AUTONNIC

Aptivolt Installation Manual

Contents

Definitions

In this manual we use some names in a specific way to describe various components of an AptiVolt A series installation. These are:

Alternator
This is any rotary generator which is intended for charging batteries at a nominal 13.5V and which is capable of delivering at least 20A.

Battery
Any electro-chemical device which stores power and which has 2 terminals at a nominal voltage in the region of 13V. It may be made of several individual cells or groups of cells in series or in parallel which some may refer to as a ***bank***. In this manual the term battery is used regardless of how it is constructed.

Chemistry
A battery may use any one of a variety of chemistries to perform the electro-chemical energy storage including lithium, nickel-iron and lead-acid of various kinds.

Mains Charger
In this manual we use the term to describe any device which produces power in the region of 12.5 to 15V and is capable of delivering 20A or more. In general, these devices will be powered by the mains or shore power. It is particularly important that the source ***is electrically isolated*** from the output.

A Series
The series is denoted by the 2nd letter in the part number so VAR20, VAS45 and VAS11 are all part of the A series. An X denotes that it will operate with any series modules.

Module Numbering
The first letter denotes an AptiVolt product.
The second letter is the Series
The third letter is the type: S source manager, R battery regulator, C communications device.

1 Installation Planning

1.1 Understanding the AptiRail™ MicroGrid

Autonnic manufactures a range of Low Voltage DC Battery Charge Management Modules under the AptiVolt® trademark. These can be connected together in a simple way to create complete, comprehensive, complex and self-managing battery charging systems supporting multiple sources and multiple batteries.

The key component in AptiVolt's charging method is the use of a microgrid and AptiVolt's particular implementation is called the AptiRail®. For all modules designed for charging, the AptiRail provides a common power access bus and the essential feature is that:

- each power source has its own Source Manager and
- each battery has its own Battery Regulator.

For extra value and convenience, Source Managers can be shared between two sources. It is the whole assembly of Managers and Regulators and the AptiRail which makes up the complete battery charging installation. A unique property of AptiVolt's solution is that AptiRail not only provides a connection for the transfer of power but that it communicates by means of its precise voltage how much power is available. The benefit is that Sources and Regulators can be assigned a Priority Level so that some sources will be used in preference to others and some batteries will be charged before others.

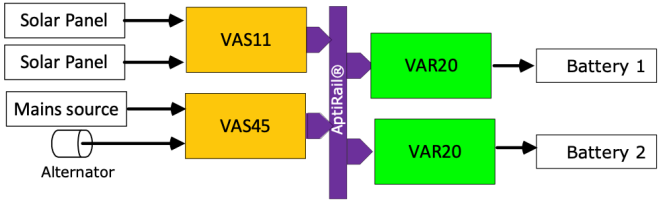

Fig 1 Overview of and AptiVolt installation

1.2 *Strategic Considerations*

The essential planning strategy is to identify all useable sources of charging power and then to identify all batteries together with an overview of where each is placed in the overall physical space.

Start with a plan of where all the parts are because only then will you be able to have a strategy for where to place each Module. For example, we show a typical mono-hull sailing boat in Fig 2.

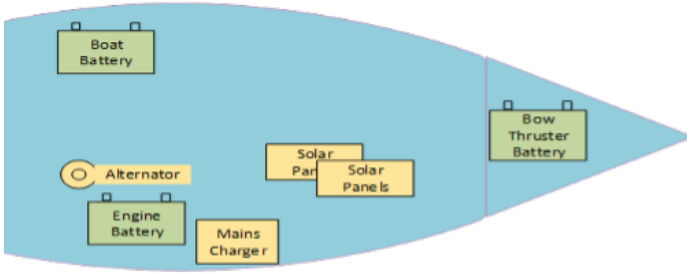

Fig 2 Typical arrangement of sources and batteries

In this boat the owner has 4 sources of power: a couple of solar panels, an engine alternator and a mains battery charger. There are also 3 batteries: Engine, boat and bow-thruster.

Looking at the data-sheet for the AptiVolt modules suggests that to meet all the needs a collection of 5 modules can be used:

1 x VAS11 for the two solar panels – it will handle up to 340W in total and conveniently it has two inputs each of 170W maximum.

1 x VAS45 which also has two inputs. One can be used for the alternator and the other for the mains charger output which is already on the boat. These modules can deliver about 270W

3 x VAR20 modules – one for each battery. These cannot be shared and each can deliver about 270W.

The next step is to plan where to place them all. The obvious thing to do would be to put all the modules together and wire the terminals to the sources and batteries – but that might not always be the most suitable. This approach is shown in Fig 3

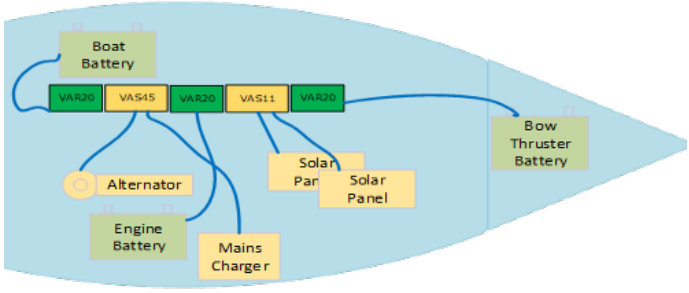

Fig 3 AptiVolt modules in one block

But it could be wired like this:

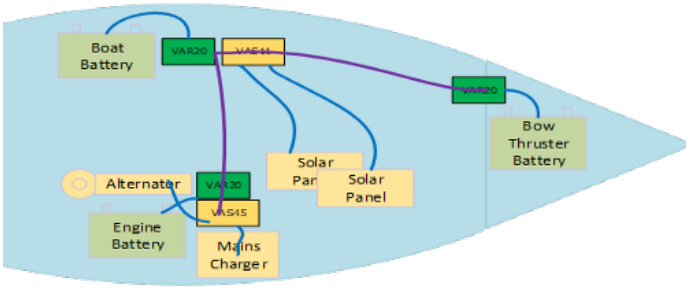

Fig 4 AptiVolt modules re-arranged

In the example shown in Fig 4, the AptiRail itself is the joining wire between the groups of modules and is shown in purple. The arrangement has resulted in a simpler installation with the temperature sensors for each of the Regulators having only a short wire directly to their battery.

