VSR ALTERNATOR REGULATOR

AN OPEN SOURCE INTELLIGENT ALTERNATOR REGULATOR

Quick Start Guide

v1.3.1 July 22, 2018

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This short guide is intended to help assist in the quick and simple installation of the 3rd generator VSR Alternator Regulator. This advanced regulator has all the options to keep your battery in optimum condition during normal charging and offers the option to equalize the batteries. Temperature sensors and current monitoring will ensure that your alternator can safely handle the higher currents required for equalizing. Please make sure to refer to the `VSR Alternator Regulator Reference Guide' for more details and installation examples beyond those shown here, as well as guidance for prior generation alternator regulators.

One critical decision when installing the VSR Alternator Regulator is how many wires to hook up. In its simplest form only 4 wires and a few jumpers are needed. However adding additional sensing capability will enable features and allow the regulator to provide for the most efficient and safe charging of your battery.

There are two variants of the VSR Alternator Regulator, one which is capable of support 12v or 24v batteries, while the other is able to support 12v, 24v, or 48v batteries. Take care not to exceed maximum voltages for the version you have. For each regulator, battery voltages of 12v, 24v, (and 48v, if supported) will automatically be detected and the regulator will make needed adjustments., They are however also able to support voltages other then these common ones. (Such as 32v). . To enable other battery voltages (e.g. 32V), please refer to the ` VSR Alternator Regulator Reference Guide' for instruction.

REGULATOR INSTALLATION

The regulator is a very versatile device with several installation options depending on your goals and objectives. Following is an overview of how to connect and configure the regulator in commonly found situations, from simple to more capable and reliable integrated systems. Additional examples may be found in the `VSR Alternator Regulator Reference Guide'.

In its simplest form only the Enable, Alt+, Alt- and Field need to be connected and the regulator will behave as many voltage-only regulators, albeit with a high level of precision. Adding additional sensing options will unlock additional capabilities, up to and including a fully integrated systems deployment.

REGULATOR PLACEMENT

Place the VSR Regulator near the alternator keeping the Alt+, Alt- and Field wires as short as reasonably practical. Take into consideration ambient temperature as well as any potential for water splashing and consider augmenting the case as needed. The VSR Alternator Regulator is very efficient and does not need much cooling beyond what is typically found in engine room compartments, but that is not to say one should test its limits!

CAUTIONARY NOTE: OVERSTRESSING SMALL-FRAME ALTERNATORS

The most common alternator found will be a small frame unit, especially if it is the OEM alternator on an engine. These alternators are good reliable units, but may not be up to the demands of delivering large amounts of current over a long period of time. Overstressing alternators can result in damage from burnt out diodes and/or internal heat stress related damage and failures. Such stress conditions are exacerbated by high acceptance battery banks like Lithium, AGM/GEL, or large capacity standard wet-cell FLA batteries.

The best way to protect a small-frame alternator is to install an alternator temperature sensor, ideally located near or on the diode pack. This will allow the VSR Alternator Regulator to monitor the alternator and reduce output as its safe

temperature limit is approached. In addition it is recommended to select ‘Small-Alt Mode’ via DIP switch to provide an overall capping of alternator loading. After some run time experience you can consider turning off Small-Alt Mode and see if the alternator is able to handle your specific installation.

CONNECTIONS

The following illustrates connection terminals on the regulator. See the following table for a description of each connection as well as suggested minimum wire size.

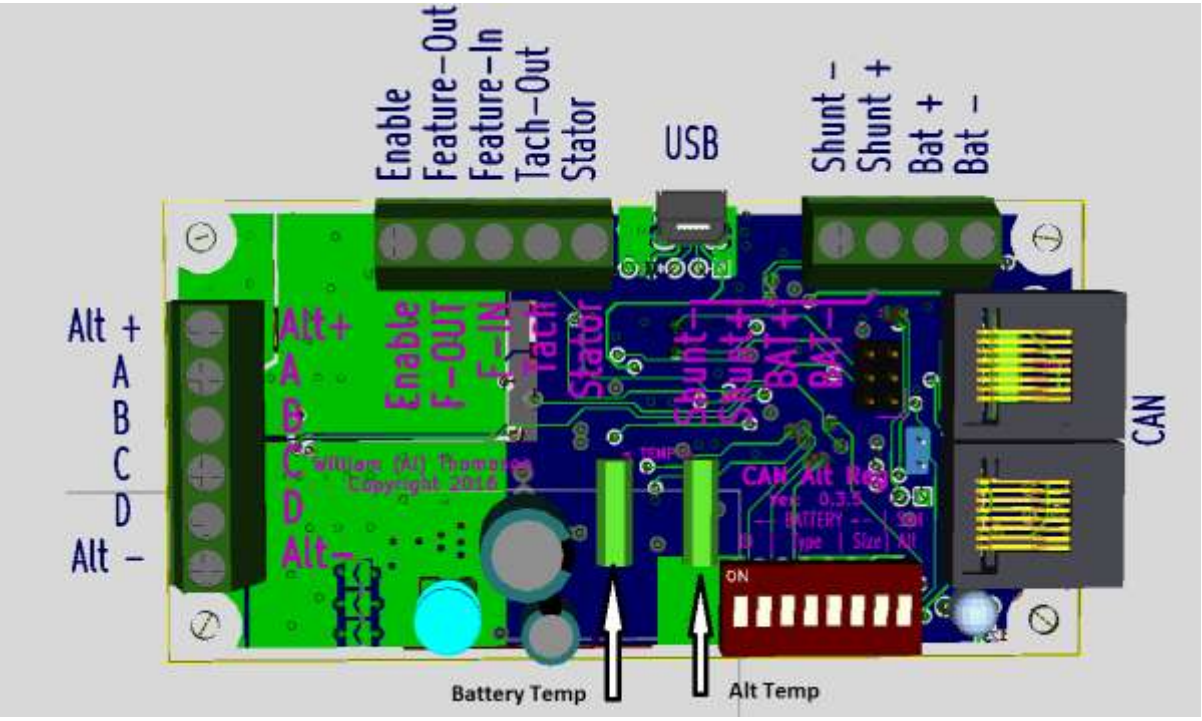

Figure 1: 3rd Generation VSR connections

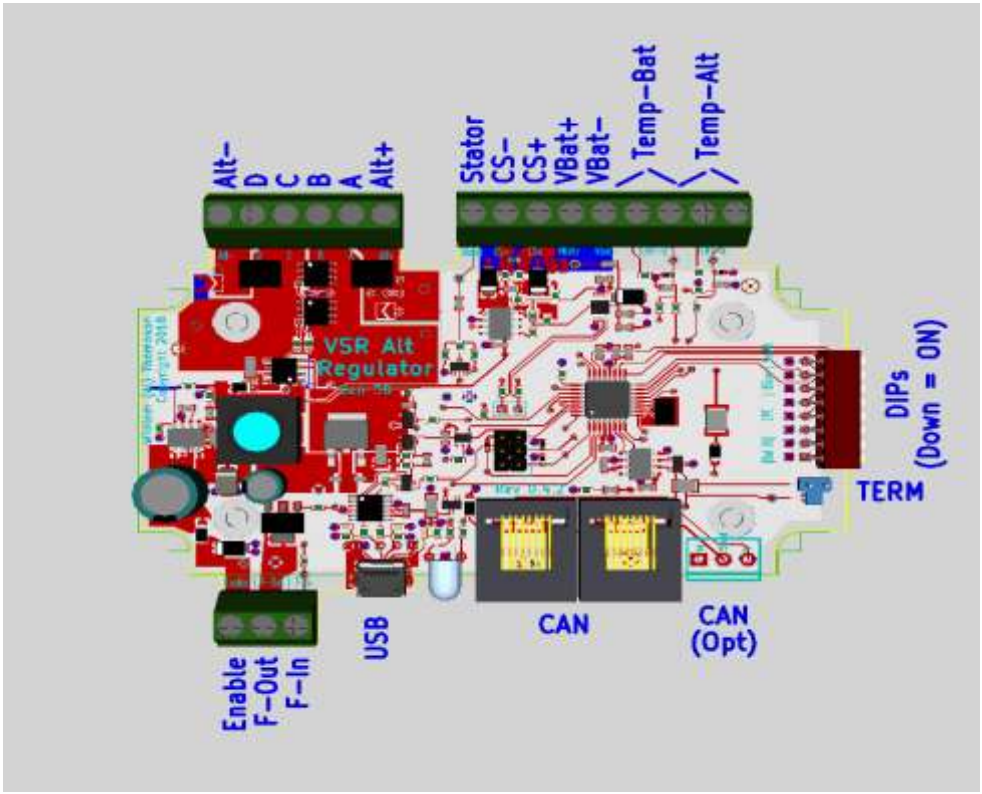

Figure 2: 3rd Generation VSR connections (Ver 3B)

