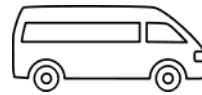


WAKESPEED™

CHARGE ⚡ SMARTER

COMMUNICATIONS AND CONFIGURATION GUIDE



Member



TABLE OF CONTENTS

About this guide	2
WS500 Pro	4
Plug-n-Go (Out of the Box default)	5
Security and Passwords	6
Optional Always ON (7/24) install.....	7
A note on High Energy system installs	8
CAN (Control Area Network) Communications	11
Victron DVCC Support	16
A note on Feature-In port	17
Firmware Recovery of Erased Wakespeed device	18
Password Recovery for WS500 Pro	20
Temperature Sensors (ATS, BTS)	20
ASCII communications	21
Receiving data FROM the regulator:	25
Sending data TO the regulator:	44
Appendix A: CAN enabled BMS	92
Appendix B: CAN messages	98
Appendix C: Sample Yacht Devices CAN-CAN bridge scrip	112
Appendix D: Details of CPE (Charge Profile Entries)	115
Appendix E: Error codes and meaning	120



WS500 Pro Notice of Compliance:

NOTE: THIS EQUIPMENT HAS BEEN TESTED AND FOUND TO COMPLY WITH THE LIMITS FOR A CLASS A DIGITAL DEVICE, PURSUANT TO PART 15 OF THE FCC RULES. THESE LIMITS ARE DESIGNED TO PROVIDE REASONABLE PROTECTION AGAINST HARMFUL INTERFERENCE WHEN THE EQUIPMENT IS OPERATED IN A COMMERCIAL ENVIRONMENT. THIS EQUIPMENT GENERATES, USES, AND CAN RADIATE RADIO FREQUENCY ENERGY AND, IF NOT INSTALLED AND USED IN ACCORDANCE WITH THE INSTRUCTION MANUAL, MAY CAUSE HARMFUL INTERFERENCE TO RADIO COMMUNICATIONS. OPERATION OF THIS EQUIPMENT IN A RESIDENTIAL AREA MAY CAUSE HARMFUL INTERFERENCE IN WHICH CASE THE USER WILL BE REQUIRED TO CORRECT THE INTERFERENCE AT THEIR OWN EXPENSE.

ABOUT THIS GUIDE

The Wakespeed® Offshore series of product offerings features a common set of configuration and communications capability. This guide is used to document both Serial (ASCII) communications and CAN (Control Area Network) capabilities. Refer to the individual devices user's guide for additional details. Using the information in this guide one can access advanced configuration capabilities of the WS500 Alternator Regulator, as well as create a vertical stacked solution with tight integration between the regulator, BMS devices, Displays and engines. More so, this guide will be helpful in the development of supporting applications to aid in the configuration and use of the WS500 Alternator Regulator.

A note of edits and revisions

As this document is revised, new additions or capability will be placed in **RED** text. It is hoped this will aid in the quick assessment of new features. This release is intended for use with Firmware v2.6.0 or above.

2.6.0 Notes:

- Support for WS500 Pro
- Added CAN Tx/Rx Error count reporting to CST; (Useful for debugging unreliable CAN subsystems)
- Increased System Watts capacity to 40kW. (\$SCA: command)
- Corrected bug of random Alternator Current value displayed on Victron Cerbo's when the local current sensing wires (Gray/Purple) were not attached to anything.
- Corrected bug where after toggling off White Space and reconfiguring regulator, old white space details were retained as opposed to cleared. (\$MSR:@ is work around)
- Improved support of re-charging Lithionics Batteries while in Reserve Power mode.
- Added support for aggregation of Victron Lynx BMS's (Based on Battery Instance) (reference Appendix A below)
- Added support for batteries designed to the Victron 11-bit CAN protocol. (Do not use this with Victron batteries, only non-Victron batteries that 'advertise' support of Victron via this 11-bit protocol) Ref: \$CCN: command.
- Improved 12v battery handling while DCDC converter is in engine-off Dynamic mode.
- Added '12v Refresh Charge' option for 12v battery in DCDC Converter. (ref \$CDD and \$DCC)
- Extended the Wakespeeds capability of BMS aggregation to the Victron Lynx BMS.

WS500 Pro Features:

- Plug-n-Go operation when connected to RV-C compatible battery
- Support for EGT Active regulation (Experiential). See ENG; and \$CNG:

WS500 PRO

Building upon the proven design and success of the WS500, the WS500 Pro offers additional capabilities and features, chiefly enabling access by Bluetooth to the Wakespeed application on both Android and iPhone. Bluetooth offers a new way to connect to your Wakespeed WS500 Pro for monitoring, configuration and updating; while still supporting direct USB access. To use press 'Bluetooth Scan' on the Device Screen in the Wakespeed Application, select the WS500 Pro(s) you wish to monitor or manage. From there you will be able to perform all the actions available via USB, or wireless. Please keep in mind a few details around Bluetooth access:

- The WS500 Pro must be powered on! Either by enabling the regulator once installed, or by applying power to the USB port before installing. Power to the USB can be anything: Cell phone charger, USB Battery, Computer (PC, Apple, Linux), or from the iPhone or Android using appropriate cables.
- There can be only one active Wireless connection to the WS500 Pro at a time. If you have two apps on hand and are unable to see a WS500 Pro while doing Bluetooth Scan, make sure another copy of the Wakespeed Application is not already connected.
- You are able to select one, or more, WS500 Pro(s) at a time to monitor or manage. Do take note of the Serial Numbers of each device so later you can specify which unit you wish to configure or update. Hint: Press the Identify button on the Bluetooth Scan screen to cause that WS500 Pro to flash out a pattern of Red/Green/Amber as a way to visually ID itself.
- Remember the USB port is still available for things like enabling wireless connect before full installation (Attach any power source), doing positive device attachment (direct USB connection with your Android + OTG + USB cable removes ANY question of which unit is being managed), as well as a way to enable Password Recovery and other recovery steps where Wireless access is not possible. Please refer to these following sections for additional details:
 - "Bench-top Configuration:" on page 24
 - "Password Recovery for WS500 Pro"
 - "Firmware Recovery of Erased Wakespeed device"

PLUG-N-GO (OUT OF THE BOX DEFAULT)

The simplest way to install a Wakespeed WS500 Pro regulator is to connect it up to a RV-C compatible battery via CAN, and go. With years of experience in High Energy Systems, the WS500 Pro features out of the box Plug-n-Go where no further configuration steps are needed – it is all automatic. The WS500 Pro will look to connect to a BMS via CAN using RV-C, and if found self-configures with no additional steps needed. In this 'Default' state the following are selected:

- The WS500 Pro will look for and lock onto RV-C compatible BMS via CAN in slave mode, otherwise remain in standby
- The regulator will auto configure for 12v, 24v, or 48v installs.
- Alternator set point of 100C, max 90% drive (18% in 48v installs).
- Battery assumed to be LiFeP04
 - Charge restricted to between 5..45c
 - Charge C rate restricted to 0.5C
- Both RV-C and NMEA2000 CAN subsystems enabled.
- Sensing of RPMs via the Yellow Stator wire will be disabled.
- Sensing of Battery Current via the local Current Shunt is disabled, battery current will be supplied by CAN from the BMS

If your install desires for further customize or optimize to better match your system, or to enable other high reliability features, use the Wakespeed App (iPhone and Android) to create other choices for a fully customized config.

Note: In order to retain security of your WS500 Pro, if you choose to use Plug-n-Go you will still want to make sure to change the password by using the Wakespeed App and connecting wirelessly to the regulator. If you fail to do this, and just run in Plug-n-Go fashion, you will have a grace period of 10x active engine start/charge cycles to change the password. If you do not connect via the Wakespeed App and edit the password, after this 10x grace period the password will be locked out and a Password Recover will need to be preformed. (Refer to "Password Recovery for WS500 Pro" below.

Hint: If you choose to pre-configure the WS500 Pro using the USB port, you can send in a blank for the password. The user will then have the same 10x grace period to change their password to their liking. See \$SCN: command below. And note this is not possible using the Wakespeed App, only by direct USB configuration of the Ws500 Pro, typically in higher volume OEM situations.

SECURITY AND PASSWORDS

Safety is critical...

Wireless access offers convenience but also introduces the risk of outside parties who could mistakenly, or maliciously, adjusting the configuration of your WS500 Pro – preventing operation, or worse, causing damage to you DC system. The WS500 Pro takes a number of steps to reduce this risk with the user defined Password being the 1st and most critical step!

Upon first Wireless connection you will be prompted to enter a new password for this device**. We suggest you use something other than the default 1234. Until the password is changed, you will only be able to monitor via Bluetooth, no changes will be allowed. After changing the password that will be remembered both in the WS500 Pro as well as within your application you will be able to make changes to the WS500 Pro. Later on if you attempt to connect using a different cell phone/tablet you will be prompted to enter the password, and again, until you do so the Wakespeed Application will only be able to monitor the WS500 Pro (Useful for service technicians who are being asked to troubleshoot an unknown device). Make sure to remember the new password, as you may well need it at a later time!

To change the password simple connect to the WS500 Pro, go to the Configuration Page and on the System Tab there is place where you can edit the System Password. Then re-configure your WS500 Pro (Three-Dots/Configure Deice) and the new password will be set. You will need to be in Expert Mode to do this.

Note** : If the WS500 Pro was previously configure either by a different copy of the Wakespeed App, or via USB, upon 1st connection you will be prompted to enter the password selected, but you will not be able to change it until you correctly 'Unlock' the regulator. Refer to "Password Recovery for WS500 Pro" below for instructions on how to recover and change the password to unlock your WS500 Pro.

OPTIONAL ALWAYS ON (7/24) INSTALL

In most installations the WS500 and WS500 Pro will be installed to run when the main engine is on. Connecting the Brown Ignition wire to a switched power point that only powers the WS500 Pro when the engine is running. There are however times when the system installer may wish to have the WS500/WS500 Pro always active. Perhaps the install is in conjunction with a Wakespeed WS48-12x, or perhaps they wish to use the WS500 Pro as a way to monitor their battery. In this case the following steps can be used as an 'alternative' install allowing for 7/24 operation:

- Connect the Brown Ignition wire to an always on power source.
- Connect the White Feature-in wire to the switched ignition power point (where you would normally attach the Brown wire)
- In the Wakespeed App, make the following changes (Note that you will need to toggle on Expert Mode)
 - On the Alternator Tab, adjust the Max field Drive and set the 'Half-power' option to 0%
 - On the System Tab, in the 'Regulator Options' section chose the 'Select Half-power mode (inverted input) option for the Feature In pull down.

Making these changes and the WS500 / WS500 Pro regulator will not be powered on at all times, while only driving the Alternator when the engine is actually running.

A NOTE ON HIGH ENERGY SYSTEM INSTALLS

The WS500 is unique in its ability to operate with a large range of system voltages due in part to the use of run-time voltage scalars (See \$SCO command). This, combined with its other wide capabilities makes it a very flexible product for use when designing and deploying 'High Energy' DC systems. However, such systems require great care in their overall design and deployment. It is incumbent upon the user of the WS500 to make sure they fully understand all aspects of their system, how components are installed and interact. The reader is encouraged to seek out Industry Standards for reliability, as well as industry Best Practices from reliable sources. How the system behaves with multiple charging sources, how extreme stress conditions are handled (both prevention, and reaction), all are needed to be well thought through. Wakespeed provides on our website a wide range of BMS and Battery systems which we have proofed in the lab – integration between the BMS and the WS500 for example; but such documents cannot cover all the considerations needed for more rich system installs which go well beyond the simple alternator/battery combo.

The following are some other considerations that might be helpful, especially with regards to 48v deployments. One is cautioned though, these are only some hints, it is fully up to the system design to assure a well functioning system in all cases and points of operations – including warnings and fault conditions. Significant damage can occur without careful thought and design of the system.

48v vs. 52v vs. 56v

In the field there are a number of different batteries that are used for '48v' deployments. Some are 15 cell LiFePO4 which at times sold as 48v batteries while 16 cell ones are sold as '52v' ones. Others use a different chemistry and are marketed at a higher 'nominal' voltage – perhaps showing 56v. The WS500 is able to accommodate all these variations, and for this note the term '48v' should be construed as applying to all as well.

The WS500 and Field Drive

At 12v and 24v voltage it is common for an alternators Field to operate at the same voltage as its specified output voltage. . 12v for a 12v battery, 24v field for a 24v battery, etc. This is not always the case with 48v alternators – in many (but not all) 48v alternator, the field is actually specified at 12v. In such cases there are a couple of ways the WS500 may be deployed with a hybrid alternator (48v output, 12v field)

1) Connect the ALT+ (Red) wire to a 12v source

With this approach, the field power source is supplied from a 12v source by connect ALT+ (Red wire) to a 12v (perhaps chassis) battery. VBAT+ (Red/Yellow wire) still needs to be connected to the battery for proper voltage sensing, but the WS500 does not require that both the target battery and the power source for the field be the same, not the same voltage.

Such a mix of voltages is a bit more complex with regards to wiring, but the WS500 functions well in the type of design. Do note that some harness (ala, the Van harness) combine ALT+ and VBAT+ into a single wire to simplify installs. In this case such a deployment will not work.

2) Apply a derate values (\$SCA command)

The \$SCA command has three 'Derate' values which can be defined: Normal, Small Alt, and Half-power. These are typically used to reduce the output of an alternator to account for system cooling concerns (ala, alternator overheating), and/or to reduce the load on the driving engine. But they can also be used to in effect reduce the 'Field Voltage' from 48v to allow direct driving of a 12v field while the ALT+ wire is attached to the 48v battery. To so this simply start with a 'Normal' derate value of 0.25 (aka, 25%), and that will reduce the average field voltage to an acceptable operation range. Most 48v deployments use this technique.

Change in Default Operation of the WS500

Due to the prevalence of 12v fields in 48v alternators, beginning with version 2.5.0 of the firmware, the WS500 will by *DEFAULT* automatically apply the 25% derate values if those have not been explicitly defined by a \$SCO command: In other words, if you take a factory fresh WS500 (or one that has been issued a \$MSR command to restore to Factory Fresh condition) and deploy it in a 48v system, field drive will be capped at 25%. If your alternator has a true 48v field (some do), you will want to explicitly issue a \$SCO command to restore the 100% field drive. (Or max field drive is otherwise appropriate)

Wakespeed has taken this step as the large majority of 48v alternators seem to have 12v fields, so we are adjusting the *DEFAULT* behavior to accommodate them. As always the regulator may be configured to better match your actual system, with the \$SCO command in this case.

Surge Protection (aka, the dreaded Load-Dump)

How to prevent and protect the system for a high energy voltage spikes. This is a very critical topic when designing a Lithium based battery system, with even more care needed in a 48v system. First a bit of background.

Alternators are by design electro-mechanical devices (vs. a pure electron device such as AC and Solar chargers) and as such there is a significant lag time for alternators to respond to changes in field drive. During normal operation the control loop of the Alternator, Battery, and WS500 take into account this nature, but if that loop is broken, a new situation needs to be addressed.

With the increased use of Li based batteries, and their accompanying BMS – the situation where the BMS goes into a protection mode and disconnects the Charge Bus of the battery creates what is known in the industry as a Load-Dump. SAE /ISO define these as a high energy even with voltages approaching a spike of 120v – in a 12v system. Double that for a 24v system. Testing in the Wakespeed lab has indicated that uncontrolled disconnects in a 48v system can, and often do, result in voltage spikes as high as 380-390v.

Clearly such high voltage spikes can (and have shown to) cause significant damage if not contained.

The Transportation sector (think cars, trucks, etc) long ago settled on a Best Practice of suppression for 12v/24v system through the use of special surge suppressing diodes know as Avalanche Diodes as the way to address these high voltage events. Relevant specifications one might reference include ISO 16750-2

By using Avalanche Diodes in the alternators rectifier block (vs. lower cost standard diodes) the system is protected from these events as the Avalanche Diodes suppress any voltage spike to perhaps 30v (in a 12v system) which are non-damaging to other devices. Most quality 12v and 24v alternators come with Avalanche Diodes and Wakespeed strongly recommends using such alternators, as they are a very critical part of an overall safe system design.

The special consideration in 48v systems is that Avalanche Diode Technology is not available in 48v alternators – the transportation sector instead focuses on well designed system which prevent load-dumpy through well designed systems. (Ref ISO 21780) As a result, 48v system designs *must* assure prevention of uncontrolled disconnect events (aka, load dump).

As such careful system design is critical for safe deployments in a 48v environment.

This is most critical during a disconnect even, there must be sufficient time to safely shut down an alternator before the contactors/FETs open, else what is known as a Load-Dump situation is created that results in system damaging voltage spikes (upwards of 400v for a 48v deployment). It is perhaps the single largest limitation of which batteries we (Wakespeed) can qualify as providing a safe system with couples with the WS500 (or any alternator based charging solution for that matter). What we need to do is receive advanced notice (Via CAN or some other communications method) of a pending disconnect before the actual disconnect. Though alternates take perhaps 400-500mS to fully shut down, we design our systems around a 2-second (min) forewarning.

CAN (CONTROL AREA NETWORK) COMMUNICATIONS

The WS500 Alternator Regulator features CAN (Control Area Network) ports. Developed in the 1980's by Bosch and targeted towards the transportation sector, CAN is now one of the most widely deployed communications standards covering not only the Transportation sector but also used in Industrial, Heavy Industry, Farming, Medical, Consumer, and more. Over a billion CAN nodes have been deployed, with modern automobiles contained upwards of 100+ individual nodes each! It is a proven reliable and robust communications standard with many features to assure deterministic and prioritized communication resulting in a solid and proven reliable communications backbone.

Utilizing CAN devices are able to integrate into a 'System' where each works in cooperation with the others. Further, the CAN allow simple and reliable way to connect computers or displays for ongoing monitoring and easy configuration.

The WS500 Alternator Regulator utilizes standards covering physical wiring, message content and other communications standards. These include:

- CAN Specification 2.0b / ISO-11898
- CiA 303
- SAE J1939
- RV-C
- NMEA-2000
- OSEnergy (Open Systems Energy - derived from the RV-C standard)

OSEnergy (Open Systems Energy) is an architectural specification whose aim is to provide a framework for the design, deployment, and operation of charging sources associated with a DC battery. Allowing them to work together in a 'systems' approach while meeting the full requirements of an associated battery as well as concurrently supplying house power needs in a consistent and efficient way. You can learn more here: <https://github.com/OSEnergy/OSEnergy>

Through the application of these standards the WS500 Alternator Regulator is able to deliver several key benefits, including:

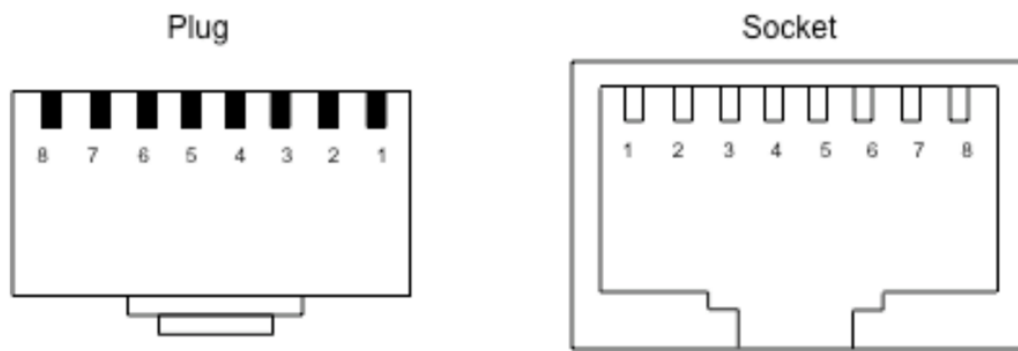
- Coordination of charging goals and objectives; all devices work towards the SAME goal vs. fighting each other.
- Tight BMS integration. CAN communications allows for the WS500 Alternator Regulator to fully integrate with the needs and directions of a BMS at levels unattainable using simple 'Charge Enable' wires.
- Prioritization of charging sources, e.g.: Utilization of Solar to its maximum capability while filling in the remaining energy needs from an engine driven alternator - thereby saving fuel.
- Remote sensing / Port Expander: The WS500 Alternator Regulator is able to take advantage of the CAN communications capability to transfer real-time battery status: voltage, amperage, and temperature as well as operational status (e.g., off-line in the case of a LiFePO4). By using this capability wiring and installations may be simplified.
- Self healing / fail over: Ability to self-recover from a failed, removed, or turned off device. The system continuously monitors all devices and adjusts as needed.
- 'Get-Home' total system failure mode: In the event of a catastrophic total system communications failure, the WS500 Alternator Regulator will fail-to-safe and operate in a stand-alone mode. Allowing for continued charging, but perhaps with less optimization and longer times needed.

CAN wiring

Use good quality CAT-5, CAT-5e, or CAT-6 cable to connect between devices in a daisy-chained fashion plugging into one of the two RJ45 connectors on the regulator. At each end of the daisy-chain install a terminator plug into the open RJ45 connector. It is important that the CAN bus be a single end-to-end chain with termination at each end. DO NOT connect an extra CAT-5 cable between the end devices making a loop – instead make sure each end point has one open RJ45 connector and then plug in the terminators.

The total length of the CAT-5 daisy-chain should be kept under 100M (300') with no more than 100x nodes total for best reliability.

The RJ45 connectors follow the CiA-303 standard, as shown here:



RJ45 connector

Pinning for RJ45 connector

Pin	Signal	Description
1	CAN_H	CAN_H bus line (dominant high)
2	CAN_L	CAN_L bus line (dominant low)
3	CAN_GND	Ground / 0 V / V-
4	(SFTY_STOP)	Optional - Machine Enable / Emergey Stop signal (Extension of CiA-303 spec)
5	-	Reserved
6	(CAN_SHLD)	Optional CAN Shield
7	(GND)	Optional ground
8	(CAN_V+)	Optional CAN external positive supply (dedicated for supply of transceiver and optocouplers, if galvanic isolation of the bus node applies) NOTE For recommended range of external power supply see clause 5.4

Figure 1 – CiA 303 CAN RJ45 connector specification

Connect the CAN_H and CAN_L signals. If supported, CAN_SHLD may also be optional connected as needed. It is generally NOT recommended to connect the CAN_GND to anything, as this may create a ground loop between it and ALT-

NMEA-2000® Support

The WS500 Advanced Alternator Regulator CAN protocol shares the same foundation and electrical specifications as NEMA2000 and produces NMEA2000 compliant messages. It needs to be noted the WS500 also by default transmits RV-C CAN messages, as well as J1939, which are not fully in line with the NMEA2000 specification. In most cases this does not caused problems when connecting the WS500 to a NMEA2000 network. However, if you do have issues with either NMEA2000 or OSEnergy communications you might try using a NMEA2000 certified CAN bridge such as the Maretron USB100 Gateway, or Yacht Devices YDNB-07 Bridge. In both cases it might be helpful to configure the bridges to filter out non-NMEA2000 messages (See Appendix C: Sample Yacht Devices CAN-CAN bridge scrip for a sample YDNB-07 scrip to accomplish this).

Wiring:

To connect into an existing NMEA-2000 network you will need to make up a patch cable. The simplest way to order a M12 Can adapter to connect the RV-C compliant CAN connection to a NMEA2000 backbone. Another approach would be to cut one end off a common CAT-5 cable and use a field attach NMEA2000 connector. Referring to “Figure 1 – CiA 303 CAN RJ45 connector specification” above as well as “Figure 2 - NMEA2000 connector pinout” below only the *CAN_H* and *CAN_L* wires need to be connected. With either approach take care not to exceed the maximum Drop-cable length of 6 meters, take care also to properly terminate the CAN network. For reference here is a wiring guide:

Signal	CAT-5 Cable		NMEA2000 Cable	
	POSITION	COLOR	POSITION	COLOR
CAN_H	1	White/Green --OR-- White/Orange	4	White
CAN_L	2	Green --OR-- Orange	5	Blue

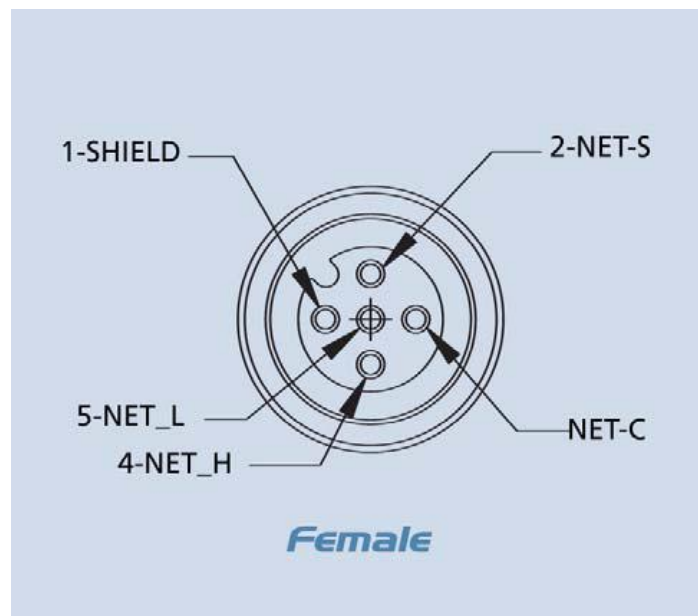


Figure 2 - NMEA2000 connector pinout

There is no need to connect the CAN-GND, and in fact doing so may cause reliability issues due to ground-loops.

A number of NMEA2000™ status output messages are supported. These messages may be useful when the WS500 is connected to a NMEA2000 network and will allow the operational status of the alternator and battery to be displayed. Refer to

Appendix B: CAN messages for a list of supported messages. Note that the WS500 will send two groups of some of the NMEA2000 messages, one set for the Battery and one set for the Regulators operation. Refer to the details of each PGN.

Be sure to properly configure the regulator when using these messages, specifically the 'Engine ID' and 'Charger Instance' using the \$CCN: command, and note also that the Battery Instance number transmitted in NMEA2000 messages is reduced by 1 from the WS500 Battery Instance (NMEA2000 uses 0 oriented numbering, while RV-C uses 1 oriented numbering).

VICTRON DVCC SUPPORT

Beginning with firmware release 2.5.2, the WS500 offers support to follow Victron utilizing DVCC. By default the WS500 will follow DVCC direction issued to it via the Cerbo, you are able to disable this via the 'Enable DVCC?:' parameter in the \$CCN: command, or by toggling the 'Support Victron DVCC' toggle in the Wakespeed App (System Tab, Expert mode enabled). There are dependencies for allowing DVCC to be utilized:

- Cerbo firmware must be v3.30 or better
- Wakespeed firmware must be v2.5.2 or better
- The Current Shunt must be located at the Alternator and not being 'Ignored'
- NMEA2000 Support (System Tab, Expert Mode) must be enabled.
- Victron DVCC Support (System Tab) must be toggled on.