The intention of the above example was to show the flexibility and adaptability of the AptiVolt system and its potential to save wire and the time to install.
But to make a final placement decision, you need to look at tactics.

1.3 Tactical Considerations

1.3.1 Priorities

The AptiVolt system includes the ability to set priorities. There are charging priorities and there are source priorities. By these means the installation can be set to meet the particular needs of the user of the whole system.

Basically a battery priority setting is to choose the order in which each battery will be charged if the amount of power available is limited. For example, the power available is up to 340W for the solar module and 270W from the alternator.

The priority setting on a VAR20 has 3 values high medium or low. It is important to note that if two VAR20s on the same AptiRail share a priority setting it is uncertain which one's battery will be charged first. A typical marine setting would be to have the VAR20 which manages the charging of the engine battery to be set to high priority, the boat battery charger set to medium and the bow-thruster or fridge battery charger set to low.

A VAS45 can also be set to any one of three levels but in this case it is about the charging priority of the VAS45 where there are two or more sharing the same AptiRail. It is important to note that this setting is for the module and is the same for both inputs – you cannot have different priorities for each of the two inputs. If you insist that the mains charger, for example, which is managed by a VAS45 is to have a lower priority to the alternator then you would need to install a separate VAS45 module. In practice the two inputs to a VAS45 are likely to be non-conflicting in that it is most probable that the engine will run when the boat is not on a marina and that the boat will be plugged into shore power only when the engine is not running.

In addition, the internal operation of the VAS45 is such that, if there are two inputs with different voltages, the higher voltage source will be used. The practical implication is that the mains charger will be likely to have a higher voltage as the alternator regulator will limit its output. In any case there is no danger.

The VAS11 allows no adjustment of its charging priority and is always at the highest setting. Even if there are several VAS11 modules they will all be at the highest level so that sunlight power will always charge the batteries whenever it is available in preference to power from the VAS45s.

1.3.2 Placing the DIN rails

Every AptiVolt module needs to be mounted on a length of DIN rail. On boats this should be of stainless steel or aluminium. The VAS11 modules require a length of 70mm and the VAR20 and VAS45 need 140mm. Always allow for another 70mm for an AptiLoop communications module to be added in later; it will make a valued contribution to the information about what is going on with your DC systems.

1.3.3 Thermal considerations

AptiVolt managers are not 100% efficient. Losses in the VAR20 and VAS45 modules amount to about 2% which at 250W can therefore be 5W each. While there is no need for a fan, provision must be made for a good flow of air. We caution that:

- Each module must be mounted vertically
- Each must have a clear air inlet path below it
- Each must have a clear air outlet path above it
- Any collection of modules should have good ventilation and not be enclosed in a box.

1.3.4 Visibility of the displays

Every module has LEDs to show it is performing as well as for setting it up at installation time. Also, the button on the front panel provides a reset feature which you might need access at any time.

Priority setting is more easily done by powering each module and setting it before installation on the AptiRail. We advise that each module is powered up, from a 12v source, and set-up using the front panel button and menu.

Note that:

A VAS11 and a VAS45 are powered from the front terminals.

A VAR20 is powered from the AptiRail input and the top terminal is +.

1.4 Ordering

Once you have done the placing plan you can order all the parts.

- In some markets kits are available which offer excellent value
- Each VAR20 comes with a VAS00 temperature sensor
- Each VAR20, VAS11 and VAS45 comes with 2 AptiRail links but you may need to order more either long ones or short ones.
- Remember to order DIN rail
- Remember to order wire to connect to the sources and the batteries.
- Do you need to order a VXC14?

2 Basic Installation

2.1 Wiring type and thickness

The power connections for AptiVolt A series modules are capable of securing wires up to 6mm^2.

In general, 4mm^2 is a good compromise and it is this wire which is used in our illustrations.

It is important to use 6mm^2 wiring where the AptiRail is extended between modules – except where this extension is solely for solar modules (eg VAS11).

We advise that each VAR20 is wired to its battery with 6mm and that this wire is no longer than 3m. 4mm wire is acceptable but it will take longer to charge.
Aptivolt provides a table of wire thickness against distance for wiring the AptiRail. If the modules are together we provide busbars.

It is important to remember that AptiRail is rated at 60A so that if there are 3 sources and 3 battery regulators all operating at peak output any wiring needs to be rated to reduce the voltage drops – see the tables.

Also the placement can help such as mixing the sources and the battery managers so that all the current does not go in one direction but can spread both ways.

But that is unlikely in a charging arrangement – for example the AptiRail extension to a bow-thruster battery's VAR20 will never be required to deliver more than 15A when charging the battery at 20A. But it should be in thick wire so as not to drop volts and alter the system's priority voltage measurements.

2.2 *Fixing the DIN rail and adding modules*

Cut the DIN rail so it is as long as the width of the modules. The wider modules are 74mm and the VAS11 is 37mm wide so the total length for this installation is in the region of 260mm.

But if you are thinking of adding more later, such as another VAR20, then its best to add that length now or consider having two shorter lengths; it all depends on the space you can allocate in your boat.