Bat+, Bat - Connected ***directly*** to the battery via 14AWG wire protected with a 2A fuse located at the battery. (Do not connect after any busses, shunts, etc..)

Alternatively, on Gen 3 regulators, these may be connected locally to the alternator if the regulator will remotely receive battery voltage via the CAN bus. Refer to "Example 3: Basic System Installation (Utilizing remote battery sensor)" on page 10

Enable: Connect to Bat+ to turn on the regulator. Most common connection point is the 'On' wire from a key switch, or perhaps connected through an Oil pressure switch. Use min 14AWG wire and a 2A fuse.

Current Shunt + ,
Current Shunt -: (Optional) If a current shunt is used to monitor battery condition connect these wires with min 16AWG twisted pair wires to the shunt. The current shunt maybe installed in either the ground wire (low shunt), or in the + voltage wire (high shunt). Do not exceed 80mV difference between CS+ and CS-, nor connect to a shunt more than 65V above ground. If a current shunt is not being used, it is suggested to place a wire between these two terminals to avoid any electrical noise confusing the regulator.

Feature In: (Optional) Connect to Bat+ (6-72v) to enable certain features

Feature Out: (Optional) Connect to a light at the dash to indicate that the alternator is charging, 0.5A *max* current. See Source Code to enable other optional capabilities.

Alternator +: Connect to + (Bat) terminal of Alternator. Use wire sized to match your expected maximum field current draw and protect with an appropriate fuse, typically 10-15A, depending on alternator size. Min 14AWG – use 12AWG or 10AWG for large frame alternators.

Alternator -: Connect to the – (gnd) terminal of the alternator using appropriate wire. (minimum 14AWG)

Stator (Optional) Connect to an alternator stator pole (often used to drive external Tachometers) via a 2A fuse and 16AWG (or larger) wire. Connection allows for increased battery voltage measurement accuracy, as well as enable several battery and alternator protection features in the regulator.

A, B, C, D: Connect to the field per the following table depending on the configuration of your alternator:

	Jumper	Alternator Field
High Drive (P / B-type)	**A - B**	**Field to C**
Low Drive (N / A-type)	**C - D**	**Field to B**

Use wire of sufficient gauge to carry the expected current.
Up to 32A (connector limited) (Min 14AWG).

Bat Temp,
Alt Temp: (Optional) Appropriate NTC temperature sender.
Note that Alt Temp may be OPTIONALLY shorted to enable half-power mode.

Service / USB: Used to initialize and debug the regulator. Generation 3 and greater contain a built in USB connector while Generation 2 requires the use of an external USB ← → TTL adapter.

CAN: Allows communication with the regulator via NMEA-2000 and/or OSEnergy protocols. Provides for remote sensing of battery and charger coordination/prioritization with other OSEnergy compliant devices. Utilize CAT-5 cables if regulator is fitted with RJ-45 connectors, otherwise use 120 Ohm twisted pair wire to the CAN terminal block.

EXAMPLE 1: BASIC INSTALLATION (MOST COMMON SINGLE ENGINE INSTALLATION)

This is the recommended basic installation of the VSR Alternator Regulator. With this configuration the regulator monitors a current shunt located at the battery as well as battery temperature and voltage to allow for accurate and safe charging. By sensing the amp shunt at the battery the VSR Alternator Regulator is able to account for all other charging sources, as well as potential house loads, when making decisions about charge state transitions in order to give a true indication of the battery's needs. Alternator temperature sensing protects the alternator from overheating/overstressing.

Install the battery voltage sensing wires (Battery+ and Battery -) DIRECTLY to the battery! Do not attach the wires after a battery switch, dual alternator diode separator, the Battery Amp Shunt, or a common 'bus bar'. Instead connect directly to the batteries for best results.

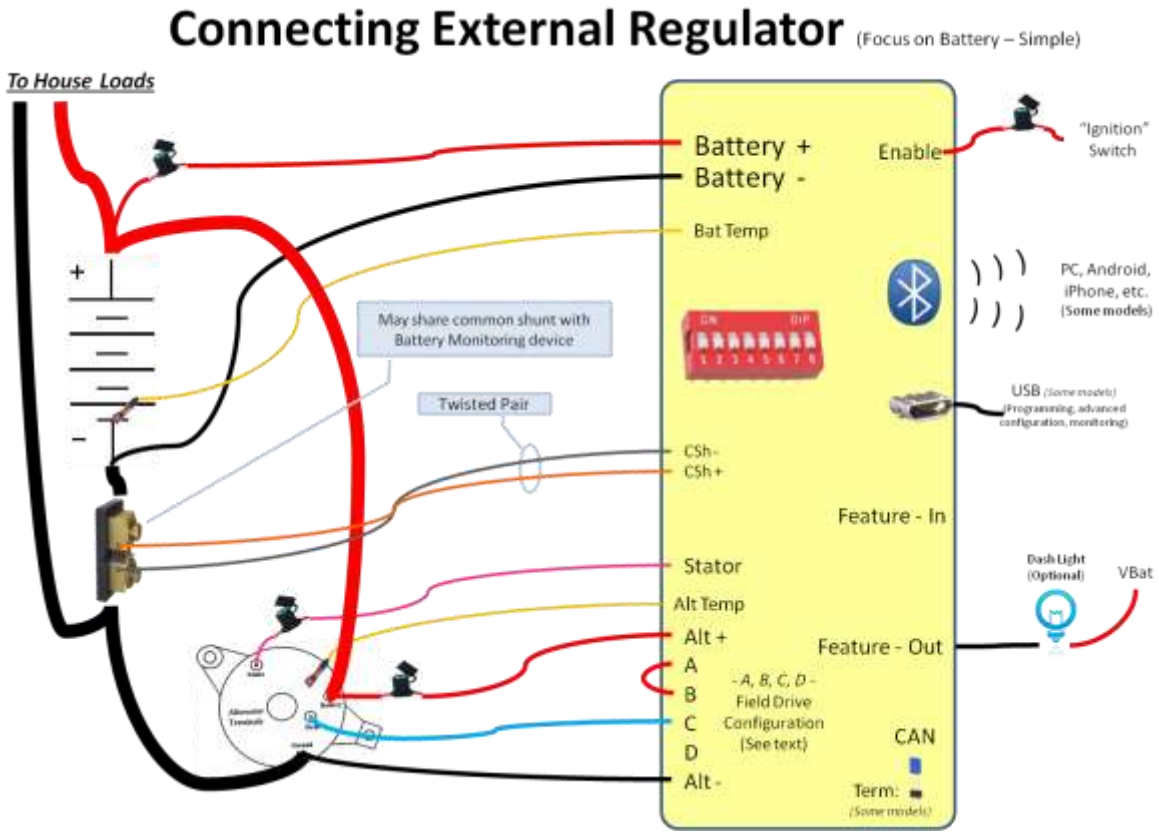

Figure 3 - Basic install for P or High Drive alternators and shunt in negative of battery cable

The shunt may be located on either the ground side of the battery as shown above or positive side of the battery as shown on the next page. It is suggested to use twisted pairs of wires from the shunt to the regulator. If you already have a shunt installed (perhaps for an Amp meter, or an existing battery monitor system) there is no need to install a 2nd shunt, just use the one already in place – the VSR Alternator Regulator is able to share existing shunts. By default, the regulator is calibrated for a 500A/50mV shunt (commonly used on battery monitors); if your shunt has a different rating adjust the system configuration using the $SCV command (Refer to the 'VSR Alternator Regulator Reference Guide). Any shunt may be used as long as the maximum sensing voltage does not exceed 80mV.

