ALTERNATOR REGULATOR

AND OPEN-SOURCED INTELLIGENT ALTERNATOR REGULATOR

Quick Start Guide

v1.1.1 - Sept 30, 2017

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QUICK START GUIDE

This short guide is intended to help assist in the quick and simple installation of the 3rd generator Alternator Regulator connected to 12v, 24v, or 48v alternators / batteries. Please make sure to refer to the `Alternator Regulator Reference Guide' for more details and installation examples beyond the few shown here, as well as guidance for prior generation Alternator Regulators.

One critical decision when installing the Alternator Regulator is how many wires to hook up. In its simplest form, only 5 wires are needed. However, adding additional sensing capability will enable features in the Alternator Regulator and allow it to provide for the most efficient and safe charging of your battery as well as for providing for concurrent house loads.

The Alternator Regulator is capable of supporting any battery / alternator voltage from '12v' to '48v', and will automatically adjust its self to support 12v, 24v, or 48v batteries. To enable other battery voltages (example, 32v), please refer to the `Alternator Regulator Reference Guide' for instruction

REGULATOR INSTALLATION

The Alternator Regulator is a very versatile device with several installation options depending on your goals and objectives. In it s simplest form, the Enable, Alt+, Alt- and Field wires are all that are needed to connect, and in this mode the Alternator Regulator will behave as many voltage-only regulators, abet with a high level of precision. Adding additional sensing capabilities will unlock additional capabilities of the Alternator Regulator, up to and including a fully integrated Systems deployment.

The following will give an overview of how to connect and configure the Alternator Regulator in different situations. The first section will illustrate typical installations, from simple to more involved; while the second section showcases some alternative installations for unique deployments, such as DC generators or high-reliability integrated systems.

REGULATOR PLACEMENT

The Alternator Regulator should be located 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 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 EOM alternator on a motor. 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 winding heat stress related damage and failures. Such stress conditions are exacerbated by high acceptance battery banks (ala, Lithium, AGM/GEL, or even large capacity standard wet-cell FLA batteries).

The best way to protect a small-frame alternator is to install an alternator temperature sensor, typically to the back of the alternator case. This will allow the Alternator Regulator to monitor the alternator and reduce output as its limit to operate safely is approached. In addition to – you may also wish to select 'Small-Alt Mode' via DIP switch to provide an overall capping of alternator loading.

ALTERNATOR REGULATOR CONNECTIONS

The following illustrates connection terminals on the Alternator Regulator. See the following table for a description of each connection, as well as suggested min size. Example deployments follow the table.