Add the modules before joining up the AptiRail. Each module has one or two DIN rail clips on the back. Hook the lower clip in first and then lift the upper clip over top of the rail. You will have to compress the springs in the lower hook to do this but once both are hooked the module becomes secure.

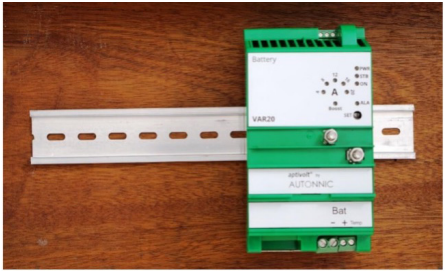

Fig 5

Fig 6

The installation begins with the DIN rail. Then the first module which can slide along the rail.
On the right is a typical block of 4 AptiVolt modules: 2 VAR20s, a VAS45 and a VAS11.

2.3 Adding AptiRail

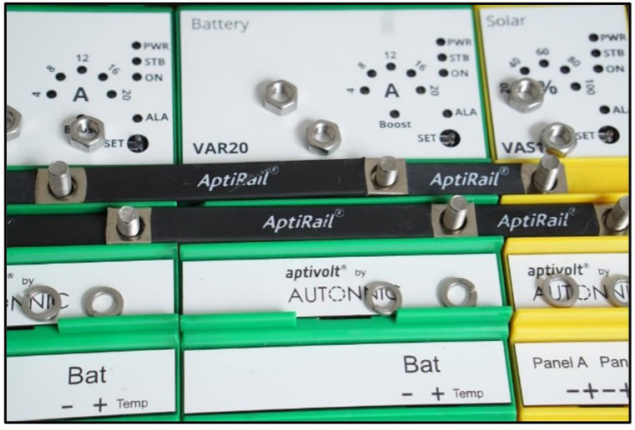

Fig 7

Now you can connect the AptiRail by fitting the busbars. 4 modules will need 3 sets of busbars. Put the outer pairs in first and then the inner pair so that the bars lie flat when two are on the same screw. The lock washers and nuts are then placed back and tightened hard. It is important that the M5 nuts are well tightened to reduce resistance.

2.4 Wiring

For the electrical installation you must ensure that all systems are off.
It is best to place all the wiring in place and then only after that is done should it be connected.
Wire up the inputs the VAS45s first and then the batteries to the VAR20s.
The inputs from the solar panel(s) to the VAS11s are best done last.

2.5 AptiLoop wiring

In any installation we advise that a wire is threaded through the AptiLoop features of each module ready for the time that a Loop Monitor might be installed. It is much easier to do this when putting in the other wiring rather than doing it later especially in a distributed placement. The ends may be joined with a separate connector or screw-terminal or the first pin of the external connector may be used as shown in Fig 8.

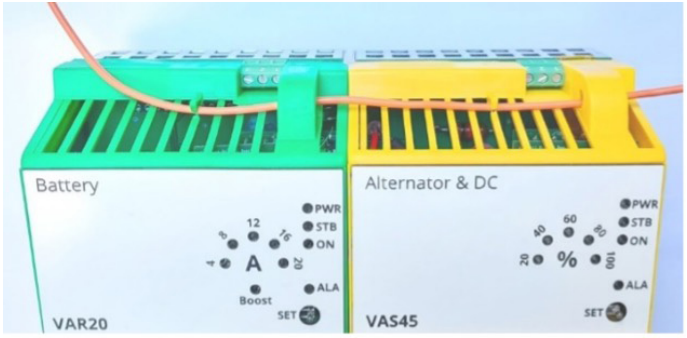

Fig 8 AptiLoop wire between modules

2.6 General Warning about Module and Alternator Protection

Alternators can be damaged by excess voltage. This can happen when an alternator is delivering current and then the load is suddenly disconnected. The AptiVolt system may do that and includes some overvoltage protection within each VAS45. The alternator inductance can create a voltage large enough to damage its own internal diodes. To prevent this we advocate strongly the fitting of a diode between an alternator and one of the batteries. This would often be the engine battery as it is likely to be near the engine. The use of blocking diodes also allows the system to charge at greater rates of charge if the alternator is able to deliver it.

Module protection should always be provided by inserting switches or MCBs of 30A rating in the wires to the batteries.

3 Connecting VAR20 and VAS11 modules

3.1 Batteries

Now that the sources are wired to the VAS45 and all the modules are connected by the AptiRail a battery can be connected.

We recommend that the wires are first connected to the VAR20 and then connected to the battery. This way you do not have live wires unconnected near the modules. First connect the -ve and then the +ve.

The +ve line should always be connected with a fuse or circuit-breaker (30A). Often there will be a spare circuit-breaker on the boats panel but it must be on the battery side. We do not recommend a circuit breaker in the alternator wire.

In any case DO NOT turn off the isolator when the alternator is running.

This way, an accidental turning off does not suddenly unload an alternator which might cause the alternator and the AptiVolt modules some problems – although we have installed a measure of protection it is best not rely on this.

Now connect the 2nd battery – again connect the VAR20 first and then go to complete the circuit at the battery – with a fuse or circuit-breaker.

If you are using the temperature sensors then connect them first, too.