SHUNT HIGH VS. LOW:

If the shunt is located in the positive size, connect the shunt leads as shown here:

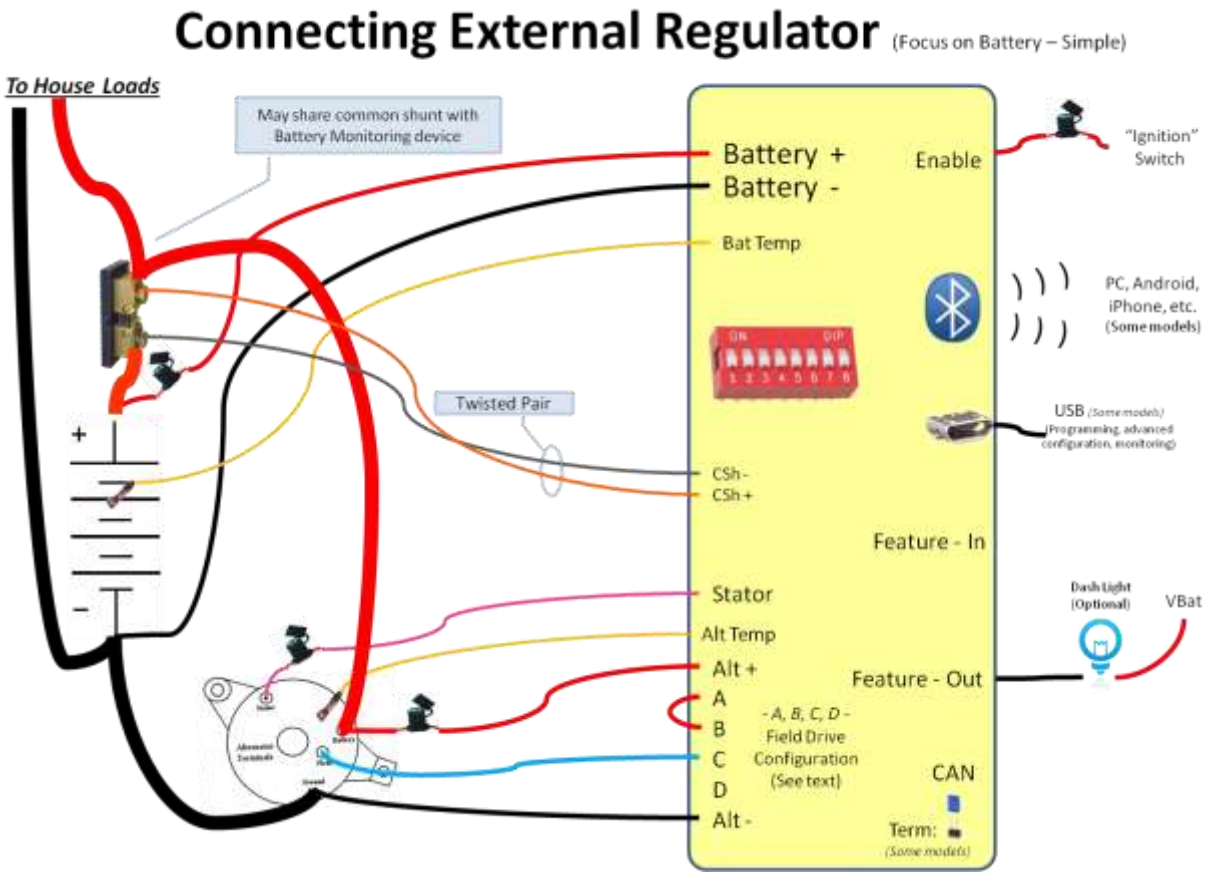

Figure 4 - Basic install for P or High Drive alternators and shunt in positive of battery cable

P VS. N TYPE ALTERNATORS:

If you have a N or Low-Drive alternator, use this diagram as an example. Note the changes to A, B, C and D vs. Figure 3 above.