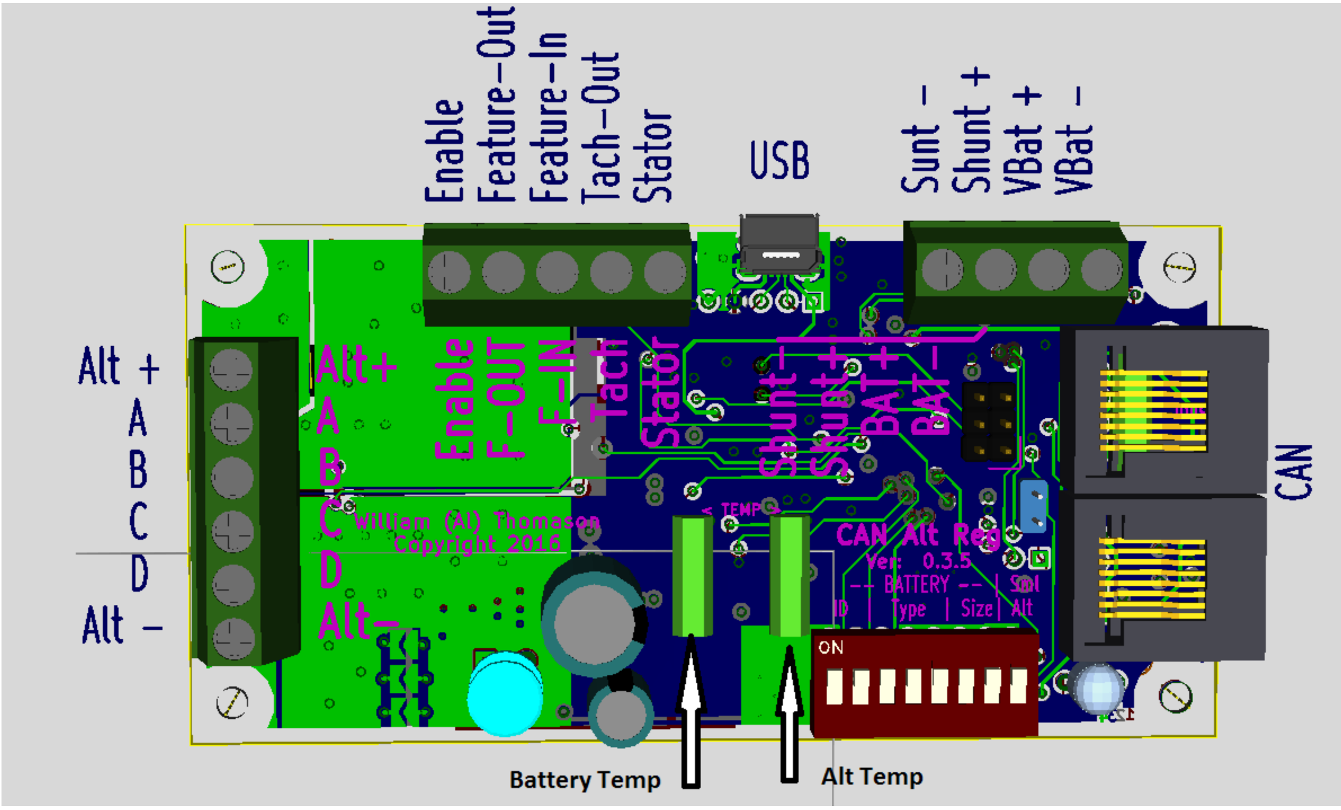

Figure 1: 3rd Generation connections

VBat+, VBat - Connect ***directly*** to the battery via 14g 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 "**Error! Reference source not found.**" on page **Error! Bookmark not defined.**

Enable: Connect to VBat+ to 'turn on' the regulator. Use min 14g wire and a 2A fuse.

Current Shunt + ,
Current Shunt -: (optional) Connect to the Current Shunt using twisted pair 16g or larger wire. The Current Shunt maybe installed in either a ground wire (low shunt), or in the + voltage wire (High Shunt). Do not exceed 80mV difference between CS+ and CS-, nor exceed connect to a shunt more than 72v above ground. If the 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 VBat (6-72v) to enable features (see FEATURE IN section).

Feature Out: (optional) Open Collector driver, connect to external Alternator LAMP at dash. 0.5A *max* current sink capability. 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 protected by an appropriate fuse. (typically 4-12A, depending on alternator size) (Min 14g – use 12g or 10g for large frame alternators)

Alternator -: Connect to the – (gnd) terminal of Alternator using appropriate wire. (Min 14g)

Stator (optional) Connect to an Alternator Stator pole via 2A fuse and 16g wire.
Used to increase 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: C**
Low Drive (N / A-type)	**C - D**	**Field: B**

Use wire of sufficient gauge to carry the expected current, up to 32A (connector limit) (Min 14g).

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: (3rd Generation) Allows communication of regulators status 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 populated with RJ-45 connectors, otherwise use 120 Ohm twisted pair wire to the CAN terminal block.

Tach-out: (3rd Generation) A conditioned signal to help drive alternator sourced tachometers – even at low charging levels.

Refer to Appendix A for some additional details on each of these connections, as well as the `Alternator Regulator Reference Guide'

Example 1: Minimal (Voltage Only) Installation

This example shows the very minimal connections needed when installing the Alternator Regulator.   Only 4 wires and a few jumpers. In this very basic installation the 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.

