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Standard Operating Procedures

Instructions for Program and Diagnose Modes

Generic Software
Version 5.00 to 5.09



Please Read Procedures Carefully!

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Disclaimer: HPEVS assumes that the installer possesses appropriate knowledge and skill to perform the installation of our drive system into the vehicle. If you feel that you DO NOT have the appropriate knowledge and skill to perform the installation, please seek help from a professional installer.

Changes to the programming, through which this manual gives instructions on how to perform, are straightforward. Making changes to certain parameters can lead to a situation where the user can lose control of the vehicle; which can lead to injury or death. Care should be taken to read the instructions and understand them thoroughly before making any changes to the parameters.



CAUTION: DO NOT HANDLE THE ELECTRICAL CONNECTORS WHEN THE SYSTEM IS ENERGIZED. DOUBLE CHECK THE VOLTAGE POTENTIAL WITH A VOLTAGE METER PRIOR TO HANDLING. FAILURE TO DO SO WILL RESULT IN INJURY OR DEATH!

Generic Software Programming

Scope: The new generic software package allows for programming of the Curtis controller. The motor kit when installed will be drivable, but the following instructions allow for tuning. Some adjustments may be required before operating the vehicle the first time.

Instructions for Program and Diagnose Modes

- 1) Have the vehicle turned off.
- 2) Press and hold the menu button.
- 3) While holding down the menu button, turn the vehicle's ignition switch to ON.
- 4) While holding the menu button down, the Spyglass will state "Ready". Once you release the menu button, you will have the opportunity to toggle between "Program" and "Diagnose".
- 5) If you want to enter into the "Program" mode, leave the word "Program" on the Spyglass, and after 5 seconds the Spyglass will change to "Rdy Prog". At this point the controller is ready for programming.
- 6) Likewise, if you want to enter the diagnostic mode, toggle the menu button so that the word "Diagnose" is displayed on the Spyglass. After 5 seconds the Spyglass will change to "Rdy Diag". At this point, the Spyglass will show certain parameters that are programmed within the controller.

Program Mode Instructions

- 1) After entering the "Program" mode, "Rdy Prog" will be displayed.
- 2) From here, you can navigate to the five main menus using the menu button but keep in mind that you have a few seconds to make your selection before the software enters the menu item displayed on the Spyglass. The five main menu items are as follows:
 - a) Throttle
 - b) Brake
 - c) Current Limits (Both Drive and Braking)
 - d) Fine Tuning

- e) Idle setup
- f) BMS setup

Throttle

- 1) Press the menu button once to display the first programmable menu item; in this case, "Throttle". If you do nothing else with the menu button, the Spyglass will display the first programmable selection for the throttle menu which is "TType" (Throttle type).
- 2) If the throttle type has already been set, wait 5 seconds and the program will toggle to the next programmable function; otherwise...
- 3) Select the throttle type that is being utilized for the application being installed. The selection availability is as follows:
 - a) Type 1= Electronic throttle (NO switch, 0-5 volt).
 - b) Type 2= 0-5K ohm 2 wire pot with switch.
 - c) Type 3= 5K ohm 3-wire pot with switch. (Default)

SAVE

- 1) After selecting a throttle type, the program will ask you to "Save?" the selection. If the wrong throttle type was selected, do not save the settings, but turn the vehicle off (key switch off) instead. To re-enter the programming, press and hold down the menu button while turning the ignition switch to ON. Follow the instructions as before to enter the "Program" mode.
- 2) To save the new parameters, press the menu button to save the changes.
- 3) The Spyglass will ask you to "Release" the menu button.
- 4) Release the menu button.
- 5) Then the Spyglass will instruct you to "Turn OFF" the system by turning the key switch to the off position.
- 6) You will now need to re-enter Program Mode to continue setup.

Throttle Deadband

- 1) The second menu item in the throttle section is “deadband”.
- 2) If the deadband has already been set, wait 5 seconds and the program will toggle to the next programmable function; otherwise...
- 3) To complete this process for both Type 2 and Type 3 which has a switch, the throttle will need to be depressed. As soon as the throttle switch is tripped, the value will be set.
- 4) After doing so, the Spyglass will display the dead band value with the wording of “TDB” (i.e. TDB 0.3V).
- 5) For setting Type 1 electronic throttle dead band, do not touch the throttle and depress the menu button to set.
- 6) After doing so, the Spyglass will display the dead band value with the wording of “TDB” (i.e. TDB 0.3V). After either of the above procedures has been completed, the program will continue to the next programmable function which will set the maximum throttle value.