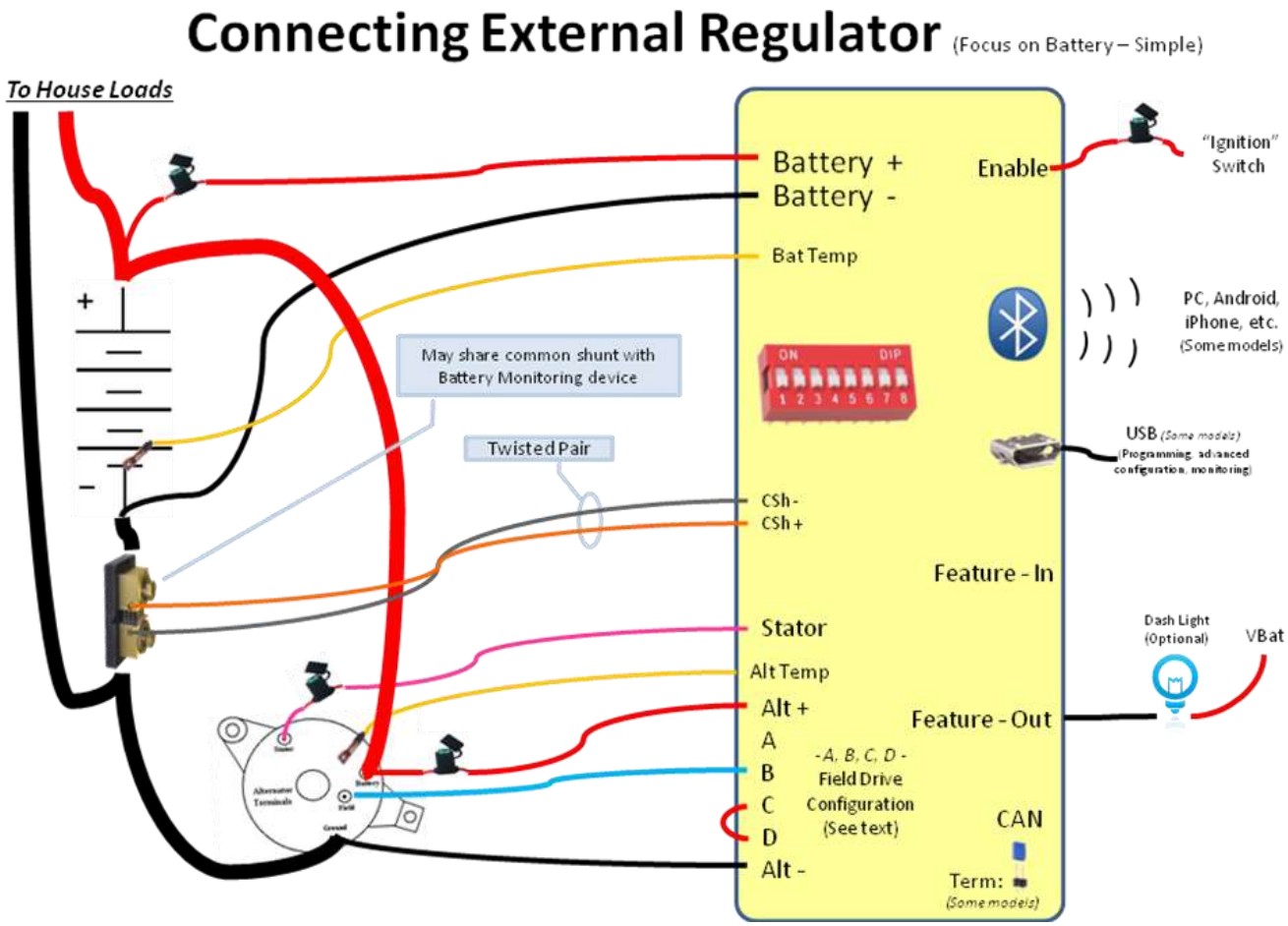

Figure 5 - Basic install for N or Low Drive alternators and shunt in negative of battery cable

EXAMPLE 2: TWIN ENGINE INSTALLATION

It is common for many marine applications to have two engines, each with an alternator to charge the batteries. In this case, simply install a regulator on each engine as you would for a single engine installation. Configure the two regulators the same and connect the Enable wire to each respective engine. You may share the same battery current shunt between both regulators. It is best if each regulator has its own Battery + and Battery – sensing wires, and the temperature sensors *cannot* be shared, each will need its own.

Connect a common CAT-5 cable between the two regulators allowing them to communicate and coordinate their charging: balancing the loads between the two engines and working towards the same charging goals as opposed to fighting each other.

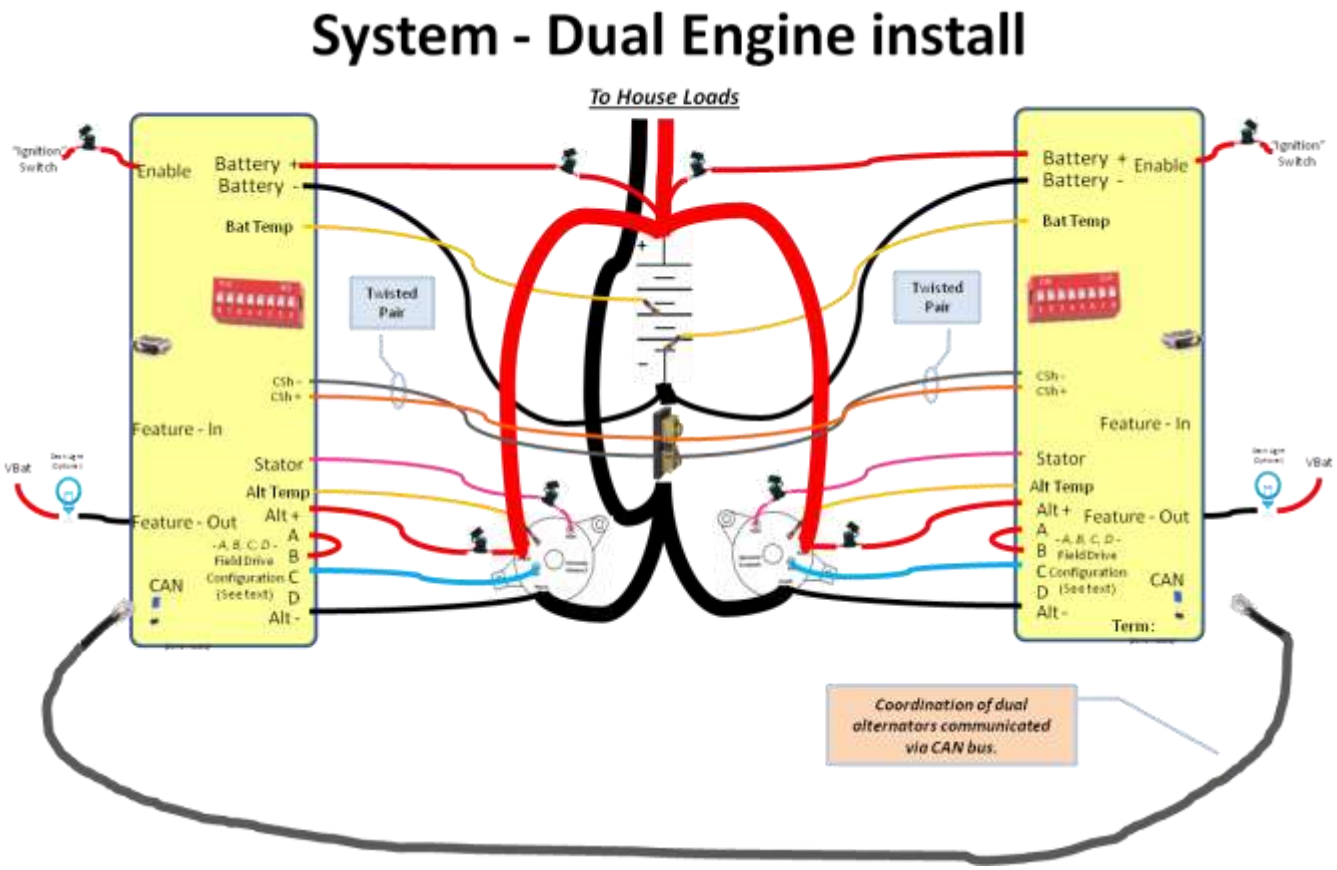

Figure 6 - Duel engine install

EXAMPLE 3: BASIC SYSTEM INSTALLATION (UTILIZING REMOTE BATTERY SENSOR)

When installing the VSR Alternator Regulator in a 'system' one of the benefits is simplified wiring. Rather than routing individual sensing wires to the battery for voltage, current, and temperature, that information may be delivered over the CAT-5 communications cable using a technique of remote-instrumentation.

Remote-instrumentation is a very reliable and long used method for reducing the wiring needs in many industrial and transportation applications. By having a device located at the battery sensing the voltage/current/temperature of the battery, the wiring burden is reduced to one cable as opposed to several discrete wires. If the installation has more than one charging source (say, twin engines, or an alternator and solar) this reduced wiring benefit becomes even greater.

To take advantage of remote-instrumentation you will first need an OSEnergy compliant monitoring device at the battery which senses battery voltage/current/temperature. Then when installing the VSR Alternator Regulator, you only need to connect sensing wires locally to the alternator saving long wires back to the battery.

At minimum, you need to connect the Bat + and bat – wires to the local alternator + and – output. Adding Alternator Temperature sensing and stator sampling allows the VSR Alternator Regulator to fully protect your alternator.

