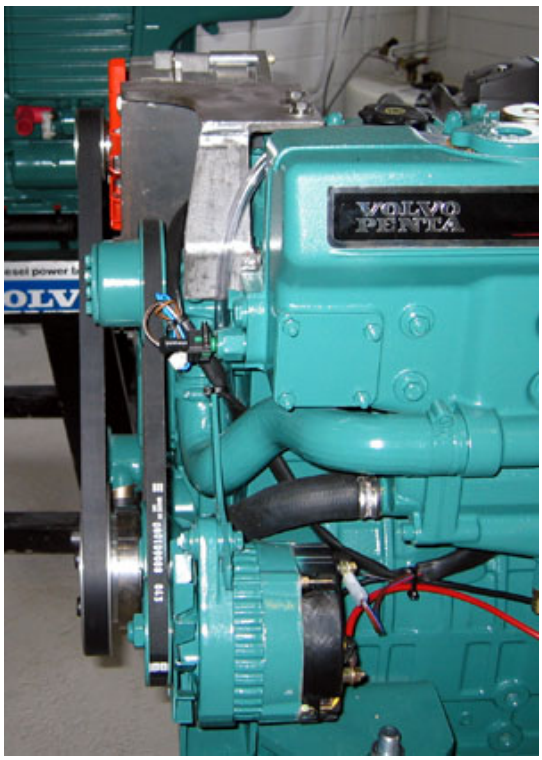
With this material at hand, Ole Petter Hillestad in Norway approached the Service Manager of Volvo in Norway, Mr. Egil Bjerkreim. Egil Bjerkreim then explained that it was all a misunderstanding and that, of course, a HOA can be added to a Volvo D2-55 with retained Volvo guarantee for the engine, at least if the HOA is placed at the same place as the Volvo 220V system and has a similar load. I understand this as an approval from Volvo.

The work could thus proceed and the final adjustments be made. Here are some pictures of the ready brackets on an equal Volvo D2-55 engine in the test bench at Electromarine as. The brackets have not been painted, yet, so they are still easily distinguished.



Screw A: see end of this text





For me, as an engineer in Mechanical Engineering, these are beautiful pictures! Look at this trustworthy construction! A great thanks to Ole Petter Hillestad, who has invested countless hours, late at night as well as on week-ends, always finding additional improvements on his sturdy design.

The kit will now be shipped to be installed on our engine onboard Regina. And I will continue to tell about our experiences, of course.

Since the brackets now have been developed for the D2-55, you can contact Electromarine as directly, if you are interested in obtaining a High Output Solution yourself.

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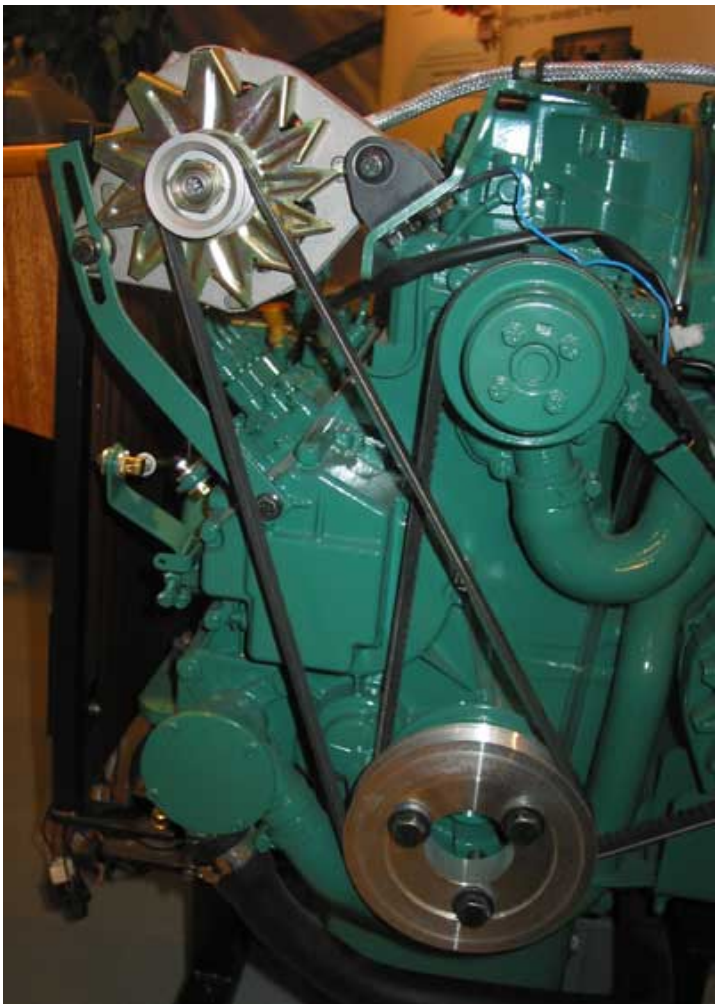
Some weeks later, in **February 2004**, I visited the BoatShow in Copenhagen, Denmark. Many Volvo representatives exhibited their services and displayed Volvo engines on their stands. Nothing extraordinary, in fact. But this year, I notices how many of these showed Volvo engines fitted with the above mentioned 220V system. Could this have something to do with a wish to "compensate" for the fact that their own 12V alternator is not sufficient?