Set Maximum Throttle

- 1) The third menu item in the throttle section is for setting the Maximum throttle input for the throttle that is being utilized. The Spyglass will display “T Max” for this function.
- 2) If the maximum throttle has already been set, wait 5 seconds and the program will toggle to the next programmable function; otherwise...
- 3) To set maximum throttle input from the throttle, press the pedal all the way down to the floor of the vehicle then press the menu button to set the parameter.
- 4) After doing so, the Spyglass will display the maximum throttle voltage value with the wording of “TMax” (i.e. TMax 5.0V).
- 5) This procedure will work for all 3 types of throttle available.

SAVE

- 1) After the changes have been made, the Spyglass will ask if you want to “Save?” the changes. If the parameters were set incorrectly, while the “Save?” is displayed do NOT press the menu button. The program will cycle to the top of the menu, which in this case is “Throttle” and you can start from the beginning. All the changes that were made will be ignored until the changes are saved.
- 2) To save the new parameters, press the menu button to save the changes.
- 3) The Spyglass will ask you to “Release” the menu button.
- 4) Release the menu button.
- 5) Then the Spyglass will instruct you to “Turn OFF” the system by turning the key switch to the off position.

Brake

- 1) After entering the “Program” mode, “Rdy Prog” will be displayed.
- 2) Press the menu button twice to toggle to the Brake menu. The Spyglass will display “Brake”.
- 3) Allow the program to switch to the first programmable selection for the brake menu which is brake type (“BType”).
- 4) If the brake type has already been set, wait 5 seconds and the program will toggle to the next programmable function; otherwise...
- 5) Select the brake type that is being utilized for the application being installed. The selection availability is as follows:
 - a) Type 0= No Brake input used (Default)
 - b) Type 1= 3-wire pot or an electronic (includes transducer or hall sensor.)
 - c) Type 2= 2 wire 0 to 5k pot.

SAVE

- 1) After selecting a brake type, the program will ask you to “Save?” the selection. If the wrong brake type was selected, do not press the menu button to save the settings; instead turn the vehicle off (key switch off). By doing so, the selection will not be saved. To re-enter the programming press and hold down the menu button while turning the ignition switch to ON. Follow the instructions as before to enter the “Program” mode.
- 2) To save the new parameters while the “Save?” is displayed, press the menu button and the new parameters will be saved.
- 3) The Spyglass will ask you to “Release” the menu button.
- 4) Release the menu button.
- 5) Then the Spyglass will instruct you to “Turn OFF” the system by turning the key switch to the off position.
- 6) You will now need to re-enter Program Mode to continue setup.

Brake Deadband

- 1) The second menu item in the brake section is “deadband”.
- 2) If the deadband has already been set or does not need to be changed, wait 5 seconds and the program will toggle to the next programmable function; otherwise...
- 3) To complete this process for both Type 1 and Type 2, press the menu button to set while the brake pedal is released.
- 4) After doing so, the Spyglass will display the deadband value with the wording of “BDB” (i.e. BDB 0.3V).
- 5) The program will now switch to the next programmable level which is setting brake maximum value.

Set Maximum Brake

- 1) The third menu item in the brake section is for setting the Maximum brake value for the brake switch that is being utilized. The Spyglass will display “Brk Max” for this function.
- 2) If the maximum brake parameter has already been set, wait 5 seconds and the program will toggle to the next programmable function; otherwise...
- 3) To set maximum brake input from the brake switch, firmly press the brake pedal then press the menu button to set. This procedure will work for both types of brake types available.
- 4) After doing so, the Spyglass will display the maximum brake voltage value with the wording of “BMax” (i.e. BMax 5.0V).

SAVE

- 1) After the changes have been made, the Spyglass will ask if you want to “Save?” the changes. If the parameters were set incorrectly, while the “Save?” is displayed do NOT press the menu button. The program will cycle to the top of the menu, which in this case is “Brake” and you can start from the beginning. All the changes that were made will be ignored until the changes are saved.
- 2) To save the new parameters, while the “Save?” is displayed press the menu button and the new parameters will be saved.
- 3) After which the Spyglass will ask you to “Release” the menu button.
- 4) Release the menu button.
- 5) Then the Spyglass will instruct you to “Turn OFF” the system by turning the key switch to the off position.