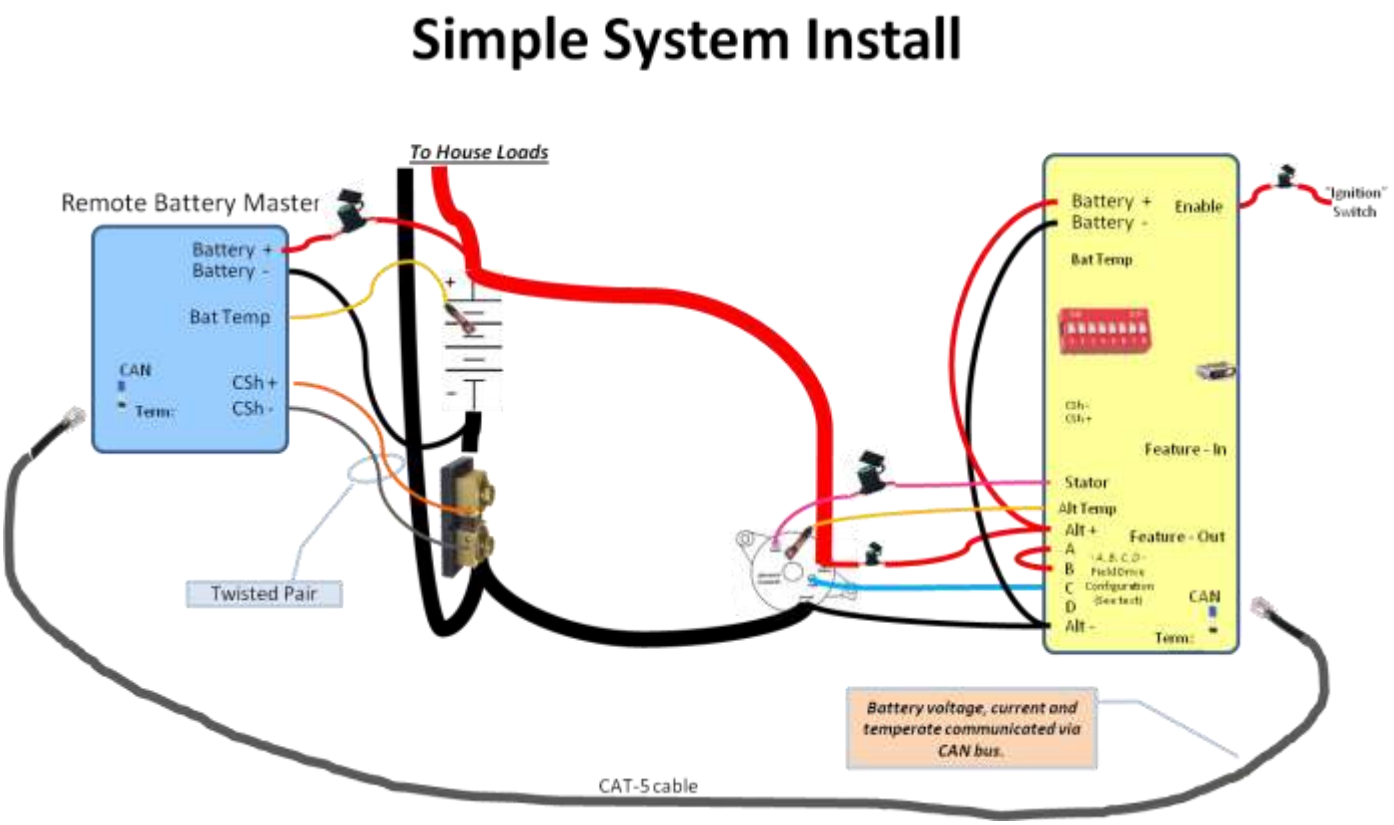

Figure 7 - Simple System Install

Additional Regulators may be added easily making the connections shown and routing a CAT-5 cable to the additional devices. For example in a twin engine installation as shown here:

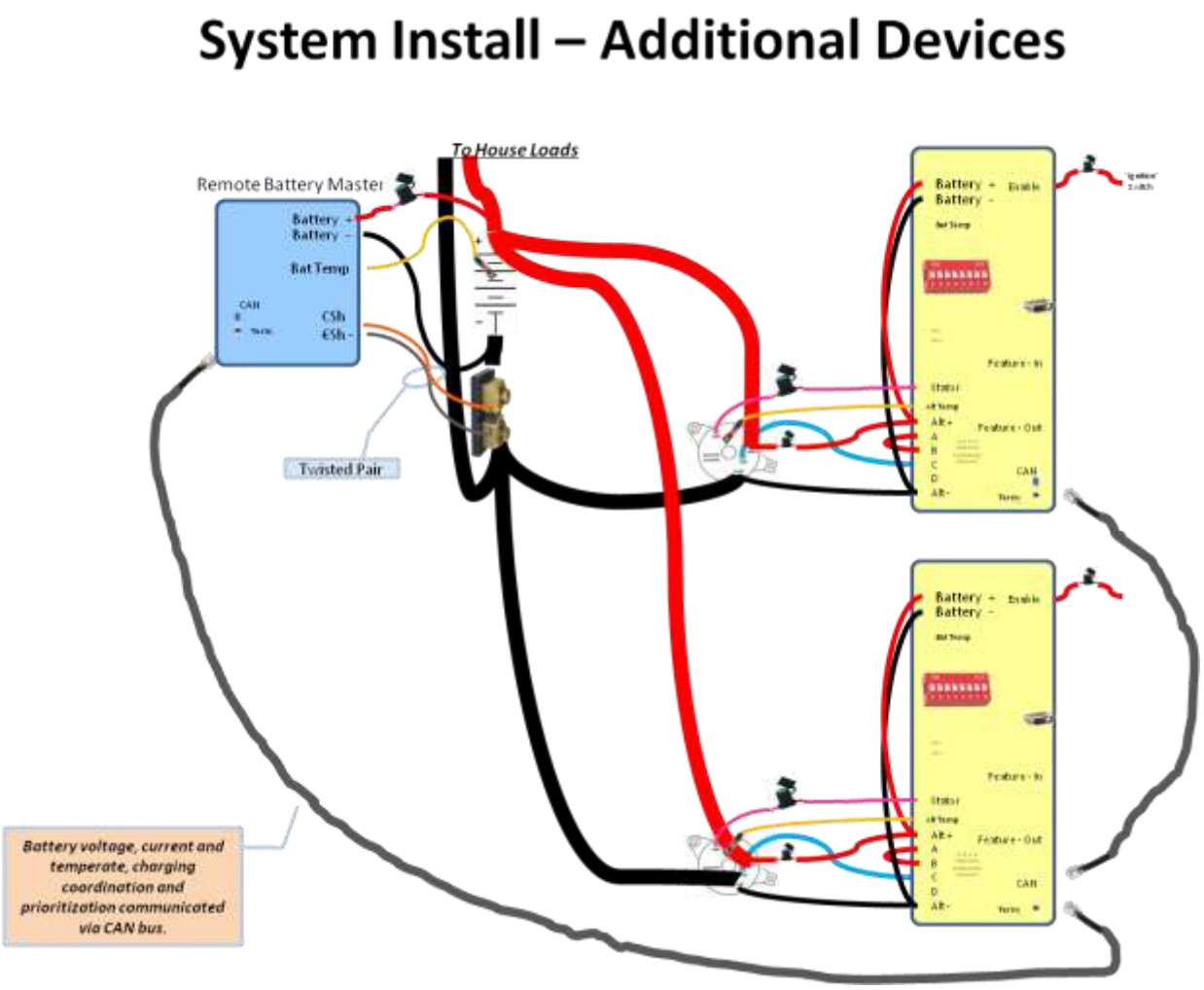

Figure 8 - Multiple charging sources in a coordinated system

EXAMPLE 4: MINIMAL (VOLTAGE ONLY) INSTALLATION

This example shows the very minimal connections needed when installing the VSR Alternator Regulator; only 4 wires and a few jumpers. In this very basic installation the VSR Alternator Regulator will function in a like way to most Voltage-only regulators, relying on battery voltage and timers to make charge decisions; and with that also brings the same limitations and risks of a voltage/timer regulator.