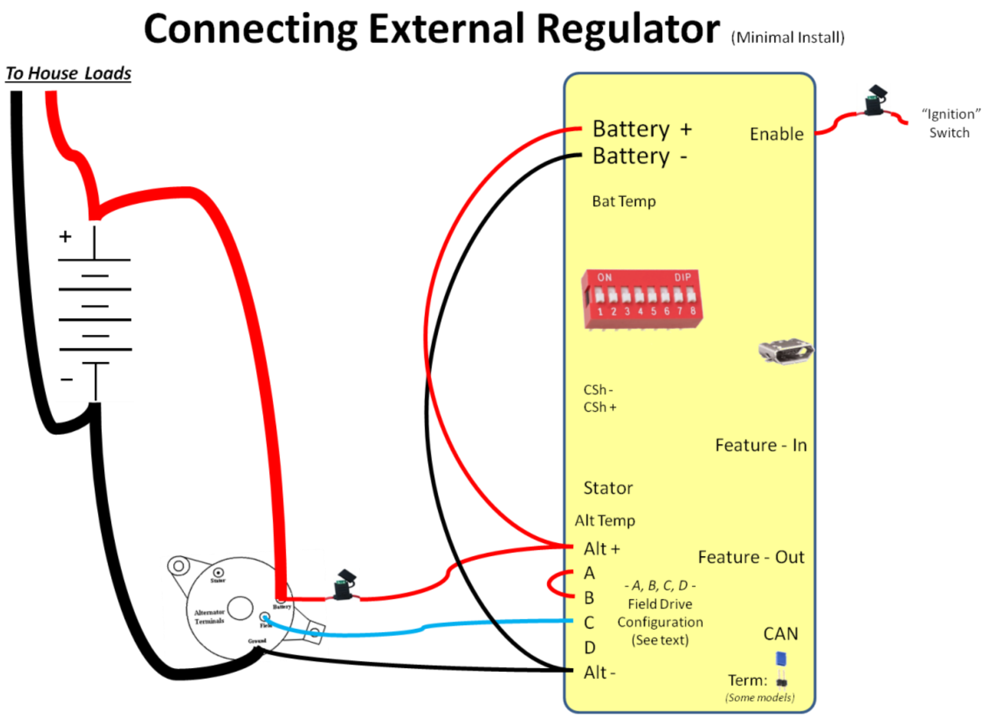

Figure 2 - Minimal Install

Though simple to install, it is not suggested the Alternator Regulator be used in this configuration as there is risk to the battery from over/undercharging, as well as the very real potential for battery and/or alternator damage due to over-stressing/temperature conditions. If you do select this installation option take great care with the DIP switch and ASCII configuration options (Alternator output capping / limitations, CPE selection of voltages and transition times among a few) to best match your typical operations.

Even with these risks it is helpful to understand this simplest installation as if any of the Alternator Regulates sensors fail the regulator will `fall-back' to simpler modes of operation, thereby allowing continued operation, though perhaps in a less efferent manner.

Example 2: Basic Stand-alone Installation (Most common single engine installation)

A very common way to install the Alternator Regulator is in a stand-alone – battery centric – configuration. 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 locating the amp shunt directly at the battery the Alternator Regulator is able to account for any other charging sources, as well as potential house loads, when making decisions about charge state transitions – to give a true indication of the status of the battery's state of charge.