Current Limits (Drive and Braking)

EXERCISE CAUTION WHEN INCREASING NEUTRAL BRAKING CURRENTS. SETTING NEUTRAL BRAKE CURRENTS TOO HIGH CAN CAUSE LOSS OF TRACTION, AND RESULT IN LOSING CONTROL OF THE VEHICLE. WE WOULD SUGGEST INCREASING NEUTRAL BRAKING CURRENTS AT A MAXIMUM OF 5% AT A TIME.

- 1) After entering the “Program” mode, “Rdy Prog” will be displayed.
- 2) Press the menu button three times to toggle to the Current Limits menu. The Spyglass will display “CrntLimt”.
- 3) If any changes are made to the following menu items, there will be an opportunity to save any of the changes at the end of the menu.
- 4) If any of the changes made are incorrect, do not save the changes when prompted and the program will return to “CrntLimt” level with all of the parameter changes not saved allowing for the correct parameters to be entered.
- 5) Allow the program to switch to the first programmable selection for the current limits menu which is Normal Neutral Braking (“NrmN”).

Normal Neutral Braking

- 1) The first menu item that can be set is the neutral braking for normal running mode (“NrmN”).
- 2) This parameter will allow for adjustment to Neutral Braking in normal mode.
- 3) If the normal neutral braking has already been set or does not need to be changed, wait 5 seconds and the program will toggle to the next programmable function; otherwise...
- 4) When this parameter is available to change, the Spyglass will display the following: (“NrmN x%”), where x= a value between 0% and 100%.
- 5) Use the menu button to change the value. The value will only increase by 1% with each menu button trigger, and will rollover to 0% if the menu button is pressed once more after 100% has been attained.

- 6) After the parameter is set to the desired value, release the menu button. After 5 seconds, the program will switch to the next parameter which is Economy Neutral Braking (**EcoN**).

Economy Neutral Braking

Skip if an Econo switch has been installed.

- 1) The second menu item that can be set is the neutral braking for economy running mode ("**EcoN**").
- 2) This parameter will allow for adjustment to Neutral Braking in economy mode.
- 3) If the economy neutral braking has already been set or does not need to be changed, wait 5 seconds and the program will toggle to the next programmable function; otherwise...
- 4) When this parameter is available to change, the Spyglass will display the following: (**EcoN x%**); where x= a value between 0 and 100%.
- 5) Use the menu button to change the value. The value will only increase by 1% with each menu button trigger, and will rollover to 0% if the menu button is pressed once more after 100% has been attained.
- 6) After the parameter is set to the desired value, release the menu button. After 5 seconds, the program will switch to the next parameter which is Shift Neutral Braking (**SftN**).

Shift Neutral Braking

Skip if a clutch switch is NOT used.

- 1) The third menu item that will allow for parameter adjustment to neutral braking while pressing the clutch to shift a manual transmission ("**SftN**").
- 2) If the shift neutral braking has already been set or does not need to be changed, wait 5 seconds and the program will toggle to the next programmable function; otherwise...
- 3) When this parameter is available to change, the Spyglass will display the following: (**SftN x%**); where x= a value between 0 and 100%.

- 4) Use the menu button to change the value. The value will only increase by 1% with each menu button trigger, and will rollover to 0% if the menu button is pressed once more after 100% has been attained.
- 5) After the parameter is set to the desired value, release the menu button. After 5 seconds, the program will switch to the next parameter which is Brake Current Limit (**BrkC**).

Brake Current Limit

Skip if a Brake input is NOT used.

- 1) The fourth menu item that will allow for parameter adjustment to the controller is Brake Current Limit ("**BrkC**"). Brake current limit sets the regen current during braking when a brake command is given.
- 2) If the brake current limit has already been set or does not need to be changed, wait 5 seconds and the program will toggle to the next programmable function; otherwise...
- 3) When this parameter is available to change, the Spyglass will display the following: (**BrkC x%**); where x= a value between 0 and 100%.
- 4) Use the menu button to change the value. The value will only increase by 1% with each menu button trigger, and will rollover to 0% if the menu button is pressed once more after 100% has been attained.

Normal Drive Current Limit

- 1) The fifth menu item that will allow for parameter adjustments to the controller is Normal Drive Current Limit ("**NrmC**"). Normal Drive Current Limit sets the maximum RMS current the controller will supply to the motor during drive operation, as a percentage of the controller's full rated current in normal operating mode. Reducing this value will reduce the maximum drive torque.