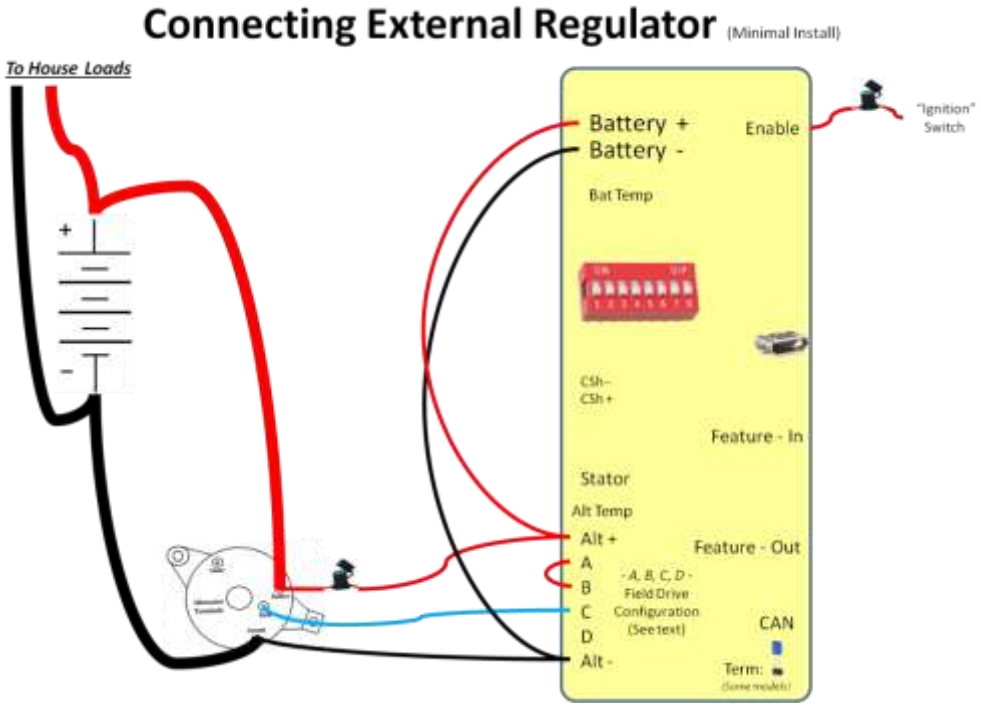

Figure 9 - Minimal Install – Voltage Only regulator for P-Type or High Drive alternators

Though simple to install, it is not suggested to use this configuration as many of the capabilities of the VSR Alternator Regulator will be disabled. If you do select this installation option take great care with the configuration options (alternator output capping/limitations, CPE selection of voltages and transition times amongst a few) to best match your typical operations and assure limited risks due to incomplete battery charging and/or alternator over-stress situations.

Even with these risks it is helpful to understand this simple installation as, if any of the regulators sensors fail, it will fall back to simpler modes of operation, thereby allowing continued operation, though perhaps in a less effective manner.

CONFIGURING THE ALTERNATOR REGULATOR

Configure your regulator using the DIP switches. With these you can select one of the default Charge Profile Entries, as well as tell the regulator the size of the battery you have (needed to more accurately decide when the battery is full).

Position	Meaning (Regulator Version 3)
1..2 <1> <2> Off, Off On, Off Off, On On, On	Battery ID The 'Battery ID' this regulator is attached to. Used in CAN connected systems. Suggested settings: 1 = House Battery 2 = Main starter battery 3 = Secondary house battery 4 = Other
3..5 <3> <4> <5> Off, Off, Off On, Off, Off Off, On, Off On, On, Off Off, Off, On On, Off, On Off, On, On On, On, On	Select Charge profile 1..8 1 = Default (Safe) & AGM #1 2 = Flooded Lead Acid #1 (Starter type , etc) 3 = Flooded Lead Acid #2 (HD – Storage/Traction type) 4 = AGM #2 (Higher charge voltages) 5 = GEL 6 = Carbon Foam (Firefly) 7 = Custom #1 (Changeable – Preconfigured HD Storage with Overcharge) 8 = Custom #2 (Changeable – Preconfigured: LiFeP04) *(See* Table *for more details)*
6,7 <6> <7> Off, Off On, Off Off, On On, On	Define Battery Capacity as: ** 1x, – 250Ah 2x, 250Ah – 500Ah 3x, 500Ah – 750Ah 4x. 750Ah and above
8	On – Use Small Alternator Mode Off – Use Large Alternator Mode Small Alternator Mode will restrict the maximum alternator output to 75% of its amperage capability. Large Alt mode limits output to 100%. (See $SCA: command to modify the these values.)

Table 1: DIP switch (3rd Generation Regulator)

Advanced Configuration

The VSR Alternator Regulator contains many configuration capabilities beyond what is possible using the DIP switches. These are accessed via the USB port and a simple computer based text terminal. Refer to the `VSR Communications and Programming Guide' for more details of the ASCII commands and status strings.

BUILT IN CHARGE PROFILES

Profile #	Battery Type	Bulk / Absorption Target Voltage	Exit Absorption when either:		Overcharge (Finish Charge)			Float		Equalize		Temperature Compensation (mV / 1c from 25c)
			Amps drop to % battery capacity	--or— Time exceeds	Target Amps	Exit Voltage	Max Time	Regulated Voltage	Regulated Amps	Target Voltage	Max Time	
#1	**Safe / AGM-1**	14.1v	3%	6 Hrs				13.4v				24mV
#2	**FLA 1** (Starter)	14.8v	1%	3 Hrs				13.5v				30mV
#3	**FLA 2** (GC, L16+)	14.6v	1%	4.5 Hrs				13.2v		15.3v	3 Hrs	30mV
#4	**AGM-2**	14.7v	1%	4.5 Hrs				13.4v				24mv
#5	**Gel**	14.1v	3%	6 Hrs				13.5v				30mV
#5	**Firefly**	14.4v	1.3%	6 Hrs				13.4v		14.4v	3 Hrs	24mV
#7**	**FLA 3** (GC, L16+)	14.4v	3%	6.0 Hrs	3%	15.3v	3 Hrs	13.1v		15.3v	3 Hrs	30mV
#8**	**LiFePO4**	13.8v	3%	1.0 Hrs				13.36v	0A			n/a

Table 2: Default Charge Profiles

All values assume the Amp shunt is installed at the battery. All Amperage exit values will automatically adjust to match the Battery Capacity as set by DIP switched 6&7

Blanks indicate that feature/mode is disabled.

See `VSR Alternator Regulator Reference Guide' for more details.

APPENDIX:

SUGGESTED BATTERY CHARGE PROFILES

The following table provides suggested Charge Profile for use with different battery types. These are guidelines and it is recommended to confirm the details with your battery manufacture. If needed select a different number or adjust the CPE entry using the advanced configuration options (reference *`VSR Alternator Reference Guide'*, ASCII Commands)

Manufacture	Type	Example Model Numbers	Suggested #
Dyno	Starter FLA	8Dc	1
	Industrial FLA	D85-xx, D125xx	3
	Deep Cycle FLA	L16-D350, , L16-2V, 8Dd	3
East Pen / Deka	AGM - Intimidator	8A24, 8A24M, 8A27, 8A27M, 8A31MTD, 8A4D, 8A8D, 8AGC2	1
	GEL - Dominator	8G24M, 8G27M, 8G31DTM, 8GCG2, 8G4D, 8G8D	5
	Industrial FLA	M75-x, M85-x, M100-x,	3
	FLA	24Mx, 27M6, DP24, DP27, DP31DT, DC24, DC27, DC31DT	1
Firefly	Carbon Foam	L-16, 2V900, 4V450, 12VE31, 12VG31	6
General Battery	Industrial FLA	6-85-x, 6-100-x, 6-125-x 12-85-x, 12-100-x, 12-125-x 24-85-x, 24-100-x, 24-125-x	3
Interstate	Cranking / Starting	24M-HD, 24M-XHD, 24M-RD, 27M-XRD	1
	Cranking / Deep Cycle	SRM-24, HD24-DP, SRM-27, SRM-27B, SRM-29, SRM-4D, GC2-XHD	3
Lifeline	AGM		1
Odysses	AGM	All	4
OPTIMA	AGM	Blue, Red, Yellow top	1
Trojan	Deep-cycle	24TM, 27TM	3
	'Golf Cart'	T-105, T-125, T-145	3
	Floor Sweeper	L-16,	3
	AGM Deep cycle	12-AGM, 22-AGM, 24-AGM, 27-AGM, 32-AGM	1
	Industrial FLA	IND9 .. IND33	3
	GEL	24-GEL, 27-GEL, 31-GEN, 6V-GEL, 8D-GEL	5
Winston	LiFeYPO4	All	8
Sinopoly	LiFeP04	All	8
GBS	LiFeP04	All	8
CALB	LiFeP04	All	8

ALTERNATOR TEMPERATURE PROBE LOCATION

In most cases the diode pack is the critical limitation in alternators and the best point of reference for measurement. However it is best to consult your alternator manufacturer for recommended placement, as well as for allowable operation limits. Figure 10 below shows the recommended location for the alternator temperature probe (on the diode pack) from Leece Neville/Prestolite.