You may optionally set the Alternator Capacity via \$SCA (or Alternator Tab in Wakespeed App). This capacity will be transmitted to the Cerbo as the capability to use for its calculations. If no value is set 200A is used by default. Note that none of the other Alternator management parameters are ignored, max temperature, derate values – all continue to function as before, DVCC simply adds an additional ability for the Victron Cerbo to provide direction. Make sure to reference the "WS500 and Cerbo GX" how-to-guide on <https://www.wakespeed.com/learn/> for details around CAN connection between the WS500 and the Victron Cerbo (and like) devices.

While under DVCC control, the regulator will receive directions from the Cerbo to consider along with all other directions (ala, the CPE,, remote BMS while in slave mode, Alternator limits for Temperature and Drive.). If the DVCC is more restrictive then what otherwise would be used for Alternator Current and Battery Voltage, those limits will be respected.

DANGER: It is important to note that DVCC is not a replacement for CAN locked WS500/BMS communications. You still need to set up any battery BMS as always to assure the safety during alarm/fault conditions. Do NOT depend solely on DVCC to provide safe integration with a BMS!

One last note: **If you make a configuration change to the WS500, example changing the definition for Shunt at the Alternator, you will need to power off the WS500 for 30 seconds to allow the Cerbo to timeout and resend any DVCC commands.** Until that is done, the Cerbo will simply remember any prior communications (Such as: Not able to support DVCC at this time as we do not have a current shunt on the alternator). Power-cycle the WS500 for 30 seconds will cause the Cerbo to reset itself.

A NOTE ON FEATURE-IN PORT

The Feature-in port allows a wide range of optional capabilities in the WS500 to be selected in real time. Throughout this configuration guide there are a number of places where the Feature-In port may be enabled to be looked at to select a given capability. There are also options to modify the behavior of the Feature-In port from its normal behavior. Care should be exercised when configuring the WS500 to assure that the desired behavior of the Feature-in port is selected, and that some other expected use has not inadvertently been disabled. Example, by utilizing the Feature-In port to select Half-Power mode often has cascading impacts such as selection of an alternative DC-DC converter set point, placing the Alternator in Standby Mode (combined with setting Half-power mode derate to 0%).

In its default behavior the Feature-In port is used to select either Equalize charge mode when Charge Profile 1..7 is used, or Float Mode when Charge Profile #8 is selected. This default behavior can be changed via the *<Feature-IN>* parameter in the \$SCO: command (ref Page 70 for details) to allow greater flexibility in system design.

In addition the state of the Feature-In port can be used to select or disable White Space independent of the Charge Mode or Feature-in Optional Behavior selected. (ref \$CNG: command on page 46, polarity of *<RFM_RPM>* parameter.)

FIRMWARE RECOVERY OF ERASED WAKESPEED DEVICE

There may become a time when the firmware has become fully erased from the Wakespeed device. Perhaps an update was interrupted mid-process, or some other event – erased Firmware can be noted because the LED does not blank its slow Green state upon first power on. (Note, there may be other reasons for No Blink, such as damaged regulator).

This section provides an overview of how Firmware is loaded into the Wakespeed devices and ways you can recover from a fully erased state.

As a summary: The WS500 / WS500 Pro has two 'modes' of operation:

- DFU Mode (aka, Firmware Update mode)
- Running Mode (a WS500 with its LED flashing)

The Firmware Update mode is built into the CPU by the manufacture, it is not something Wakespeed has written – but is hard-codes into the CPU itself. While in DFU Mode one is able to download a .DFU file into the regulator. There are two ways to enter DFU Mode:

- Automatically via one of the ASCII commands
- By pressing-and-holding the reset button for 5 seconds. Upon release the regulator hardware will restart in DFU mode.

Normally we use the 'Automatic' way via the Wakespeed App: When the user selects to update firmware the app will ask the regulator what firmware version it presently has, it will also pull from the Cloud the latest firmware – and if a newer version is prompt the user if they wish to update. If they say yes, the App will then automatically place the into firmware update mode (DFU or OTA as appropriate) to complete the firmware update.

But if the regulator has no firmware, or damaged firmware, preventing the app from doing the above (Asking the current version, automatically placing the regulator into DFU mode) one is able to update firmware via physical connection to the regulator using USB and selecting 'Expert Mode' in the Wakespeed app:

1. Download the latest Wakespeed App from the Android store (Must be version 1.9 or above)
2. On the Settings Screen (Press the house, then Settings), press 'Update Now' to assure the last firmware is pulled from the cloud. (After this you will no longer need an internet connection, ala, if moving to the boat.)
3. While still on the Setting Screen, toggle on Expert Mode. We will need to use this to manually walk through the Firmware Update Steps.
4. Select the Device Screen (Home icon, then Device)
5. Make sure the 'Selected Device' matches the Wakespeed product you are looking to update (WS500 or WS500 Pro).
6. Connect a USB cable + OTG adapter between your Android device and the Wakepeed device.
7. On the Wakespeed device, press-n-hold the Reset button for 5 seconds. Release it.
 - (You may receive an Android pop-up asking for permission for the Wakespeed app to connect to the 'Bootloader' If so, say Always and Yes/OK. Hopefully this is only a one-time Android ask)
8. The 'Firmware Update' button should become available (Black vs. Gray).
9. Select Firmware Update bar

10. At this point press the 'Select Existing File' option and then select the 'Previously user firmware files' option and select the version of firmware you downloaded in step 2 above. MAKE SURE TO SELECT A COMPATIBLE FIRMWARE FOR THE WAKESPEED DEVICE YOU ARE UPDATING!
11. After selecting the firmware to use, press the Next button
12. The Wakespeed app will confirm the device is in DFU mode. Press Next button again to begin update
13. Firmware will update at this point.
14. If the Wakespeed device does not reset itself automatically, do it manually by pressing and then quickly releasing the ease the Reset button.

You should now have an operational Wakespeed device.

Other options for raw loading firmware into a Wakespeed device include:

- Request an RMA from support@wakespeed.com
- Use of Wakespeed Windows based 'Universal Transfer Tool'
- Use of Developer Tools, such as ST Micros 'STM32CubeProgrammer' tool.

PASSWORD RECOVERY FOR WS500 PRO

If at some time the password for a WS500 Pro is lost, or has been changed and the new password is not known, there are some steps which can be taken to 'reset' or 'recover' the password. Please also note that if the WS500 Pro has been installed in a play-n-play fashion, and the password was not changed – after the 'Grace Period' the password will automatically be changed to a random value. One of these Password Recovery steps may be used to unlock the device.

The key is that there is positive proof the operator has physical access to the WS500 Pro, and for that the USB connector is used. Remove the WS500 Pro lid and then either:

- 1) With the engine off, connect up any USB power source: Cell Phone Charger, PC, Android, USB Battery power source. Anything to allow the Logic side of the WS500 to power on.
- 2) With the engine on, you need to connect up some type of computer: Android + OTG adapter, Windows PC, Apple PC. Anything that is more than just a power source. There is no need to run any special program on that computer, simply connect it to the USB port using an appropriate USB cable and adapter if needed.

After demonstrating physical access you can use the Wakespeed Application to reset the password. Do one of the following:

- 1) Upon connecting via a Bluetooth Scan, when prompted change the password to one you wish to use.
- 2) Upon connecting via a Bluetooth Scan, when prompted press "Read Only" and then move to the Configure screen and select from the three-dots menu "Copy Device". The configured password will be shown on the System Tab.
- 3) Upon plugging in a Android + OTG to the USB port, either do the three-dots / Copy device to reveal the password, or create a new configuration, including the new password you wish to use, and select three-dots / Configure Device.

TEMPERATURE SENSORS (ATS, BTS)

All temperature sensors used on Wakespeed products are the same and fully interchangeable – the difference is just the length of the wires. But they can become physically damaged, which often shows up as the dial on the Wakespeed Application Monitor tab being grayed out. To field test a Temperature Sensor, unplug it from its connector and using an Ohm Meter measure the resistance of the two pins in the Temperature Sensor. At room temperature they should show around 10K ohms. Less if it is hotter, more if colder. But one might expect a range from 5-15K Ohms outside of extra conditions. Open or shorted indicate a damaged temperature sensor.

Refer to the "Extending Wires" leaning guide if you need to extend any temperature sensor, or run them a long distance from the WS500.

ASCII COMMUNICATIONS

The WS500 Alternator Regulator utilizes ASCII communications as a machine-independent M2M (Machine to Machine) method for communicating between the WS500 and outside devices allowing for configuration, advanced monitoring / logging and diagnostics.

This manual is largely dedicated to documenting the ASCII protocol used by Wakespeed products; and though by their nature they are readable by Humans – and many interact with the Wakespeed Alternator Regulator directly via ASCII, it was primarily intended to communications to other tools – such as the Wakespeed application and 3rd party solutions (OPE Tether, OGSS Configuration tool, Ruby scripts, etc).

Wakespeed Application

One example of how these ASCII messages are used is with the Wakespeed Application. The applications allows for the creation of fully customized configurations based on selecting the alternator, battery, (optionally) BMS, as well as other system level features. Available for both iPhone and Android the application will create custom ASCII configuration files which can be used to configured the WS500 or WS500 Pro. More so, when used with an Android one can use an OTG cable to allow for direct connection to the WS500 / WS500 Pro USB port allowing for sending the configuration to the WS500 as well as monitoring, logging and firmware update without the need for a Windows PC. **All these capabilities are extended to both the Android and iPhone using a wireless Bluetooth connection on the WS500 Pro.**

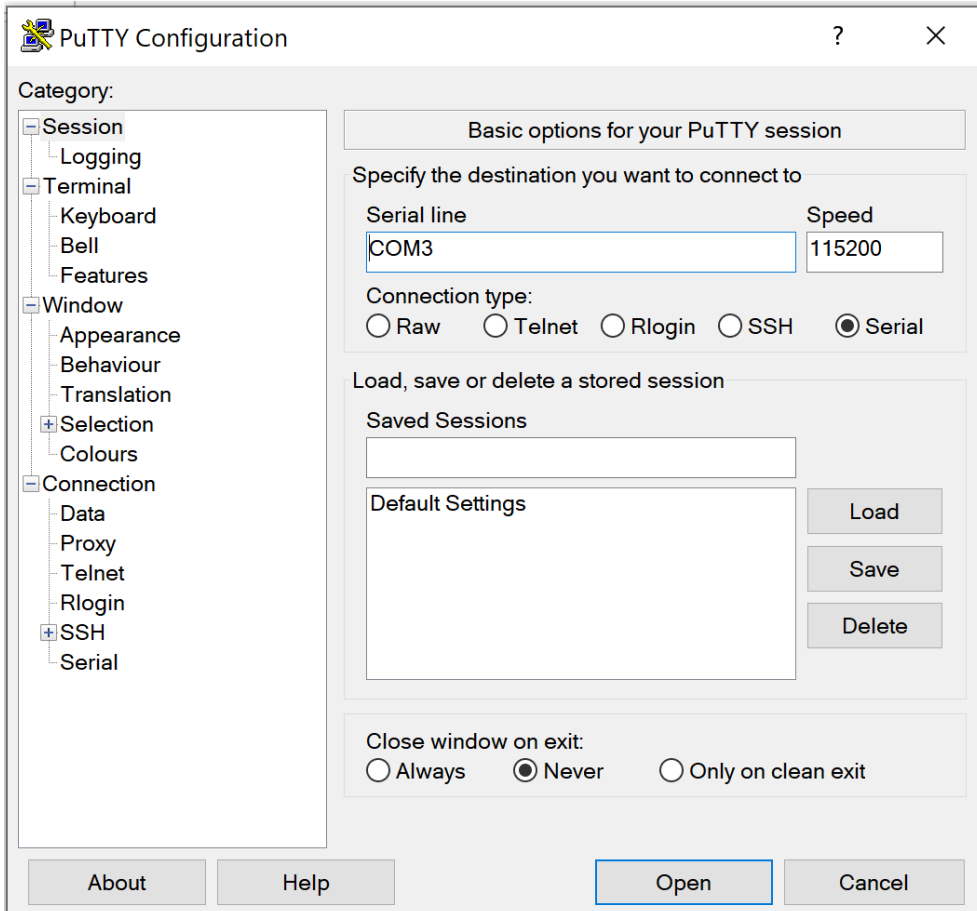
Hint: If you press and hold the ‘Next’ button at the bottom of the Configuration screens, a small raw ASCII window will open allowing you to see raw ASCII traffic from the regulator.

Terminal Programs

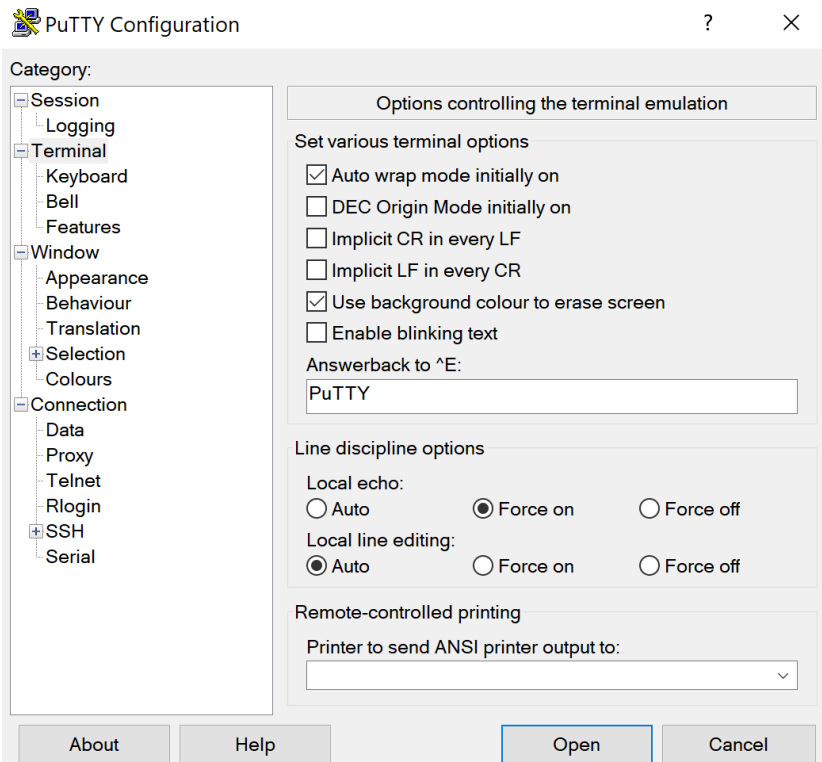
If one wishes, the raw ASCII data may be accessed directly using serial terminal programs and a computer. Many operating systems have built in terminal programs, or 3rd part programs such as PuTTY may be used to directly access the raw ASCII communication capability of the WS500 via its USB port. After connecting the regulator to the computer you can use one of these to open a communications window to the WS500 Alternator Regulator. A special note, some terminal programs do not send a complete end-of-line terminator (CR+LF). To support these environments, the WS500 Alternator Regulator will recognize the character ‘@’ as an alternative EOL indicator.

Remember that any configuration changes you make to the regulator may not take effect until the regulator is restarted. When you have finished, make sure to issue the \$RBT: command to not only assure changes are saved to the regulator’s non-volatile memory, but that the changes are then utilized by the regulator. (refer to \$RBT: - ReBooT system on page 89). After rebooting the WS500 Alternator Regulator verify the changes you sent were recognized by the regulator by inspecting the various status strings.

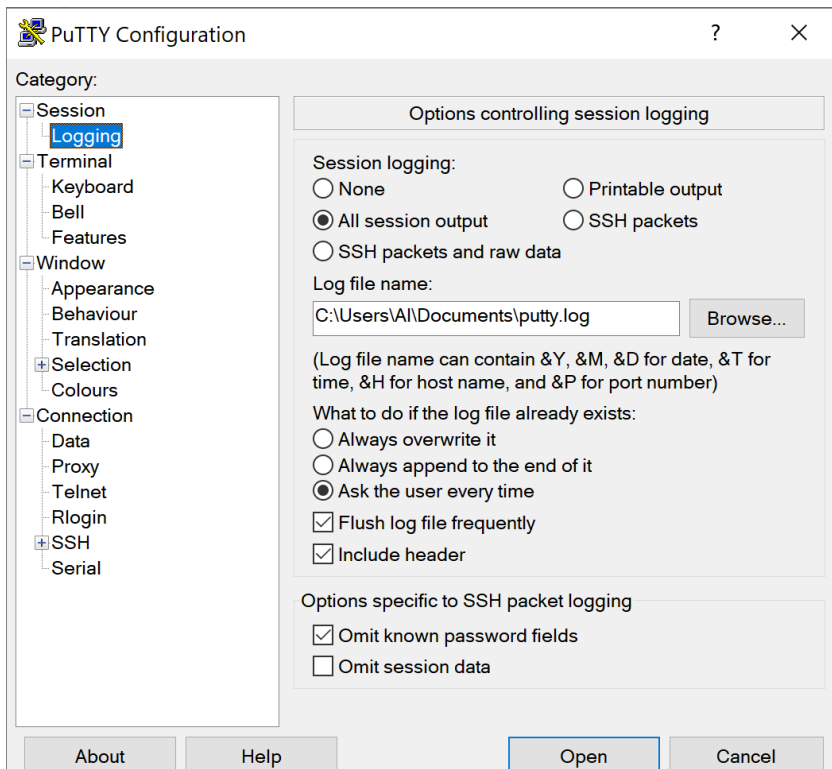
PuTTY: A versatile option is the free ‘Putty’ program (www.putty.org). It supports a wide range of OSs and includes a very nice logging function. To use connect up the USB cable and start Putty. Configure as shown here – selecting the Serial Line which your USB serial port is associated with, and setting the speed to 115200 and clicking the Serial Connection Type redial button.



Next click on the Terminal category and click the Forced-on button for local echo (as indicated on the following page), this will assure you can see what you are typing.



Finally, if you wish to keep a logfile of the session click on the Logging category, enter a file name and select the 'Printable Output' button as shown here:



Logging sessions is very helpful for debugging your installations, the files are comma separated and easily import into Excel using the import wizard specifying commas (,) as the separator. Refer to *“Receiving data FROM the regulator”* below for details on the output.

Once you have done your configuration press the Open button to start the terminal session. A hint for Windows users: If you have a need to Paste anything into Putty, know it does not use the normal CTRL-V command. Instead, position the cursor in the black display windows and click the RIGHT button, which will cause the clipboard to be pasted and sent to the WS500.

Bench-top Configuration:

When a USB cable is connected to the WS500 Alternator Regulator power is supplied to the logic portion of the hardware. This allows you to do bench-top configuration before completing the installation on the actual alternator. Make sure to do a \$RBT: command as your last step. After the regulator reboots make sure to verify your changes before installing the regulator in a live installation.

Bench-top configuration of the WS500 Pro may be done via Bluetooth simply by supplying power to the WS500 Pro using the USB port. No need to mock up a harness, no need to run a special PC program – simple connect anything to the USB port to supply power and then configure the WS500 Pro from your iPhone or Android using Bluetooth. Some potential power ideas:

- Cell Phone charger
- USB Battery source
- Any USB port on a computer: Windows, Apple, Linux, etc.
- Android device with OTG cable (Will also allow direct configuration of WS500 Pro without needing to scan for and then connect via Bluetooth)
- iPhone using a USB-B adapter cable to provide power. Also connect via Bluetooth to do actual configuration (Apple will not enable data transfer via attached USB cable, use Bluetooth instead)

RECEIVING DATA FROM THE REGULATOR:



= Features supported by Alternator Regulators (WS500, WS500 Pro)



= Contains features exclusive to the WS500 Pro Alternator Regulator



= Features supported by DC-DC Converters (e.g., WS48-12x when used with a WS00/WS500 Pro)

Receiving data FROM the regulator:

		25	
DST; -- DC-DC ENERGY TRANSFER STATUS		29	
DCV; -- DC-DC ENERGY TRANSFER CONFIGURATION		30	
ENG; -- ENGINE CONFIGURATION			31
CST; , -- CAN STATUS		32	
CPE; -- CHARGE PROFILE ENTRY		36	
NPC; -- NAME & PASSWORD CONFIGURATION			38
SCV; -- SYSTEM CONFIGURATION		39	
SST; -- SYSTEM STATUS			41
FLT; -- FAULTED		43	
AOK; -- ACKNOWLEDGE		43	
NAK; -- NEGATIVE ACKNOWLEDGE		43	
DBG; -- DEBUG		43	
RST; -- RESET		43	

All status outputs are suspended during the receiving and processing of a command string. In this way, a command which expects a response (ala \$RSC:) can be assured the next string sent back by the regulator is the response to the

requesting command (though one should still do error checking and validation, as the simple regulator will often ignore commands containing a syntax error in them)

Formats are in clear ASCII using comma separated fields. Note the presence of double commas (separated by a space) between major 'sections', this is to simplify manual reading of the strings. Each string is delivered as one continuous line with a CR/LF termination.

Additional details of each status may be discovered by examine the command string for changing those parameters.

AST; -- ALTERNATOR STATUS



AST: "AST;, Hours, , BatVolts, AltAmps, BatAmps, SystemWatts, ,TargetVolts, TargetAmps, TargetWatts, AltState, ,BTemp, ATemp, ,RPMs, , AltVolts, FTemp, DVCC_LimitAmps, FLD%"

Hours: Time regulator has been powered up, in hours and fraction (to 2 digits) of hours.

BatVolts: Derived Battery Volts, in volts and fractions of volts (to 1mV resolution). Used to decide charge mode changes.

AltAmps: Measured Alternator Amps, in Amps and fraction of Amps (to 1/10th of an Amp).

BatAmps: Derived Battery Amps being used to decide charge modes.

Voltage and current readings made by the WS500 Alternator Regulator are directly reported as *AltVolts* and *AltAmps*. Unless overridden by an external source (example via a Remote Battery Sensor) those same values will be assumed to be *BatVolts* and *BatAmps* and used by the regulator to make charge state decisions.

SystemWatts: Current measured System Watts being delivered.

TargetVolts: Volts the regulator is attempting to bring the battery to. Either from the internal Charge Profile entry, or if the regulator is locked onto a BMS, from the goals being send to it.

A Negative Value for *TargetVolts* indicates the device is following DVCC guidance, which is asking for a more restrictive voltage goal then would normal be targeted.

TargetAmps*: Battery limit amperage the regulator will limit current to.

TargetWatts*: Watts the regulator is actually working to limit the system to.

*Note: * If the WS500 Alternator Regulator is configured with no limits for Battery Amps and/or System Watts a self-impose limits of 1,000A / 15,000W as max values. AST; will report these working values.*

AltState: Current state of the Alternator, per the following table:

Value	
0,1,4	- Alternator Off
2,3	- Alternator FAULTED (See Fault Code)
5	- In special DC-Disconnected CV mode.
6	- Alternator in Idle (Ala, Half-power Mode with active DC-DC converter)
9	- In CONFIGURATION mode
10	- Alternator Standby mode, or in delay mode while engine warms up.
11,15	- Ramping towards BULK mode.
12,20	- In BULK mode
21	- In ACCEPTANCE mode
22	- In OVER CHARGE mode
30	- In FLOAT mode
31	- In FORCED_FLOAT mode (via Feature_in pin and CPE = #8, or missing required sensor)
36	- In OFF (Post Float) mode
38	- In EQUALIZE mode
39	- In CVCC mode (only available in system under direction of CAN master)

BTemp: Measured temperature of NTC sensor attached to B-port in degrees C or battery temperature received via external CAN sensor. -99 indicates temperature has not been measured, NTC sender has failed, not attached, and there is no remote temperature information available via the CAN connection.

ATemp: Measured temperature of NTC sensor attached to Alt-port in degrees C. -99 indicate temperature has not been measured, or NTC sender has failed. -100 indicates the Alternator temp NTC probe is shorted (to select ½ power mode)

RPMs: Measured RPMs of engine (Derived from Alternator RPMs and the Engine/Alternator drive ratio)

(The following additions are available with Firmware version 1.0.0 and above)

AltVolts: Measured Alternator Volts, in volts and fractions of volts (to 1mV resolution)

FTemp: If equipped, this is the temperate of the FETs in degrees C.
-99 indicated FET temperate cannot be measured.

DVCC Limit Amps: If enabled, what it the Device Limit amps as requested by Victron DVCC. -1.0 indicates either DVCC is not enabled, or inactive at this time. (Was Famps prior to 2.5.2:)

FLD %: % (0..100%) field is being driven.

DST; -- DC-DC ENERGY TRANSFER STATUS



“DST;, DCDC_State, Volts, ,12vBatVolts, 12vBatCurrent, 48vBatCurrent, DCDC_Temp”

DCDC_State: Operational status of optional DC-DC converter. See AltState table above for additional details.

Value	
0	- Converter Off (or not present)
1,4,6	- Converter in Standby or Idle mode
2,3	- FAULTED (See Fault Code below)
10..40	- 48v Battery Charging Modes: (Reference AST Table above)
81	- 12v Battery Support mode.
82	- 12v Battery Refresh Charge

Volts: Presently active target Voltage goal/trigger. (See \$CDD on page 82 for details)

12vBatVolts: Measured 12v battery voltage as reported by the DC-DC converter. Note this may be remotely senses battery voltage, or it may simply be the voltage at the DC DC Converters Secondary Battery terminals.

12vBatCurrent: If DC-DC Converter is capable, this is the measured current of the secondary battery.

48vBatCurrent: If DC-DC Converter is capable, this is the measured current of the primary battery.

Note: With both the 12v and 48v battery current values, the values reflect current supplied/consumed only by the DC-DC Converter, not the entire battery. A Positive value indicated energy transfer out of the DC-DC Converter and INTO the respective battery

DCDC_Temp: Internal temperature of the DC_DC Converter, in degrees C

Note: DST: will only be sent if the optional DC-DC converter has been configured and enabled (See \$CDD: command on page 82). If enabled, it will alternated with the AST status string.

DCV; -- DC-DC ENERGY TRANSFER CONFIGURATION



“DCV;, Model, Mode, , Volts, Volts_HalfPower, ,48v Charge Limit Amps, ,12v support Limit Amps, 48v Cutoff Voltage, 48v Cutoff SOC”, ,12v Refresh Volts, 12v Refresh Hold, 12v Refresh Days

Model: Model of DC-DC Converter configured to support (See \$CDD: command)

Mode: Operational mode of optional DC-DC converter bridging the Primary (Target, or High Side) and Secondary (Low Side, e.g.: Chassis) battery.