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

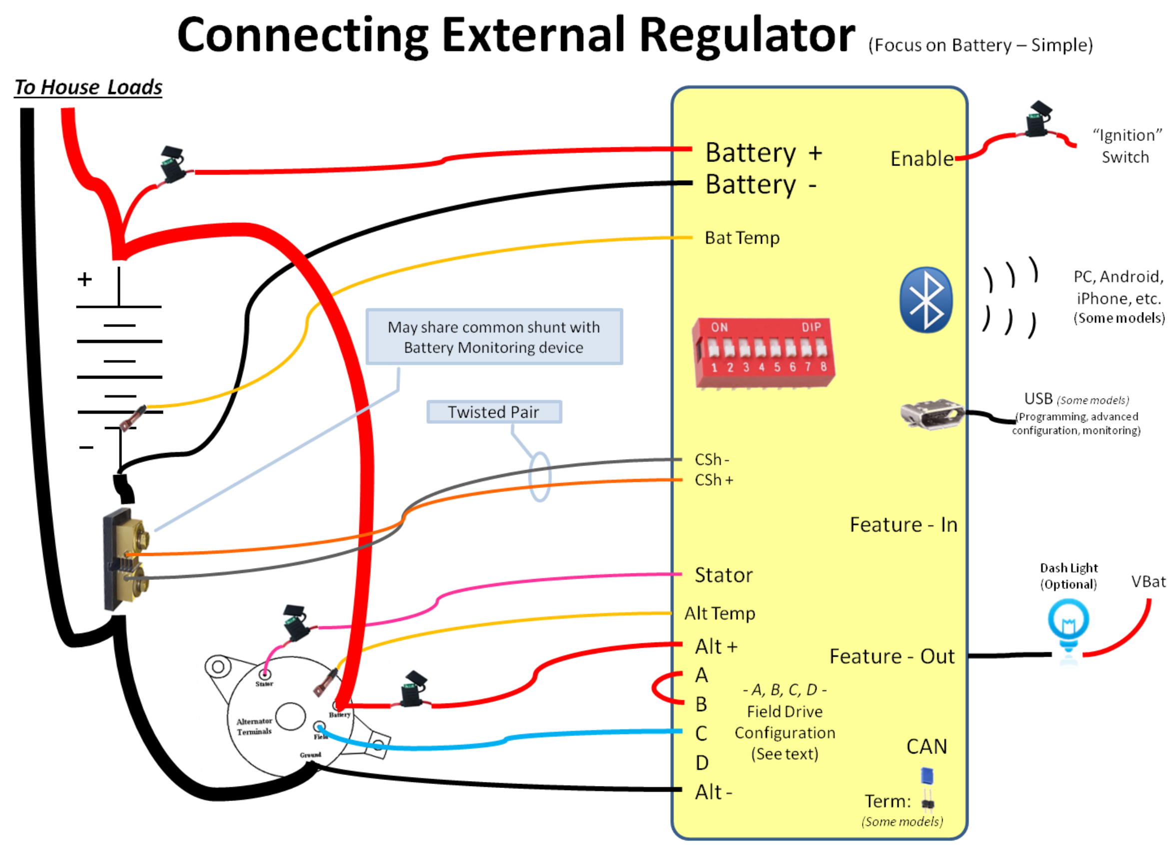

Figure 3 - Basic install, shunt LOW

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 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. Any shunt may be used as long as the maximum sensing voltage does not exceed 80mV.

Connecting External Regulator (Focus on Battery – Simple)

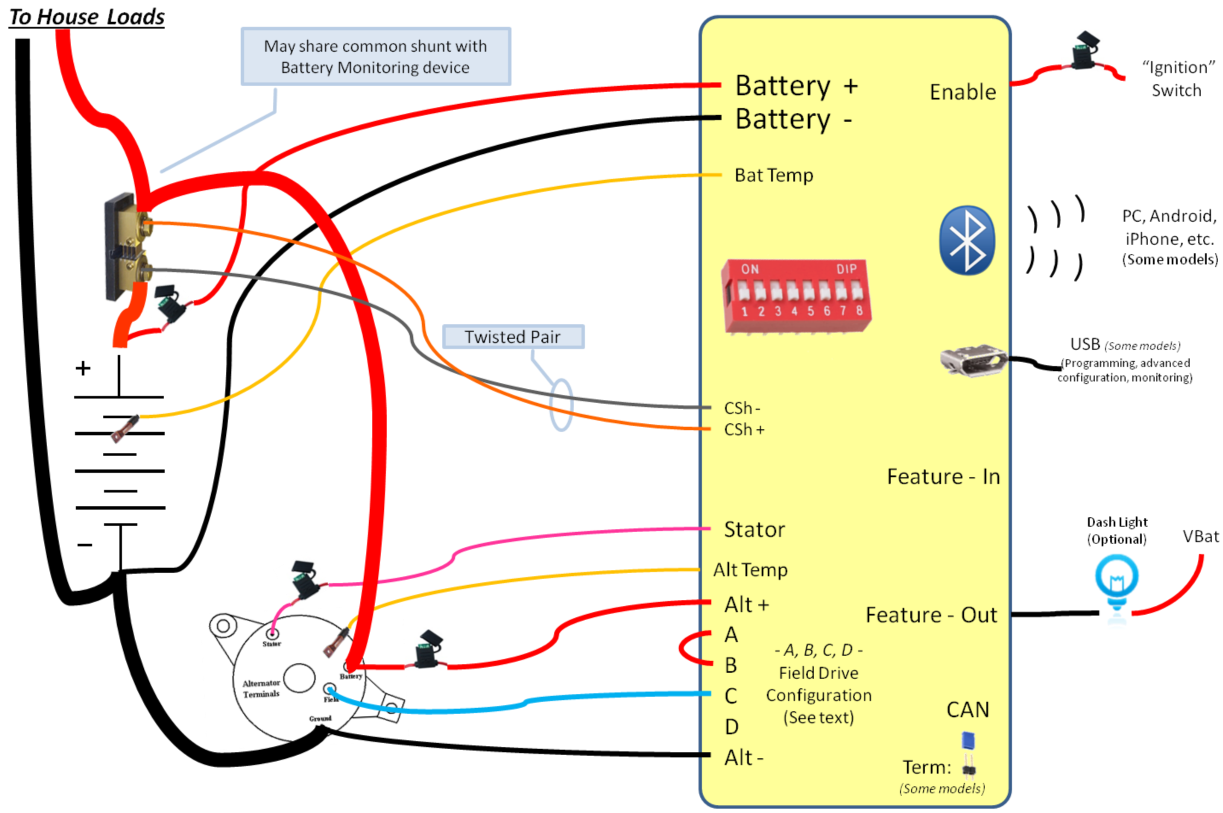

Figure 4 - Basic install, shunt HIGH

EXAMPLE 3: 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.