Everywhere, you could read signs saying "*Volvo D2-55: 12V 60A and 220V 10A*".

While it certainly sounds professional to produce 220V directly from your main engine, I prefer our own system onboard REGINA obtaining 220V through an inverter, thus also enjoying 220V without the main engine having to run. Charging is then done with the HOA, while the engine is on duty, anyway. Getting 220V from the main engine for battery charging is a waste, in my opinion, since you can't charge more than the shore power charger allows for anyway, i.e. 12V 60A in our case.

If you need ample 220V during longer periods than an inverter could supply from your 12V battery bank, or if you wish to charge efficiently withouth the main engine running, I would rather look at an auxiliary diesel gen-set than putting a 220V system onto the main engine.



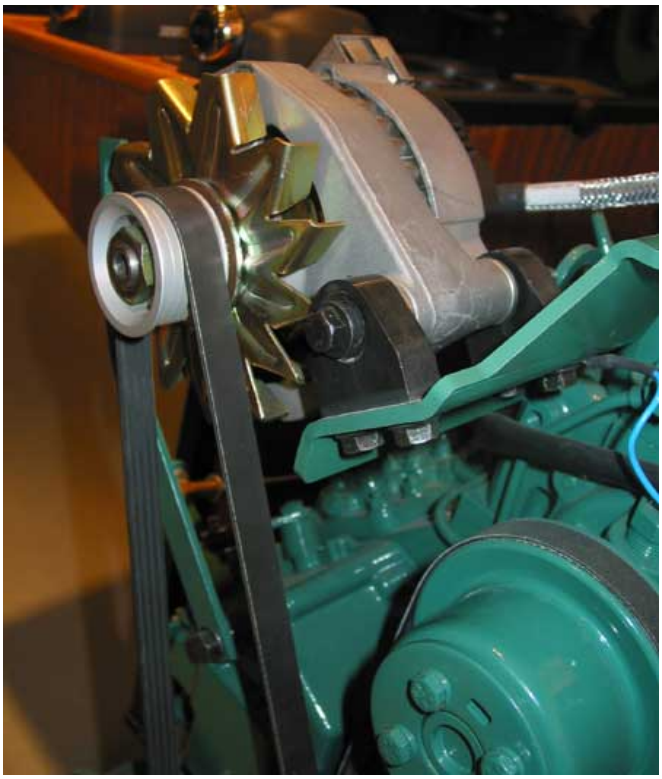
Volvo's 220V alternator giving 10A

220V or not from your main engine, I found it most interested to observe how Volvo's own 2.2 kW system was actually fitted onto the D2-55 and to compare Volvo's own installation with Electromarine's AMPTECH 160A alternator of a similar load.