Voltage: 12v battery Target voltage, above this charge assist mode is enabled.

Volts HalfPower: 12v battery Target voltage when regulator is in Half-power mode

48v Charge Limit Amps: Max current while in ‘48v charge’ mode.

12v Support Limit Amps: Max current while in “12v support” mode.

48v Cutoff Voltage: If the 48v drops below this, 12v support mode is disabled.

48v Cutoff SOC: If the 48v drops below this, 12v support mode is disabled.

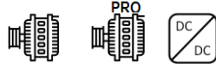
12v Refresh Volts: 12v battery Target voltage when doing ‘12v Refresh’ charge

12v Refresh Hold: Time to hold 12v Refresh Volts when doing ‘12v Refresh’ charge

12v Refresh Days: Number of days to initiate a ‘12v Refresh’ charge.

Note: DCV: will only be sent if the optional DC-DC converter has been configured, ala the Model is not set = None. (See \$CDD: command on page 82)

ENG; -- ENGINE CONFIGURATION



"ENG;, J1939MaxLoad, ,RFM_RPM, RFM1, RFM2, RFM3, RFM4, RFM5, RFM6, RFM7, RFM8, ,Setpoint in _Setpoint"

J1939MaxLoad: Maximum Engine Load allowed as reported via J1939

RFM_RPM: Maximum expected engine RPMS for tachometer based engine loading management

RFM(n): Max field drive % modifier to be applied at each RPM bucket from 0..RFM_RPM

EGT_Setpoint: Setpoint in Degrees C for active regulation of engine load based on.
(WS500 Pro Only)

Reference \$CNG: command on page 46

CST; , -- CAN STATUS



“CST; , BatteryID, IDOverride, Instance, Priority, , Enable NMEA2000?, Enable OSE?, , AllowRBM?, IsRBM, ShuntAtBat?, , RBM ID, IgnoringRBM?, Enable_ALT_CAN, , CAN_ID, , EngineID, BitRate, Aggregate BMS, N2K Alt Sense, , Enable-DVCC?, DVCC Active?, , CAN_TxErr, CAN_RxErr”

BatteryID: Battery number (or Instance) the regulator is associated with. 1..100

The following ‘convention’ is suggested – but not required:

1. Main House Battery
2. Primary Engine Starter battery (port engine)
3. Secondary House Battery
4. Secondary Engine Starter battery (starboard engine)
5. Generator Starter Battery
6. Forward Thruster battery
7. Aft Thruster Battery

IDOverride: Battery number (or Instance) is set via the DIP switches, however it is possible to ‘override’ the DIP switches using the \$CCN: command. (0= no override)

Instance: Charger Instance (1..13). Set with \$CCN: command (Default = 1)

Priority: Device priority, used to decide which devices should provide charging current, as well as who will be potential ‘master’ device. Set with \$CCN: command (Default = 70)

Enable NMEA2000?: 0 or 1, Is regulator configured to send NMEA-2000 messages? (1 = Yes)

Enable OSE?: 0 or 1, Is regulator configured to send OSEnergy type messages? (1 = Yes)

By using the \$CCN: command, the user may disable portions of the CAN message stack. One would do this in cases where conflicts exist with existing devices on a shared CAN bus. An example might be the regulator is installed into an existing NMEA-2000 system, and it is desired to have NMEA-2000-like status be sent out; however some of the OSE messages cause issues with existing NMEA-2000 instruments. In this case the user may choose to disable OSE messages.

CAUTION: If OSE messages are disabled, all CAN-based value-add capabilities of the regulator will also be disabled. Including remote instrumentation, common charging goal, and charging device prioritization, BMS slave mode. DISABLE OSEnergy MESSAGING WITH CAREFUL

CONSIDERATION and perhaps consider setting up isolated networks instead with a CAN bridge to forward the NEMA2000 messages to the proper NMEA2000 bus.

- AllowRBM?: 0..2: Is regulator configured to attempt to act as the Remote Battery Master? (1 = RBM, 2 = 'Virtual RBM')
- IsRBM?: 0..2: Does regulator currently think it is the Remote Battery Master? (1 = RBM, 2 = 'Virtual RBM')
- ShuntAtBat?: 0 or 1, Does regulator currently think its shunt is directly connected to the battery? (1 = Yes, 0 = No)

The WS500 Alternator Regulator is able to assume the role of the Remote Battery Master, thereby acting as the central coordinator for all charging sources. In practice, using the regulator as the RBM typically would occur only with small installations, twin engines installations are a common example. However, one is also able to configure a more extensive system where the WS500 Alternator Regulator is configured as a backup device. Set this via the \$CCN: command

RBM ID: Remote Battery Master ID: ID number of remote device which is currently recognized as the Remote Battery Master. 0 = WS500 Alternator Regulator has not associated itself with RBM.

IgnoringRBM?: 0 or 1, Is the regulator ignoring the Remote Battery Master? (1 = Yes)
If the Remote Battery Master sends information which seems unbelievable, this flag will be set and the regulator will ignore it. **Such a condition indicates something is wrong in the overall system and that should be investigated and resolved.** Conditions which will cause this fault include:

- Indicated Battery Voltage too high, or too low. (8..18v for normalized 12v battery)
- Indicated Battery Current too high (> +/- 2,000A)
- Voltage difference between battery and alternators > 1.5v (indicating issue with alternator wiring)
-

Enable_ALT_CAN: Bit-mask enabling alternative CAN based remote sensing and/or RBMs. See \$CCN: on page 77 for details.

CAN_ID: This is the current CAN Node ID, or node address which the WS500 Alternator Regulator has been assigned.

EngineID: Engine ID (or number) the WS500 Alternator Regulator with the engine it is mounted on. Used for monitoring J1939 RPMs messages as well as sending NMEA2000 RPMs back out. Note by convention EngineID = 0 is the default value.

BitRate Data communication rate CAN is set for.

Aggregate BMS: Indicates optional aggregation of BMS / RBM's.

N2K Alt Sense: N2K Alternator Current Sensor Instance (0..250). 0 = Disabled.

Enable DVCC?: 0 or 1, Is regulator configured to listen to Victron DVCC? (1 = Yes)

DVCC Active? 0 or 1, Is regulator presently operating under DVCC control?

CAN_TxEr Error count reported by CAN controller for Transmitted Messages. Resets upon power-cycle/reboot.

CAN_RxEr Error count reported by CAN controller form Received Messages. Resets upon power-cycle/reboot.

Note: Depending on the CAN controller subsystem, accumulated error counts may be capped to some limited value. When using, consider any number other than 0 to be an indication of potential physical CAN system issues.

CPE; -- CHARGE PROFILE ENTRY



In response to RCP: command, this displays the current values of a Charge Profile Entry. Special note on Charge Profile Entries: All voltage and current values in Charge Profile tables are displayed in their normalized '12V' values. See Defining Charging Voltages and Amps for additional information.

“CPE;, n, acptVBAT, acptTIME, acptEXIT, res1, , ocAMPS, ocTIME, ocVBAT, ocaEXIT, , floatVBAT, floatAMPS, floatTIME, floatRESUMEA, floatRESUMEAH, floatRESUMEV, , pfTIME, pfRESUME, pfRESUMEAH, , equalVBAT, equalAMPS, equalTIME, equalEXIT, , BatComp, CompMin, MinCharge, MaxCharge, , RdcVolts, RdcLowTemp, RdcHighTemp, RdcAmps, , floatSOC, , MaxAmps, , pfVBAT, MaxBatVolts”

- n: Charge Profile 'n' is being displayed/returned (1..8)
- acptVBAT: Target battery voltage during BULK and ACCEPT phase
- acptTIME: Time limit to stay in ACCEPT mode – in Minutes.
- acptEXIT: Amp limit to trigger exiting ACCEPT mode
- res1: Reserved for future use (dV/dT exit criteria, currently = 0, disabled)

- ocAMPS: Max Amps which will be supplied by during OVERCHARGE mode.
- ocTIME: Time limit to stay in OVERCHARGE mode – in Minutes.
- ocVBAT: Target battery voltage during OVERCHARGE phase
- ocaEXIT: Amp limit to trigger exiting OVERCHARGE mode

- floatVBAT: Target battery voltage during FLOAT phase
- floatAMPS: Max Amps which will be supplied by during FLOAT mode.
- floatTIME: Time limit to stay in FLOAT mode – in Minutes.
- floatRESUMEA: Amp limit to trigger resumption of BULK charge mode
- floatRESUMEAH: Amp Hours withdrawn after entering Float to trigger resumption of BULK charge mode
- floatRESUMEV: Volt limit to trigger resumption of BULK charge mode

Note: If the regulator is in FORCED_FLOAT mode via the FEATURE-IN pin, then none of the above checks to exit float mode (e.g., floatTIME) will be performed. However, regulation will still occur to *floatVBAT* and *floatAMPS*.

pfTIME: Time limit to stay in POSTFLOAT mode – in Minutes, before resuming FLOAT charge mode.

pfRESUME: Battery Voltage that will trigger resumption of FLOAT charge mode

pfRESUMEAH: Amp Hours withdrawn after entering Post Float to trigger resumption directly to BULK charge mode

equalVBAT: Target battery voltage during EQUALIZE phase

equalAMPS: Current limit of Alternator while in EQUALIZE mode

equalTIME: Time limit to stay in EQUALIZE mode – in Minutes.

equalEXIT: Amp limit to trigger exiting EQUALIZE mode

BatComp: Temperature Compensations value per 1-degree C (normalized to '12v' battery)

CompMin: Minimum temperate to apply compensation at. In degrees C

MinCharge: Minimum temperate to charge the battery at, below this will force into a standby mode.

MaxCharge: Maximum temperate to charge the battery at, above this will force into a standby mode.
 Note: Prior editions INCORRECTLY indicated regulator would enter FLOAT mode..

RdcVolts: Battery low Volts trigger for Reduced Charging

RdcLowTemp: Battery low Temperature trigger for Reduced Charging.

RdchHighTemp: Battery high Temperature trigger for Reduced Charging.

RdcAmps: Current limit while in Reduced Charging state.

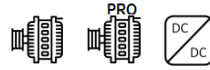
flaotSOC: SOC level to trigger resumption of BULK charge mode .

MaxAmps: Maximum battery charge current during any charge phase.

pfVBAT: Target battery voltage during POST-FLOAT phase

MaxBatVolts: Optional max battery voltage fault threshold

NPC; -- NAME & PASSWORD CONFIGURATION



"NPC;, **Enable BLE?**, Name, Password, , DeviceID, **DOM** "

Enable BLE? Is the wireless BLE RF capabilities enabled? (WS500 Pro ONLY)

Note, if BLE is not supported on the device, no value will be sent – instead a NULL, e.g.: Two commas in a row.

Name: Name of Regulator (Used for CAN device ID) (ASCII up to 18 characters)

Password: Password (ASCII up to 18 characters). Note that if the password has a leading dot (.) character, it is 'hidden' and "*****" will be returned for its value.

DeviceID Semi-Unique device ID of WS500 Alternator Regulator

DOM What date was this device manufactured? (WS500 Pro ONLY)

SCV; -- SYSTEM CONFIGURATION



"SCV;, Lockout, *BTS2ATS?*, RevAmp, SvOvr, BcOvr, CpOvr, ,AltTempSet, drtNORM, drtSMALL, drtHALF, PBF, ,Amp Limit, Watt Limit, , Alt Poles, Drive Ratio, Shunt Ratio, ,IdleRPM, TachMinField, Warmup Delay, Required Sensor, DC_Disconnected_VBat, FeatureIN_mod, TriggerHalfPowerRPM, Ignore Sensor, Feature-OUT mod, ,BMS Amp Cap, Promiscuous Mode"

Lockout: Current lockout level. (0..2), see \$SCO: command.

BTS2ATS?: 0 or 1: Is BTS being used as 2nd Alternator Temp Sensor? (1 = yes)

RevAmp: 0 or 1: Reverse polarity of Amp Shunt readings? (1 = yes)

SvOvr: System Voltage auto-detect (=0), or force (1.0x .. 4.0x → 12v .. 48v)

BcOvr: Override Battery Capacity DIP switches (Dip 5/6). (0.00 = No)

CpOvr: Override Charge Profile DIP Switches (Dip 2..4) (0 = No)

AltTempSet: Target max running setpoint for Alternator, in degrees C

drtNORM: Normal Amp reduction (de-rating) fraction

drtSMALL: Amp reduction (de-rating) fraction when in SMALL - MODE

drtHALF: Amp reduction (de-rating) fraction when in half-power mode.

PBF: Pull-back factor, for reducing Field Drive at lower RPMs.

Amp Limit: Defined Alternator size, or -1 to enable auto-sizing. Set this = 0 for installations where Alternator Sizing is not to be regulated (ala, battery focused installations).

Note: During startup, and unless defined, this value will present: 1,000

Watt Limit: Defined System size, or -1 to enable auto-sizing. Set this = 0 for installations where Watts loading is not to be regulated (ala, battery focused installations).

Note: During startup, and unless defined, this value will present: 15,000

Alt Poles: Number of poles on Alternator

Drive Ratio: Ratio of engine and alternator drive pulley

Shunt Ratio: Amp Shunt ratio in Amps / mV

IdleRPM: Idle RPM value used as basis for Field Drive Reduction at lower RPMs.

TachMinField: Minimum % of field drive that will be applied if TACH MODE is enabled.

Warmup Delay: Number of seconds after power on before entering RAMP mode.

Required Sensor: Key indicating critical sensors which have been configured via the \$SCA: command

DC_Disconnected_VBat: Indicated how charging device should behave when it received a DC-Disconnect message via the CAN.

FeatureIN_mod: Is the behavior of Feature-In being modified from default?

TriggerHalfPowerRPM: RPM value under which Half-power mode will be selected.

Ignore Sensor: Which sensors should be ignored? (Prevents unwanted noise from causes false readings)

FeatureOUT_mod: Is the behavior of Feature-Out port being modified from default?

BMS Amp Cap: Has a BMS Amperage Limit been defined?

Promiscuous Mode: Has the device been configured to auto-restart on most hard faults?

SST; -- SYSTEM STATUS

“SST; , Version , ,Derate Mode, System Options, , CP index, BC Mult, SysVolts, ,AltCap, CapRPMs, , Ahs, Whs, ,ForcedTM?, RequiredSensorFlag, ,BLE-ReadOnlyState?”

Version: Firmware revision identifier. Will have format of “AREG” followed w/o a space by the version number. E.g., “AREG1.0.1”

Derate Mode: The following table indicates which of the Derate Factors are being used at the moment:

Value	Derate Mode
0	Derate Normal
1	Derate Small Alt Mode
2	Derate Half Power

Note that prior to 2.5.1, only Normal and Small Alt Mode were indicated

System Options: Bit field indicating various modes / features status per the following table.

Value	Indicator
+1	Is Tach Mode enabled? (+1 = Yes)
+2	Is the Feature-IN port activated, ala, has Voltage been applied to the Feature-in wire? (+2 = Yes)
+4	Is White Space activated at this time? (+4 = Yes)

This is a Summed table, in that each indicator is added into a final number as shown here.
 Example: A *System Mode* value indicated that Tach Mode has been enabled, and that the device is presently operating in Half-Power mode.

Note that prior to 2.5.1, only Tach Mode indicator was implemented.

CP Index: Which Charge profile (1..8) is currently being used?

BC Mult: What adjustment factor for Battery Amp Hour Capacity (1-10x) is currently being used? Fractional values may also be used to fine tune the system to a given battery size. This needs to be entered via the \$SCO: command.

SysVolt: Detected system voltage. Adjusts target Charge Profile Volts per the following table:

SysVolt	Detected System Voltage	Charge Profile VOLTAGE Adjustment Factor
1	12v	1x
2	24v	2x
2.67	32v	2.667x
4	48v	4x

Fractional values may also be used to support battery voltages such as 8v, 32v, 42v. Those values will need to be selected manually via the \$SCO: command.

Alt Cap: If regulator is configured to auto-determine the capacity of the alternator, this will be the current high-water mark noted.

CapRPMs: And this will be the RPMs at which that capacity was noted at.

AHs: The number of Amp-Hours that have been produced in the current charge cycle.

WHs: The number of Watt-Hours produced in the current charge cycle.

ForcedTM?: 0 or 1, has user forced Tach-Mode on via the \$SCT: command.

RequiredSensorFlag: Is a Required Sensor missing? 0 indicates no missing Required Sensor has been detected, for non-zero values reference \$SCA: command on page 60 for details.

BLE ReadOnlyState?: 0 or 1. Indicates if the WS500 Pro is being held in a Read-Only state, primarily due to the Password not having been changed via the \$SCN: command. Until this is done the WS500 Pro will not allow any changes to be preformed wirelessly, it will be in a Bluetooth 'read-only state'. Users will be able to monitor status but not be allowed make any changes wirelessly.

1 = BLEReadOnlyState

(WS500 Pro ONLY, WS500 will always report 0)

FLT; -- FAULTED



FLT: "FLT;, FaultCode, RequiredSensorStatus "

System has Faulted, fault code number.

RequiredSensorStatus is a combined number following the pattern as defined by the \$SCA command and detailed in 'Table 1 - Required Sensor Encoding ' on page number 65

Following this, the AST, SST and SCV will be printed, as well as the currently active CPE.

AOK; -- ACKNOWLEDGE



Sent after a successfully received change command (\$CPx, or \$SCx), \$MSW, or \$EDB

NAK; -- NEGATIVE ACKNOWLEDGE



Sent to indicate the rejection of a received change command (\$CPx, or \$SCx), \$MSW, or \$EDB. NAK is a new capability added in Firmware version 2.3.x and may be used in addition to AOK timeouts to indicate a miss formed command.

DBG; -- DEBUG



Special string with extra internal parameters for use in debugging internal operations.

RST; -- RESET




















































Regulator has been requested to reset. This can take up to 10 seconds to complete.

SENDING DATA TO THE REGULATOR:

All commands begin with the character '\$', contain 3 letters(CAPS) followed by a ':' and then parameters as requested by the command. All must end with a CR (or CR/LF) or may optional be terminated with the character '@'. A complete 'string' must be received within 60 seconds from the '\$' to the ending '@'/CR/LF, else the regulator will abort the capture of that string and begin looking for a new '\$' starting character.

Sending data TO the regulator:

	44		
\$CNG: - Changes eNGine Configuration table			 46
\$CPA:n - Change ACCEPT parameters in CPE user entry n (n = 7 or 8)			48
\$CPO:n - Change OVERCHARGE parameters in CPE user entry n (n = 7 or 8)			49
\$CPF:n - Change FLOAT parameters in CPE user entry n (n = 7 or 8)			50
\$CPP:n - Change POST-FLOAT parameters in CPE user entry n (n = 7 or 8)			52
\$CPE:n - Change EQUALIZE parameters in CPE user entry n (n = 7 or 8)			53
\$CPB:n - Change BATTERY parameters in CPE user entry n (n = 7 or 8)			54
\$CPR:n - RESTORES Charge Profile 'n' to default values			55
\$DEP: - DEPEndency			56
\$RAS: - Request All Status back			57
\$RCP:0 - Request to send back currently selected CPE			58
\$RLF: - Request Last Fault			59
\$SCA: - Changes ALTERNATOR (and System) parameters			60
\$SCT: - Changes TACHOMETER parameters		68	
\$SCO: - Override features			70
\$SCN: - Changes NAME (and PASSWORD)			 74
\$SCR: - RESTORES System Configuration table to default			76

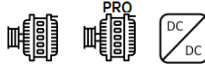
\$CCN: - Change parameters in the CAN Configuration table	 	77
\$CDD: - Change parameters in the DC-DC Configuration table		82
\$CCR: - RESTORES CAN Configuration to default	 	88
\$MSR: - RESTORE all parameters to factory default.	 	88
\$EDB: - Enable DeBug serial strings	 	89
\$RBT: - ReBooT system	 	89
\$FRM: - Force Regulator Mode	  	90

Defining Charging Voltages and Amps – All volts and amps used in the Charge Profile Entries are represented by a normalized 12v 500Ah battery and are automatically scaled depending on the sampled battery voltage at startup and the setting of the Battery Capacity DIP switches.

Take care that the MAXIMUM length of a string is fixed at 70 characters, including the line termination character(s). When assembling a command to send make sure not to exceed this length, remove any extra spaces if present to assure total length is under 70 characters.

****Note on Requesting Status commands.** All 'Request' commands will reply via the serial port. In addition, IF the request arrived via the J1939 CAN 'Terminal' DGN (17E00h), a copy of the reply will also be returned to the requesting CAN node. This is useful to gain access to the advanced ASCII setup parameters of the WS500 Alternator Regulator via the CAN.

\$CNG: - Changes eNGine Configuration table



Use to set parameters associated with Engines that are not already defined elsewhere

\$CNG: <J1939MaxLoad>, <RFM_RPM>, <RFM1>, <RFM2>, <RFM3>, <RFM4>, <RFM5>, <RFM6>, <RFM7>, <RFM8>, <EGT_Setpoint>

J1939MaxLoad: < FLOATING POINT NUMBER (0.0 → 1.20)> Indicated the maximum percentage engine load that should be allowed as reported via J1939 PGN Number 61443. Field Drive of the Alternator will be reduced as needed to lower total Engine Load to at or below *J1939MaxLoad* % target.

Another way *J1939MaxLoad* may be used is if PGN 61443 does not contain the Engine Load % field, but does contain the Throttle Position field – if the reported throttle position exceeds *J1939MaxLoad*, the regulator will then be placed into half-power mode.

Set = 0 to disable monitoring of J1939 based engine load. (Default)

RFM_RPM: <WHOLE NUMBER (-10,000 → 10,000)> RPM based Field Modifier. The RFM capability allows for an RPM based curve of 'White Space' engine power which may be directed to the Alternator. This is for use to support white-space engine load capping via a non J1939 based approach. *RFM_RPM* defines the upper expected limit of Engine RPMs. From there 8x engine RPM ranges are defined which are then associated with the RFMx caps. ***RFM_RPM is rounded down to the nearest 100x RPM value, and then used to define each of the 8x 'buckets'.***

A non-zero value for *RFM_RPM* enables the RPM Field Modifiers, which may be triggered in one of two ways. 1st: If *RFM_RPM* is a positive value, FEATURE-IN will be re-purpose FEATURE-IN to enable RFM mode when active; overriding the default use of FEATURE-IN. Care must be made if the installation requires access to Forced-Float mode (CPE #8), or Equalize Mode (CPE# 1-7) via external hardware switches as this re-purpose of FEATURE-IN overrides any other use, even if the Feature-In modifier has been used (See \$SCO: command). Typically, one should expect to use CAN based communications to the regulator for access to those functions when FEATURE-IN has been repurposed to RFM. (Setting = 0 will restore FEATURE-IN to behave in its normal fashion)

The 2nd way to activate RPM Field Modifiers is to use a negative value for *RPM_PRM*. In this case, the Modifiers will be active at all times, independent of the FEATURE-IN; the function of which will not be altered.

Set = 0 to disable RPM based White Space definitions. (default = 0)

RFMx: <FLOATING POINT NUMBER (0.0 → 1.0)> Used in conjunction with *RFM_RPM* above. In each case when active via FEATURE-IN the *RFMx* is used to further modify the active 'De-Rate' value (drtNORM, drtSMALL, drtHALF – reference \$SCA command). In this way loading may be adjusted to an Engine RPM dependent limit when the engine is servicing another non-alternator load (example, a marine engine driving a propeller – feature-in would be connected to the Transmission interlock switch).

The RFMx factors provide an *additional* modification to the maximum allowed field drive. As an example of the relationship between *RFM_RPM* and RFMx, the following commands are issued:

\$CNG: 0.0,3200, 0.1, 0.2, 0.4, 1.0, 1.0, 1.0, 0.95, 0.5@

Will result in the following max PWM field drive limits when FEATURE-ON is active:

RPMs	Normal	Half	Small Alt
0-400	10%	5%	7.5%
400-800	20%	10%	15%
800-1,200	40%	20%	30%
1,200-1,600	100%	50%	75%
1,600-2,000	100%	50%	75%
2,000-2,400	100%	50%	75%
2,400-2,800	95%	42%	67%
2,800 and above	50%	25%	71%

(Table built using default \$SCA: derate values of 100%, 50% , & 75%):

RFMx only modify the upper limit for field drive, all other functions of the regulator remain in place and at any given point in time the actual field drive % may well be below the upper limit. Note also that care should be used in configuring RFMx modifiers, especially if RPMs are measured using the stator, as setting the field drive cap to low could prevent accurate RPM readings thereby preventing the regulator from ever starting any alternator field drive.

White Space will also impact the amount of current used during *48v Battery Charging mode* of the DCDC Converter. See the \$CDD command on page 82

EGT_Setpoint: <WHOLE NUMBER (0 → 2,000)> Degrees C for active regulation of engine load based on EGT. EGT senses via CAN using NMEA2000 or RV-C messages. Value of 0 (default) disables EGT Regulator. (WS500 Pro ONLY)

\$CPA:n - Change ACCEPT parameters in CPE user entry n (n = 7 or 8)

This command will cause the ACCEPT (and BULK) portion of a Charge Profile Entry to be updated. Parameters must be in the following order and include comma “,” separators where indicated. Extra spaces before and/or after the parameters are allowed.

```
$CPA:n <VBat Set Point>, <Exit Duration>, <Exit Amps>, <Reserved>
```

n: (7 → 8) ‘n’ is the Charge Profile Table Entry that will be modified. Use range 7 to 8.

VBat Set Point: <FLOATING POINT NUMBER (0.0 → 16.5) > Voltage the Regulator will use during ACCEPT phase. When this voltage has been reached, the regulator will transition from BULK to ACCEPT phase. This value is a floating-point number and entered for a normalized 12v system (See note: Defining Charging Voltages and Amps)

Exit Duration: <WHOLE NUMBER (0 → 600 (10 hours)) > After entering ACCEPT phase, a timer will be started. After ‘ExitDuration’ minutes have expired ACCEPT mode will exit and the regulator will move to OVER-CHARGE mode. Setting ‘ExitDuration’ = 0 will disable time based exiting of ACCEPT mode and only AMP based monitoring will be used.

Exit Amps: <WHOLE NUMBER (-1 → 200)> After entering ACCEPT phase, delivered amps will be monitored and if they fall to (or below) ‘ExitAmps’ ACCEPT mode will exit and the regulator will move to OVER-CHARGE mode. This is providing that the battery voltage is at the target VBat Set Point above (to prevent early exiting from low amps being delivered as a result of the engine slowing down to say very slow idle).