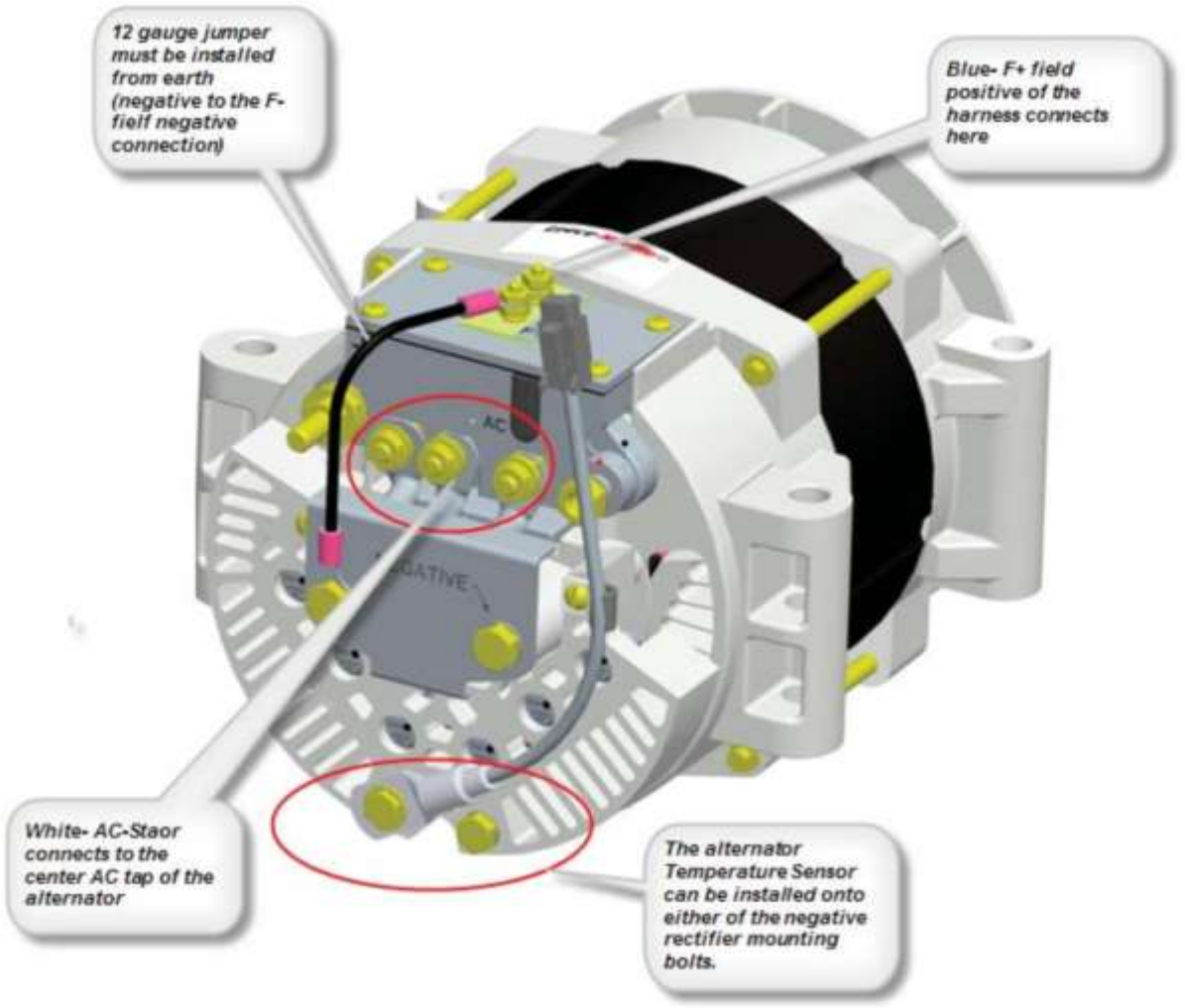

Figure 10 - Example alternator temperature probe location

ACCESSORIES – PROBES, CASES, SHUNTS, ETC.

To install your regulator you may need some or all of the following. There are many ways to purchase these and the examples given are only one option.

Temperature probes:

The Alternator Regulator uses NTC temperature probes to optionally monitor battery and/or alternator temperature. There are several sources for NTC probes, do make sure to get ones with these specifications:

- Resistance: 10K Ohms
- Beta: 3950

(Note: It is possible to alter these values (to some extent) by making changes to the Source Code)

There are positions for two sensors, A and B which are typically used for Alternator and Battery respectively. Gen 2 regulators use screw connectors, while Gen 3 uses a common JST XH2.54 2P connector. When sourcing for sensors you should be able to find many probes which already have the connector installed.

Searching Ebay or Amazon for "NTC 10K waterproof 3950" will quickly bring up a wide range of suppliers, with cable lengths from 0.5m to 5m. Here is a photo of one bundle of 5x sensors – with attached JST connectors:

You may also add extension wires to temperature probes. There is no + or – so these sensors wires may go to either side of the connector.

Fuse Holders:

It is recommended to install fuses in the locations indicated in the example Installations. Choose a fuse of appropriate rating. Use a good quality water resistant fuse holder and fuses which you are able to secure easily and locally. Remember, fuses are primarily intended to protect wires, not the device, with one exception: the Field fuse will also help protect the regulator's field drive circuit – choose a fuse about 50% higher than the expected maximum field draw. For smaller alternators, a 10A fuse should be sufficient, while larger units may need a 15A fuse. If you are driving multiple alternators in parallel from one VSR Alternator Regulator, adjust the fuse size accordingly, but do not exceed 32A maximum rating.

Current Shunts:

Many installations already have a battery current shunt installed, often as part of an existing battery monitor. If so, simply attach the Current Shunt leads to that existing shunt. The shunt may be located in the + or the – wire with no adjustments needed for your regulator. Do pay attention to the + and – connections (refer to example installation diagrams).

By default, the VSR Alternator Regulator is configured for a 500A/50mV shunt (common on many battery monitors). If you are using a different shunt, use the $SCA: command to calibrate the regulator for different shunt value.

CAUTION: Do not use a shunt who's voltage exceeds 80mV, or inaccurate results will occur as well as a potential for damage.

Shunts are known for being less then accurate, and if you find the calibration of the VSR Alternator Regulator is off, you may use the $SCA: command to adjust for any error.

(Refer to the `VSR Alternator Regulator Reference Guide' for details of the $SCO command and how to use it.)