I note that Volvo has chosen a single belt with 4 "V's". Our belt is wider with 6 "V's". I think this safety margin is important, since our AMPTECH 160A is giving ample power already at low rpm's, which, in turns, puts a higher load onto the belt.

Also interesting is to compare the brackets itself. I am glad to observe that our bracket is even stronger with a further "arm" reaching over and around the standard belt, preventing a pivoting movement of the alternator. This arm is lacking on the Volvo bracket.

The four pictures here are taken at the Copenhagen show showing the Volvo 220V system on a D2-55 engine.



Volvo's own 220V system installed on a D2-55 engine shown at an exhibition.

Volvo uses a single belt with 4 "Vs" to transmit the 2.2 kW from the engine to the 220V alternator

In **March 2004**, the project was concluded, but not totally without some amendments. The initial brackets made by Electromarine was built for the most recent version of D2-55, which has a threaded hole as standard for future equipment, such as this bracket. I have marked this extra hole as "Screw A" on a picture above. However, our Volvo D2-55 built in 2002 was not of the most recent type and thus lacked this hole. Since I did not want to drill my own holes in the engine block, Ole Petter Hillestad of Electromarine amended the bracket, instead using a hole shared with the fuel-filter (see "Screw B" below). Maybe the additional arm used on the bracket is "overkill", since Volvo's own 220V system does not have one, but I personally would not trust holding all this tilting load by screws in the aluminium alloy of the cylinder head alone.

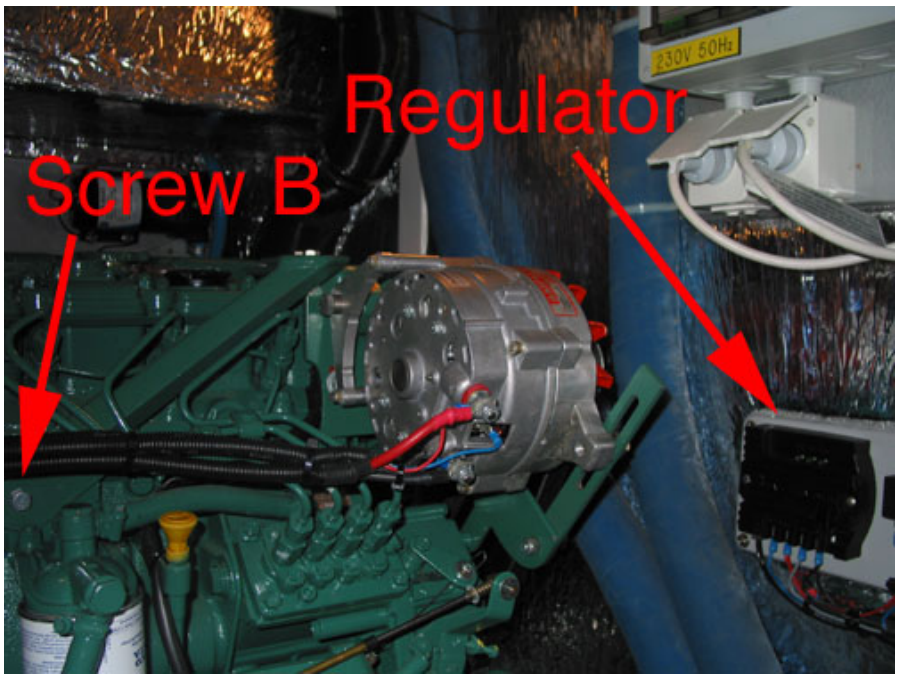
So, for your all of you having a Volvo D2-55 and who are thinking of retrofitting an HOA, it might be good to know that

there are two possibilities, either using "Screw A" on newer engines or "Screw B" on older models. Since I observed that the space could become a bit confined when using "Screw A" if you also have Volvo's hot water system installed, I would personally in first place suggest our final solution with "Screw B".

Below, please find some photos of the final installation onboard Regina.

The new amended brackets with an arm showing aft instead of to port now fixed with "Screw B"

The installed HOA onboard Regina.