- 2) If the normal drive current limit has already been set or does not need to be changed, wait 5 seconds and the program will toggle to the next programmable function; otherwise...
- 3) When this parameter is available to change, the Spyglass will display the following: (NrmC x%); where x= a value between 5% and 100%.
- 4) Use the menu button to change the value. The value will only increase by 1% with each menu button trigger and will rollover to 5% if the menu button is pressed once more after 100% has been attained.

Econo Drive Current Limit

Skip if an Econo switch has NOT been installed

- 1) The last menu item that will allow for parameter adjustments to the controller is Econo Drive Current Limit ("EcoC"). Econo Drive Current Limit sets the maximum RMS current the controller will supply to the motor during drive operation, as a percentage of the controller's full rated current in economy operating mode. Reducing this value will reduce the maximum drive torque.
- 2) If the econo drive current limit has already been set or does not need to be changed, or if a switch has not been installed to toggle between econo mode and normal mode, wait 5 seconds and the program will toggle to the save function; otherwise...
- 3) When this parameter is available to change, the Spyglass will display the following: (EcoC x%); where x= a value between 5 and 100%.
- 4) Use the menu button to change the value. The value will only increase by 1% with each menu button trigger and will rollover to 5% if the menu button is pressed once more after 100% has been attained.

SAVE

- 1) After the changes have been made, the Spyglass will ask if you want to "Save?" the changes. If the parameters were set incorrectly, while the "Save?" is displayed do NOT press the menu button. The program will cycle to the top of

the menu, which in this case is “Rgn Crnt” and you can start from the beginning. All the changes that were made will be ignored until the changes are saved.

- 2) To save the new parameters, while the “Save?” is displayed press the menu button and the new parameters will be saved.
- 3) After which the Spyglass will ask you to “Release” the menu button.
- 4) Release the menu button.
- 5) Then the Spyglass will instruct you to “Turn OFF” the system by turning the key switch to the off position.

Fine Tune

- 1) After entering the “Program” mode, “Rdy Prog” will be displayed.
- 2) Press the menu button four times to toggle to the fine tune menu. The Spyglass will display “FineTune”.
- 3) If any changes are made to the following menu items, there will be an opportunity to save any of the changes at the end of the menu.
- 4) If any of the changes made are incorrect, do not save the changes when prompted and the program will return to “FineTune” level. Any parameter changes that were made will be ignored and the software will revert back to the previously saved parameters.
- 5) Allow the program to switch to the first programmable selection for the fine tune menu which is adjusting the tachometer frequency (“T> Hz”).

Tachometer Frequency Set Up

- 1) Tachometer frequency allows the user to set-up the vehicles tachometer to work correctly based on the number of cylinders the original internal combustion engine had that was removed from the vehicle. NOTE: This set-up will only work for digitally controlled tachometers and may or may not work with tachometers that use pulses from a distributor. Optional Isolation module required.
- 2) The following set-up parameters are the target frequency levels:
 - a) 4 cylinder engine= 266 Hz (Default)

- b) 6 cylinder engine= 400 Hz
- c) 8 cylinder engine= 532 Hz
- 3) If the frequency output has already been set or does not need to be changed, wait 5 seconds and the program will toggle to the next programmable function or the header of ("FineTune"); otherwise...
- 4) When this parameter is available to change, the Spyglass will display the following: ($T > x\text{Hz}$); where x = a value between 0 and 3999. Use the menu button to adjust the value to the desired level. This process will INCREASE the value by 1.
- 5) Adjusting the value is done by pressing the menu button. Holding down the menu button will increment the number as well. After adjusting the parameter, wait 5 seconds and the program will toggle to the next menu item allowing for a decrease in the value ($T < x\text{Hz}$).
- 6) The program will allow you to decrease the frequency if you need to for any reason. The Spyglass will display ($T < x\text{Hz}$); where x = a value between 0 and 3999. Use the menu button to adjust the value to the desired level. This process will DECREASE the value by 1.
- 7) After the parameter is set to the desired value, release the menu button.
- 8) After 5 seconds, the program will switch to the next programmable parameter which is Field Weakening Rate ($\text{FWR } \%$).