Setting ‘ExitAmps’ = 0 will disable amp-based exiting of ACCEPT mode and only time monitoring to ‘ExitDuration’ will be used.

Setting ‘ExitAmps’ = -1 will disable amp-based exiting of ACCEPT mode and time monitoring of ‘ExitDuration’ will be used as above. In addition, when the time spend in Acceptance mode has exceed 5x the duration spent in Bulk mode, the regulator will also trigger an exit. (Adaptive Acceptance).

Note: If you set BOTH ‘ExitDuration’ & ‘ExitAmps’ = 0, the regulator will bypass ACCEPT mode.

Reserved: <0> Must be 0.

Example:

```
$CPA:7 14.5, 200, 40, 0@ #7: 14.5VOLTS, EXIT AFTER 200 MINUTES OR UNDER 40AMPS  
$CPA:8 12.4, 0, 20, 0@ #8: 12.4 VOLTS, EXIT ONLY ON AMPS UNDER 20  
$CPA:810.4,0,20,0@ #8: 10.4 VOLTS, EXIT ONLY ON AMPS UNDER 20.  
(SHOWN WITH OPTIONAL ‘@’ FOR ARDUINO IDE TERMINAL SUPPORT)
```


\$CPO:n - Change OVERCHARGE parameters in CPE user entry n (n = 7 or 8)



This command (with its parameters) will cause the OVER-CHARGE (Sometimes referred to as FINISH phase) portion of a Charge Profile Entry to be updated. Parameters must be in the following order and include comma “,” separators where indicated. Extra spaces before and/or after the parameters are allowed.

\$CPO:n <Limit Amps>, <Exit Duration>, <Exit VBat>, <Exit Amps >

n: (7 → 8) ‘n’ is the Charge Profile Table Entry that will be modified. Use range 7 to 8.

Limit Amps: <WHOLE NUMBER (-5 → 50)> After entering OVER-CHARGE phase, delivered amps will be monitored and regulated to ‘LimitAmps’. Setting ‘LimitAmps’ = 0 will disable OVER-CHARGE mode.

Exit Duration: <WHOLE NUMBER (0 → 600 (10 hours)) > After entering OVER-CHARGE phase, a timer will be started. After ‘ExitDuration’ minutes have expired OVER-CHARGE mode will exit and the regulator will move to FLOAT mode. Setting ‘ExitDuration’ = 0 will disable OVER-CHARGE mode.

Exit VBat: <FLOATING POINT NUMBER (0.0 → 20.0) > Once battery voltage reached ‘ExitVBat’, OVERCHARGE phase will be exited. This value is a floating-point number and entered for a normalized 12v system (See: Defining Charging Voltages and Amps). Setting ‘ExitVBat’ = 0 will disable OVER-CHARGE mode.

Exit Amps: <WHOLE NUMBER (0 → 50)> If defined, ‘ExitAmps’ will keep the regulator in OVER-CHARGE phase until the battery acceptance current has fallen to (or below) this value. During this time voltage will remain at ‘ExitVBat’. ‘ExitAmps’ will NOT override the overall ‘ExitDuration’ transition criteria. Set = 0 to disable this option.

In all applications of OverCharge phase, Battery Voltage will be limited to the MAXIMUM of either ‘Exit Vbat’ as defined in \$CPO, or ‘VBat Setpoint’ as defined in the \$CPA command above.

During operation, if Vbat falls notably below the batteries Bulk/Acceptance target as defined by CPA, the device will revert back to Bulk/Acceptance phase. If this occurs repeatedly, review your amperage transition values as it may be they are too low. Or it simply may be a one-off condition where a large load was placed in the system and the charging device is not able to support, requiring energy to be withdrawn from the battery.

In another special application of OverCharge phase (available in firmware v2.4.x and above), the *limit amps* may be set to -1. In this case ‘Exit Vbat’ is often set to match that of the Float target voltage and the above mentioned revert to Bulk/Acceptance is not checked for. This usage of Overcharge can be helpful to manage the transition from Acceptance phase to Float in cases where it is desired to keep an external tachometer active.

\$CPF:n - Change FLOAT parameters in CPE user entry n (n = 7 or 8)



This command (with its parameters) will cause the FLOAT portion of a Charge Profile Entry to be updated. Parameters must be in the following order and include comma “,” separators where indicated. Extra spaces before and/or after the parameters are allowed.

\$CPF:n <V_{Bat} Set Point>, <Limit Amps>, <Exit Duration>, <Revert Amps>, <Revert Amp-hours>, <Revert Volts>, <Revert SOC>

n: (7 → 8) ‘n’ is the Charge Profile Table Entry that will be modified. Use range 7 to 8.

V_{Bat} Set Point: <FLOATING POINT NUMBER (0.0 → 16.5)> Voltage the Regulator will use during FLOAT phase. This value is a floating-point number and entered for a normalized 12v system. Setting this value to 0.0v will cause all charging to stop during ‘float’ mode. (See note: Defining Charging Voltages and Amps)

Limit Amps: <WHOLE NUMBER (-1 → 50)> While in FLOAT phase delivered Amps will be monitored and regulated to ‘LimitAmps’. Setting ‘LimitAmps’ = -1 will disable this feature and only ‘V_{BatSetPoint}’ will be regulated.

Exit Duration: <WHOLE NUMBER (0 → 30000 (500 hours))> After entering FLOAT phase, a timer will be started. After ‘ExitDuration’ minutes have expired FLOAT mode will exit and the regulator will move to POST-FLOAT mode. Setting ‘ExitDuration’ = 0 will cause the regulator to remain in FLOAT mode unless triggered by another exit criteria.

Revert Amps: <WHOLE NUMBER (-300 → 0)> While in FLOAT mode, if ‘RevertAmps’ are exceeded it is an indication that a large load has been placed on the battery and current is being withdrawn, the regulator will re-start a charge cycle, looping back to BULK mode. Setting ‘RevertAmps’ = 0 will disable this feature.

RevertAmps is most useful in the case where the amp shunt is placed on the battery, as when the amp draw from the battery exceeds *RevertAmps*, it is a clear indication energy is being drawn from the battery. In this case, set *RevertAmps* equal to the number of amps being drawn from the battery that should be used to trigger a revert to bulk.

In cases where the amp shunt is installed on the alternator, this can also be of use by sizing *RevertAmps* to a value slightly above expected house load values. However, perhaps a better indication is to set this to =0, and use *RevertVolts*.

Revert Amps-hours: <WHOLE NUMBER (-250 → 0)> After entering FLOAT mode if the accumulated number of Amp Hours removed from the battery exceeded ‘RevertAmp-hours’ the regulator will re-start a charge cycle, looping back to BULK mode. Setting ‘RevertAmp-hours’ = 0 will disable this feature

This is another way to indicate the need to restart charging of the battery, and perhaps a better approach than raw RevertAmps, but it is only usable if the amp shunt is placed on the battery.

Revert Volts: <FLOATING NUMBER (0.0 → 16.5)> While in FLOAT mode, if battery voltage drops below '*RevertVolts*' we assume this indicates a large load has been placed on the system and the regulator will re-start a charge cycle, looping back to BULK mode. Setting '*RevertVolts*' = 0 will disable this feature.

Revert SOC: <WHOLE NUMBER (0 → 100)> While in FLOAT mode, if the batteries SOC (State Of Charge) as reported by a CAN attached BMS or other RBM drops below '*RevertSOC*' the regulator will re-start a charge cycle, looping back to BULK mode. Setting '*RevertSOC*' = 0 will disable this feature.

In determining to exit Float Mode, a rolling average value for measured Amps and Volts is used. This way short term events (e.g., a surge of a refrigerator starting up and before the Alternator can respond) will not pull the regulator out of Float mode. Note also that the revert Amp-hours are a negative value, and measure the number of AHs removed from the battery after entering Float mode.

\$CPP:n - Change POST-FLOAT parameters in CPE user entry n (n = 7 or 8)



This command (with its parameters) will cause the POST- FLOAT portion of a Charge Profile Entry to be updated.

Parameters must be in the following order and include comma “,” separators where indicated. Extra spaces before and/or after the parameters are allowed.

\$CPP:n <Exit Duration>, <Revert VBat>, <Revert Amp-hours>, <VBat Set Point>

n: (7 → 8) ‘n’ is the Charge Profile Table Entry that will be modified. Use range 7 to 8.

Exit Duration: <WHOLE NUMBER (0 → 30000 (500 hours)) > After entering POST-FLOAT phase, a timer will be started. After ‘ExitDuration’ minutes have expired POST-FLOAT mode will exit and the regulator will revert to BULK phase. Setting ‘ExitDuration’ = 0 will cause the regulator to remain in POST-FLOAT mode unless triggered by another exit criteria.

Revert VBat: <<FLOATING POINT NUMBER (0.0 → 16.5)> While in POST-FLOAT mode, if the system battery voltage drops below ‘RevertVBat’ it is an indication that a large load has been placed on the system and the regulator will re-start a charge cycle, looping back to BULK mode. Setting ‘RevertVBat’ = 0 will disable this feature.

Revert Amps-hours: <WHOLE NUMBER (-250 → 0)> After entering POST-FLOAT mode if the accumulated number of Amp Hours removed from the battery exceeded ‘RevertAmp-hours’ the regulator will re-start a charge cycle, looping back to BULK mode. Note that this trigger goes directly to Bulk, as opposed to back to Float mode. Setting ‘RevertAmp-hours’ = 0 will disable this feature

VBat Set Point: <FLOATING POINT NUMBER (0.0 → 16.5) > Voltage the Regulator will use during POST-FLOAT phase. This value is a floating-point number and entered for a normalized 12v system. If set = 0.0 (default), charging will be disabled during post-float mode.

\$CPE:n - Change EQUALIZE parameters in CPE user entry n (n = 7 or 8)



This command (with its parameters) will cause the EQUALIZATION portion of a Charge Profile Entry to be updated. Parameters must be in the following order and include comma “,” separators where indicated. Extra spaces before and/or after the parameters are allowed.

\$CPE:n <VBat Set Point>, <Max Amps>, <Exit Duration>, <Exit Amps>

n: (7 → 8) ‘n’ is the Charge Profile Table Entry that will be modified. Use range 7 to 8.

VBat Set Point: <FLOATING POINT NUMBER (0.0 → 20.0)> Voltage the Regulator will use during EQUALIZE mode. This value is a floating-point number and entered for a normalized 12v system (See note: Defining Charging Voltages and Amps). Setting ‘VBat’ = 0 will disable EQUALIZE mode.

MaxAmps: <WHOLE NUMBER (0 → 50)> Optional additional current limit while in EQUALIZE phase; the regulator will cap delivered AMPS to ‘MaxAmps’. Setting ‘MaxAmps’ = 0 will disable this amperage capping.

Exit Duration: <WHOLE NUMBER (0 → 600 (10 hours))> After starting an EQUALIZE phase, a timer will be started. After ‘ExitDuration’ minutes have expired EQUALIZE will emanate and the regulator will enter FLOAT mode. Setting ‘ExitDuration’ = 0 will disable EQUALIZE mode.

Exit Amps: <WHOLE NUMBER (0 → 50)> During EQUALIZE mode delivered Amps will be monitored and if it falls to (or below) ‘ExitAmps’ equalization will be terminated and the regulator will move to FLOAT mode. Note that as a precaution, Battery Voltage is not checked when sampling Equalization Exit Amps (as it is in Acceptance and Overcharge). It is up to the operator to keep the engine speed up and allow for a full equalization session to occur. Setting ‘ExitAmps’ = 0 will disable Amp based exiting of EQUALIZE mode and only Time monitoring will be used.

\$CPB:n - Change BATTERY parameters in CPE user entry n (n = 7 or 8)



This command (with its parameters) will cause the remaining portion of a Charge Profile Entry to be updated.

Parameters must be in the following order and include comma “,” separators where indicated. Extra spaces before and/or after the parameters are allowed.

\$CPB:n <VBat Comp per 1°C>, <Min Comp Temp >, <Min Charge Temp>, <Max Charge Temp>, <Rdc Volts>, <Rdc Low Temp>, <Rdc High Temp>, <Rdc Amps>, <MaxBatAmps>, <MaxBatVolts>

n: (7 → 8) ‘n’ is the Charge Profile Table Entry that will be modified. Use range 7 to 8.

VBat Comp: <FLOATING POINT NUMBER (0.0 → 0.1)> This is used to adjust all target VBat voltages based on the current Battery Temperature in 1 degree C increments. This value is a floating-point number and entered for a normalized 12v system at 25c. (See note: Defining Charging Voltages and Amps). Set = 0.0 to disable temperature based voltage compensation.

Min Com Temp: <WHOLE NUMBER (-40 → 40)> Additional compensation to battery target voltages will be stopped when the battery is at or below this temperature in degree C.

Min Charge Temp: <WHOLE NUMBER (-50 → 10) > If the battery drops below this temperature, charging will be disabled. Once temperature rises above *Min Charge Temp*, a new charge cycle will start.

Max Charge Temp: <WHOLE NUMBER (20 → 95) > If the battery reaches this temperature, the system will be disabled to protect it. If the battery temperature continues to rise, the system will eventually FAULT when battery temperature exceeds *Max Charge Temp* by 20%. Note that Min and Max Temp limits will override any outside direction the WS500 regulator received; even if a CAN connected BMS is asking for charging, if either of these hard stop limits are exceed the regulator will enter Disabled mode.

Rdc Volts: <FLOATING POINT NUMBER (0.0 → 12.0) > If the Battery Voltage is at or below this value, the regulator will work in Reduced Charge mode, where the maximum amps delivered to the battery will be limited to *Rdc Amps*. Set *Rdc Volts* = 0.0 to disable checking of battery voltage for Reduced Charging mode.

Rdc Low Temp : <WHOLE NUMBER (-99 → 20) > If the battery temperature falls to or below this value in degrees C, the regulator will enter Reduced Charge mode. Set = -99 to disable this test

Rdc High Temp : <WHOLE NUMBER (-99 → 95) > > If the battery temperature rises to or above this value in degrees C, the regulator will enter Reduced Charge mode. Set = -99 to disable this test

Rdc Amps : <WHOLE NUMBER (0 → 100) > When the regulator is in Reduced Charge mode, battery acceptance current will be limited to this value. Rdc Amps is defined relative to the normalized 500Ah battery and is adjusted by the system battery capacity. As with *Max/Min Charge Temp*, the any of the

RDC triggers (Temp, voltage) will also override any directions arriving from the BMS. Set = 0 to disable Reduced Charge mode.

Max Bat Amps : <WHOLE NUMBER (0 → 2000) > If set, this will be the maximum amperage allowed to flow into the battery. Remember, this value is set relative to the 12v/500A 'nominal' battery and it is also adjusted by the Battery Capacity Multiplier; so a value of 250 would cause the regulator to limit charging current to a 0.5c rate. Set = 0 (default) to disable Max Battery Amps

Max Bat Volts: <FLOATING POINT NUMBER (0.0 → 20.0)> *Max Bat Volts* is used to provide an additional fault check for the maximum allowed battery voltage under all conditions. If at any time Max Bat Volts is exceeded, the device will enter a FAULT state. This check is in addition to existing built-in high voltage limits, and allows for a more restrictive value to be defined by the installer. Set = 0.0 (default) to disable this extra check

\$CPR:n - RESTORES Charge Profile 'n' to default values



Restores to default (values at compile time) Charge Profile Entry 'n'. After entry 'n' is restore, the regulator will be restarted automatically.

\$CPR:n

n: (7 → 8) 'n' is the Charge Profile Table Entry that will be restored. Use range 7 to 8.

\$DEP: - DEPEndency



Dependency is a way to allow the device to confirm both the correct device type, as well as a minimum firmware version required to utilize this configuration. In most cases sending in configuration strings with additional parameters (ala, new capabilities) that the present level of firmware, the device will simply ignore the extra parameters; and this might cause undesirable behavior. Beginning with firmware version 2.4.2, an optional \$DEP may be used to allow the device to check to see if the firmware is able to support all configuration commands and parameters.

\$DEP: <Version>, <Version> ...

Version: (String) 'Version' is in the same form as that reported out by \$SST; and contains both the device type as well as a minimum release of firmware needed. Take care when declaring <version> as the format is well defined: *mmmmxx.yy.zz*

mmmm: a 4 character string containing the device type. Supported devices types are:

- AREG: WS500 Alternator Regulator; OEM branding is also an AREG device.
- DCDC: WS3000r DCDC Converter. OEM branding is also a DCDC device.

xx, yy, zz: Numeric values separated by two '.' xx, yy, zz must be complete and numeric (No wide cards allowed). The device firmware must be equal to or greater than the defined xx, yy, xx

Examples of \$DEP are:

AREG2.4.2 → WS500 Alternator Regulator, firmware must be 2.4.2 or above
DCDC2.4.3 → WS3000r DCDC Converter, firmware must be 2.4.3 or above.

\$DEP: DCDC2.4.3, AREG2.4.2 @

\$RAS: - Request All Status back



This command will instruct the WS500 Alternator Regulator to send out via the Serial port a copy of the all known status strings. It is useful for external applications to capture the current status w/o needing to await the arrival of each string (which could take several minutes or more, depending on how status strings are spaced out).

\$RAS:

After all status strings have been sent, "AOK" will be sent to indicate the end.

\$RCP:n -Request to send back CPE entry #N (n=1..8)



This command will instruct the WS500 Alternator Regulator to send out via the serial port the SAVED contents of the CPE entry N, where N is a number from 1 to 8. See “CPE: Charge Profile Entry” for description of resulting transmission.

\$RCP:n

\$RCP:0 - Request to send back currently selected CPE



Special version of Request for CPE, this will send back the currently selected (via the DIP switched) CPE.

\$RCP:0

Note, the CPE entry sent back in response to a \$RCP: command will reflect the current values contained in FLASH memory which may not match what the regulator is currently working with. If a CPE has been modified and saved to FLASH, those modifications will be reflected. However, until the WS500 Alternator Regulator is rebooted it will not utilize those values. For current active targets being used, look at AST; and SCV; status strings.

Note on Change Requests to Charge Profiles: The only Charge Profile 7 or 8 (the two customizable entries) may be modified via an ASCII command. This is to reduce the potential for major errors in the regulator.

Also, take great care in setting these values, esp the exiting time and amp thresholds. Some of these thresholds can be disabled by setting to 0, disabling that threshold test. If both Amps & time values are disabled, it is possible for the regulator to stay in a full charge state indefinitely, likely causing damage to the battery. As the WS500 Alternator Regulator may be deployed with the amp shunt at the Alternator, or at the battery, some of the CPE entries will behave differently depending on which deployment model is used. And some entries might have no meaning. Great Flexibility results in Great Responsibility...

All Change Profile commands will reply with “AOK;” if the command was processed successfully. However, to assure the changes are STORED and used the regulator must be reset using the \$RBT: command after all changes have been made.

\$RLF: - Request Last Fault



This command will instruct the WS500 Alternator Regulator to send a copy of the Last Known Fault information, including the Fault Number and a copy of the AST and CST strings at the time of the fault – preceded by two dots (..). After the last string is sent out, \$AOK will be sent.

If no recorded Fault exists, only the \$AOK will be sent. \$MSR will clear any saved last-fault information (along with all other configuration information!).

\$RLF:

After all status strings have been sent, “AOK” will be sent to indicate the end. Example of Low Voltage Fault:

\$RLF:@

```
..FLT;,14,0
..AST;,0.00, ,0.06,-3.8,-3.8,0, ,13.10,100,15000,2, , -99,-99, ,0, ,0.06,19,-99,0
..CST;,1,0,2,70, ,1,1, ,1,0,1, ,0,0,0, ,129, ,0,0,0
AOK;
```

\$SCA: - Changes ALTERNATOR (and System) parameters



Used to update the system configuration entries associated with the Alternator and System.

\$SCA: <BTS2ATS?>, < Alt Target Temp >, <Alt Derate (norm) >,<Alt Derate (small) >,<Alt Derate (half) >, <PBF>, <Alt Amp Cap>, <System Watt Cap.>, <Amp Shunt Ratio>, <Shunt Reversed?>, <Idle RPMs>, <Warmup Delay>, <Required Sensors>, <Ignore Sensors>, <BMS Amp Cap>

BTS2ATS?: <WHOLE NUMBER (0, or 1) > If *BTS2ATS?* is set = 1, the Battery Temperature Sensor will be treated as a 2nd Alternator Temperature Sender. The warmer of the two sensors will be used as Alternator Temperature for both reporting and regulation. Useful if two alternators are being driven from one regulator using a common field. Make sure the Battery temperature is being supplied via the CAN.

Using the BTS for a 2nd ATS is also useful with the DC-DC converter option; it allows two alternators to be monitored.

(Default = 0)

Alt Target Temp: <WHOLE NUMBER (15 → 150)> Operating temperature the regulator should attempt to keep the Alternator under in degrees C. If the Alternator temperature exceeds this value, the regulator will reduce field current to allow the alternator to return to a safe operating temperature. If the Alternator temperature continues to rise and exceeds this temperature by 10% the regulator will fault out and stop producing power.

Alt Target is used by the DC-DC converter to reduce power transfer as alternators reach their target temperature.

Alt Derate(norm),

Alt Derate(small),

Alt Derate(half): <FLOATING POINT NUMBER (0.0 → 1.00) > These derating values are used to limit the alternator's maximum current output to some % (10% to 100%) of its demonstrated capability (see *Alt Amp Cap*). The three values correspond to the mode the Alternator:

- Normal - Condition when either of the other modes are not selected.
- Small Alternator Mode – selected via DIP switch 8.

- Half Power Mode – Selected by shorting the Alternator NTC temperature sensor wires. Half-power mode may also be selected when engine RPMs fall below the threshold set via <Trigger Half-power RPMs> in the \$SCT: commend below, or via the Feature-In (See \$SCO: command below).

In operation, De-rating values are applied to BOTH the Alt Amp Cap as well as the internal maximum field PWM drive. In this way, a smaller alternator is protected, even if the amp shunt is not connected.

If a given *Alt Derate* values is set = 0.0 (0%), this will cause the alternator to be shut down and the system to enter a ready-idle state. Such a condition can be useful if deploying a DC-DC converter (See \$CDD command on 82) by always powering the regulator and using half-power to select between when the engine is running or turned off, but in all cases allowing the DC-DC converter to be managed. When released from read-idle mode, the alternator will change to pre-ramp mode and do its normal startup process.

Note: When setting the 'Alt Derate(x)' values, make sure the 'Normal' derate value is as large or larger than any of the other two, else an internal error/hard fault may occur.

Note: Beginning with release 2.5.0, if Derate values have not been explicitly set by sending a \$SCA: configuration command to the device (meaning, the device is running using factory default configuration values for \$SCA parameters), and the system deployed is a 48v system, the derate values noted above will be reduced automatically to approximately a quarter of the default values. This is done to account for the large number of 48v alternators which utilize a 12v field. It is STRONGLY recommended that with 48v installs (and all installs for that matter) that the device be fully configured to match the system design, including appropriate derate values for the alternator.

PBF: < INTEGER (-1 → 10)> Pull-back factor for reducing Field Drive at lower RPMs.

Note: It is suggested that White Space feature be used instead of PBF, as they are simpler to define and have additional capability. See \$CNG: on page 46

If the WS500 Alternator Regulator is able to determine RPMs (via the Stator wire), the Alternator Field Drive will be reduced when the regulator detects the engine is at Idle. At idle the max PWM will be capped at around 1/4 of full field, which should result in some current being produced. As RPMs are increased, this 'Field Drive Capping' will slowly be removed. PBF determines how quickly this pull-back is scaled off.

Set = 0 (DEFAULT) to disable this feature.

Set = -1 to cause Field Drive to be reduced to a maximum of 70% drive in the case where the WS500 Alternator Regulator is no longer able to measure RPMs via the Stator-in signal. This might be for example where an engine is operating at extremely low RPMs, below the cut-in point for the alternator. Or where the engine is no longer running. The 70% limit will only be enabled if at one time during operation the regulator was able to measure RPMs successfully.

If PBF is used, for many engine / alternator combinations a value of 1 will result in good operations. However, if you have installed a large alternator on a rather modest sized engine, you might notice the engine struggles when trying to increase RPMs from idle. In that case, increase the PBF value. A factor of 8x or so might be needed in the case of a small sail-boat engine with a large 150A or greater alternator (consider also using the Alt Amp Cap and/or System Watts Cap capabilities as well to restrict maximum engine loading at higher RPMs).

If the engine has a large capacity relative to the alternator size, consider reducing the PBF to 1. Doing so will allow a greater production of amps while at idle, while at the same time preventing the alternator from being driven at Full Field during low RPMs (and hence low cooling)

Finally, if your system matches an engine with great capability, and the alternator has good cooling / heat management – you can set the PBF factor = 0 to disable any capping of field drive while the engine is at idle. This will allow for maximum alternator output at idle, however if the regulator is enabled but the engine is not actually running, field drive will increase to Full Field until a fault check causes the regulator to reset. Do not leave the ‘ignition’ in the ON position, without the engine actually running to prevent this situation. It would be advisable to assure there is a temperature sensor attached to the alternator in this case – to prevent unintended overheating during prolonged idle periods.

Note: Field pull back is dependent upon the stator sensing wire being connected to the alternator. If the regulator is unable to reliably sense RPMs, all idle pull-back features will be disabled. Note also that one should make sure to configure the tachometer via the `§SCT:` command.

Alt Amp Cap: `<WHOLE NUMBER (-1→ 500) >` Alternator Amperage Capacity (`<Alt Amp Cap>`) is an uncommon factor and primarily used when the Current Shunt located at the alternator (vs. the battery). When defined the regulator will limit the Amperage output of the alternator to this value, after applying the ‘*Alt Derate xxx*’ factors. (Reference Derate factors above) There is no adjustment made to this value based on system voltage or selection of system battery size – the values declared will be used directly. A special feature is enabled by setting this = -1: the regulator will drive the alternator as hard as it can for a short period of time when 1st entering Bulk phase and in this way will auto-sample the alternator size based on its capabilities.

(Default = 0, disabled)

Do note with this option, there may be some interactions between the field % pullbacks and an attempt to reduce what is perceived as ‘alternator current’ pullback, for example during half-power mode.