CAT-5 Communications Cable

A common CAT-5 cable is used to connect the VSR Alternator Regulator with other OSEnergy compliant devices to allow monitoring and coordination of a DC System. Any CAT-5 or CAT-5e cable will work, as well as CAT-6 cable. Connect the CAT-5 cable in daisy-chain fashion, making sure the 'Terminator' jumper is on place ONLY on the end of the daisy chain (remove the terminator jumper from any devices in-between).

Enclosure:

The VSR Alternator Regulator dissipates very little heat and no heat-sink is needed, just air flow around the components (PCB standoffs are sufficient). Plastic boxes are suitable with common NEMA 4x 'Water-proof' boxes available at electrical supplies and/or building supply houses being an attractive low cost option; especially when combined with water-tight bulkhead glands around the cables in and out of the box. Some examples:

Figure 11 - E989PPJ 5" X 5" X 2"Junction Box

Figure 12 - Uxcell® Waterproof Box 200x120x75mm

UPDATING FIRMWARE

A key capability of the VSR Alternator Regulator is the ability to add features and enhancements by updating the firmware. All that is needed is a USB cable and a Windows™ compatible machine.

Go to this URL: https://github.com/AlternatorRegulator/alt-Binary

Download and unzip the latest firmware as well as installation tools and batch files. Using the instruction connect a USB cable between your PC and the VSR Alternator Regulator and then run the update bat file. Once completed you will have the latest firmware installed in your regulator.

SELECTING EQUALIZE MODE

Equalize Mode (if enabled by the battery Charge Profile) is selected by connecting the FEATURE-IN wire to Bat+ Take great care in this mode, and watch carefully how your battery is responding to the maintenance equalize charging cycle. To stop Equalization disconnect the FEATURE-In port from Bat+

LED BLINK PATTERNS

The on-board LED will blink out patterns to inform the user of its current status, errors, and pending actions (e.g., about to restart). Patterns are made up by a combination of blink patterns, and the speed at which they blink. The following table describes the patterns.

Status	Blink Pattern
Idle	
Ramp Bulk	
Accept	
Over Charge	
Float Post-float	
Equalize	
Error	 Pattern repeated twice then followed by flashing out of error # (2 or 3 digits.)
Restarting	
	< 1 Second > < 1 Second > < 1 Second > < 1 Second > < 1 Second > < 1 Second >

The LED will blink GREEN during normal stand-alone operation. If the regulator is linked into a system and following the common guidance the LED will blink YELLOW instead of GREEN. As an example, in a twin engine installation one VSR

Alternator Regulator should blink out GREEN – this is the regulator which will be coordination charging goals, while the other regulator will blink out YELLOW indicating it is in sync.

The LED will blink RED if there is a fault condition. Refer to ` Error codes and meaning' below for details on fault codes and LED fault blinking patterns.

MAXIMUM LIMITATIONS OF ALTERNATOR REGULATOR

The following table documents maximum allowed values during the operation of the VSR Alternator Regulator. Exceeding any of these values may cause unpredictable operation and/or damage. All voltages are referenced to Bat- unless otherwise noted.

Item	Min	Max	Symbol
VBat+		32	Volts
Enable	8.5	32	Volts
CS+	-0.5 **	32	Volts
CS-	-0.5 **	32	Volts
CS+ vs. CS-	-80	80	mVolts
Feature-In	-0.5	32	Volts
Feature-out		32	Volts
		0.5	Amps
Alt+		32	Volts
Field (B or C) current		32	Amps
Ambient Temperature	-40	100	Celsius

Table 2 – Maximum Limitations 12-24v regulators

Item	Min	Max	Symbol
Bat+		65	Volts
Enable	8.5	65	Volts
CS+	-0.5 **	65	Volts
CS-	-0.5 **	65	Volts
CS+ / CS- Delta	-80	80	mVolts
Feature-In	-0.5	65	Volts
Feature-out		65	Volts
		0.5	Amps
Alt+		65	Volts
Field (B or C) current		32	Amps
Ambient Temperature	-40	100	Celsius

Table 3 – Maximum Limitations 12..48v regulators

** Special care should be noted of the Current Shunt lower voltage limitations. If the current shunt is located in the ground line and at some distance from the battery (e.g. at the alternator), too small of a ground wire between the shunt and the battery could easily exceed the limits and create a ground-loop. Increasing the size of the ground cable, and/or relocating the amp shunt to the Alternator + wire are potential solutions.

ERROR CODES AND MEANING

The following is a description of error codes as reported via the ASCII status and/or the LED blinking pattern. Most errors are hard-faults, indicating a condition which the VSR Alternator Regulator is unable to decipher and as such will shut down until corrected, in order to prevent any potential systems or battery damage. A few errors will attempt to auto-restart to see if the failing condition clears (example, error low battery voltage).

Code	Meaning	Auto-restart?	Suggested corrective actions
12	Battery Temperature exceeded upper safety limit	No	Something is causing the battery to overheat. • Check charge profile to make sure it is a correct match. • Check battery water level (if applicable). • Verify temperature probe location and function • (are Alternator and Battery temperature probed swapped?) • Move batteries to lower temperature room (e.g., not in engine room)
13	Battery Voltage exceeded upper safety limit.	No	Something has caused the battery voltage to reach very high levels. • Verify Vbat+ and Vbat- sensing wiring • If RBM is active, verify its configuration and operation • Verify if another charging source is present and pushing battery voltage too high.
14	Battery Voltage exceed lower limit	Yes	The VSR Alternator Regulator is not able to measure Battery Voltage, or it is very very low. • Verify Vbat+ and Vbat- sensing wires • Heck to see if battery is extremely over-discharged • Check for shorted cell in battery • Is there a battery connected? (Often caused during bench-top configuration before regulator is installed) The VSR Regulator will attempt to restart if it sensing low battery voltage, this will allow for transitory conditions – such as too low voltage while craning the engine, or perhaps a switch not in the correct place. Until proper minimal voltage is detected, no charging will occur.

21, 23, 24	Alternator Temperature exceeded upper safety limit	No	Something is causing the alternator to overheat beyond that the VSR Regulator is able to control. • Enable Small-Alt mode Dip switch • Increase cooling to alternator (Separate air vent) • Verify alternator fan is functioning • Upgrade alternator to larger frame / capacity.
22	Alternator Speed exceeded (Excessive RPMs)	No	The alternator is spinning too fast, there is risk of mechanical damage. • Verify Stator wire is connected correctly • Verify the VSR Regulator has been calibrated correctly for your alternator pulley ratios (See Technical Reference Guide) • Check engine drive and alternator pulley diameters, verify they are appropriate for engine make and alternators max RPMs specification.
41	VSR Regulator overheating	No	The VSR Alternator Regulator is overheating • Check mounting location, move to cooler location? • Review Field drive amperage, excessive? • Potential indication of damaged Field Driver FETs, have devices checked and repaired if needed.
42	Required Sensor missing / failed	No	The VSR regulator has been configured to verify the presence and functions of critical sensors (temperature sensors, current shunts, etc) using the advanced configuration capability. Once (or more) of these sensors is not present or has failed. Contact you installer for guidance.
51, 52	BMS has issued a Battery Disconnect command	No	An attached BMS (Battery Management System) has sent a Battery is Disconnected notice to the VSR Alternator Regulator, indicating the battery has been taken off-line for some reason to protect it. Refer to the BMS instructions to assess why this situation has occurred. (Typically from over-charging, and/or over-discharging – mostly associated with LiFeP04 batteries)
INTERNAL FAULTS			
31..39, 53	Internal logic error	No	An internal self-check has failed in the VSR Alternator Regulator. • If possible, note condition and report this issue • Make sure you have the latest Firmware installed.

100+	Internal hardware error	No	There is detected in internal hardware error in the VSR Alternator Regulator. Have regulator inspected and repaired if needed.