Field Weakening Rate

- 1) The next menu item that will allow for parameter adjustments to the controller is Field Weakening Rate (" $\text{FWR } \%$ "). Field Weakening Rate determines the control loop gains for field weakening. Setting the rate too low may create surging in the vehicle as it accelerates at mid to high speeds. Setting the rate too high may create high frequency oscillations (usually audible) when the vehicle accelerates at mid to high speeds.
- 2) If the field weakening rate has already been set, wait 5 seconds and the program will toggle to the next programmable function; otherwise...

- 3) When this parameter is available to change, the Spyglass will display the following: (FWR x%); where x= a value between 0% and 100%.
- 4) Use the menu button to change the value. The value will increase by 2% with each menu button trigger, and will rollover to 0% if the menu button is pressed once more after 100% has been attained.
- 5) After the parameter is set to the desired value, release the menu button. After 5 seconds, the program will switch to the next parameter which is setting the baud rate of the CAN bus (BR Kbs).

CAN Baud Rate Setting

- 1) The next menu item that will allow for parameter adjustments to the controller is CAN Baud Rate ("BR Kbs").
- 2) If the baud rate has already been set, wait 5 seconds and the program will toggle to the save function; otherwise...
- 3) When this parameter is available to change, the Spyglass will display the following: (BRxxxKbs); where x= the set baud rate. The values available are 125Kbs, 250Kbs and 500Kbs.
- 4) Use the menu button to change the value.
- 5) After the parameter is set to the desired value, release the menu button. After 5 seconds, the program will switch to the save function.

SAVE

- 1) After the changes have been made, the Spyglass will ask if you want to "Save?" the changes. If the parameters were set incorrectly, while the "Save?" is displayed do NOT press the menu button. The program will cycle to the top of the menu, which in this case is "FineTune" and you can start from the beginning. All the changes that were made will be ignored until the changes are saved.

- 2) To save the new parameters, while the “Save?” is displayed press the menu button and the new parameters will be saved.
- 3) After which the Spyglass will ask you to “Release” the menu button.
- 4) Release the menu button.
- 5) Then the Spyglass will instruct you to “Turn OFF” the system by turning the key switch to the off position.

Idle Control

- 1) After entering the “Program” mode, “Rdy Prog” will be displayed.
- 2) Press the menu button five times to toggle to the Idle Setup menu. The Spyglass will display “IdleStup”.
- 3) Idle setup allows the user to turn on or off Idle for the vehicle.
- 4) Included in this menu list is the parameter that allows for the user to have choice to press the clutch during startup. **Optional Start Switch Input must be used for Idle Function to work.**

Idle OFF

- 1) The first menu item that will come up on the Spyglass is “Idle ON” and “Idle OFF”.
- 2) Selecting “Idle OFF” will disable Idle.
- 3) Then the user will have the chance to change the creep torque (“CTrq”). Creep torque parameter determines the amount of torque applied to the vehicle at a stop with no throttle input, to emulate the feel of an automatic transmission automobile.
- 4) Use the menu button to change the value. The value will increase by 1% with each menu button trigger, and will rollover to 0% if the menu button is pressed once more after 100% has been attained.
- 5) **Creep Function should only be use in conjunction with a brake input.** The brake input will proportionally cancel the creep torque thus reducing the amount of brake pressure required to hold the vehicle.

Idle ON

- 1) Selecting "Idle ON" will enable idle.
- 2) The user will be able to select whether or not if the clutch will be used in starting the vehicle. Select "ClSw Yes" to enable this option, otherwise select "ClSw No" to disable this function.
- 3) When the ability to increase the RPM level of idle, the Spyglass will display (>xRPM).
- 4) The increase will increment by 10.
- 5) If the level of RPM needs to be decreased, the next option will allow for this.
- 6) When the ability to decrease the PRM level of idle, the Spyglass will display (<xRPM).
- 7) The increase will increment by 10.

Idle Torque

- 1) This option allows for the user to adjust the amount of torque at idle.
- 2) The Spyglass will display (ITrq x%); where x = a number from 0 to 100. The Spyglass will rollover from 100 to 0 when the maximum value of 100 has been reached and the menu button has been pressed. The 0 to 100% indicates the percentage of the motors full torque ability.