With Alternator Amperage Cap disabled, reduced power modes will apply the scaling factor to the PWM duty cycle. It should be noted that there may not be a direct relation between reductions in PWM duty cycles and delivered Amperages – care should be used when setting up the system. (Default: 1.00, 0.75, 0.50 respectively)

Beginning in firmware release 2.5.2, the use of a declared Alternator Capacity had been modified to better fit some install design decisions. Details include:

- There is no utilization of `<Alt Amp Cap>` unless the Current Shunt is indicted to be attached to the Alternator (reference `§CCN: <Shunt At Bat>`) and has not been set to be ignored (reference `<Ignore Sensor>` below)

- De-rate factors are no longer applied to Alternator Capacity. Primarily this change we needed as many 48v alternators use a very restrictive De-Rate value to avoid over-voltage to the field. Going forward installers are encouraged to restrict alternator output either via the appropriate Derate value, Whitespace, or the <System Watts Capacity> parameter below.
- The value of <Alt Amp Cap> is utilized as part of Victron DVCC support. Note that if <Alt Amp Cap> is not defined, a default value of 200A will be used while in DVCC mode. This is also dependent on the WS500 being able to measure Alternator Amperage
- The value of <Alt Amp Cap> will be used to limit the maximum amount of Alternator Amperage output, providing the WS500 is able to measure Alternator Amperage.

System Watts Cap: <WHOLE NUMBER (-1 → 40000)> This regulator will limit the system wattage to this value. Its primary use is to protect the driving engine and/or belts – by limiting the maximum amount of Work the engine is asked to do in behalf of the alternator. (Work being a function of BOTH Volts and Amps, hence Watts). It may also be used to limit the total amount of power being delivered into the battery by all charging sources. There is no derating or adjustment made to this value based on system voltage or selection of system battery size. <System Watts Capacity> is used to after applying the 'Alt Derate xxx' factors. It is used to protect the alternator from over current usage. A special feature is enabled by setting this = -1, the regulator will drive the alternator as hard as it can for a short period of time when 1st entering Bulk phase. This will then be used to define the Amp Limit of the Alternator.

Note on Alt Amps and System Watts: You may set either of these parameters =-1 to allow the regulator to automatically calculate limits based on the sampled capability of the alternator, or set them = 0 to disable that feature. Though these two are interlaced, they are indeed separately monitored and adjustments to the Field PWM are made independently for each.

.(Default = 0, disabled)

Amp Shunt Ratio: <WHOLE NUMBER 500 → 60000> Enter the ratio of your Amp measurement shunt in terms of AMPS / mVolts. e.g., if you have a 250A / 75mV shunt, you would enter 3333 (250/0.075). And you may adjust the number to allow for fine tuning of the Amp Shunt. e.g., if your shunt has a 3% error, you could enter 3433

Caution: Shunt Voltage is limited to +/-80mV. Do NOT exceed this value!

Shunt reversed?: <WHOLE NUMBER (0, or 1) > Allows software correction if the Amp Shunt was wired backwards. Set = 1 and Amp readings will have their polarity changed.

Idle RPMs: < INTEGER (0 → 2500) > Used in conjunction with PBF to manage Field Drive at lower RPMs. As RPMs rise above Idle RPMs, field drive will be increased at a rate determined by PBF. During normal operation, Idle RPMs can be detected automatically by the WS500 Alternator Regulator. However, in more sensitive installations where the management of the alternator Field Drive at low RPMs is critical, additional system reliability can be achieved by defining the IDLE RPMs value to be used in all calculations. In extreme installations (very small engine with large efficient alternator), Idle RPMs may be defined artificially high; doing so will cause the regulator to increase its pull back of Field Drive during low RPM operations.

Set = 0 (DEFAULT) to enable 'auto' determination of Idle RPM.

Warmup Delay: < WHOLE NUMBER (-600 → -15 15 → 600) > Hold-off period when regulator is 1st powered on before it will begin to apply a load to the engine. This is the number in seconds of delay the regulator will remain in PRE-RAMP mode before moving into RAMP mode. Default = 30 seconds. Beginning with v2.4.1 firmware, use of a negative number for Warmup Delay will cause the Fast Ramp feature to be disabled, resulting in a slow ramping up of alternator at all times. This is more consistent with how v2.2.0 firmware always operated.

If a negative value is used for Warmup Delay, then Fast Ramping is disabled and all ramps will be at a slower pace. One might use this in cases where the underlying engine is not able to adjust quickly, perhaps an older mechanical injection diesel, or if the installer wishes to provide slower changes for some other reason – belt wear, etc. Using a negative value for Warmup Delay will slow down the pace of all load increasing changes. Do not, this will NOT reduce the ability to pull back when needed, example a limit is reached. This only impacts how quickly loads are applied.

Required Sensors: < WHOLE NUMBER (0 → 255) > Many capabilities depend on the presence of sensors. Battery compensation requires the presence of a battery temperature sensor; Alternator Temperature regulation requires the presence of an alternator temperature sensor. If one or more of these sensors are not installed, or fail during operation, results could be less than desired. As a precaution against this, *Required Sensors* allows the identification of critical sensors, and if any of them are missing or fail the regulator will take action to reduce demands placed on the system.

Required Sensors allows the identification of critical sensors. It is a number created by summing up the value associated with each potential critical sensor. For example: if you wished to indicate the Alternator and Battery temperature sensors are critical, you would enter 3 (1+2). The value of 0 disables critical Required Sensor checks and the regulator will utilize other existing fall-back modes.

Sensor	Value	Default Action of missing sensor
Alternator Temperature Sensor	1	Enable Half-Power mode
Battery Temperature Sensor	2	Force to FLOAT mode
Battery Current **	4	Force to FLOAT mode (See note**)

CAN RBM	8	Disable charging, Feature-in may be used to Force to Float when CPE #8 is selected
Force FAULT override	128	Overrides 'Default' action and forces regulator into FAULT mode.

Table 1 - Required Sensor Encoding

If at any time one of the Required Sensors are identified as failed or missing the LED will flash its normal patterns, but in RED. In addition the feature-out port / dash-lamp it will also flash out error codes during a fault.

If the WS500 Alternator Regulator has been configured to repurpose the BTS for a 2nd alternator, a failure in either ATS or the repurposed BTS (now known as ATS2) will trigger the Alternator Temperature Required Sensor check.

The WS500 Alternator Regulator may also be configured to cause a non-recoverable FAULT condition, overriding the default actions listed in Table 1 by adding 128 to the summed number. In the prior example of Bat and Alt sensors being critical, sending 131 instead of 3 will cause the regulator to FAULT if either is noted as missing or fails.

Battery current / Battery Temperature values arriving via the CAN from a remote battery master or BMS may be used to satisfy the Bat Temp and or Bat Current checks in *Required Sensors*. In addition, by selecting *CAN RBM* a check for the entire presence of a remote battery master or BMS may be required as well.

Note** When not receiving Battery Current via the CAN, and utilizing the shunt for measurements, it is difficult to determine if an Amp Shunt has failed vs. a true reading 0A of current. Because of this, the WS500 Alternator Regulator will delay check for the presence of a working Current Shunt until after Bulk has been completed. A current reading of greater than 5A at any time during BULK phase will be used as an indicator that the current shunt is present and working, as will the arrival of battery current measurements via the CAN. Once this determination is made no additional checks will be made – as a valid operation condition for the regulator may at times have a battery current of 0A (example, when actively regulating current to 0A in FLOAT mode).

Ignore Sensors: <WHOLE NUMBER (0 → 255) > A companion to *Required Sensors*, this bit-flag parameter will cause the regulator to ignore measurements on the flagged sensors. Typically this is only used where sensing is done via Remote Sensing, example: If Battery Current is supplied via CAN from the BMS, and the local current shunt is not used - by setting the *Ignore Sensor* bit, random noise is prevented from causing miss readings. The stator is another key example, if not used one can ground that signal wire, or set the *Ignore Sensor* bit for the Stator.

Ignore Sensors is a number created by summing up the value associated with each potential critical sensor. For example: if you wished to ignore the Alternator temperature and current shunt readings, you would enter 5 (1+4).

Sensor	Value
Alternator Temperature Sensor	1
Battery Temperature Sensor	2
Local Current Shunt	4
Stator **	8
Feature In (always treated as Inactive)	16

Table 2 – Ignore Sensor Encoding

Note: ** Beginning with Firmware 2.5.2, “Ignore Sensor Stator” MUST be set in order to receive Engine RPMs via NMEA2000 Engine Parameters Rapid (127488), and if NOT Set – transmission of Engine Parameters Rapid will be suppressed.

Be careful with the relationship between *Ignore* and *Required Sensors*, an ignored sensor will cause a positive trap if it is ‘required’ and the value is not supplied elsewhere. Also be careful with the Feature-In signal wire, especially as it is at times used with BMS’s in a legacy configuration to signal that charging should be stopped.

BMS Amp Cap: <WHOLE NUMBER (0 → 2500) > BMS Amperage Capacity (<BMS Amp Cap>) issued to define a global system limit in a like way that <System Watts Capacity>. *BMS Amp Cap* defined the maximum charge amperage the BMS is defined to support. If the battery SCPB MaxAmps (aka, C rate) allows current to exceed the maximum allowed BMS current, the regulator will restrict current so as to not over-load the BMS rating. *BMS Amp Capacity* is clipped to 10A increments, so a defined value of 258A will be saved as 250A

If BMS Aggregation is enabled, the total BMS current allowed will be increased to match that of the total recognized online and active BMS’s.

If a RBM is controlling the charge cycle, sending in goal battery current limits, *BMS Amp Cap* will be ignored.

Set = 0 (Default) to disable BMS Current Limit.

\$SCA: will reply with "AOK;" if the command was processed successfully. However, to assure the changes are STORED and used the regulator must be reset using the \$RBT: command after all changes have been made.

Example - Large alternator powered by large main engine:

- If not already done, set regulator's name
- Disable Idle adaptive pullback (alternator has massive cooling capability, and engine has sufficient reserve)
- Adjust amp shunt to 250A/75mV
- Define engine idle @ 550 RPMs
- Must have Alternator Temperature sensor present, else cause regulator to FAULT
- Leave other values as default (See Appendix D:)

```
$SCN:1,MainsAlt,5555@  
$SCA:0,95,1.0,0.75,0.50,0,0,0,3333,0,550,60,129@  
$RBT:@
```

Example - Detailed configuration. Large alternator powered by large main engine, 1500AH industrial FLA battery:

- Set name to MainsAlt
- Acceptance @ 14.4v until acceptance current is less than 1% of capacity, 8hr max.
 - *8hr Time limit is set as fall-back in case of battery current sensing failure.*
- 13.2v float - revert back if 2% of capacity is removed
- 15.3v Equalize, 3Hr duration.
- No overcharge nor post-float phases.
- Allow Alternator to operate up to 105c
- 30mV temp comp

```
$SCN:1,MainsAlt,4449@  
$SCA:0,105,1.0,0.75,0.50,0,0,0,3333,0,550,30,0@  
$CPA:7 14.4,480,5,0@  
$CPO:7 0,0,0,0@  
$CPF:7 13.2,-1,0,0,-10,12.7,0@  
$CPP:7 0,0,0,0.0@  
$CPE:7 15.3,0,180,0@  
$CPB:7 0.030,0,-45,45,0,-99,-99,0,0@  
$SCO:7,3,1,0,0@  
$RBT:@
```

Example: Shorted warm-up delay to 15 seconds, leaving the rest of the configuration at the default values:

```
$SCA:0,90,1.0,0.75,0.50,-1,0,0, 10000,0,0,15,0@
```

\$SCT: - Changes TACHOMETER parameters



Update calibration ratios and parameters associated with alternator driven tachometers. It should be noted the regulator will function correctly without changing any of these parameters; you need only change them if you wish to estimate the RPMs of your engine to be reported by the WS500 Alternator Regulator.

\$SCT: <Alt Poles>, <Eng/Alt drive ratio >, <Tach Min Field>, <ForceTM>, <Trigger Half-Power RPM>

Alt Poles: <WHOLE NUMBER (2 → 25)> Number of poles in the alternator.

Eng/Alt Drive Ratio: <FLOATING POINT NUMBER (0.5 → 50)> Enter the ratio your engine drive pulley diameter vs. the alternator drive diameter. Example, if your engine has a 7" drive pulley, and the Alternator has a 2.6" drive pulley, then enter: 2.6923 (7.0 / 2.6)

Tach Min Field: <WHOLE NUMBER (0 → 30)> This is the % value the PWM will be kept at as the minimum drive when *ForceTM* (Below) has been enabled. *BE VERY CAREFUL* with this value as it will set the floor in which the alternator is driven. If that floor is too high, it will prevent the regulator from 'regulating', burning out the battery. This is the actual PWM value sent to the field drive; though it is capped at 30%.

~~Set *Tach Min Field* = -1 to enable auto-determination.~~ (Note: Disabled, installer must set value manually. -1 will be treated as Disabled (0))

If a *Tach Min Field* value is set (any value greater than 0), and TACH-MODE is enabled, the regulator will use this value as a minimal field drive %. Even during the warm-up period. You may have to experiment with this value to get one which matches your system, taking care not to make it too great, as that could cause issues with overcharging of your battery.

Set = 0 (default) to not inject any artificial PWM % min value.

And a special note on Li based installs be very careful with *Tach Min Field* as incorrect setting will prevent the regulator from fully stopping charging when the battery has reached its target SOC.

ForceTM: <0, or 1> Setting the value to 1 will enable Tach-mode. (0 = DEFAULT)

A WORD OF CAUTION WITH TACH MODE AND WS500 FIRMWARE RELEASE 2.5.1+

Installs which use the Alternators Stator Wire to drive the engine Tachometers have a well know problem , Tach 'Dropping Out', particularly during the transition between Acceptance and Float stages. Many Alternator Regulators allows the user to define a Minimum Field Drive in order to allow some level of Alternator output at all times thereby keeping the tachometer active. The WS500 offers this capability via the \$SCT: command. (See page 68).

However, there is risk associated with such an approach, and especially with Li battery installs of causing an over-charge situation and resulting BMS initiated disconnect. With this in mind, up to Firmware Release 2.5.0, if at any time the measured battery voltage or current was significantly above the present goal, the WS500 would set field output to 0%, even if the user had specified a *Tach Min Field %* as set in the \$SCT: command. Safer for the system, but did cause the Tachometer to drop out at times.

Based on field feedback, beginning with Firmware release 2.5.1, the WS500 will respect the user defined *Tach Min Field %* value at all times, unless the WS500 is in Idle/Standby mode, or a faulted condition.

Users are cautioned to be aware of the significant change and assure their system performs not only as expected but in a safe way if they are using TachMode and Tach Min Field % settings.

Trigger Half-Power Mode RPM: <WHOLE NUMBER (0 → 10,000)> If the measured engine RPMs is below this value, the regulator will be forced into Half Power mode (See \$SCA command above)– in the same way as if the ATS sensor lines are shorted. This feature is most usable of the regulator is CAN connected to the engines J1939 bus and therefore able to reliably pick up engine RPMs (as opposed to using Stator sensing directly).

Set = 0 (DEFAULT) to prevent RPM triggered Half-Power Mode.

Example: \$SCT: 12,2.83,0,0,500@

\$SCT: will reply with "AOK;" if the command was processed successfully. However, to assure the changes are STORED and used the regulator must be reset using the \$RBT: command after all changes have been made.

\$SCT: will not be recognized if system has been locked-out via the \$SCO: command.

\$SCO: - Override features



Overrides the DIP Switches for Charge Profile and Battery Capacity selection, as well as other capabilities of the device. This command also allows the selection of auto detect for system voltage (12v, 24v, 48v), or forcing a fixed defined target system voltage.

\$SCO: <CP_Index>, <BC_Index >, <SV_Override>, <Lockout>, <Feature-IN>, <Feature-OUT>, <Promiscuous Mode>

CP Index: <WHOLE NUMBER (0 → 8)> Which Charge profile entry should be used? (1..8). Set = 0 to use DIP switches for selection.

BC Index: < FLOATING POINT NUMBER (-10.0 → +10.0)> Which Battery Capacity Multiplier entry should be used against normalized 500Ah battery? (1..4). Set = 0.00 to restore selection to DIP Switch value. It is possible to also receive the battery capacity via CAN. In normal cases the *BC Index* will be overridden by a CAN received value. However, if you do not wish the *BC Index* to be overridden by CAN received values; configure *BC Index* with a negative value. The multiplier will have the same effect, the sign of the value only indicates if the *BC Index* should also override any CAN received value or not. Positive = yes, allow a CAN supplied value to override; negative = no, ignore both the DIP switch and any value is supplied via the CAN.

SV Override: < FLOATING POINT NUMBER (0.0 → 4.5)> Enable (by setting = 0.0) or override the auto system voltage detection feature by defining the SV multiplier to be used. Though Auto detect is a nice feature, being able to fix the system voltage can improve reliability and allow support for battery voltages which are not a whole number multiple of the '12v' normalized battery used in the CPE tables. The following table shows some common values which may be used:

SV_Override value	Forced System Voltage	Charge Profile VOLTAGE Adjustment Factor
0	Auto	Auto
1	12v	1x
2	24v	2x
2.67	32v	2.67x
3	36v	3x
3.5	42v	3.5x
4	48v	4x

(Set SV Over-ride = 0 to restore auto-selection of 12v, 24v, or 48v system voltages)

Lockout: <WHOLE NUMBER (0 → 2)> Security feature: Restricts ability to perform changes and/or provide input to the regulator which can impact how the Alternator charges the battery. ***BE CAREFUL:*** Once lockout is enabled (value other than 0), it can ***ONLY*** be cleared by doing a master reset, or returning the device to the factory for resetting. No other command, not even \$MSR: (unless given the password) will be able to clear a non-zero lockout. ***Be especially careful with lockout=2, as the ONLY way to recover the regulator from this state will require returning the device to the factory.***

0 = No locking out.

1 = Prevent any configuration changes.

~~2 = Prevent any configuration changes — may NOT be cleared via \$MSR method.~~

~~(Redacted in v2.4.3, option 2 behaves the same as option 1.)~~

To clear a Lockout level 1, issue the \$MSR: command with the devices password (See \$SCN command). ~~A level 2 lockout is not clearable and the regulator will need to be returned to the factor for servicing.~~

Feature-IN: <WHOLE NUMBER (0 → 2)> Modifies the behaviors of the Feature-in port according to the following table. Applying a modifier will override any other default behavior.

Feature-IN Override	Option	Modified behavior of Feature-IN port
0	Default	
1	CPE #8 Force To Float (Inverted)	Function of Feature-IN will be inverted. Active will allow normal operation; while inactive will force the regulator into FLOAT mode. For use only with CPE #8, otherwise this option has no effect.
2	Select Half-power (Inverted)	If Feature-in is not active, regulator will be placed into Half-power mode (See \$SCA command above). When selected, activating Feature-in will release regulator from half-power mode.

Feature-OUT: <WHOLE NUMBER (0 → 3)> Modifies the behaviors of the Feature-out port according to the following table. Applying a modifier will override any other default behavior.

Feature-OUT Override	Option	Modified behavior of Feature-OUT port
0	Default	
1	Activate in post Float	Feature-out will remain inactive until the Post-Float phase is reached. Often used to signal generator-stop when a battery is fully charged. The device entering a HARD FAULT will also activate the Feature-out with this option.
2	Battery Heater Active	Caused Feature-out to become active when the battery heater is indicated as being active via CAN. Useful to drive enable pin on external power source for battery heater as BMS indicates a need.
3	Fault indicator **	Feature-out will become active ONLY if the WS500 is in a faulted condition. In this case both the initial 'engine warm up check' and the blinking out of the fault code number is suppressed and instead the Feature-out will be active (grounded) only when a true fault occurs.
4	Excessive Alternator Temp Fault indicator **	Feature-out will become active if at any time excessive Alternator Temperature is noted causing a High Alternator Temperature fault
5	DCDC Converter Warm	Feature-out will become active if a connected Wakespeed WS48-12X DCDC Converter's internal temperature reaches 75% or more of its rated upper temperature operating limit. This can be used to enable external forced air cooling if needed (Take care not to exceed the current limit of the Feature-Out port, 500mA. If needed use an external relay.)

Note: ** With these Fault Indicators, the Feature-out will hold-ff for 2 seconds after the device has actually entered a fault mode before being activated.

Promiscuous Mode: <0, or 1> Setting the value to 1 will allow a number of hard faults to self reset as opposed to requiring power cycling to clear. Reference "Appendix E: Error codes and meaning" with items marked with the modifier of 0x4000. (0 = DEFAULT)

\$SCO: will reply with "AOK;" if the command was processed successfully. However, to assure the changes are STORED and used the regulator must be reset using the \$RBT: command after all changes have been made.

\$SCO: will no longer be recognized once it has been locked-out.

Example - Configure to override DIP switches and positively define system voltage and battery capacity:

- If not already done, set regulators name
- Use CPE#3 (FLA#2 – large batteries)
- 1500AH battery (BC Index = 3)
- 12v system (SV Override = 1)
- Lockout NOT enabled (Allows continued changes)

```
$SCN:1,MainsAlt,5555@  
$SCO:3,3,1,0,0@  
$RBT:@
```

\$SCN: - Changes NAME (and PASSWORD)



Update Name and Password configuration. The name is used by the CAN subsystem to identify *this* regulator.

\$SCN: < Enable Wireless? >, < Reg Name >, < Reg Password >

Enable Wireless?: <WHOLE NUMBER (0, or 1)> Should the Wireless RF subsystem be enabled to support Bluetooth access? Set = 1 (Default) to enable Bluetooth. Set = 0 will disable RF subsystem at hardware level. (WS500 Pro Only)

Reg Name: <STRING (up to 18 characters, no spaces, comma, or '@') > Name used for CAN ID. If you have twin engines, you might wish to set these to descriptive names.

Reg Password: <STRING (up to 18 characters, no spaces, comma, or '@') > If the *Reg Password* string starts with a dot (.) character, this will be considered 'Hidden' and not reported out in the NPC status string. Do not that in such cases the '.' is still considered part of the password and will need to be sent in anytime it is needed (For example, to release a lockout level).

A NULL password may be optionally supplied. Doing so will case the existing password to not be changed. And of specific detail with the WS500 Pro, if a NULL password is sent in, the issuing of the \$SCN: string, while it will change the *Reg name* and *Enable Wireless*, it will NOT count as having changed the Password for Wireless access and security. This capability can be helpful when pre-configuring a WS500 Pro via USB, but then leaving the regulator in a state that will prompt the end user to change the password.

\$SCN: will reply with "AOK;" if the command was processed successfully. However, to assure the changes are STORED and used the regulator must be reset using the \$RBT: command after all changes have been made.

\$SCN: will not be recognized if system has been locked-out via the \$SCO: command.

Examples:

`$SCN:1,MainsAlt,5555@` ← Enabled Wireless, set name to MainsAlt, and password to 5555
`$SCN:0,MainsAlt,.5555@` ← Disable Wireless, set name to MainsAlt, and password to 5555 which will not be shown as part of the NPC, status string.
`$SCN:1,MainsAlt@` ← Enabled Wireless, set name to MainsAlt, do not set the password. When someone connects to a WS500 Pro via Bluetooth they will be prompted to change the password to something they wish. If after 10x engine starts the do not change the password, it will be set for them. (See

Security and Passwords above on page 6)

\$SCR: - RESTORES System Configuration table to default



Restores System Configuration values to original factory default values.

\$SCR: will reply with “AOK;” if the command was processed successfully. However, to assure the changes are STORED and used the regulator must be reset using the \$RBT: command after all changes have been made.

\$SCR: will not be recognized if system has been locked-out via the \$SCO: command.

\$CCN: - Change parameters in the CAN Configuration table



Configure the CAN Configuration Table for this regulator

\$CCN: <Battery Instance Override>, <Device Instance >, <Device Priority>, <AllowRMB?>, <ShuntAtBat?>, <Enable-OSE?>, <Enable-NMEA2000?>, <Enable_ALT_CAN?>, <Engine ID>,<BitRate>,<DC_Disconnected_VBat>, <Aggregate_BMS>,<Enable-DVCC>

Battery Instance Override: <WHOLE NUMBER (0 → 100)> What battery instance is this device associated with? (1..100). Set = 0 to use DIP switches for selection.

Device Instance: <WHOLE NUMBER (1 → 13)> Which instance of charging devices is this? Allows unique identification of charging sources. Device Instance is mostly used by external displays. It is considered good practice to give each regulator a unique *Device Instance* number, however if the installer fails to do that the WS500 will automatically adjust the *Device Instance* number in case of a conflict. (Default = 1)

Device Priority: <WHOLE NUMBER (1 →250)> What is the relative priority of this charging device?

A key value of the OSEnergy protocol is the ability to prioritize charging sources. This value is what is used to decide a given charging sources priority. If the needs of the associated battery (and any additional loads) can be met by higher priority charging sources the regulator will reduce its output to 0A. However, if the battery/load needs cannot be meet the regulator will deliver current to its limits as needed. If there are two or more charging sources with the same priority, battery /load needs will be split between them. (Useful in dual engine installations to balance loads between both engines). (Alternators Default=70)

Device priority is also used to decide who should act as the Remote Battery Master, or the overall coordinator in the system to assure all charging devices are working towards the same goal. If *AllowRMB?* Is enabled, the WS500 Alternator Regulator will assume the RBM role if no other higher device exists. This can be useful in simple installations where no Battery Monitor is installed or as a fall-back for a failed battery monitor.

Allow RBM?: <WHOLE NUMBER (0..2)> Should the WS500 Alternator Regulator attempt to act as the Remote Battery master?

0 = Do not allow the regulator to assume the RBM role.

1 = Allow the regulator to potentially assume the RBM role. (Default)

2 = Allow the regulator to potentially assume the RBM role as a 'Virtual' device.

Used in combination with <enable_ALT_CAN?>, a *Virtual RBM*, is a mode where the "alternative supported CAN" data is re-transmitted as a RV-C compliant RBM. Note that in this mode, though the WS500 will represent the alternative CAN supported BMS as an RV-C compliant device, if another device with higher priority is present the WS500 will following RV-C spec and stop transmitting as an RBM.

Also, in the lack of an active alternative CAN device, Virtual RBM mode will defer back to a standard RBM mode.

Shunt At Bat?: <WHOLE NUMBER (0, or 1)> Is the shunt connected to the Battery? Used during RBM mode to know if we are seeing alternator or battery current. 0=no, 1=yes(default)

Enable OSE?: <WHOLE NUMBER (0, or 1)> Should the WS500 Alternator Regulator send and receive OSEnergy (RC-V) status and coordination messaged via the CAN bus? 0=no, 1=yes(default)

There may be some simple installations where one wishes to use the WS500 Alternator Regulator to only broadcast status to NMEA2000 devices, and the OSEnergy messaging (RV-C standard) causes issues with some existing NMEA2000 devices. Do note that disabling OSEnergy mode will remove many of the systems benefits such as coordinated / prioritized charging, simplified remote instrumentation, and more.