Screw B is the one holding the fuel filter, now also acting to prevent the brackets to tilt towards the pulleye. The long lever means that the force on "Screw B" is minimised. Also visible is the

external intelligent 3-step regulator by Mastervolt.

Our experiences so far after a couple of weeks during **April 2004** is very positive. The output is regulated according to the current needs and the status of the batteries. We have so far not gone beyond 25% dischargning of the batteries (75% full) meaning that we have so far not experienced the very high charging abilities of the HOA. The Regulator goes up to around 100 amps and then quickly reduces its output according to the current status of the batteries, i.e how discharged they are. My experiences, so far, is that we charge with some 60 A with battery status between 75%-85%, with some 40A with battery status around 85%-90% and with 10-20A when almost full. During this coming summer, I will do more tests, since these figures are only based on some days of week-end sailing so far.

*

While I personally was content with the installation, since it was a clear improvement over the Volvo alternator, Ole Petter Hillestad from Electromarine A/S could still see some potentials in our system. So, in **June 2004**, we made some calculations. Our current installation used 16 mm2 cable to feed the up to 160A from the alternator to the batteries. The minus-cable (black) was 5.4 m long going to the DCC4000 shunt and the plus-cable (red) was 6.9 m long going to the batteries. Thus, a total of 12.3 m. According to ISO-standard the Voltage drop is according to the formula

$$E = \frac{0{,}0164 \times I \times L}{S}$$

- where

  E = Voltage Drop
  S = the cross-sectional area of the conductor, in square millimetres
  I = the current in ampere
  L = the lenght, in metres, of the conductor from the positive power source to the electrical device and back to the negative source connection

In our case, this meant:

$$E = \frac{0{,}0164 \times 160A \times 12.3m}{16mm2} = 2\ V$$

A voltage drop of 2V in the feeder cable is too much for the regulator to handle, explains Ole Petter. I can follow his thoughts, since if the alternator produces 14,5V, only 12,5V end up for charging by the batteries. Not enough, if you want to get most of your HOA!

The impact of low voltage onboard is not to be neglected, I learnt. Some even believe that 12V is generally too little on a 40 foot boat with today's amount of electrical equipment, since the cable dimensions need to be so big, due to Voltage drop. Maybe, the future lies in 24V systems., who knows. 24V is standard on all fishing vessels.

We have now exchanged the installed 16mm2 cables with 50mm2 cables. It is an RK-cable with multiple strands to allow for maximum flexibility and suitable for vibration. In our case, the cable is called H07V-K, which is produced in England and originally developed for robot production.

With 50mm2 the above formula gives:

$$E = \frac{0{,}0164 \times 160A \times 12.3m}{50mm2} = 0.6\ V$$

This is much better and lets the intelligent regulator work as intended, says Ole Petter.

Our experience so far gives yet better charging with

over 135A under "bulk-phase".

Karolina and Jonathan in the engine room working with exchanging the feeder cables

The new 50 mm2 feeder cables fitted on the alternator. The smaller cables are control cables from the regulator.

With new cables installed and we receive over 130A during bulk charge, compared to some 90A with the thinner cables.

One more comment on the **regulator**:

I have been speaking a lot about the alternator itself and the brackets above. Strong brackets and a good alternator is of course essential for a trouble free power production onboard. The brackets have been a special issue, since it is crucial that they can withstand the high tension and vibration. Even the Volvo-brackets for their 220V system was not as strong as I want them to be.

The third component is an intelligent external regulator. Without it one misses on important issue: the optimal charging characteristics while preventing overcharging the batteries. Some of you might have the larger Volvo D2-75 engine (standard in the HR43) or you retrofit your D2-55 engine with the larger 115A rated alternator from the D2-75. But please be warned, since it does not have an external intelligent regulator. Only with an external 3-step regulator you can configure your boat for optimum charging.

Three diodes on our regulator indicate the charging phases, similar to your shore power charger with the display mounted at the nav-station. One diode lit indicates "bulk charging", 2 diodes means "absorption" and 3 small lamps means "float charging".