SAVE

- 1) After the changes have been made, the Spyglass will ask if you want to "Save?" the changes. If the parameters were set incorrectly, while the "Save?" is displayed do NOT press the menu button. The program will cycle to the top of the menu, which in this case is "IdleStup" and you can start from the beginning. All the changes that were made will be ignored until the changes are saved.
- 2) To save the new parameters, while the "Save?" is displayed press the menu button and the new parameters will be saved.

- 2) To save the new parameters, while the “Save?” is displayed press the menu button and the new parameters will be saved.
- 3) After which the Spyglass will ask you to “Release” the menu button.
- 4) Release the menu button.
- 5) Then the Spyglass will instruct you to “Turn OFF” the system by turning the key switch to the off position.
- 6) To exit the program menu, cycle the key switch from on to off, then turn the key switch back on to return to a run mode.

Orion BMS

- 1) After entering the “Program” mode, “Rdy Prog” will be displayed.
- 2) Press the menu button six times to toggle to the BMS Setup menu. The Spyglass will display “BMSSetup”.
- 3) BMS setup allows the user to adjust parameters for use with the ORION Battery Management System (BMS).
- 4) The default CAN bus address that is set in the Curtis controller to receive messages from the Orion BMS is 0x300h. If changes are made to the CAN bus addresses that are setup in the Curtis controller, the CAN bus addresses WILL have to be adjusted in the Orion BMS as well.
- 5) If any changes are made to the following menu items, there will be an opportunity to save any of the changes at the end of the menu.
- 6) If any of the changes made are incorrect, do not save the changes when prompted and the program will return to the “BMSSetup” level. Any parameter changes that were made will be ignored and the software will revert back to the previously saved parameters.

BMS OFF

- 1) If the BMS setup is set for “BMS OFF”, the software will revert back to the header of “BMSSetup”.

BMS ON

- 1) While the option is available to switch to “BMS ON” from “BMS OFF”, press the menu once to switch to “BMS ON”.
- 2) Allow the program to switch to the first programmable selection for the BMS setup menu which is adjusting the CAN bus address for receiving information from the BMS. The Spyglass will display “>xxx hex” when the adjustment can be made.

BMS Address

Increasing CAN Bus BMS Address

- 1) If an adjustment needs to be made to the BMS address so that receiving information from the BMS can be established, or if the default CAN bus addresses for communicating with the Orion BMS is being utilized by a different system on the vehicle, adjustments to the address can be made. The CAN bus address MUST be the same for both the controller and the Orion BMS.
- 2) To increase the CAN bus address for the controller for receiving information from the Orion BMS, the Spyglass will display “>xxx hex”; where x= the hexadecimal address that will be used to receive information from the BMS. Default = 0x300h with the second message is set at +1 (0x301h).
- 3) Press the menu button to toggle the increase.
- 4) If an increase to the CAN bus BMS address is not needed, wait 5 seconds and the program will toggle to the next programmable function “<xxx hex” (Decrease CAN bus BMS address).

Decreasing CAN Bus BMS Address

- 1) To decrease the CAN bus BMS address for the controller for receiving information from the Orion BMS, the Spyglass will display "<xxx hex".
- 2) Press the menu button to toggle the decrease.
- 3) If a decrease to the CAN bus BMS address is not needed, wait 5 seconds and the program will toggle to the next programmable function "BR Kbs" (CAN bus baud rate).

CAN Bus Baud Rate

- 1) The baud rate of the CAN bus can be changed in this section. When the Spyglass displays "BR Kbs", the baud rate can be changed.
- 2) The default baud rate is set to 250 Kbs. The available selections are 125 Kbs, 250 Kbs and 500 Kbs. The factory baud rate setting for the Orion BMS is set to 250 Kbs. The baud rates between the CAN bus and the Orion BMS MUST match to operate correctly.
- 3) Press the menu button to toggle the change.
- 4) If a change to the baud rate is not needed, wait 5 seconds and the program will toggle to the next programmable function "LCB>" (Low Cell Cutback Begin).

Low Cell Cutback Begin Increase

- 1) Low cell cutback begin sets the voltage of the lowest cell where current limiting will begin.
- 2) When the Spyglass displays "LCB>", the parameter can be increased.
- 3) The default setting for this parameter is set to 2.85V, with a parameter range of 2.00V-3.20V.
- 4) Press the menu button to toggle the increase.

- 5) If an increase to the low cell cutback begin is not needed, wait 5 seconds and the program will toggle to the next programmable function “LCB<” (Low Cell Cutback Begin Decrease).