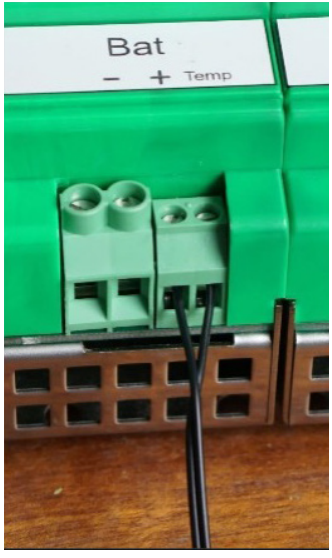

Fig 9

Each VAR20 is capable of using a battery temperature probe to modulate its output voltage according to the needs of the selected battery chemistry. Each VAR20 is supplied with the VAS00 sensor. If you do not fit it the module will use a value of battery temperature of 25°C for its charging algorithms but there is a disadvantage: the battery is likely to be under-charged in cold weather.

The wire may be extended and for this you do not need thick wire – any wire will do but take care not to connect any part of the wire to anything else. The two wires are not polarised as it uses resistive sensing.

3.2 Testing

Now that a battery is connected you can test the system by applying power. The best source to use is the mains battery charger which can be easily turned on and off. So if your boat has mains available turn on the charger, which you will have connected to one of the inputs of the VAS45, and see that the VAS45 lights operate and that the VAR20s are also operating.

3.3 Solar

Finally connect the solar panels. It is preferable to wire panel power equally between the two inputs. In any case the maximum current is 10A on each input so beyond 165W you have no choice as that is the maximum power each input will handle (the panels are operated at close to their Maximum Power Point of around 16.5V).

The wiring of the VAS11 is more tolerant of lead length and wire thickness. It will depend on the size of the panels. If you are installing 100W or more then use $4mm^2$ wire. It also may be more convenient to mount the VAS11 in a place you can see it so as to observe more readily how the panels are charging. In this case the AptiRail is a wire connection between the M5 terminals on the VAS11 and its equivalent ones on the other modules. We recommend using $4mm^2$ wire and fork M5 crimp terminals on the ends of the wire.

3.4 External Logic Input and Output

AptiVolt modules have a connector at the top shown in Fig 10.

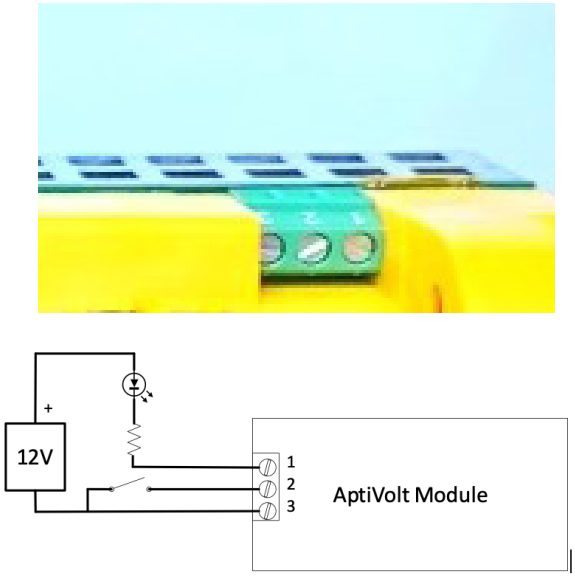

Fig 10

The function of these 3 connections is as follows:

1 - Ground. This is the same as battery 0V and the -ve AptiRail bus.

2 - This is a logic input. It is held at about 1V and its function is to shut down the module if joined to Ground; this should always be done by connecting it to pin 1 and not any other Ground. This can be by a computer output or by a switch.

Close the switch to turn the module off.

3 - Logic Output. This connection is connected to Ground when the module is working. If the module is in standby or fault-mode this output is open. It can be connected to a computer input or an LED indicator. It must not be connected to voltage greater than 24V and must not be allowed to sink a current of more than 50mA. The LED is on when the module is on.

4 Connecting the VAS45 module

4.1 *Existing Conditions*

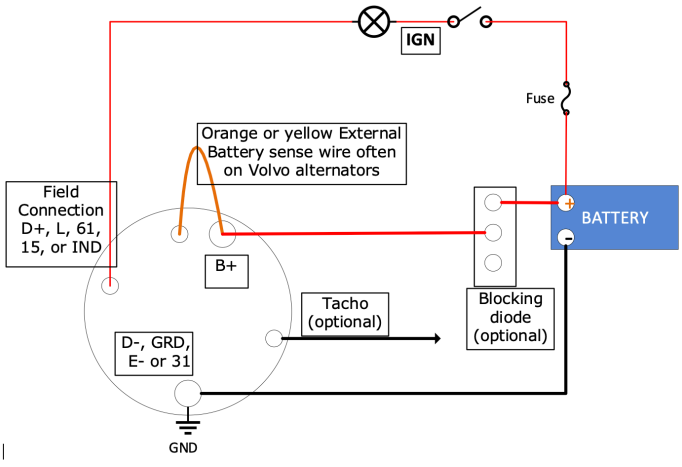

Fig 11 shows a common installation before an AptiVolt system is added.

It will include all the wiring to connect an alternator to the engine battery and the diagram shows the placement of a Blocking Diode if one is fitted. The figure also shows the auxiliary wiring to power the alternator Field. It is commond not to include any disconnection switch which, if operated under load, would cause a voltage spike capable of damaging the alternator. The presence of a Blocking Diode is an excellent way to avoid this potential source of damage.

Fig 11 Common Engine Alternator Wiring to a single battery

4.2 *Adding the VAS45*

Fig 12 shows the recommended wiring to add the VAS45 and the details of each component are in the following sections.