The great thing with an external regulator is its flexibility: The timing for absorption can be adjusted

depending on the size of battery bank, the individual temperature sensor on the batteries prevent overheating, the float charging can be optimized in line with your typical load and the charging can be adjusted according to different battery types, e.g. GEL and AMG, which need different charging characteristics and voltage and may not be overcharged.

The regulator is thus the "brain" in your HOA system and once configured, it can be left alone to do an intelligent job all by itself.

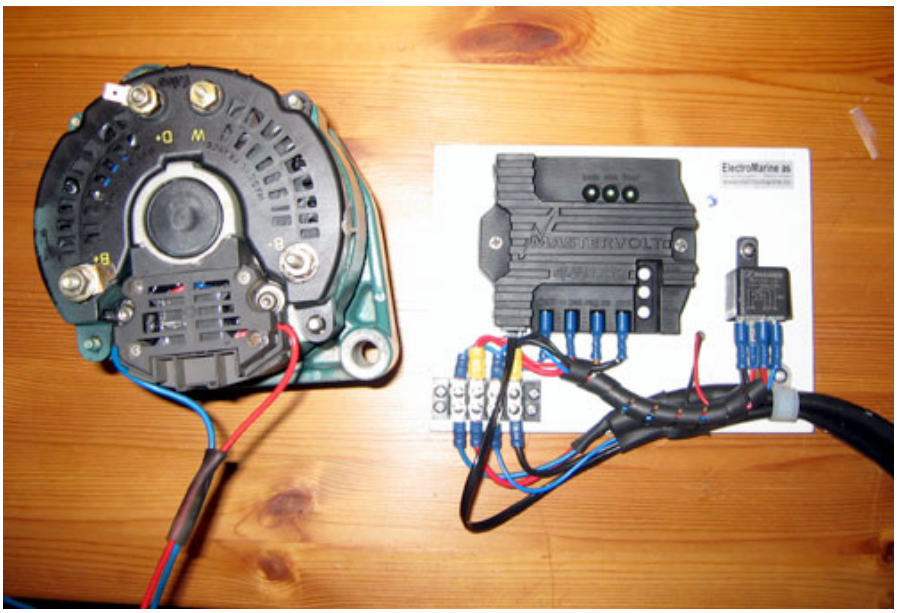
An internal fixed and not adjustable regulator, such as in the Volvo alternators, are always charging on "the safe side". Suitable for all sorts of batteries, its charging characteristics is suboptimized and charging takes a lot of time suitable for powerboats and trucks only, with constantly running engines.

.So, when building your charging system, make sure you get a good external regulator.

External Regulator on standard Volvo (Valio) alternator.

In our discussion group for HR owners, the possibility to add an intelligent external regulator onto a standard 60A Valeo alternator (the so called "Volvo-alternator") has been discussed in detail.

Without having any own experiences, it is said that one can get almost twice the currency and thus close to the rated 60A out of the alternator, by installing an external regulator. It is said that one regulator even can regulate two 60A Valeo alternators, thereby providing almost 100A, instead of typically 60A.



A Mastervolt regulator (right) controlling a standard Volvo/Valeo alternator (left), here made by Electromarine A/S for a Hallberg-Rassy 34 with a MD2030 engine.

Thus, for all of you who have a Volvo engine with two 60A rated alternators installed and are disappointed about its charging abilities, have a look at the possibilities to upgrade these with an external regulator. Also, if you wish to keep your only alternator and just want to improve its regulation, this could be an interesting solution. No brackets are needed, no mechanical installation, just some wiring (see picture above).

However, if you still only have one alternator and want to add a second alternator to your engine, I would personally still opt for the "real" HOA-kit, giving best charging options and full redundancy.

Electromarine A/S in Norway has experience with some 50 installations so far, where cold-rated Valeo alternators have been upgraded with a Mastervolt regulator.

In **January 2005** I receive the information from Electromarine that the brackets, the alternator and the external 3-step regulator for the Volvo Penta D2-55 engine has gone into "mass-production". The name of the product? It's called "REGINA" !

Thank's Ole Petter for a fantastic service and joint development of this power solution!