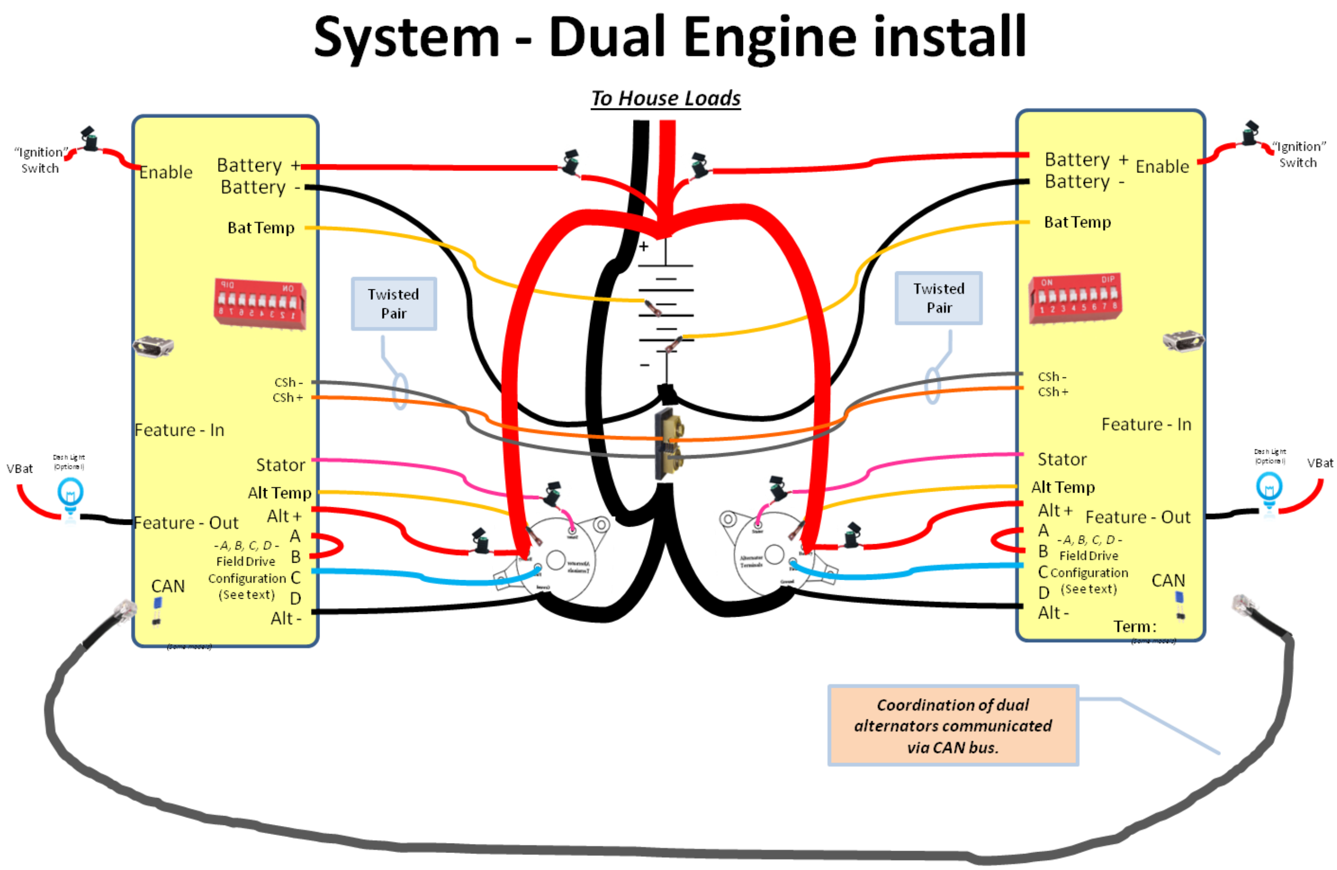

Figure 5 - Duel engine install with communications

EXAMPLE 4: BASIC SYSTEM INSTALLATION (UTILIZING REMOTE BATTERY SENSOR)

When installing the 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 CAN bus 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 and sending that information via the CAN bus to the alternator regulator, the wiring burden is reduced to one CAN cable as opposed to several discreet 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 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 VBat + and Vbat – wires to the local alternator + and – output. Adding Alternator Temperature sensing and stator sampling allows the Alternator Regulator to fully protect your alternator.