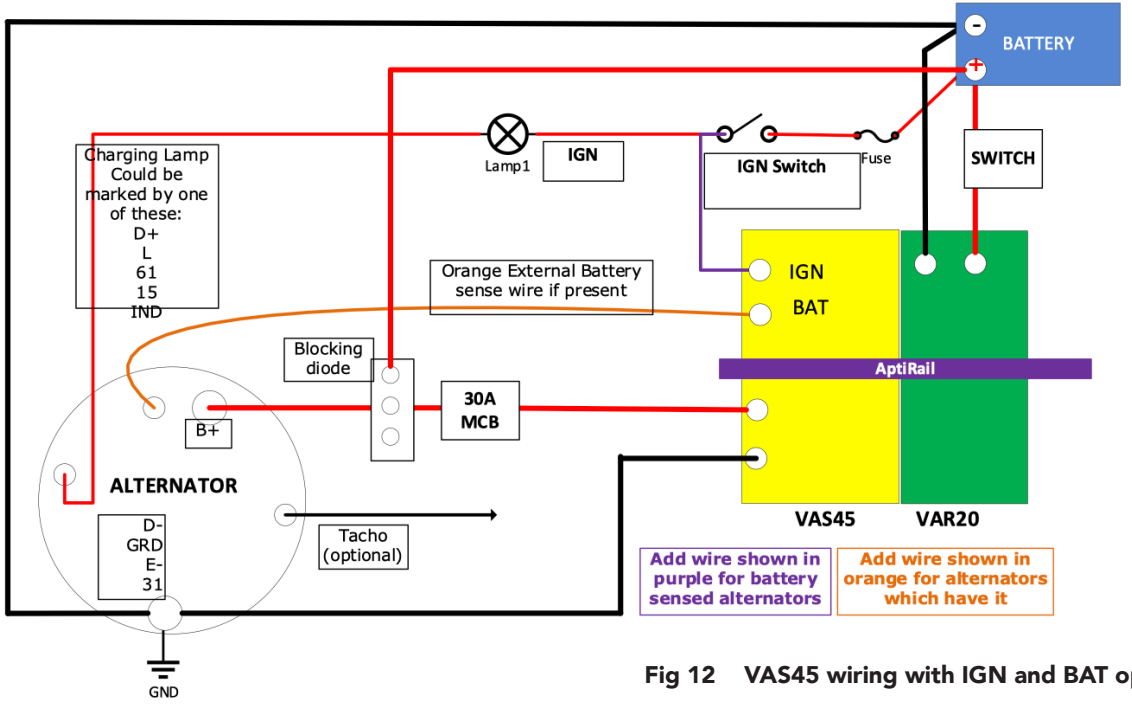

Fig 12 VAS45 wiring with IGN and BAT options

4.2.1 Power Wiring

A new charging wire to the VAS45 is taken best taken from either the output terminal of the alternator or else from its connection to the blocking diode. It will depend on which wiring is shortest. It is best to use the shortest wire path.

The negative side should run directly to the ground terminal of the alternator.

4.2.2 Auxiliary wiring

In some cases, the alternator will require additional wiring so that it operates correctly. It will already have the field wiring installed but some alternators will not produce power unless they can detect the presence of a battery. Such alternators require the addition of the purple wire shown in Fig 11. Others may also need the wiring shown in Orange. If those connections exist before AptiVolt is fitted then Fig 12 shows how to maintain the signals when AptiVolt is added.

4.2.3 Additional details

There will be a + output from the alternator which will go the lead which will be terminated in the + input of a VAS45. The -ve output is often the chassis of the alternator and you will need to identify it and secure the lead for -ve to it. Then connect these leads to the corresponding VAS45 inputs.

For example, if the alternator is to be input A then both leads need to go the A terminals with particular care to get the + to + and – to -.Most boats will already have a mains battery charger. The output of this can be wired to the other input of the VAS45. Again, it is important that it is off and that the polarity is strictly maintained.

As before we strongly advise that the wire is put into the boat before being connected.

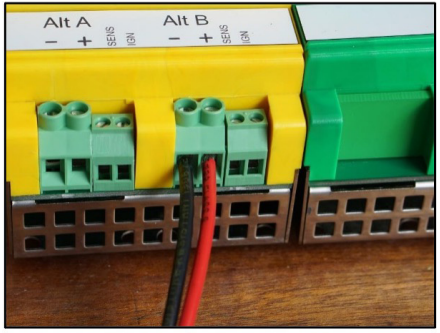

Fig 13

4.2.4 Mains sources

Each VAS45 has two inputs which could each be used for an alternator but it is likely that one will be for an alternator and the other for a mains-derived source of power. This would typically be the battery charger which is already on board. It may work without other wiring. It may need a link to a battery if it is a charger which requires a battery to be connected. The other terminals (BAT and IGN) are there to help this just as for alternators.

Any source connected to the VAS45 should be capable of delivering at least 20A.

5 Module Settings

5.1 Basic Settings

Manual settings can be made using the key shown in Fig 14 in reference to the State Diagrams shown in Figs 17, 18 and 19.

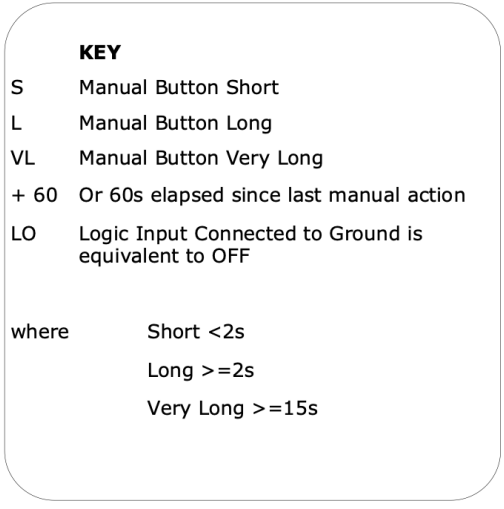

Fig 14

All Autonnic modules in the AptiVolt range have operational interaction. In general interaction is needed only for:

Initial set-up
Fault clearance

Each module has options which can be set using the front-panel button in the lower right-hand corner of the display. The display will change so as to assist the set-up.