Enable NMEA2000?: <WHOLE NUMBER (0, or 1)> Should the WS500 Alternator Regulator send out NMEA-2000 like status messages via the CAN bus? 0=no, 1=yes(default)

Enable_ALT_CAN: <WHOLE NUMBER (0 → 255) > Though RBMs supporting RV-C/OSEnergy protocols provide the best level of integration, there are other CAN based BMS and remote sensors which may be utilized. *Enable_ALT_CAN* is a way to signal which of those additional protocols to support. Note that some protocols are able to provide full RBM direction, while others only offer a limited amount of remote sensing. It is up to the installer to assure which messages are supported by the attached device and if the resulting system integrations meet expectations and needs. A value of 0 (default) will disable any additional CAN protocol support, and it should also be noted that a given device may require other configuration changes such as adjusting CAN baud rate, and even disabling some optional protocols supported (e.g., NMEA2000)

Protocol	Value	Features
NMEA2000 RAT	1	Battery current and temperature via NMEA2000 battery monitor.
SMA	2	BMS devices supporting 11-bit ‘Sunny’ SMA type messages. Aka, ‘Victron BMS’ protocol
SMA w/“Zero Output Technology” enabled.	3	Enabled active regulation of battery current to 0A (and passed voltage goal) instead of disabling alternator with so signaled from BMS.
MG Energy Systems	4	Support for MG Energy Systems BMS.
MG Energy Systems w/“Zero Output Technology” enabled.	5	MG Energy Systems BMS with active regulation of battery current to 0A.
Discover (AES)	6	Support for Discover Battery CAN messages (AEBus Protocol)
Discover (AES) w/“Zero Output Technology” enabled.	7	Support for Discover Battery AEBus with active regulation of battery current to 0A when SOC >= 100%
Lithium Werks	11	Support for Lithium Werks BMS using proprietary communications protocol.
Lithium Werks	12	Utilizes active regulation of battery current to 0A

w/"Zero Output Technology" enabled.		when 'do not charge' state is requested from BMS.
LUX	13	'LUX' 11-bit BMS protocol.
LUX w/"Zero Output Technology" enabled.	14	Enabled active regulation of battery current to 0A (and passed voltage goal) instead of disabling alternator with so signaled from BMS.
Victron LYNX BMS	16	Support for Victron LYNX BMS
Victron LYNX BMS w/"Zero Output Technology" enabled.	17	LYNX BMS with active regulation of battery current to 0A.
Victron SmartShunt	18	Receive Battery Amps, and optional Temperature, via Cerbo / SmartShunt combo.
Victron CAN-bus	21	A protocol defined by Victron for 3 rd party batteries. Based loosely on SMA, but ads some special proprietary additional messages. DO NOT USE WITH VICTON BMS's, see LYNX protocol above!
Victron CAN-bus w/"Zero Output Technology" enabled.	22	

Table 3 – Alternative CAN protocols support

Note: Prior to Firmware v 2.1.0, Enable_ALT_CAN was a single value of 0 or 1 and used to specify only NMEA200_RAT support. Some notes for supported BMS's:

- In all cases, if a proper RV-C device is found and qualified, it will take precedence over any of the above 'Alternative' CAN devices.
- In the case of MG Energy, if a SmartLink device is discovered and qualified, it will take over control vs. the individual BMSs. In the case of no SmartLink, or a failed SmartLink, the device will fall-back to directly communicating with the BMS's. See *Appendix A: CAN enabled BMS* on page 92 for additional details.

DANGER: Beginning with Firmware 2.5.2, support for Victron DVCC was added. If enabled in the Cerbo, AND charging current is sensed (e.g., the Current Shunt is located on the Alternator vs. the battery), DVCC directions will be followed, providing the overall Battery Current does not exceed its charging current limit. This however does NOT relieve the need for direct BMS integration, as alarms and warnings are still needed to be processed outside DVCC. Refer to the Wakespeed Application for an up to date list of supported batteries/BMS's

Engine ID: <WHOLE NUMBER (0 → 250)> Used to associate the regulator with the engine it is mounted on. Specifically with regards to RPMs. The regulator monitors for a matching J1939 engine RPM (PGN: 61444) and will use it instead of measured stator RPMs. Also, if NMEA2000 messages are enabled and the regulator is able to measure RPMs – NMEA2000 PGN: Engine parameters rapid (#127488) will be sent with the RPMs indicated as being associated with this Engine ID. Default ID = 0.

BitRate: <WHOLE NUMBER (0 → 4)> If supported by hardware, allows CAN communications rate to be changed from the default 250Kbps.

Value	Rate
0	Default (250Kbps)
1	100Kbps
2	125Kbps
3	250Kbps
4	500Kbps
5	1,000Kbps (-PRO Only)

DC_Disconnected_VBat: <FLOATING POINT NUMBER (0.0 → 20.0)> If a DC-Disconnect command is received via the CAN bus, the charging source will normally be placed into a Disabled mode. However, it may also be optional placed into a CV state using this voltage.

A value of 0.0 (default) causes transition to DISABLED mode or FAULT stat.

Aggregate BMS: <WHOLE NUMBER (0 → 10)> Some installs utilize more than one BMS in a given battery bank. This may be done to support slightly different locations (ala, port and starboard side of a vessel due to space constraints and/or weight distribution), or more commonly to increase maximum available current by paralleling BMSs. In doing so, not all BMS devices will perform aggregation, instead they will present themselves as different Battery Instance ID's, despite being connected to the same physical DC bus. *Aggregate BMS* allow support of this type of install by monitoring for any BMS or potential RBM with not only the configured *Battery Instance* number (See above), but also up to 10 Battery Instances. From the base *Battery Instance* up to *Battery Instance + Aggregate BMS*. Example, if *Battery Instance* is set for 2 (either via the DIP switches, or *Battery Instance Override* above) and *Aggregate BMS* is set for 5, then ANY battery Instance from 2 to 6 will be consider all part of the same 'battery' and aggregated by the WS500.

Aggregation will sum up the battery current, and capacity; will monitor for any given battery device coming on line or going offline. The request charge state will be the least aggressive (e.g., if ONE online battery asked for Float, then the WS500 will enter Float mode even if the remaining batteries are asking for Bulk). The battery with the most extreme temperature (Hot or cold) will be used to make temperature related decisions, and if a given battery goes off line the WS500 will continue to monitor and respond to the remaining batteries. Once if ALL batteries go offline the WS500 will enter a fault state.

Aggregate BMS is an advanced capability, and it is up to the installer to test and assure the overall system responds in an expected way. Note that if enabled, Remote Voltage Sensing is disabled and the WS500 MUST be installed with the voltage sensing wires attached to an appropriate point in the battery bank. At present, the following BMS's have been proofed with aggregated:

- MG Energy BMS
- Lithionics NeverDie™ BMS

A value of 0 (default) will disable any battery aggregation.

Enable DVCC?: <WHOLE NUMBER (0, or 1)> Should the WS500 Alternator Regulator look for DVCC directions from a Victron Cerbo (or like)? If enabled, the WS500 will look for limits / directions for Alternator Amperage as requested via DVCC. Note that to allow this Alternator Current must be measured, either by setting *Shunt at Bat* = 0, or by supplying alternator current by an optional N2K_Alt_instance device.

0=no, 1=yes(default)

\$CCN: will reply with "AOK;" if the command was processed successfully. However, to assure the changes are STORED and used the regulator must be reset using the \$RBT: command after all changes have been made.

\$CDD: - Change parameters in the DC-DC Configuration table



Configure the DC-DC converter for this regulator

\$CDD: <Model>, <Mode>, <Volts>, <Volts_HalfPower>, <48v_Charge_Amps_limit>, <12v_Support_Amps_Limit>, <48V_LimitV>, <48V_LimitSOC>, <12v_Refresh_volts>, <12v_Refresh_Hold>, <12v_Refresh_Days>

Model: <WHOLE NUMBER (0 → 5)> Which DC-DC converter is attached?

Value	Brand	Supported Modes
0	Not Present (default)	n/a
1	WS3000r APS12BI58-3000 **	0..3
2	WS3000r-24 **	0..3
3	WS1500 **	0..3
5	Wakespeed WS48-12X	0..3

Default = 0 (None)

** Contact support@wakespeed.com regarding these 1st generation offerings.

Mode: <WHOLE NUMBER (0 → 3)> How should optional DC-DC converter behave?

Value	Mode
0	Off, Disable, Not Present
1	48v Battery Charging only
2	12v Battery Support only
3	Dynamic

The WS500 Advanced Alternator Regulator has the ability to manage an optional external DC-DC converter and control the transfer of power between two separate DC busses:

- 48v Battery: The Battery the WS500 is attached to and managing. Typically a higher voltage House Battery (ala, 48v Lithium house battery). Note that there may or may not be an alternator connected to the Primary Battery and controlled by the WS500.
- 12v Battery: A separate battery system the other side of the DC-DC convert is attached to. Typically the 12v chassis battery. For example the 12v chassis starter battery with its associated factory 12v alternator. In this case the WS500 is not directly managing the factory 12v alternator, though the DC-DC converter is manages to take into account the capability and needs of both the 12v battery and its associated 12v alternator.

In 48v Battery Charging mode the converter is used to transfer power from the 12v battery/alternator to help meet the charging needs of the 48v house battery the WS500 is primarily connected to. Note that if there is also a 48v Alternator the WS500 is controlling, both the alternator and the DC-DC converter will be managed to meet the battery charging needs.

In 12v Battery Support mode, power is taken from the 48v battery and directed to the 12v battery. This might be for example when the vehicle has stopped and the engine is turned off. Power can be transferred from the 48v House battery down to the 12v 'starter' battery and any attached 2v legacy devices (Lights, Refrigerator, etc). In this way there is no need for a separate 12v house battery and all lagecy 12v loads can be powered via the 48v battery without discharging the starter battery.

Dynamic mode intelligently manages between 48v Charging and 12v Support mode, directing power as needed and available between the two systems in real time.

In a typical application the WS500 is attached to the 48v house battery, with our without an associated alternator (also controlled by the WS500) and the 12v chassis battery with the chassis alternator. 12v legacy loads (Room lights, 12v refrigerator, etc) are connected directly to the 12v starter battery (Perhaps with a Low Voltage safety cut-off) to complete a simple 12v House to more capably 48v house battery transition. The DC-DC converter is then configured to either charge the 48v battery using excess power from the 12v Chassis Alternator when the vehicle is running, or transfer power from the 48v house system to the 12v chassis system when the vehicle has stopped to support ongoing 12v loads. As a side benefit, the 12v chassis system is also provided with additional power when the vehicle is actually starting, to augment the existing starter battery with additional amps pulled from the 48v house battery.

Another configuration is where the chassis alternator is fully replaced with a 48v alternator. By enabling only 12v Support the DC-DC converter can emulate a 12v alternator, recharging the starter battery after starting the vehicle as well as suppling power for all ongoing chassis needs beyond any legacy 12v loads.

See note of how MODE can be overridden while in the Half_power state depending on the value of *Volts_HalfPower* . See more below.

Default = 0 (Off/Disabled)

Volts: <FLOATING POINT NUMBER (0.0 → 16.0**)> This value is used (Depending on selected Mode) when pulling power from the 12v system to the 48v battery as well as when transferring power from the 48v system to the 12v one..

During *48v Charging* mode, the voltage of the 12v battery is monitored and used to regulate how much power is drawn from the 12v system. If the 12v battery system falls below this value, power transfer reduced or will be stopped.

During *12v Support* mode, the DC-DC converter will deliver this fixed voltage. A typical value is 13.8v to allow charging of the Starter battery while the engine is running, emulating a common 12v alternator as well as supplying additional power if the demand on the 12v side exceeds the capability of the chassis 12v alternator (Starting, or perhaps heavy load such as 12v winch).

Dynamic Mode, allows for the real-time switching between *48v Charging* and *12v Support* mode as dictated by the real-time status of the 12v battery system.

If set = 0.0 (default), the DC-DC converter only will only provide the max DC-DC converter amps to the 48v battery with no regards to any voltage dip on the 12v battery system. Use 0.0 with care.

Volts_HalfPower: <FLOATING POINT NUMBER (-16.0 → 16.0**)> Optional target voltage which is selected if the system is running in Half-Power mode. (See \$SCA command on page 60, \$SCT command on page 68, as well as \$SCO command on page 70). Typically this is used in conjunction with some indication for when the engine is running or not via the Feature-in wire where *Volts_HalfPower* is selected for the DC-DC converter operate when the chassis is not running, to set a lower 12v battery voltage – preventing the risk of overcharging the 12v battery, as well as reduce overall power draw on the 48v battery when the vehicle has stopped.

Using a negative value will cause the DCDC converter to be forced into *12v Support (Mode = 2)* when the system is operating in HalfPower mode, overriding the normal configured modes. Care is needed as this override is absolute, and will occur even if the configured *Mode* is set for any other value (other than Disabled). As well as this will prevent the DCDC Converter from cycling on and off as needed to maintain the 12v battery, perhaps increasing power consumption. But in this way the installer is able to have more control over if the DCD Converter depending on if the engine is running or not.

Set = 0.0 (default) will cause the DC-DC converter to be fully disabled in Half-power mode.

48v_Charge_Amps_limit: <WHOLE NUMBER (-500 → 500**)> While charging the 48v Battery, the DC-DC converter will limit the amount of power transferred between batteries via the DC-DC converter its maximum capability or *48v_Charge_Amps_limit*, whichever is less. The current limit is typically measured on the 12v battery side of the DC-DC converter (Check the Supported DC-DC converter table above for any notes). A value of 0 (default) will cause the DC-DC converter to run at its maximum capability. Set *48v_Charge_Amps_limit* to match the DC-DC converter installation wiring as well as limits to the 12v battery alternator capability.

If White Space is active, its overlay will be applied to the *48v_Charge_Amps_limit*, allowing reduction of loading on the 12v alternator at lower RPMs. See \$ENG command on page 46

A negative value will cause *48v_Charge_Amps_limit* to be reduced by 50% when HalfPower mode is selected. Perhaps useful in the case where there are 12v charging sources still active when the engine is off (MPPT controller attached to the 12v battery for example)

12v_Support_Amps_Limit: <WHOLE NUMBER (0 → 500**)> While supporting the 12v battery/system with power from the 48v battery, the DC-DC converter will limit the amount of amps transferred between batteries to the maximum of its capability, or *12v_Support_Amps_Limit*. Whichever is less. This current limit is typically measured on the 12v battery side of the DC-DC converter, unless noted above below in the Supported DC-DC converter table. A value of 0 (default) will cause the DC-DC converter to run at its maximum capability. Set this to match the DC-DC converter installation wiring as well as the maximum discharge limit of the primary battery.

*** Note: All the DC-DC related limits will be validated against the selected Device Type. If a value outside the allowed range of the device has been specified (Min and/or max), a 'Miss-configured' fault will be issued as there is something wrong with the system design. Make sure to validate all these limit values against the specific device specification sheets.*

48V_LimitV: <FLOATING POINT NUMBER (0.0 → 20.0)> While operating in *12v Support* mode – where power is pulled from the 48v battery to support the 12v battery/system, if the 48v battery voltage drops below this value, *12v Support* mode is disabled. Setting *48V_LimitV* provides for protection of over-discharging the 48v battery.

NOTE: In line with the normalized 12v/500Ah battery concept used in other parameters, such as the CPx values, this number will be adjusted during runtime for the actual nonomial battery voltage. Example, setting a value of 12.2v here will cause *12v Support* to stop if the 48v battery drops below 48.8v

As with most all other Battery Related voltage values, the value here is normalized in line with the all other CPE values. In this way the system will automatically adjust for a 24v or 48v install without needing to modify this value.

Set = 0.0 (default) to disable this check

48V_LimitSOC: <WHOLE NUMBER (0 → 100)> While operating in *12v Support* mode – where power is pulled from the 48v battery to support the 12v battery/system, if the 48v battery SOC drops below this value, *12v Support* mode is disabled. Setting *48V_LimitSOC* provides for protection of over-discharging the 48v battery.

Set = 0 (default) to disable this check

12v_Refresh_volts: <FLOATING POINT NUMBER (0.0 → 20.0)> It can be that after some time the 12v battery could use a 'Refresh' charge, to 'Top it off'. Setting *12v_Refresh_volts* allows for this topping off by temporarily setting a new 12v 'volts' limit to be used while in *12v Support* mode, overriding the *Volts* and *Volts_halfpower* values above. Refresh Charge allows for a 'Boost' to be given to the 12v battery. All other configurations are respected, including if the *12v Support* mode is even enabled. While doing a *12v Refresh* charge the only change is the target 12v voltage level being adjusted.

A value of 0.0 (default) disables 'Refresh' charge mode.

12v_Refresh_Hold: <WHOLE NUMBER (0 → 120)> While in a *12v Support* mode, after *12v_Refresh_volts* is reached, hold the 12v battery at this level for *12v_Refresh_Hold* minutes before exiting *12v Refresh* mode and resuming normal operation.

A value of 0 (default) will cause the immediate exit upon the 12v battery reaching its Refresh Voltage goal.

12v_Refresh_Days: <WHOLE NUMBER (0 → 100)> Initiate a '12v Refresh' phase after *12v_Refresh_Days* . Is based on when the WS500 / WS500-Pro was powered on.

A value of 0 (default) disables 12v Refresh charge mode.

Note: If the 12v battery's voltage raises above <12v_Refresh_volts> while in a Refresh cycle, that cycle will be terminated as it is assumed an external charging source is now taking care of the 12v battery.

When supporting a DC-DC converter additional capabilities of the WS500 which may be utilized. Example the application of 'Required Sensors' (ref \$SCA: command), and specifically the requirement of a CAN connected BMS/RBM. By setting Required Sensors, one will be able to disable the DC-DC converter when there is no CAN connected battery present. An example might be in a case where the house battery is physically located in a trailer which can be disconnected from the tow vehicle. By using Required Sensors with RBM, no power will be presented to the trailer wiring unless a CAN communication link has been established beforehand with the BMS.

Consider also the placement of an ATS (Alternator Temperature Sensor) on the 12v alternator. Doing so will allow the WS500 to control the power demands of the DC-DC converter taking into account the 12v alternator temperature in addition to only voltage; reducing those demands if the temperature rises above the Alternator Temp Setpoint in the \$SCA command. By utilizing CAN based BMS connection, and remote instrumentation of the battery temperature, the BTS can be repurposed for a 2nd ATS allowing both the 48v and the 12v alternator to both be monitored.

Consult details in the selected DC-DC Converter for additional voltage and/or current limits, which may likely be lower than the ASCII command limits shown here.

\$CDD: will reply with "AOK;" if the command was processed successfully. However, to assure the changes are STORED and used the regulator must be reset using the \$RBT: command after all changes have been made.

\$CCR: - RESTORES CAN Configuration to default



Restores CAN Configuration values to original as-compiled (default).

\$CCR: will reply with “AOK;” if the command was processed successfully. However, to assure the changes are STORED and used the regulator must be reset using the \$RBT: command after all changes have been made.

\$CCR: will not be recognized if system has been locked-out via the \$SCO: command.

\$MSR: - RESTORE all parameters to factory default.



Restores all configurable parameters to the factory default values. This is a combination of the \$CCR: , \$CCR commands, the \$CPR:n commands for all Charge Profile Entry tables, and \$RBT; command. Alternator will RESET after this command is completed.

\$MSR: <Password>

Note \$MSR is disabled if the Regulator has been locked out via the \$SCO command. If successful, the regulator will reply with “AOK;” and then reboot.

Password: <STRING (up to 18 characters, no spaces, comma, or ‘@’) > Optional *Password* may be supplied to clear a level 1 lockout. (Take note of the space between the ‘:’ and the <password>, example: *\$MSR: 1234@*)

\$MSR: will not be recognized if system has been locked-out (level 1) via the \$SCO: command unless the correct devices password is supplied. Note that a lockout level 2 is not clearable, even if the correct password is supplied.

Note: Some versions of firmware require a space between the : and the password, example:

\$MSR: 1234@

As opposed to:

\$MSR:1234@

\$EDB: - Enable DeBug serial strings



Will cause regulator to start sending \$DBG; strings via ASCII communication ports. If it is powered down, or reset (ala a Fault, or by receiving a command string that causes a reset), the regulator will restore to its default handling of \$DBG: strings.

\$EDB:

Note: To turn off Debug Mode, send command \$EDB:0@

\$RBT: - ReBooT system



Will cause regulator to reset. This is useful to load any changes from saved Flash memory into the regulator for its use.

\$RBT:

\$RBT: will not be recognized if system has been locked-out via the \$SCO: command.

It is strongly suggested that you use the \$RBT command after you have finished making changes to the Alternators configuration via other ASCII commands. This will restart the regulator, allowing those changes to be recognized – but more important some hardware needs the \$RBT: command as a signal to actually save requested changes in non-volatile memory. If your device using what is known as EEPROM-Emulation, any changes you make will not be saved until you issue the \$RBT: command.

\$RBT: will respond with the string *RST*; if it is accepted and the device will then restart (reboot). Note that this is different than the more common \$AOK; response.

\$FRM: - Force Regulator Mode

This command (with its parameters) will force the regulator to change its current mode to the one indicated. Once forced into a mode the regulator will continue to manage the system accordingly, even if this means the regulator immediately exits the forced mode. For example, if you force the regulator into Float mode, but the Amps being taken from the battery exceed the exit_float criteria, the regulator will return to the Bulk phase.

\$FRM:<Mode>, <duration>

Mode: <Character> The ASCII character *immediately* following the ':' will be used to force the alternator mode. Character must match EXACTLY the following (including case), must be IMMEDIATELY after the ':', but may be followed by any number of additional characters.

- B = Force into BULK mode.
- A = Force into ACCEPTANCE mode.
- O = Force into OVER-CHARGE mode.
- F = Force into FLOAT mode.
- P = Force into POST-FLOAT mode.
- E = Force into EQUALIZE mode.
- I = Force into Idle (Standby) mode (WS500 Pro Only)
- C = Force into CONFIGURATION mode (Held until changed, or regulator reset)

Any other character will be ignored and no change will be made. If the active Charge Profile has 'disabled' a given phase, the regulator will immediately exit that phase – even if it is 'forced' into it, and switch to the next appropriate phase. Also note that if the exit criteria of a forced-mode phase is met, the regulator will again exit that phase quickly. In such cases the mode may be changed before the next \$AST string is sent.

Configuration Mode is a special mode where the regulator will listen and process all CAN and ASCII communications, but it will not actively drive the alternator nor doing error checking. It can be useful if you wish to do extensive configuration of the regulator without worrying about overheating the field, or have faults reported due to not yet in place sensors. As well as allowing simpler bench-top configuration w/battery under-voltage faults occurring. Once entered, the only way to exit CONFIGURATION mode is to \$RBT: or power-cycle the regulator.

Duration: <WHOLE NUMBER (0 → 99999)> Optional parameter, will cause this requested MODE to be held for seconds. Any request to change to an active Charge State will be blocked until <Duration> seconds has elapsed, a new \$FRM: command is sent in, or the regulator is reset. Internal CPx charge profiles changes as well as those from a RBM will be blocked. Fault modes, or requests to enter Idle modes, etc. will be acted upon even if <Duration> has not been exhausted.

Value of 0, or no value, will not cause any blocking.

(WS500 Pro Only)

Examples:

\$FRM:B → Forces regulator into BULK mode
\$FRM:Bulk → Forces regulator into BULK mode
\$FRM:Bob@ → Forces regulator into BULK mode (Note use of '@' as needed with Arduino IDE terminal)
\$FRM:b → Ignored (lower case 'b')
\$FRM:I,600@ → Force regulator into Idle mode for the next 10 minutes.

No pre-existing condition check is made when receiving these mode change commands. For example, normally you would be able to enter Equalize mode only if the regulator was already in Float or Post-float mode. However, the \$FRM: command can force the regulator into Equalize mode directly from any state, including Bulk or Ramping. (Do remember: as noted above - if conditions are such, it may not stay in Equalize very long.)

APPENDIX A: CAN ENABLED BMS

The ability for the WS500 Alternator Regulator to communicate with BMS devices using the CAN (Control Area Network) provides for a higher level of integration and reliability than is possible using only legacy methods (e.g., Charge Enable wire), as well as installation simplification via remote instrumentation of battery current, voltage, and/or temperature (BMS support dependent). The WS500 primarily utilized RV-C CAN protocol (ref: <http://www.rv-c.com/>), and providing a battery/BMS is also compliant with this standard the WS500 will operate seamlessly without any additional configuration needed.

In addition, other CAN protocols may be supported. This appendix provides details of optional CAN protocols supported by the WS500 regulator. Refer to the command \$CCN: on page 77 and how the 'Enable_ALT_CAN' field is defined.

WARNING: Not all BMS devices provide advanced notification of pending DC disconnect. It is up to each installer/designer to verify the details of the BMS and its integration with the Wakespeed WS500 Advanced Alternator Regulator to assure a reliable system. It is suggested that at minimum a 2 second warning be issued by the BMS before any actual physical disconnect occurs.

CAN based BMS integration can be a challenging concept at first, though the end result does allow for a simpler and more robust overall system install. If the installer has any questions about what is contained in here, or the suitability of a given BMS, send an Email to: support@TJCMicro.com

NMEA2000_RAT: Should the WS500 Alternator Regulator look for a NMEA2000 device to supply remote sensing of battery Amperage and Temperature via PGN: 127508 and PGN: 127506 for SOC and SOH. To reduce confusion in the NMEA2000 network, if *Enable_NMEA2000_RAT* is set = yes, and the sending of PGN 127508 messages for the Battery Instance will be suppressed. When using NMEA2000_RAT mode, great care is needed in the overall setup with regards to the Battery Instance. Some systems ignore this field and set all devices to Instance=0, which will cause great confusion.

Example product(s) include:

- Maretron DCM100

SMA: The ‘Sunny’ SMA CAN protocol is an 11-bit message commonly used in the Solar and Electric Vehicle industry. It allows for a BMS to tell charging sources to start, stop, and which goals to utilize. Often know as the SMA protocol, it is also reflective of the Victron 11-bit BMS protocol, though at a different CAN speed. Some representative BMS’s which use this protocol includes:

- MG Energy (<https://www.mgennergysystems.eu/>) *
- REC BMS (<https://www.rec-bms.com/> , <https://rec-bms-na.com/>) *
 - *MUST* use ‘Victron’ variant of this BMS
- Orion Jr (<https://www.orionbms.com/>)
 - Select ‘Victron Inverter’
- SIMP BMS (<https://github.com/tomdebree/SimpBMS>)

* Note: These SMA BMS’s have been tested in the lab and/or in field installations. Others may have only been confirmed via specifications. Contact support@wakespeed.com if you have any questions on a specific BMS.