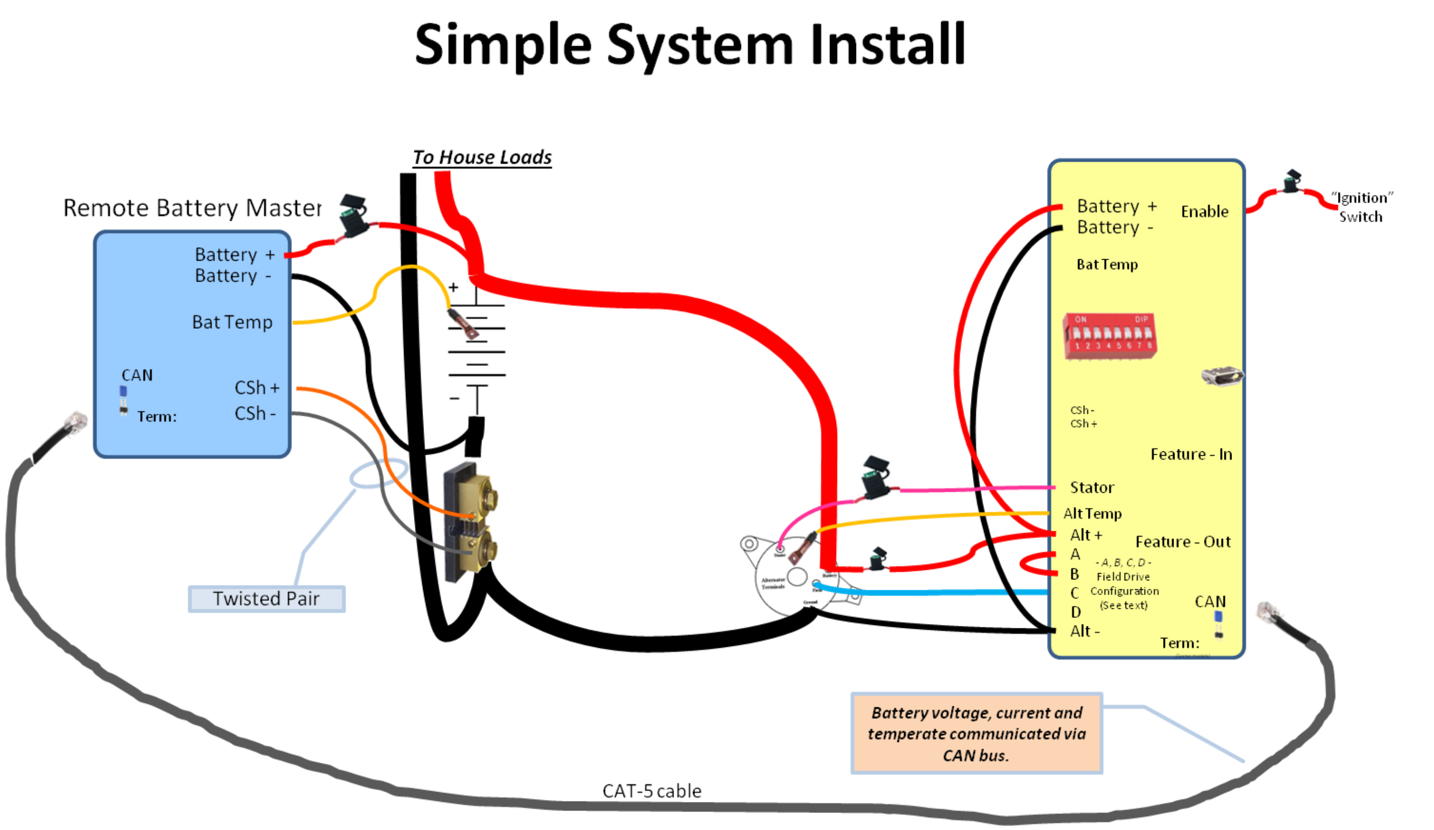

Figure 6 - Simple System Install

Additional Alternator Regulators may be added easly making the connections shown and routing a CAT-5 cable to the additional devices. (for example, in a twin engine installation),

Configuring the Alternator Regulator

The simplest way to configure your Alternator Regulator is via 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 type) 4 = AGM #2 (Higher charge voltages) 5 = GEL 6 = Reserved for Future Use 7 = Custom #1 (Changeable – Preconfigured HD Storage with Overcharge) 8 = Custom #2 (Changeable – Preconfigured: LiFeP04) *(See* Table 2 *for more details)*
6,7 <6> <7> Off, Off On, Off Off, On On, On	Define Battery Capacity as: 1x, – 500Ah 2x,, 500Ah – 1,000Ah 3x, 1,000Ah – 1,500Ah 4x. 1,500Ah 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 change these values.