During operation a fault might occur. This is likely to be due to overheating or over current.

The modules should be in a well-ventilated place. But sometimes this can be heated by poor placement near the engine or where sunlight can heat them. Each module monitors its own current and its own temperature and will shut down if safe values are exceeded.

Each module has a common normal operation set of LEDs:

1 Power on – green
2 Running – yellow
3 Heartbeat – flashing blue
4 Fault – red

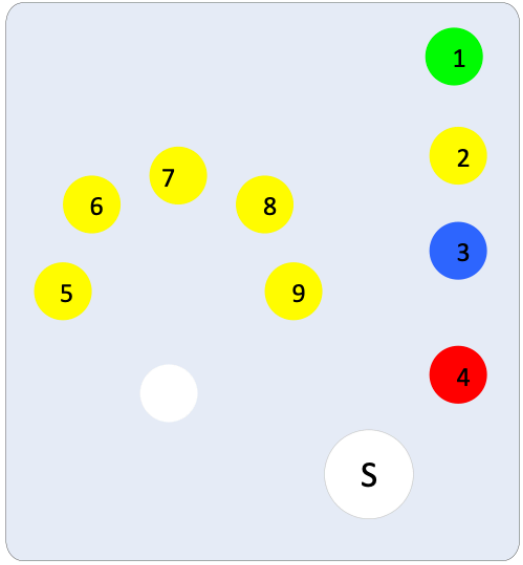

Fig 15 VAS45 and VAS11 panels where S is the switch

In addition, each has a set of 5 LEDs, shown as 5 to 9, which indicate the amount of current the module is handling. In the case of the VAS11 and VAS45 this is expressed as % of full rating.

For the VAR20 the LEDs show the current in Amps and it has an additional LED to show if it is in Boost Charge mode.

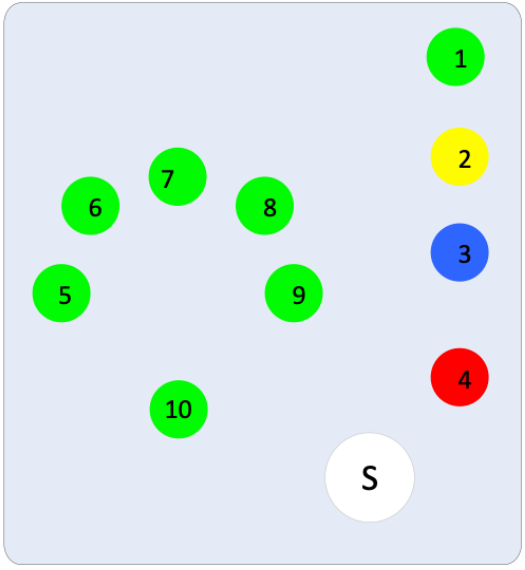

Fig 16 VAR20 panel

The 5 LEDs are brightness modulated to allow interpretation of currents in a continuous manner. The intention is that a glance at the panels will show which battery is being charged and by how much and where that power is coming from.

The state diagrams show the options which can be set using the display and button. Also shown are the effects of the internal fault flag and the operation of the Logic Input - see section 3.4.

5.2 VAS11

We suggest that you use the power setting on the VAS11 which is just below the output of the installed panels. In this way the panel power is most highly resolved on the LEDs. We recommend using the 80W setting if you have 80W or less and 120W for between 80W and 120W and the 240W setting for anything higher than 120W.

When power is applied (the sun shines!) it will go to the normal operation state and stay there. A fault will set the Fault flag, show the Red LED and stop the heartbeat. For set-up you may connect a 12V source to the panel terminals. This may be done while the panel is still connected.

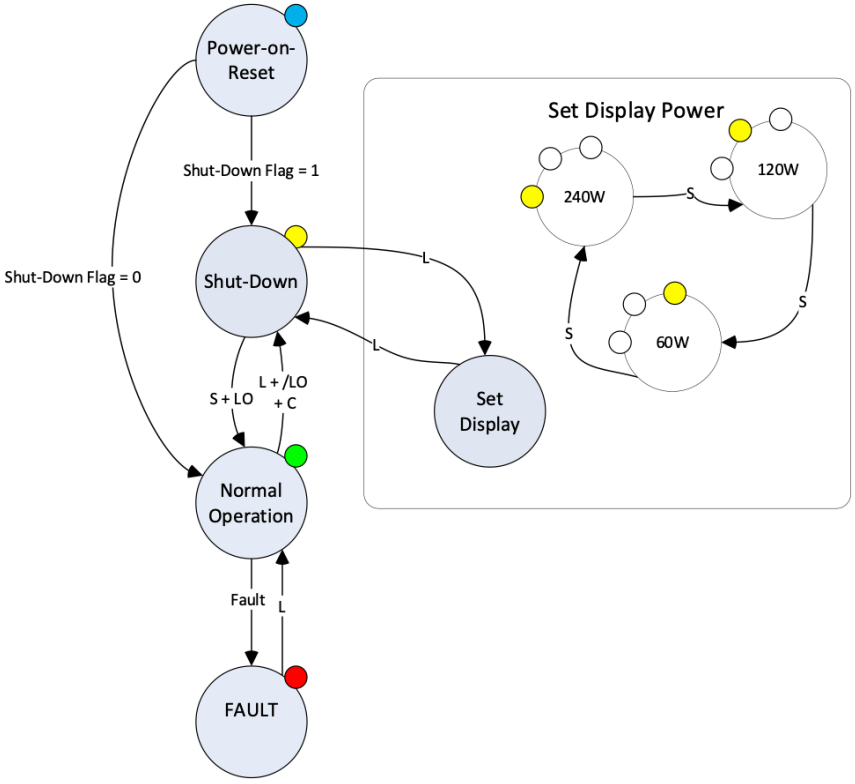

Fig 17 VAS11 State Diagram

5.3 VAR45

The setting of a VAS45 is more easily done using a mains charger source. Set up the priority as high. The VAS11 is always the highest and keeping the VAS45 on a high setting means its output voltage will be lower which is slightly preferable. This changes when you have more than one VAS45 where you need to choose which is to be preferred.