The 11-bit CAN messages will be ‘converted’ into an OSEnergy type device with a fixed CAN-ID of 69 and a priority of 120. Aggregation is not supported. The following CAN messages are utilized. (Refer to your BMS guide for details of these messages)

- 0x351: Battery Charge Voltage, Charge Current Limitation
- 0x356: Battery Current, Battery Temperature
- 0x35A: Alarm/Warning

Both 0x351 and 0x356 must be broadcasted at a minimum rate of 1,000mS to allow the WS500 to recognize a device and begin following its directions. Once doing so, if *Battery Charge Voltage* and *Charge Current Limitation* (Message 0x351) are both non-zero the WS500 will enter CV/CC mode using those goals. A zero value for one or both of those will cause the WS500 to enter standby. Optionally, if *SMA w/Zero Output Technology*” is selected a zero goal value for current with a non-zero value for voltage will cause the WS500 to actively regulate battery current to 0A, while leaving the alternator able to supply energy to ongoing house loads.

Message 0x356 may be used to remotely supply *Battery Current* readings to the WS500, reducing the need to install a physical current shunt. In addition, *Battery Temperature* measurements will be used in combination with the presently active CPE to enforce hard charging limits based on high and/or low temperatures, even if the BMS continues to request charging.

0x35A: The Alarm/Warning message will be monitored for any active indication. Upon receiving a Warning indicators, the WS500 will stop charging and perform a recoverable fault (regulator will restart). However if a Fault flag is received, the WS500 will enter a non-recoverable hard fault.

Different BMS devices behave differently, but the best practice is if the BMS sends out a warning and/or fault 2 seconds before doing a physical disconnect to prevent voltage spikes in the system from an uncoordinated disconnect.

MG Energy System: The MG Energy Systems line of BMSs and batteries supports both an 11-bit SMA like interface and a 29-bit based messaging protocol. It is preferred to utilize the 29-bit messages. When selected the 29-bit protocol is a J1939 compatible messaging system utilizing a series of public and private messages that will then ‘converted’ into an OSEnergy type device using the original CAN node address and with a fixed priority of 120. The MG Energy System BMS issues a proper warning before disconnects, assuring safe shutting down of the alternator.

MG Energy System support allows for remote instrumentation of battery current and temperature, the sending of battery charge goals and limits (Voltage/current), Dynamic C-Rate management based on installed battery capacity, as well as Aggregation of up to 10x

As with the SMA protocol, when *Battery Charge Voltage* and *Charge Current Limitation* are both non-zero the WS500 will enter CV/CC mode with those goals. A zero value for one or both of those will cause the WS500 to enter standby. Optionally, if “w/Zero Output Technology” is selected a zero goal value for current with a non-zero value for voltage will cause the WS500 to actively regulate battery current to 0A, while leaving the alternator active to supply energy to ongoing house loads.

Beginning with 2.5.1, support for the MG Energy SmartLink has been added. During running if a SmartLink controller is detected the Wakespeed WS500 will lock onto that while ignoring the individual BMS’s. If a SmartLink is not present the WS500 will monitor each BMS directly to perform aggregation.

Victron LYNX BMS: The Victron line of LYNX BMSs are supported using a proprietary 29-bit protocol which is compatible with J1939. When selected the LYNX messages are ‘converted’ into an OSEnergy type device using the original CAN node address with a fixed priority of 120.

LYNX BMS support allows for remote instrumentation of battery current and temperature, the sending of battery charge goals and limits (Voltage/current), and Dynamic C-Rate management based on installed battery capacity.

Regulators disable or ‘Zero Output Technology’ options may be selected to adjust how the WS500 behaves when the BMS request no additional battery charging. . The LYNX BMS will also issues a proper warning before disconnects, assuring safe shutting down of the alternator.

Beginning with firmware release 2.6.0, the Wakespeed will now allow aggregation of more than one Victron Lynx BMS. Contact Victron for details on any changes needed to the Lynx. To enable:

- Toggle on ‘Aggregate BMS’ option on the System Tab
- Configure each Lynx BMS to a unique Device/Battery Instance.

The WS500 / WS500 Pro will aggregate any Lynx BMS that falls within a Battery Instance window defined by the ‘Battery Instance’ as set in the Wakespeed Application and 10+ more instances.

Ref: https://www.victronenergy.com/media/pg/Lynx_Smart_BMS_NG/en/paralleling-lynx-smart-bmses.html#:~:text=A%20parallel%20redundant%20battery%20bank,continuous%20power%20supply%20and%20operation.

Victron SmartShunt / Cerbo: The Victron SmartShunt may be used to monitor battery current and optionally temperature. Much like NMEA2000-RAT mode, N2K PGN 127508 is used to convey information, but a special check is made for the Battery Instance = 239 – assuring only the ‘...main (system) battery’ details are received.

Much of Victron’s equipment is unique in that it largely focuses on a single battery, with some support for a 2nd ‘starter’ battery. By using the *Victron SmartShunt / Cerbo* selection the WS500 will look for the message sent by the Cerbo; with a detail that the Cerbo may select from a verity of installed Victron equipment to determine ‘main’ battery details.

Reference Victron ‘Cerbo GX manual / MFD Integration by NMEA 2000’ ([Link](#)), in section 14.2 *Supported Devices / PGNS, Battery monitors* for more details.

Lithium Werks:** Support for the Lithium Work BMS is provided via a proprietary CAN communications protocol. When enabled, this protocol will allow for the Lithium Werks BMS to send charge goals and limits (Voltage and current) to the WS500 Alternator Regulator. Battery current and Temperature are also provided as well as BMS warning and alarming states.

Both normal and Zero-output technology is supported, and the communications protocol may allow for stable active current regulation using the Remote shunt, however if instability is noted a physical shunt may need to be installed. The Lithium Werks BMS does not provide a 2-seconds advanced notice of impending disconnect, as such some level of mitigation steps will need to be put into place in the overall system design.

****Note: As of June 2021, this protocol has not been proofed in the field. Contact support@wakespeed.com to enquire about the latest status.**

LUX: The LUX protocol is a slight variant of the SAM protocol. Also an 11-bit message, it is common in China sourced BMS's. As with the SMA handling, LUX 11-bit CAN messages will be 'converted' into an OSEnergy type device with a fixed CAN-ID of 69 and a priority of 120. Aggregation is not supported. The following CAN messages are utilized. (Refer to your BMS guide for details of these messages)

- 0x351: Battery Charge Voltage, Charge Current Limitation
- 0x356: Battery Current, Battery Temperature
- 0x359: Alarm Only (Warning ignored)
- 0x35C: Charge Enable Bit

Details for message 0x351 and 0x356 are the same as with SMA, detail for message 0x359 is the same as the SMA 0x35A but a different address. Message 0x35C includes byte-0, bit 8 to incident if charging is allowed. It (along with a goal current of 0A in message 0x351) will be used to direct the WS500.

Batteries which have been proofed with the LUX protocol include:

- Dyness: B4850 (<https://www.dyness-tech.com.cn/product/26.html>)
 - Requires use of 'Wakespeed' BMS firmware, contact Dyness.
- PylonTech US3000C
 - Requires use of 'Wakespeed' BMS firmware, contact PylonTech

Discover Battery (AES): Support for the Discover Battery BMS is provided via a proprietary CAN communications protocol - AEBus. When enabled, this protocol will allow for the Discover Battery BMS to send charge goals and limits (Voltage and current) to the WS500 Alternator Regulator. Battery current and Temperature are also provided as well as BMS warning and alarming states.

Both normal and Zero-output technology is supported, and the communications protocol may allow for stable active current regulation using the Remote instrumentation, however if instability is noted a physical shunt may need to be installed. The Discover Battery BMS does not provide a 2-seconds advanced notice of impending disconnect, as such some level of mitigation steps will need to be put into place in the overall system design.

Victron DVCC: Beginning with 2.5.2 of Wakespeed firmware, combined with release 3.30 of Cerbo code, the WS500 is able to take charging directions from the Cerbo via DVCC. This allows the prioritization of alternators along with all other charging sources in a Victron deployment.

DVCC is a separate, companion if you will, to the control point already established via WS500 and BMS interaction as noted in this appendix – **DVCC DOES NOT REMOVE THE NEEDS TO INTERFACE AND LOCK ONTO THE BMS!** The Wakespeed needs to directly interact with a SUPPORTED BMS in order to safely process stress and alarm conditions, while it can optionally take coordinated charging directions from the Cerbo via DVCC.

APPENDIX B: CAN MESSAGES

The WS500 Alternator Regulator contains a Control Area Network (CAN) subsystem. The purpose of this network is to allow communications of status, configuration, and coordination of charging in a systems view.

The WS500 Alternator Regulator utilizes a mixture of open source standards including:

- OSEnergy – (<https://github.com/OSEnergy/OSEnergy>) Open Systems Energy initiative: Overriding specification defining communication hardware and protocols allowing for coordination of charging devices.
- J1939 – SAE standard providing basic coordination of nodes and communications of messages
- NMEA-2000 – Marina orientated status messages. Proprietary specification built upon J1939.
- RV-C -- (RV-C.com) True open source specification targeting primary Recreation Vehicle industry also based on J1939. Extended to include many needed communications to support the OSEnergy initiative.
- Others: A few selected 2.0A (11-bit addressing) messages are supported as documented in \$CCN on page 77.

CAN messages summary

The following summarizes the pgn's sent and/or received via the WS500 Alternator Regulator over the CAN bus. Items in **BOLD** are utilized by the WS500 (Sent or received) – though the actual messages may be impacted if a subsystem is enabled as well as if the WS500 is operating as the RBM for the system.

Instances:

A key concept for all the CAN based communications is Instances. Instances allow for the identification of unique devices and the messages associated with such devices. The WS500 utilizes 3 distinct 'Instances':

- Battery Instance
- Charger Instance (Alternator)
- Charger Instance(s) (DC-DC Converter)
- 2nd Battery (Low Side) instance (DC-DC Converter)
- Engine Instance

When parsing CAN based messages, it is important to keep the concept of Instance in mind. A detail of NMEA2000 messages: NMEA2000 defines the 1st occurrence of a Battery Instance as 0, while RV-C uses 1 (0 is invalid). For NMEA2000 messages the WS500 will use 'BatteryID - 1'.

Charger Instances will use the OSEnergy standard (RV-C compliant) representation of instances. Alternator based messages will be represented with (Charger Instance + 0x30); 0x30 being assorted with 'Engine Driving' charging sources. As an example: The 1st 'charger' instance will be 49 (for WS500 instance #1), and 50 for a 2nd WS500 if installed.

The user is able to configure any of these Instance numbers (Battery, or Charger) – and details are up to the installer.

DC-DC Converter:

If the optional DC-DC converter is installed and configured additional status messages will be sent. The Instance number used by the DC-DC converter as associated with the primary battery will be:

- DC-DC Converter Charger Instance = \$CCN <Device Instance > + 0x70
- 2nd (Low Side) battery Instance :
 - \$CCN<Battery Instance Override> + 1
 - – OR –
 - \$CCN <Battery Instance> + \$CCN <Aggregate BMS>

The 2nd battery 'Instance' number is set automatically as n+1, where n is the primary (High Side) Battery Instance number. Example, if the main battery instance number is 1, then the 2nd battery instance will be 2. However, if BMS Aggregation has been enabled via the \$CCN <Aggregate BMS> value, then 'n' become the entire set of instance numbers

aggregated. So, if the main battery instance is 1, but aggregation is set to 10x, then instances 1..10 are aggregated and the 2nd battery becomes instance 11

When the DC_DC converter is present and enabled, the following CAN status messages may be transmitted:

- Charger Status - 1FFC7h
- Charger Status2 - 1FEA3h

Note that with the addition of a DC-DC Converter up to 3x sets of 'charger status' messages may be broadcasted :

- Primary Battery Alternator based status
- Primary Battery DC-DC Converter based status (If enabled)
- 2nd battery DC-DC Converter based status.

'Housekeeping' Messages:

Each of the supported CAN protocols has a number of house keeping messages, these are fundamental to the protocol and the user is referred to the respective standards for details. Some examples of 'Housekeeping' messages supported by the WS500 include:

- 0xEA00 – J1939 Address Request
- 0xEE00 - J1939 Address Claimed
- 0xEA00 - J1939 DGN/PGN Request
- 0xFEEB - J1939 Product identification message
- 0xFEDA – J1939 Software Identification message
- 0xE800 - J1939 Acknowledgment
- 126208 – NMEA2000 Request Group Function
- 126464 – NMEA2000 PGN Tx and Rx list
- 126996 - NMEA2000 Product Information

NMEA-2000 messages

```

/*****
// NMEA2000-DC Detailed Status - PGN127506
// Tx:
// - SID Sequence ID. If your device is e.g. boat speed and heading at
same time, you can set
// same SID for different messages to indicate that they are
measured at same time.
// - DCInstance DC instance.
// - DCType Defines type of DC source. See definition of tN2kDCType
// - StateOfCharge % of charge (If provided by BMS)
// - StateOfHealth % of health
// - TimeRemaining Time remaining in minutes
// - RippleVoltage DC output voltage ripple in V

```

Two copies of 127506 will be sent out:

- One identifying a 'Battery' DCType and "BatteryID - 1" for the instance.
- One identifying as 'Alternator' DCType and using "Charger Instance" + 0x30 for the instance.

If the DC-DC Converter is active, three additional messages will be sent out:

- One identifying a 'Battery' DCType and "2nd (Low Side) battery Instance" as defined above for the instance.
- Two identified as 'Converter' DCType and using "Charger Instance" + 0x70 (HS) or 0x71(LS) for the instance.

```

/*****
// NMEA2000-Charger Status - PGN127507
// Tx:
// - Instance ChargerInstance.
// - BatteryInstance BatteryInstance.
// - Operating State see. tN2kChargeState
// - Charger Mode see. tN2kChargerMode
// - Charger Enable/Disable boolean
// - Equalization Pending boolean
// - Equalization Time Remaining double seconds

```

```

/*****
// NMEA2000-Battery Status - PGN127508
// This PGN will not be sent if ENABLE_NMEA2000_RAT is set = YES.
// Tx:
// - BatteryInstance      BatteryInstance.
// - BatteryVoltage      Battery voltage in V
// - BatteryCurrent      Current in A
// - BatteryTemperature  Battery temperature in Å,Å°K. Use function CToKelvin, if you
want to use Å,Å°C.
// - SID                  Sequence ID.

```

If EnableAltCan = NMEA2000_RAT is selected (See \$CCN: command), the 'Battery' copy of this PGN will be suppressed, to reduce the potential for confusion in a multi-WS500 install.

```

/*****
// NMEA2000-Battery Status - PGN127508
// This is a 2nd copy of PGN127508 which is sent containing the Alternator specific
details
// Tx:
// - AlternatorInstance   ChargerInstance** (0x30 + Charger Instance from $CCN:)
// - AlternatorVoltage   Alternator voltage in V
// - AlternatorCurrent   Alternator Current in A
// - AlternatorTemperature Alternator temperature in Å,Å°K. Use function CToKelvin, if
you want to use Å,Å°C.
// - SID                  Sequence ID.

```

Notes: The use of PGN127508 is more accurately describes a DC Source message, and not restricted to 'Batteries'. This sent instance is transmitted using the Alternator specific measured values. As an example, if the device is configured to NOT have the 'Shunt At Bat', it can be assumed the shunt is located on the alternator itself (with Battery current being delivered via CAN), and this message is then able to be used to see that detail via NMEA2000.

VAlt+ measurements have proven to be too unreliable; all 'VAlt' measurements are based on the value sensed by the Vbat+ line. The Charger Instance number follows the OSEnergy/RV-C standard in that it contains both the Charger Instance number as well as an Identifier that this is an Alternator. Charger Instance consists of 0x30 being added to the defined Charger Instance number via \$CCN:

```

/*****
// Charger Configuration Status      127510
// Note this has not yet confirmed to be right.
// Tx:
// - ChargerInstance           ChargerInstance.
// - BatteryInstance          BatteryInstance.
// - Charger Enable/Disable    tN2kOnOff
// - ChargeCurrentLimit       CurrentLimit
// - CharginAlgorithm
// - ChargerMode
// - BatteryTemperature
// - Equalization Enable/Disable
// - Over Charge Enable/Disable
// - Equalization Time Remaining seconds

/*****
// NMEA2000-Battery Configuration Status  -- 127513
// Tx:
// - BatteryInstance          BatteryInstance.
// - BatType                   Type of battery. See definition of tN2kBatType
// - SupportsEqual             Supports equalization. See definition of tN2kBatEqSupport
// - BatNominalVoltage        Battery nominal voltage. See definition of tN2kBatNomVolt
// - BatChemistry             Battery See definition of tN2kBatChem
// - BatCapacity              Battery capacity in Coulombs.
// - BatTemperatureCoeff      Battery temperature coefficient in %
// - PeukertExponent          Peukert Exponent
// - ChargeEfficiencyFactor    Charge efficiency factor

```

```

//*****
// Converter (Inverter/Charger) Status 127750
// Tx:
// - 1 Sequence ID
// - 2 Connection Number
// - 3 Operating State
// - 4 Temperature State
// - 5 Overload State
// - 6 Low DC Voltage State
// - 7 Ripple State
//
    Note that 127750 does not describe a mode for fixed voltage/current charge (CVCC
mode), and as such 'Bulk' will be used will be used in those cases.

```

```

//*****
// Engine parameters rapid - 127488
// Rx:
// - EngineInstance      Engine instance.
// - EngineSpeed **      RPM (Revolutions Per Minute)    (Both send and receiving of N2K
RPMs supported)
// - EngineBoostPressure in Pascal
// - EngineTiltTrim

```

*Note: ** Beginning with Firmware 2.5.2, receiving of Engine Parameters Rapid will only be processed if "Ignore Sensor Stator" is set.*

```

//*****
// Engine parameters dynamic -- 127489
// Rx:
// - EngineInstance      Engine instance.
// - EngineOilPress      in Pascal
// - EngineOilTemp       in Kelvin
// - EngineCoolantTemp   in Kelvin
// - AltenatorVoltage    in Voltage
// - FuelRate            in litres/hour
// - EngineHours         in seconds
// - EngineCoolantPress  in Pascal
// - EngineFuelPress     in Pascal
// - EngineLoad          in % (Receive only)
// - EngineTorque        in %

```

```

//*****
// Temperature -- 130316
// Rx:
// - SID                  Sequence ID.
// - TempInstance        Must = defined Engine Instance
// - TempSource          Must = 14
// - ActualTemperature   Temperature in Kelvins
// - SetTemperature      Set temperature in Kelvins.

```

Note: Temperature is ONLY used to sense EGT. TempInstance must match configured Engine Instance. TempSource must = 14 (EGT)


```

/*****
// Engine parameters rapid - 127488
// Tx:
// - EngineInstance      Engine instance.
// - EngineSpeed        RPM (Revolutions Per Minute)    (Both send and receiving of N2K
RPMs supported)
// - EngineBoostPressure  in Pascal
// - EngineTiltTrim

```

Note: Tx rate and Priority of Engine Parameters Rapid has been reduced from 100mS/3, to 500mS/7 to better match expected usage (Human display) and reduce potential for CAN message blocking of other critical messages.

Beginning with Firmware Release 2.5.2, the Tx of Engine Parameters Rapid will be suppressed if "Ignore Sensors: Stator" is set.

RV-C messages (in support of OSEnergy standard)

```

/*****
// DC Source Status 1
// Input:
// - Instance           DC Instance (bus) ID.
// - Device Priority   Relative ranking of DC Source
// - DC Voltage       0..3212.5v, in 50mV steps
// - DC Current       -2M..2MA, in 1mA steps (0x77359400 = 0A)

/*****
// DC Source Status 2
// Input:
// - Instance           DC Instance (bus) ID.
// - Device Priority   Relative ranking of DC Source
// - Source Temperature -273 to 1735 Deg-C in 0.03125c steps
// - State of Charge   Batteries: % SOC; DC Charging sources: Current % output.
// - Time Remaining   Estimated number of minutes until SOC reaches 0% or 100%
// - Time Remaining Interpretation Time to Full Charge, or time to Full Discharge?

/*****
// DC Source Status 3 - 1FFFBh
// Input:
// - Instance           DC Instance (bus) ID.
// - Device Priority   Relative ranking of DC Source
// - State of Health   % expected remaining lifetime
// - Capacity Remaining Current capacity / capability of battery in Ah
// - Relative Capacity % of current capacity vs. design specified capacity.
// - AC RMS Ripple       in mV
*/

/*****
// DC Source Status 4
// Input:
// - Instance           DC Instance (bus) ID.
// - Device Priority   Relative ranking of DC Source
// - Desired Charge Mode Charging mode / state being requested.
// - Desired DC Voltage Target voltage for chargers to deliver 0..3212.5v, in 50mV
steps
// - Desired DC Current Target current for all chargers to deliver combined -
1600A..1612.5A, in 50mA steps (0x7D00 = 0A)
// - Battery Type

/*****
// DC Source Status 5
// Input:
// - Instance           DC Instance (bus) ID.
// - Device Priority   Relative ranking of DC Source
// - DC Voltage       High precision value in 1mV. Useful for remote instrumentation
// - VDC ROC             Rate-of-change (dV/dT) in mV/s -- 32000 = 0 mV/s

/*****
// DC Source Status 6 - 1FEC7h
// Input:

```

```

// - Instance           DC Instance (bus) ID.
// - Device Priority    Relative ranking of DC Source
// - HV Limit Status    Reached upper operational voltage range?
// - HV Limit Disconnect Safety disconnect?
// - LV Limit Status      Reached lower operational voltage range?
// - LV Limit Disconnect  Safety disconnect?

```

Note: DC Source Status 6 is only received, not transmitted.

```

//*****
// DC Source Status 11 - 1FEA5h
// Input:
// - Instance           DC Instance (bus) ID.
// - Device Priority    Relative ranking of DC Source
// - PwrOnOff           Status of main Battery Switch / Contactor (TRUE = connected)
// - ChrgOnOff         Status of Charge Bus switch (TRUE = connected)
// - ChrgDet           Has a charge source been detected?
// - ResvStat            Is battery running on its 'reserved capacity'?
// - BatAHCap          Battery capacity in Ah's
// - DCPower           Watts being received or delivered to/from battery (as opposed to
AMPs in DC_STATUS_1)

```

```

/*****
// Charger Status - 1FFC7h
// Input:
// - Instance
// - Charge Voltage          0..3212.5v, in 50mV steps
// - Charge Current          -1600..+1512.5 in 50mA steps (0x7D00 = 0A)
// - % max current
// - Operating State         (Bulk, float, etc)
// - Default PO state
// - Auto Recharge
// - Force Charged
*/

/*****
// Charger Status2 - 1FEA3
// Input:
// - Instance                Instance of charger
// - DC Source Instance      DC Instance (bus) ID associated with
// - Device Priority          Relative ranking of DC charging Source
// - DC Voltage              0..3212.5v, in 50mV steps
// - DC Current              1600..+1512.5 in 50mA steps (0x7D00 = 0A)
// - Temperature            -40..210 in deg-C, in 1C steps

/*****
// Charger Configuration Status - 1FFC6h
// Input:
// - Instance
// - Charging Algorithm
// - Controller Mode
// - Battery Sensor Present
// - Charger AC Line         Line 1 or 2 (AC Chargers only)
// - Battery Type
// - Battery Bank Size       0..65,530 Ah, 1Ah increments
// - Maximum charging current 0..250, 1A increments
*/

/*****
// Charger Configuration Status2 - 1FF96h
// Input:
// - Instance
// - Max Charge Current %
// - Max AC current %        Of attached line          (AC Chargers only)
// - Shore Breaker Size      0..250, 1A increments (AC Chargers only)
// - Default Batt Temp
// - Recharge Voltage        0..3212.5v, in 50mV steps
*/

/*****
// Charger Configuration Status3 - 1FECCh

```

```

// Input:
// - Instance
// - Bulk Voltage          0..3212.5v, in 50mV steps
// - Absorption Voltage    0..3212.5v, in 50mV steps
// - Float Voltage        0..3212.5v, in 50mV steps
// - Temp Comp            mV/K
*/

/*****
// Charger Configuration Status4 - 1FEBFh
// Input:
// - Instance
// - Bulk Time            0..65,530min in 1min steps
// - Absorption Time      0..65,530min in 1min steps
// - Float Time          0..65,530min in 1min steps
*/

/*****
// Charger Equalization Status - 1FF99h
// Input:
// - Instance
// - Time Remaining      0..65,530min in 1min steps
// - Pre-Charging
*/

/*****
// Charger Equalization Configuration Status - 1FF98h
// Input:
// - Instance
// - Equalization Voltage 0..3212.5v, in 50mV steps
// - Equalization Time    0..65,530min in 1min steps
*/

/*****
// General Reset - 17F00h
// Input:
// - Reboot                Cause Device to Reboot
// - Clear Faults          Same as Reboot
// - Restore to Default     Restore device to 'Default' State
// - Reset Statistics      Reset any counters, or timestamps, etc.
// - Test Mode             Enable DBG; strings
// - Restore to Factory    Restore device to 'Factory' State
// - Enter Firmware Update Mode
*/

/*****
// Terminal - 17E00h
// Input:
// - Source / Destination
// - Count                0..8
// - Characters           Buffer with up to 8 characters
*/

```

```

/*****
// RV-C (ISO) Diagnostics message - 1FECAh
// Input:
// - On / Off
// - Active / Standby
// - DSA                Default Source Address (RV-C defined DSA)
// - SPN                Service Point Number (Fault code appended with 0x7F000)
// - FMI                Failure Mode Identifier
// - Occurrence Count
// - DSA Extension      Required Sensor Flags
// - Bank Select
*/

```

Note: Reported Fault Numbers are defined in "Appendix E: Error codes and meaning" below. The Hard/Soft Fault bits (0x8000, 0x4000 etc) are stripped off first by ANDing the number with 0xFFF, before ORing in the 0x7F000 ISO offset. So in code:

```
SPN = (FaultNumber & 0xFFF) | 0x7F000;
```