Low Cell Cutback Begin Decrease

- 1) To decrease the low cell cutback begin, wait for the Spyglass to display “LCB<”.
- 2) Press the menu button to toggle the decrease.
- 3) If a decrease to the low cell cutback begin is not needed, wait 5 seconds and the program will toggle to the next programmable function “LCF>” (Low Cell Full Cutback Increase).

Low Cell Full Cutback Increase

- 1) Low Cell Full Cutback parameter sets the voltage of the lowest cell where full current limiting is in force.
- 2) When the Spyglass displays “LCF>”, the parameter can be increased.
- 3) The default setting for this parameter is set to 2.40V, with a parameter range of 1.80V-LCB.
- 4) Press the menu button to toggle the increase.
- 5) If an increase to the low cell full cutback is not needed, wait 5 seconds and the program will toggle to the next programmable function “LCF<” (Low Cell Cutback Begin Decrease).

Low Cell Full Cutback Decrease

- 1) To decrease the low cell full cutback begin, wait for the Spyglass to display “LCF<”.
- 2) Press the menu button to toggle the decrease.
- 3) If a decrease to the low cell full cutback is not needed, wait 5 seconds and the program will toggle to the next programmable function “MCF>” (Maximum Current Full Cutback Increase).

Maximum Current Full Cutback Increase

- 1) Maximum Current Full Cutback parameter sets the maximum current allowed when low voltage full cutback is in force.
- 2) When the Spyglass displays “MCF>”, the parameter can be increased.
- 3) The default setting for this parameter is set to 20%, with a parameter range of 0-100%.
- 4) Press the menu button to toggle the increase.
- 5) If an increase to the low cell full cutback is not needed, wait 5 seconds and the program will toggle to the next programmable function “MCF< ” (Maximum Current Full Cutback Decrease).

Maximum Current Full Cutback Decrease

- 1) To decrease the maximum current full cutback, wait for the Spyglass to display “MCF<”.
- 2) Press the menu button to toggle the decrease.
- 3) If a decrease to the maximum current full cutback is not needed, wait 5 seconds and the program will toggle to the next programmable function “MCV>” (Maximum Cell Voltage).

Maximum Cell Voltage Increase

- 1) Maximum cell voltage parameter sets the voltage at which regen is turned off to prevent overcharging.
- 2) When the Spyglass displays “MCV>”, the parameter can be increased.
- 3) The default setting for this parameter is set to 3.65V, with a parameter range of 3.00-4.00V.
- 4) Press the menu button to toggle the increase.
- 5) If an increase to the maximum cell voltage is not needed, wait 5 seconds and the program will toggle to the next programmable function “MCV< ” (Maximum Cell Voltage Decrease).

Maximum Cell Voltage Decrease

- 1) To decrease the maximum current full cutback, wait for the Spyglass to display “MCV<”.
- 2) Press the menu button to toggle the decrease.
- 3) If a decrease to the maximum cell voltage is not needed, wait 5 seconds and the program will toggle to the next programmable function “LSC>” (Low SOC Cutback Increase).

Low SOC Cutback Increase

- 1) Low SOC (State of Charge) Cutback parameter sets the SOC at which current limiting is in force.
- 2) When the Spyglass displays “LSC>”, the parameter can be increased.
- 3) The default setting for this parameter is set to 20%, with a parameter range of 0-100%.
- 4) Depress the menu button to toggle the increase.
- 5) If an increase to the low SOC cutback is not needed, wait 5 seconds and the program will toggle to the next programmable function “LSC<” (Low SOC Cutback Decrease).

Low SOC Cutback Decrease

- 1) To decrease the low SOC cutback, wait for the Spyglass to display “LSC<”.
- 2) Press the menu button to toggle the decrease.
- 3) If a decrease to the low SOC cutback is not needed, wait 5 seconds and the program will toggle to the next programmable function “MCL>” (Maximum Current Low SOC Increase).

Maximum Current Low SOC Increase

- 1) Maximum Current Low SOC (State of Charge) parameter sets the maximum current allowed when SOC is lower than LSC.
- 2) When the Spyglass displays “MCL>”, the parameter can be increased.

- 3) The default setting for this parameter is set to 20%, with a parameter range of 0-100%.
- 4) Press the menu button to toggle the increase.
- 5) If an increase to the maximum current low SOC is not needed, wait 5 seconds and the program will toggle to the next programmable function “MCL<” (Maximum Current Low SOC Decrease).