If there is an AptiRail extension from the VAS45 to the VAR20(s) not only should this be done in 6mm^2 wire, but the VAS45 output should be set to the highest priority.

The basic set-up is of the Priority.

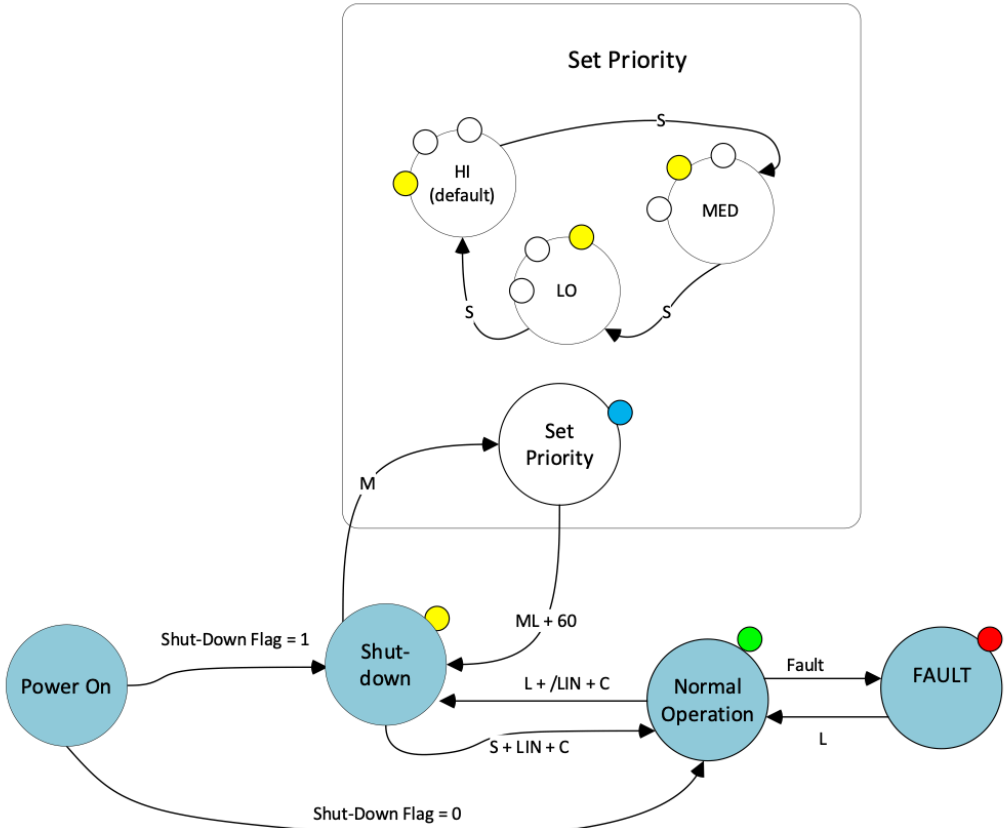

Fig 18 VAS45 State Diagram

5.4 VAR20

The priorities are how you are using the batteries; most common choices are high for the engine battery and medium for the boat battery. Low can be for the fridge battery or the bow-thruster VAR20s.

The chemistry settings will need to correspond to the battery type. The default is for Gel Lead-Acid and High Priority.