Table 1: DIP switch (3rd Generation Regulator)

Advanced Configuration

The Alternator Regulator contains a rich of 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 `Alternator Regulator Reference 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 / 1f from 77f)
			Amps drop to	or Time exceeds	Target Amps	Exit Voltage	Max Time	Regulated Voltage	Regulated Amps	Target Voltage	Max Time	
#1	**Safe / AGM-1**	14.1v	15A	6 Hrs				13.4v				13.2mV
#2	**FLA 1** (Start)	14.8v	5A	3 Hrs				13.5v				16.8mV
#3	**FLA 2** (GC, L16+)	14.6v	5A	4.5 Hrs				13.4v		15.3v	3 Hrs	16.8mv
#4	**AGM-2**	14.7v	3A	4.5 Hrs				13.4v				13.2mv
#5	**Gel**	14.1v	5A	6 Hrs				13.5v				16.8mv
#6		Reserved for Future Use										
#7**	**FLA 3** (GC, L16+)	14.4v	15A	6.0 Hrs	15A	15.3v	3 Hrs	13.1v		15.3v	3 Hrs	16.8mv
#8**	**LiFePO4**	13.9v	15A	1.0 Hrs				13.36v	0A			n/a

Table 2: Default Charge Profiles

All values are normalized for 12v / 500Ah battery and assume the Amp shunt is installed at the battery. If the shunt is mounted at the alternator, adjust the Exit_amp values to account for house loads. (A suggestion is to add 5A to the values shown in the above table.) All Amperage exit values will automatically scale up by the Battery Capacity Dip switch and likely match larger batteries with larger 'house loads'.

Blank sections indicate that feature is disabled.

See `Alternator Regulator Reference Guide' for more details.

APPENDIX A:

Alternator Temperature Probe Location

In most cases the Diode Pack is the critical limitation and the point of reference for measurement – however it is best to consult your alternator manufactures for recommended placement - as well as for allowable operation limits. Figure 7 below shows the recommended location for the alternator temperature probe from Leece Neville / Prestotolite -- on the Diode Pack.