To extract the core Fault Number use: **FltNum = (SPN & 0xFFF);**

J1939 messages:

```

/*****
// J1939 Engine Load - 61443
// Rx:
// - Engine Load          -- Must match .ENGINE_INSTANCE to be processed.

/*****
// J1939 Engine Speed - 61444
// Rx:
// - Engine Speed        -- Must match .ENGINE_INSTANCE to be processed.
// Tx:
// - Engine Speed        -- Note that the 'Engine Instance' will be the CAN NODE
//                        address of the device, example 0x80, and NOT
//                        the configured .ENGINE_INSTANCE

/*****
// J1939 Alternator Information message- FED5h (65237)
// Tx:
// - Alternator Speed
// - Alternator 1 Status
// - Alternator 2 Status
// - Alternator 3 Status
// - Alternator 4 Status
//
//                        -- Note that the 'Engine Instance' will be the CAN NODE
//                        address of the device, example 0x80, and NOT
//                        the configured .ENGINE_INSTANCE

*/
```

APPENDIX C: SAMPLE YACHT DEVICES CAN-CAN BRIDGE SCRIP

The following scrip has been developed by Yacht Devices to use in their YDNB-07 to perform filtering of CAN messages and only allow the appropriate NMEA2000 messages to pass. Refer to the YDNB-07 uses guide for how to install this script on the YDNB-07.

```
*****
# P R O G R A M   G E N E R A L   I N F O R M A T I O N
#
# Advanced NMEA 2000 filter
#
# Program Version: 1.01 @ 31.07.2020
#
# (C) Yacht Devices LTD, 2020
# Author: Korolev Alexey
#
*****
#
# Version control section
#
# 1.01 @ 31.07.2020
# cleanup comments
#
# 1.00 @ 31.07.2020
# initial tests passed
#
# 1.00b @ 28.07.2020
# initial release
#
*****

*****
# P R O G R A M   D E S C R I P T I O N
#
# Bridges CAN1 (J1939, RVC, N2K) <---> CAN2 (pure N2K)
#
# need to have the addresses on CAN1 be viewable on CAN2.
#
# CAN1 -> CAN2 PGNs to be forwarded:
#
# 127488, 127501, 127506, 127507, 127508, 127510, 127513, 127750, 127751
#
# CAN2 -> CAN1 PGNs to be forwarded:
#
# ISO 059904, 127488, 127506, 127508
#
# everything else needs to be blocked.
#
*****

*****
# L I C E N S E   I N F O R M A T I O N
#
# This program is free software: you can redistribute it and/or modify
# it under the terms of the GNU General Public License as published by
# the Free Software Foundation, either version 3 of the License, or
# (at your option) any later version.
#
# This program is distributed in the hope that it will be useful,
# but WITHOUT ANY WARRANTY; without even the implied warranty of
# MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE. See the
# GNU General Public License for more details.
#
```



```

# You should have received a copy of the GNU General Public License
# along with this program. If not, see <https://www.gnu.org/licenses/>.
#
#*****
#*****
# H A R D W A R E   I N F O
#
#-----
# Y D N B - 0 7
#
# Target hardware: Yacht Devices YDNB-07 NMEA 2000 bridge
# YDNB-07 hardware revision: any
# YDNB-07 firmware: any
#
# CAN1 speed 250 kbps
# CAN1 connected to NMEA 2000 network segment with J1939, RVC, N2K PGNs
# CAN2 connected to NMEA 2000 network segment with N2K PGNs only
#
#*****

#=====   P R O G R A M   S T A R T   =====

# D E B U G   S E T T I N G S   S E C T I O N
#
# uncomment the line below to get an MCU assembly code in YDNBSAVE.CFG file
#DECOMPILER=1

# uncomment the line below to record a diagnostics file YDNBLOG.TXT
#DIAGNOSTICS=30

# uncomment the line below to record a diagnostics file in binary format (CAN file)
#LOG_FORMAT=BINARY

# B R I D G E   H A R D W A R E   S E T T I N G S   S E C T I O N
#
# Disable forwarding on both interfaces
FW_CAN1_TO_CAN2=OFF
FW_CAN2_TO_CAN1=OFF

# I N I T I A L I Z A T I O N
#

#placeholder for init()
init()
{
# --- user-configurable options -----
# --- user-configurable options ends -----
}

# CAN1 -> CAN2
# 127488
match(CAN1, 0x1F20000, 0x01FFFF00)
{
    send()
}
# 127501
match(CAN1, 0x1F20D00, 0x01FFFF00)
{
    send()
}
# 127506
match(CAN1, 0x1F21200, 0x01FFFF00)
{
    send()
}
# 127507
match(CAN1, 0x1F21300, 0x01FFFF00)
{

```

```

    send()
}
# 127508
match(CAN1, 0x1F21400, 0x01FFFF00)
{
    send()
}
# 127510
match(CAN1, 0x1F21600, 0x01FFFF00)
{
    send()
}
# 127513
match(CAN1, 0x1F21900, 0x01FFFF00)
{
    send()
}
# 127750
match(CAN1, 0x1F30600, 0x01FFFF00)
{
    send()
}
# 127751
match(CAN1, 0x1F30700, 0x01FFFF00)
{
    send()
}

# CAN2 -> CAN1 PGNs to be forwarded:
# 127488
match(CAN2, 0x1F20000, 0x01FFFF00)
{
    send()
}
# 127506
match(CAN2, 0x1F21200, 0x01FFFF00)
{
    send()
}
# 127508
match(CAN2, 0x1F21400, 0x01FFFF00)
{
    send()
}

# ISO 059904
match (CAN2, 0xEA0000,0xFF0000) {
    send()
}

#==== P R O G R A M   E N D S   =====
# EOF

```

APPENDIX D: DETAILS OF CPE (CHARGE PROFILE ENTRIES)

The following will give more details on how each parameter impacts battery charging.

```
Typedef struct { // Charging Profile Structure -- how will we
CHARGE a battery?

    float      ACPT_BAT_V_SETPOINT; // Set point for Ramp, Bulk and Acceptance
battery voltage. // Alternator will transition from BULK mode

into Accept Mode when this voltage is // reached, and then start the Accept Duration
counter.

    uint32_t   EXIT_ACPT_DURATION; // Stay in Accept mode no longer then duration
in mS (Set = 0 to disable Acceptance phase // and move directly to OC or Float mode)

    int        EXIT_ACPT_AMPS; // If Amps being delivered falls to this level
or below, exit Accept mode and go to next // Set ExitAcptAmps = 0 to disable Amps
based transition and only rely on // EXIT_ACPT_DURATION timeout.
// Set ExitAcptAmps = -1 to disable Amps
based transition and rely on // EXIT_ACPT_DURATION timeout
or
ADPT_ACPT_TIME_FACTOR adaptive duration. // Set ExitAcptAmps = Same value used for
used.
LIMIT_OC_AMPS if Overcharge mode is to be // Note: If both Time and Amps are set = 0,
Acceptance will be bypassed. // Place holder. FUTURE: EXIT_ACPT_DVDT Add
    int        PH_AI; // need to decide what it is :- )
dV/dt exit criteria for Acceptance mode, // Place holder.

    float      PH_AF; // Overcharge mode is sometimes used with AGM

batteries and occurs between Acceptance and // Float phase.
// During Overcharge phase, Amps are capped at
this low value. (Set this = 0 to disable // OC mode.)
// Overcharge will continue until the battery
// Will remain in Overcharge mode holding
// (Set = 0 to disable this exit check - and
// EXIT_OC_VOLTS)
// Over Charge mode duration in mS. Do not
// 0 to disable max time allowed)
// ( as a safety step, setting OC_VOLTS or

    int        LIMIT_OC_AMPS;
this low value. (Set this = 0 to disable

    float      EXIT_OC_VOLTS;
voltage reaches this level.

    int        EXIT_OC_AMPS;
LIMIT_OC_VOLTS until Amps being delivered falls

exit OC mode immediately upon reaching

    uint32_t   EXIT_OC_DURATION;
exceed this duration in total OC time. (Set =

DURATION = 0 will also disable OC mode..)
```

```

int          PH_OI; // Place holder.  FUTURE:  EXIT_OC_DVDT  Add
dV/dt exit criteria for Overcharge mode,

                // need to decide what it is :-)

float        FLOAT_BAT_V_SETPPOINT; // Set point for Float battery voltage, do not
exceed this voltage.
int          LIMIT_FLOAT_AMPS; // During Float, manage system to keep Amps into
Battery at or under this value.  May = 0,

                set = -1 to disable limit.
uint32_t     EXIT_FLOAT_DURATION; // Alternator will stay in Float mode this
int32_t (in mS) before entering Post-Float (no

                charging) mode.  Set = 0UL disable
transition to Post-float mode.
int          FLOAT_TO_BULK_AMPS; // If Amps being delivered exceeds this value,
we will assume a LARGE load has been placed

                on the battery and we need to re-enter
entering BULK phase feature // BULK phase.  Set this = 0 to disable re-
int          FLOAT_TO_BULK_AHS; // If the number of Ahs removed from the battery
after 1st entering Float mode exceed this

                value, revert back to BULK.
shunt is at the battery.  Set = 0 to disable // Note this will ONLY be usable if the Amp

                this feature.
float        FLOAT_TO_BULK_VOLTS; // As with Amps, if the voltage drops below this
threshold we will revert to Bulk.  Set =

                0 to disable.
int          FLOAT_TO_BULK_SOC; // If the batteries SOC (as reported by a CAN
attached BMS or RBM) drops below this value,

                reg will revert to BULK. Set = 0 to disable.

uint32_t     EXIT_PF_DURATION; // Only stay in Post_float mode (no charging)
this amount of time.  Set = 0UL to disable

                times based Post-float exiting and exit only
float        PF_TO_BULK_VOLTS; // If during Post-Float mode VBat drops below
this voltage, re-enter FLOAT mode.

                on Voltage.
mode based on voltage. // If during Post-Float mode VBat drops below
// Set = 0.0 to disable exiting of post-float
enter post-float mode from float-mode (by // Config note:  IF you configure the system to
setting a time value EXIT_FLOAT_DURATION),
PF_TO_BULK_VOLTS = 0, the regulator will in AND you
// set both EXIT_PT_DURATION and
effect turn off the
alternator once charging is completed
and not restart a charge cycle
until powered down and up again.  This can //
be useful if you truly want a
one-time only charge.
// You could also config the
FEATURE-OUT port to indicate the complete

                charge cycle has finished, to
say power-off the driving engine?
int          PF_TO_BULK_AHS; // If the number of Ahs removed from the battery
after 1st entering Post Float mode exceed

                this value, revert back to BULK.
shunt is at the battery.  Set = 0 to disable // Note this will ONLY be usable if the Amp

```

```

        float          EQUAL_BAT_V_SETPOINT;
target voltage. Set = 0 to prevent user from

        int           LIMIT_EQUAL_AMPS;
to this value. Set = 0 to disable amp

        uint32_t      EXIT_EQUAL_DURATION;
longer then this (in mS). If set = 0, then

        int           EXIT_EQUAL_AMPS;
Equalization while at VBat setpoint -- exit

        float          BAT_TEMP_1C_COMP;
factor for every 1C temp change. Note this

        int           MIN_TEMP_COMP_LIMIT;
(in deg-c), limit temp compensation

        int           BAT_MIN_CHARGE_TEMP;
stop charging and force into Float Mode to

        int           BAT_MAX_CHARGE_TEMP;
stop charging and force into Float Mode to

operations but require a lower max energy

BAT_MIN_CHARGE_TEMP or BAT_MAX_CHARGE_TEMP

        float          BAT_LOW_RC_VOLTS;
charging current to BAT_CAP_AMPS value.

        int           BAT_LOW_RC_TEMP;
charging current to BAT_CAP_AMPS value.

        int           BAT_HIGH_RC_TEMP;
charging current to BAT_CAP_AMPS value.

        int           BAT_RC_AMPS;
are tripped, cap battery acceptance

where the Regulator will over-ride an RBMs

or is just being lazy and not asking for

} tCPS;

this feature.

// If Equalize mode is selected, this is the
entering Equalization mode.
// During equalization, system will limit Amps
limits during Equalization Mode.
// Regulator will not stay in Equalization any
Equalization mode will be disabled.
// If Amps fall below this value during
equalization. Set = 0 to disable exit by
Amps and use only time.

// Battery Temperature is compensated by this
is based off of BAT_TEMP_NOMINAL (25c)
// If battery temperature falls below this value
voltage rise to prevent overvoltage in very
very cold places.
// If Battery is below this temp (in deg-c),
protect it from under-temperature damage.
// If Battery exceeds this temp (in deg-c),
protect it from over-temperature damage.

// Some batteries allow extended temperature
transfer during those times.
// Note that these will NOT over-ride the
values above, but will allow pull-back as we
approach them.
// If battery voltage is below this level, cap
Set = 0.0 to disable low-volts check
// If battery is below this temp (in deg-c), cap
Set = -99 to disable lower boundary check
// If battery is above this temp (in deg-c), cap
Set = -99 to disable upper boundary check
// If one of the Reduce Charging triggers above
current to this value. (If no amp shunt,
est PWM pullback) Set = 0 to disable.
// Note, for safety, this is the ONE condition
request battery acceptance current.
Normally we follow the RBM,
// but if the RBM is not configured correctly -
reduced current in the case of extreme
battery temps, we
// we will act locally.

```

```
#define BAT_TEMP_NOMINAL      25          // Nominal temp which .BAT_TEMP_1C_COMP is based
around (in deg-C).
#define BAT_AMPHR_NOMINAL    500         // CPE's are based on a 500Ah 'nominal' battery
size
#define BAT_VOLTS_NOMINAL    12          // which is also a '12v' battery
```

Actual content of the CPE tables. Remember, all references are against a 'normalized' 12v / 500Ah battery.

```

onst tCPS PROGMEM defaultCPS[MAX_CPES] = {
  //      Bulk/Accept          Overcharge          Post Float          Float
                                     Temp Comp      Extended Range      Equalization

  {14.1f, 6.0*3600000UL, 15, 0,0.0,      0, 0.0 , 0,      0*3600000UL, 0,0.0,      13.4f, -1, 0*3600000UL, -10, 0, 12.8f, 50,0.0,
    0*3600000UL, 0.0, 0, 0,0.0,      0.0f, 0,      0*3600000UL,
    0,      0.004f*6, -9, -45, 45,      0.0, -99, -99, 0, 100,
    0.0}, // #1 Default (safe) profile & AGM #1 (Low Voltage
    AGM).

  {14.8f, 3.0*3600000UL, 5, 0,0.0,      0, 0.0 , 0,      0*3600000UL, 0,0.0,      13.5f, -1, 0*3600000UL, -10, 0, 12.8f, 50,0.0,
    0*3600000UL, 0.0, 0, 0,0.0,      0.0f, 0,      0*3600000UL,
    0,      0.005f*6, -9, -45, 45,      0.0, -99, -99, 0, 100,
    0.0}, // #2 Standard FLA (e.g. Starter Battery, small
    storage)

  {14.6f, 4.5*3600000UL, 5, 0,0.0,      0, 0.0 , 0,      0*3600000UL, 0,0.0,      13.2f, -1, 0*3600000UL, -10, 0, 12.8f, 50,0.0,
    0*3600000UL, 0.0, 0, 0,0.0,      15.3f, 25, 3.0*3600000UL,
    0,      0.005f*6, -9, -45, 45,      0.0, -99, -99, 0, 100,
    0.0}, // #3 HD FLA (GC, L16, larger)

  {14.7f, 4.5*3600000UL, 5, 0,0.0,      0, 0.0 , 0,      0*3600000UL, 0,0.0,      13.4f, -1, 0*3600000UL, -10, 0, 12.8f, 50,0.0,
    0*3600000UL, 0.0, 0, 0,0.0,      0.0f, 0,      0*3600000UL,
    0,      0.004f*6, -9, -45, 45,      0.0, -99, -99, 0, 500,
    0.0}, // #4 AGM #2 (Higher Voltage AGM)

  {14.1f, 6.0*3600000UL, 5, 0,0.0,      0, 0.0 , 0,      0*3600000UL, 0,0.0,      13.5f, -1, 0*3600000UL, -10, 0, 12.8f, 50,0.0,
    0*3600000UL, 0.0, 0, 0,0.0,      0.0f, 0,      0*3600000UL,
    0,      0.005f*6, -9, -45, 45,      0.0, -99, -99, 0, 100,
    0.0}, // #5 GEL

  {14.2f, 0.5*3600000UL, 25, 0,0.0,      30, 14.4f,15, 0.5*3600000UL, 0,0.0,      13.4f, 0, 0*3600000UL, 0,-50, 13.0f, 0,0.0,
    0*3600000UL, 0.0, 0, 0,0.0,      0.0f, 0,      0*3600000UL,
    0,      0.000f*6, 0, 5, 45,      0.0, 7, 42, 25, 250,
    0.0}, // #6 Battleborn

  {14.4f, 6.0*3600000UL, 15, 0,0.0,      15, 15.3f, 0, 3.0*3600000UL, 0,0.0,      13.1f, -1, 0*3600000UL, -10, 0, 12.8f, 50,0.0,
    0*3600000UL, 0.0, 0, 0,0.0,      15.3f, 25, 3.0*3600000UL,
    0,      0.005f*6, -9, -45, 45,      0.0, -99, -99, 0, 100,
    0.0}, // #7 4-stage HD LFA (& Custom #1 changeable
    profile)

  {14.2f,      0, 0, 0,0.0,      0, 0.0 , 0,      0*3600000UL, 0,0.0,      0.0 , 0, 0*3600000UL, 0,-50, 13.0f, 70,0.0,
    0*3600000UL, 0.0, 0, 0,0.0,      0.0f, 0,      0*3600000UL,
    0,      0.000f*6, 0, 0, 50,      0.0, 5, 45, 25, 200,
    0.0} // #8 LiFeP04 (& Custom #2 changeable profile)

  // #1 Default (safe) profile & AGM #1 (Low Voltage AGM).
  // #2 Standard FLA (e.g. Starter Battery, small storage)
  // #3 HD FLA (GC, L16, larger)
  // #4 AGM #2 (Higher Voltage AGM)
  // #5 GEL
  // #6 Battle Born
  // #7 4-stage HD LFA (+ Custom #1 changeable profile)
  // #8 LiFeP04 (+ Custom #2 changeable profile)
};

```

APPENDIX E: 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 WS500 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).

Many error codes are related to internal logic checks, if those are received look for a firmware upgrade. However, some errors codes occur during installation errors and / or system issues. A prime example is the Alternator overheating errors – which typically indicate a need to either increase cooling and/or enable SMALL-ALT-MODE or increase its pullback. These alternator overheating issues are very common when using small frame alternators (anything under 30lbs) combined with large battery banks or any Li based battery bank.

Other error codes are related to the overall system operation. Examples are the Battery Disconnected faults, where the regulator receives notification that the BMS has (or will soon) disconnect the battery from charging sources to protect it. Any overvoltage or disconnect error must be investigated carefully to determine the cause of the overvoltage condition and corrected. (Likely miss-configuration, though perhaps incorrect auto-detect of system voltage)

FET over temperature (error #41) is an indication of a hardware issue with the regulator its self, or perhaps a short in the alternator field.

```
//---- Error codes. If there is a FAULTED status, the variable errorCode will contain one of
these...
//      Note at this time, only one error code is retained. Multi-faults will only show
the last one in the checking tree.
//      Errors with + 0x8000 on them will cause the regulator to re-start, others will
freeze the regulator.
//      (Note combinations like 10, and 11 are not used. Because one cannot flash out 0's,
and kind of hard to
//      tell if 11 is a 1+1, or a real slow 2+0)

//---- Error codes. If there is a FAULTED status, the variable errorCode will
contain one of these...
//      Note at this time, only one error code is retained. Multi-faults
will only show the last one in the
checking tree.
//      Errors with + 0x8000 on them will cause the regulator to re-start,
others will freeze the regulator.
//      (Note combinations like 10, and 11 are not used. Because one
cannot flash out 0's, and kind of hard
to
//      tell if 11 is a 1+1, or a real slow 2+0)
//      Errors with a +0x4000 will be optionally treated as a 'promiscuous'
hard fault.
//      If the regulator is configured in 'promiscuous Mode'
```



```

//          these faults will be treated with an auto-restart, just like
//          0x8000

#define FC_LOOP_BAT_TEMP          12 + 0x4000U // Battery Temperature greatly exceeded
//          configured upper limit.
#define FC_LOOP_BAT_HIGHV        13 + 0x4000U // Battery Voltage greatly exceeded upper
//          limit, measured by VBat+
#define FC_LOOP_BAT_LOWV         14 + 0x8000U // Battery Voltage too low to operate as
//          measured on VBat+
//          // Damaged or missing sensing wire or fuse?
//          (or engine not started!)
#define FC_LOOP_BAT_MAXV         15 + 0x4000U // Voltage at Vbat+ exceeded Max Bat Volts
//          as defined by $CPB:
#define FC_LOOP_SHORTED_BAT_TEMP 16 + 0x4000U // Battery Temperature is shorted
//          (Defective)

#define FC_LOOP_ALT_TEMP         21 + 0x4000U // Alternator Temperature greatly exceeded
//          configured upper limit.
#define FC_LOOP_ALT_TEMP_RAMP    24 + 0x4000U // Alternator Temperature greatly exceeded
//          configured upper limit.
//          // (2nd temp reached / exceeded while
//          ramping - this can NOT be right, to
//          reach target while ramping means way too
//          risky.)
#define FC_LOOP_ALT_TEMP_ROC     25          // Alt Temp is rising REALLY fast, damaged?

#define INTERNAL_ERROR           31..39

#define FC_SYS_FET_TEMP          41          // Internal Field FET temperature exceed
//          limit.
#define FC_SYS_REQUIRED_SENSOR   42          // A 'Required' sensor is missing, and we
//          are configured to FAULT out.
#define FC_NO_VALT_VOLTAGE       43 + 0x8000U // No voltage has been sensed on the VALT+
//          line, blown fuse?
#define FC_EXCESSIVE_VALT_OFFSET 44 + 0x4000U // There is excessive voltage offset
//          between VALT+ and VBat+ sense lines -
//          2.5v. (Not checked in 'Split' voltage
//          systems)
#define FC_LOOP_VALT_MAXV        45 + 0x4000U // Voltage at VALT+ exceeded Max Bat Volts
//          (Plus additional allowance for IR drop)
//          as defined by $CPB:
#define FC_LOOP_ALT_HIGHV        46 + 0x4000U // Voltage greatly exceeded expected upper
//          limit battery limit as measured at VALT+

#define FC_CAN_BATTERY_DISCONNECTED 51 + 0x4000U // Received a generic CAN message that the
//          battery charging bus has been
//          disconnected.
#define FC_CAN_BATTERY_HVL_DISCONNECTED 52 + 0x4000U // A CAN command has been received asking
//          for the battery bus to be disconnected
//          due to High Voltage.
//          // (Note that depending on the BMS, other
//          alarms may trigger this same fault, ala,
//          high charge current)

```

```

#define FC_LOG_BATTINST 53 // Battery Instance number is out of range
                             (needs to be from 1..100)
#define FC_TOO_MANY_AGGREGATION 54 // Too many different BMS's are asking to
                                     be aggregated.
#define FC_CAN_AEBUS_FAULTED 55 + 0x8000U // AEBus device (Discovery battery) has
                                             send a warning or fault status.
                                             // As there is no fore-warning of a
                                             disconnect,
                                             // treat all warnings as a pending
                                             disconnect and fault. But then do auto-
                                             restart to see if it clears.
#define FC_TOO_MANY_VEREG_DEVICE 56 // Too many Vereg (Victron) devices present
                                     to track
#define FC_CAN_BATTERY_LVL_DISCONNECTED 57 + 0x4000U // A CAN command has been received asking
                                                         for the battery bus to be disconnected
                                                         due to Low Voltage.
#define FC_CAN_BATTERY_HC_DISCONNECTED 58 + 0x4000U // A CAN command has been received asking
                                                         for the battery bus to be disconnected
                                                         due to High Current.
#define FC_CAN_BATTERY_HT_DISCONNECTED 59 + 0x4000U // A CAN command has been received asking
                                                         for the battery bus to be disconnected
                                                         due to High Battery Temperature.

#define FC_CAN_BATTERY_LT_DISCONNECTED 61 + 0x4000U // A CAN command has been received asking
                                                         for the battery bus to be disconnected
                                                         due to Low Battery Temperature.
#define FC_CAN_BATTERY_HVL_LIMIT 62 + 0x8000U // A CAN status has been received that the
                                                  battery has reached its upper limit, but
                                                  not yet disconnecting. Charging should
                                                  stop.

#define INTERNAL_ERROR 71..79

#define FC_DCDC_NOT_RESPONDING 81 + 0x8000U // Configured to do DCDC, but after a
                                             number to reset attempts, seems the
                                             device is wedged or not present
#define FC_DCDC_HS_OVP 82 + 0x4000U // Primary Battery (HS) of DC-DC converter
                                       Over-voltage trip
#define FC_DCDC_HS_UVP 83 + 0x8000U // Primary Battery (HS) of DC-DC converter
                                       Under-voltage trip
#define FC_DCDC_LS_OVP 84 + 0x4000U // Secondary Battery (LS) of DC-DC
                                       converter Over-voltage trip
#define FC_DCDC_LS_UVP 85 + 0x8000U // Secondary Battery (LS) of DC-DC
                                       converter Under-voltage trip
#define FC_DCDC_OVER_TEMP 86 + 0x8000U // DCDC Convert too hot.
#define FC_DCDC_MISCOFIG 87 // A configuration value has exceeded the
                               selected DC-DC converter limits.
#define FC_DCDC_MULTICONTROLLER 88 // More than one device seems to be trying
                                       to control the DCDC converter.
#define FC_DCDC_MISMATCH 89 // Attached DCDC Converter is not same as
                               make/model specified.

```

```

/-- The 9x codes are special ones, they do not cause a true FAULT, but indicate some altered
condition and mode of operation.
// Mostly these are used to support DM_RV (aka, ISO Diag) and CAN connected monitors such as
the Victron Cerbo.
// At present these codes will only be used over ISO_DIAG (CAN), will NOT cause a Regulator
hard fault, and will only be issued
// if the attached RBM is listed as a BMS or higher priority per RV-C (120 or above).
#define FC_CAN_BMS_SYNC_LOST          91          // Used to signal that an existing BMS sync
has been lost and we are in an alt mode
(ala, Gethome)

#define FC_FORCED_TO_IDLE             92          // Use to indicate that the reg has been
forced into Idle via perhaps the
Feature-in line, or some RPM based
trigger.

#define FC_DVCC_TIMEOUT              93          // Device has lost the DVCC lock, reverting
back to non-DVCC mode of operation.

#define INTERNAL_ERRORS               1xx

#define INTERNAL_DCDC_ERRORS         21x

```