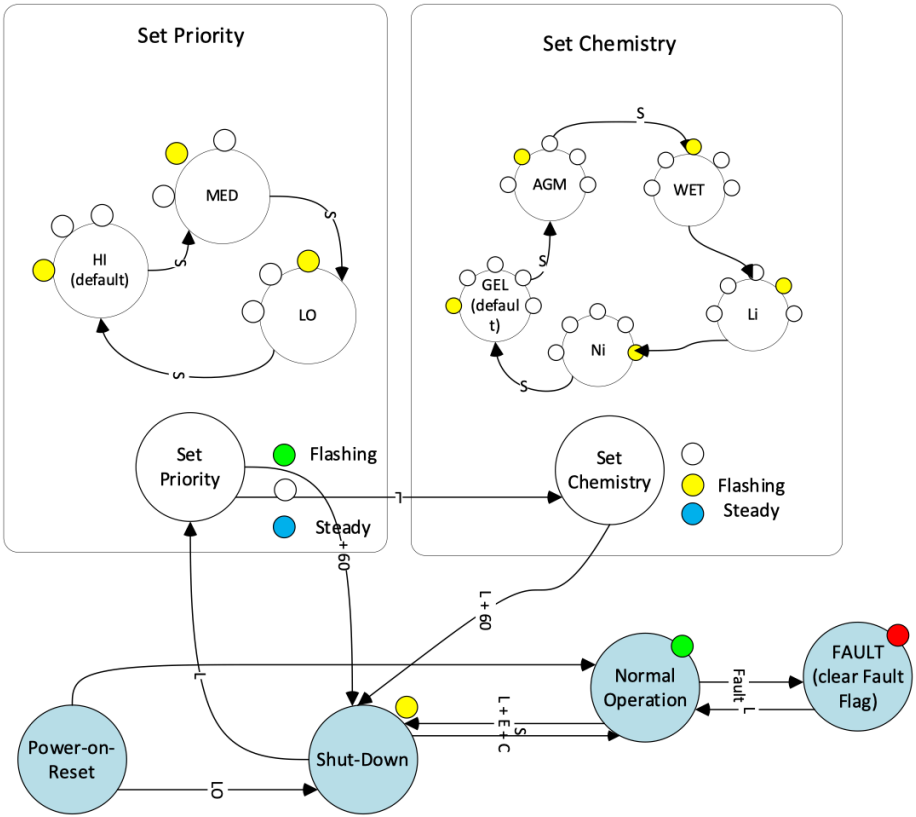

Fig 19 VAR20 State Diagram

The table below, in Fig 20, shows the battery chemistry setting values against the setting number represented by the LED position during the set-up process. All values are for operation at 25°C which the VAR20 will use in the absence of a temperature probe. If the VAR20 detects that a probe is connected it will use the sensed value and modify the table at the rate of approximately -10mV/°C .

	Chemistry	Boost	Standby	Restart
1	GEL Lead-Acid	14.0	13.6	12.5
2	AGM Lead-Acid	14.7	13.7	12.5
3	Wet Lead-Acid	14.2	13.6	12.5
4	Lithium Ion	14.5	13.6	12.0
5	Nickel (Fe or Cd)	13.6	13.0	12.8

Fig 20 Chemistry voltage settings

6 AptiLoop

6.1 What it is

The AptiVolt range includes communications. We have invented a special inductive loop serial network with its own protocol for easy installation and called it AptiLoop. It is for use with different systems that are not electrically connected.

This isolation is especially important in power systems which cannot share an electrical connection. It also allows for communication with powered units which are sealed and water-proof; this will allow it to be used in future applications beyond AptiVolt battery management systems.

By using this communications, individual modules or a group of modules can be set up and monitored with a computer or tablet or phone. The modules do not have to be on the same AptiRail.

The AptiLoop protocol is built into each module and the VXC14 is an interface between AptiLoop and USB.

6.2 How it works

Each module contains an inductive core and so does the VXC14. A wire – it can any wire – is threaded through the two (or more) cores and the ends are connected together form a loop of conducting wire as shown in Fig 8. Current is induced in this wire and so generates a voltage in each of the cores which effectively joins all the modules together.

If any module transmits by generating current in the wire all the other modules can receive the information. Only one can drive the loop so it is a 'simplex' system. Before it can be used with more than one module each must to be given a separate loop address (see section 6.3 'APS') and this is done at the factory with the following standard settings:

VAR20 1-4
VAS11 5
VAS45 6

6.3 The commands

This section is a summary of what is available.

APA is about setting up each module to transmit data continuously or not and what kind of data it will send. It is excellent to monitor a single module to be able to explore all that it is doing internally.

APE can enable a module or else shut it down.

AFE is a request for a fault code if the module is in the fault state.

API is a request for information about the module itself. The reply includes its revision and serial number.

APQ requests that the module sends all its electrical information such as input and output currents and voltages.

APS is a command to set the AptiLoop address of the module as each module must have a unique address within the range 1 to 9.
Address 0 is a wild address and any module on the AptiLoop will respond so no module in the same loop as others can have this address. It is used to modify a single module and so is ideal for setting up a module which either has not been given an address or for which the address is unknown. By addressing it as '0' it will respond and this is done by threading the loop just between it and the VXC14.

6.4 Module responses

These are fully detailed in the Document 'Aptivolt Interface Protocol' which is available either by email from Autonnic or can be downloaded from the AptiVolt page on the Autonnic.com website.

6.5 Using the VXC14

Each module can initially be addressed by placing the AptiLoop wire just between the VXC14 and the module to be set up. Here is a summary of the use of the commands and the full details are in the Protocol document.

The module details are requested with API,0 where the 0 is used because the address might not be known. The module will respond with its address, type, serial number

and hardware and software revisions.

It is important to give the module the address you want it to have before placing it in a AptiLoop with other modules. And also it is important that it does not transmit spontaneously. The APA command can set a module to transmit it's data continuously which is good to have for monitoring but no control can be taken over the AptiLoop while this is going on. The command APA,0,0 will stop this continuous transmission and APA,0,3 will start it.

Where a computer is assigned to monitor all modules in a loop it can be programmed to find out which modules are present by requesting module information with the API command going from 1 to 9. From this list of modules the computer can then request operating data using the APQ,n command where n is one of the modules discovered using the API command. Each can be requested for it's data in turn and a typical data set returned will include input voltage, input current, output voltage, output current, temperature and so on.

The computer then has a constantly maintained table of all the parameters for all modules connected to the AptiLoop.

7 Product Liability And Safety Warnings

PRODUCT LIABILITY

Autonnic Research Limited accept no responsibility for the use and/or operation of this equipment. It is the user's responsibility to ensure that under all circumstances the equipment is used for the purposes for which it has been designed.

WARNING - ELECTRICAL HAZARD

This equipment uses high current electrical power. Connections with high current may get hot if operated outside the specifications and/or not made properly. All connections must be fitted with means of the appropriate rating to disconnect.

WARNING - NAVIGATION HAZARD

The AptiVolt Battery Management System is designed to assist in maintaining the batteries in your yacht. It is not designed to totally replace conventional seamanship procedures and precautions and all necessary precautions should be taken to ensure that the vessel is not placed into danger.

CAUTION

The A series equipment is designed for use with 12V DC power systems only. The connection of any power source not intended for 12V use may result in permanent damage to the equipment and endanger the vessel.

LITHIUM BATTERIES

If you are using Lithium batteries make sure that you have chosen the appropriate battery setting.

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AptiVolt Manual A series May 23 - Version 3