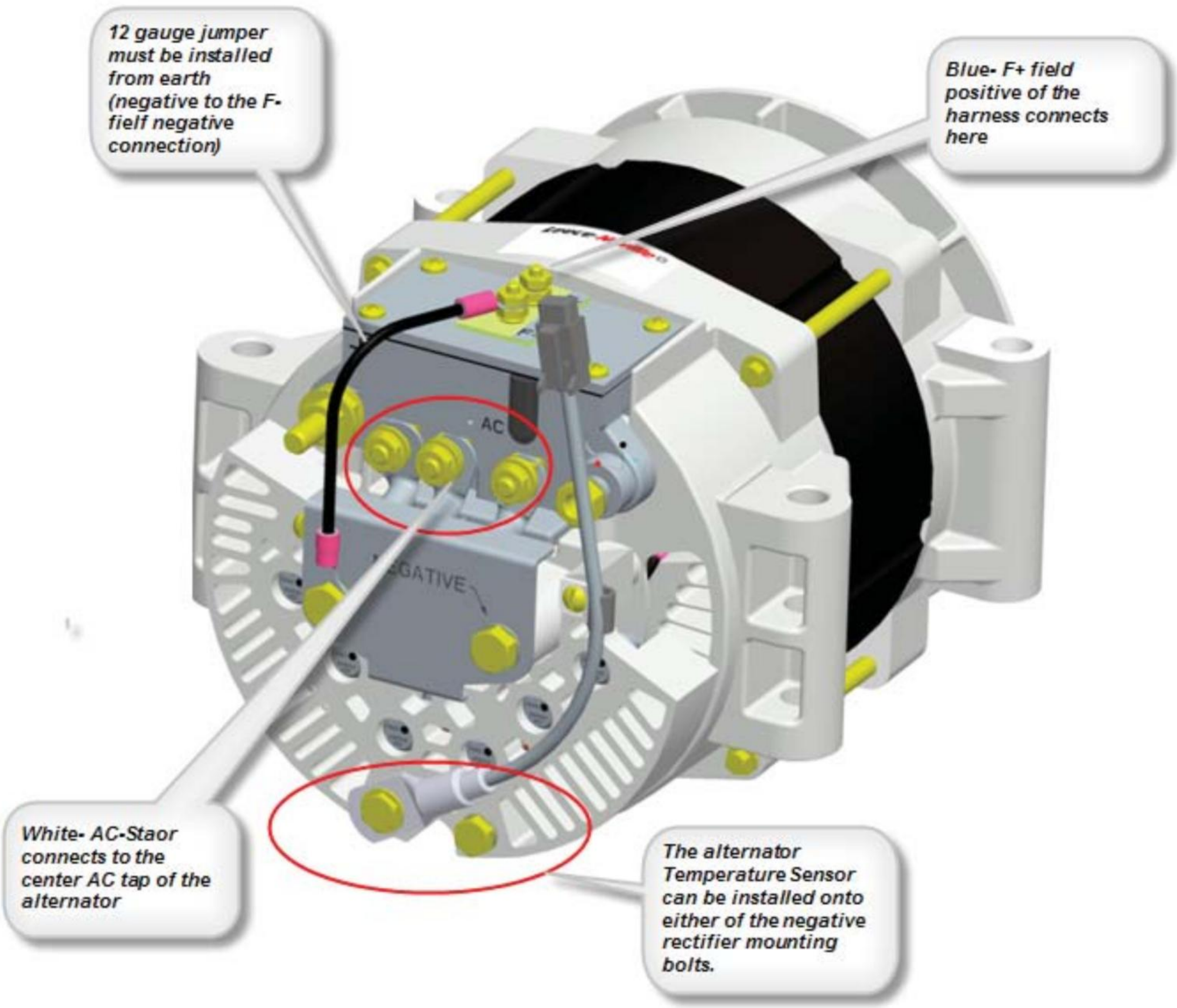

Figure 7 - Example Alt Temperature probe location

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 – 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:

Fuse Holders:

It is recommended to install fuses in the locations indicated in the Example Installations. Chose 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 Alternators Regulators field drive circuit – choose a fuse about 50% higher than you 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 Alternator Regulator, adjust the fuse size accursedly, but do not exceed 32A as that is the terminal strips maximum rating.

Current Shunts:

Many installations already have a battery current shunt installed, often as part of an existing battery meter. Is 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 on page: 1). You can verify the shunt is working correctly by connecting a computer to the Serial/USB port (see page: **Error! Bookmark not defined.**) and monitoring the AST; status strings (page: **Error! Bookmark not defined.**). If you find you have the shunt installed backwards, correct the wiring or use the $SCA: command (page: **Error! Bookmark not defined.**) to indicate the 'shunt is reversed'.

By default, the 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 inform the Alternator Regulator of the 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 Alternator Regulator is off, you may use the $SCA: command to adjust for any error.

CAT-5 Cable

Used only on the Gen 3 (CAN enabled) regulator, CAT-5 cable is used to connect the 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 from each OSEnergy compliant device in a daisy-chain fashion, making sure the 'Terminator' is enabled on each end of the daily chain (remove the terminator from any nodes not on the end).

Enclosure:

The Gen 2 Alternator Regulator was designed to fit inside its heat-sink, largely for protection – though there is a little heat which must be dissipated. Aside from protective heat sinks, die-cast aluminum box would be another suitable choice, just make sure that the driver FETS as well as the voltage regulator (Q1 and U1) are solidly attached to the case. (Make sure to use appropriate electrical isolation for any heat-sinked component)

Gen 3 of the 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 for this release of the regulator. NEMA 4x 'Water-proof' boxes available at electrical supplies and/or building supply houses can be 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 8 - E989PPJ 5" X 5" X 2"Junction Box

Figure 9 - Uxcell® Waterproof Box 200x120x75mm

Also check the blog / mailing list / github for any updates as well as potentially for custom 3D-printed cases which others may have designed.

Maximum limitations of Alternator Regulator

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

Item	Min	Max	Symbol
VBat+		65	Volts
Enable	8.5	65	Volts
CS+	-0.5	65	Volts
CS-	-0.5	65	Volts
CS+ vs. CS-	-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

Special care should be noted of the Current Shunt lower voltage limitations. If the current shunt is located in the ground line and a distance from the battery (example 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.

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	

A Version 2 board only blinks GREEN.

If using the CAN enabled Systems Regulator (Version 3 or later), the LED will blink GREEN during normal operation. If the regulator is linked into a 'system' and being coordinated by a remote battery manager, the LED will blink YELLOW instead of Green. These colors can be used to quickly identify which device is currently acting as the battery master and that the system is configured correctly. It also allows quick visualization of which node has taken over in the case of a failed battery master. The LED will blink RED if there is a fault condition.