Maximum Current Low SOC Decrease

- 1) To decrease the low SOC cutback, wait for the Spyglass to display “MCL<”.
- 2) Press the menu button to toggle the decrease.

SAVE

- 1) After the changes have been made, the Spyglass will ask if you want to “Save?” the changes. If the parameters were set incorrectly, while the “Save?” is displayed do NOT press the menu button. The program will cycle to the top of the menu, which in this case is “BMSSetup” and you can start from the beginning. All the changes that were made will be ignored until the changes are saved.
- 2) To save the new parameters while the “Save?” is displayed, press the menu button and the new parameters will be saved.
- 3) After which the Spyglass will ask you to “Release” the menu button.
- 4) Release the menu button.
- 5) Then the Spyglass will instruct you to “Turn OFF” the system by turning the key switch to the off position.
- 6) To exit the program menu, cycle the key switch from on to off, then turn the key switch back on to return to a run mode.

Program Mode Quick Reference

In program mode, you are allowed to make tuning adjustments to the controller through the menu button so that you can attain the driving “feel” that you want. The following list is the menu items for program mode:

1) Throttle

- a) **Type** (throttle type; 1, 2 or 3)
 - i) **Save?** (Hold the menu button down, writes the new parameters to the controller)
 - ii) **Release** (Release the menu button)
 - (1) **Turn Off** (Turn the key switch of the vehicle to off)
- b) **Deadband** (sets low end throttle dead band)
 - i) **Set** (sets low end dead band setting)
- c) **T Max** (throttle max)
 - i) **Set** (sets maximum dead band setting)
- d) **Save?** (Hold the menu button down, writes the new parameters to the controller)
- e) **Release** (Release the menu button)
 - i) **Turn Off** (Turn the key switch of the vehicle to off)

2) Brake

- a) **BType** (brake type; 0, 1 or 2)
 - i) **Save?** (Hold the menu button down, writes the new parameters to the controller)
 - ii) **Release** (Release the menu button)
 - iii) **Turn Off** (Turn the key switch of the vehicle to off)
- b) **Deadband** (sets low end throttle dead band)
 - i) **BDB** (sets low end dead band setting voltage)
- c) **Brk Max** (Brake Max)
 - i) **BMax** (sets maximum dead band setting voltage)
- d) **Save?** (Hold the menu button down, writes the new parameters to the controller)
- e) **Release** (Release the menu button)

f) **Turn Off** (Turn the key switch of the vehicle to off)

3) **CrntLimt** (Drive and Braking Currents)

- a) **NrmN** (normal mode neutral braking current %)
- b) **EcoN** (economy mode neutral braking current %)
- c) **SftN** (reduces neutral braking % for shifting purposes)
- d) **BrkC** (brake current limit %)
- e) **NrmC** (Normal drive current limit %)
- f) **EcoC** (Econo drive current limit %)
- g) **Save?** (Hold the menu button down, writes the new parameters to the controller)
- h) **Release** (Release the menu button)
- i) **Turn Off** (Turn the key switch of the vehicle to off)

4) **FineTune** (Fine tuning)

- a) **T> Hz** (Increases Tach Frequency Hz)
- b) **T< Hz** (Decreases Tach Frequency Hz)
- c) **FWR %** (Adjust Field Weakening Rate %, increases by 2)
- d) **BR Kbs** (Adjusts Baud Rate of CAN communication. 125KBAUD, 250KBAUD, 500KBAUD)
- e) **Save?** (Hold the menu button down, writes the new parameters to the controller)
- f) **Release** (Release the menu button)
- g) **Turn Off** (Turn the key switch of the vehicle to off)

5) **IdleStup** (Idle control set-up)

- a) **Idle ON** (Turn Idle ON; follow menu item **C** below to continue programming)
- b) **Idle OFF** (Turn Idle OFF)
 - i) **CTrq** (Creep torque available when Idle is set to OFF. Allows for the amount of torque applied when the vehicle when at a stop and no throttle input)
 - ii) **Save?** (Hold the menu button down, writes the new parameters to the controller)

- iii) **Release** (Release the menu button)
 - iv) **Turn Off** (Turn the key switch of the vehicle to off)
 - c) **ClSw Yes** (Enables clutch switch so that clutch needs to be depressed to start vehicle)
 - d) **ClSw No** (Disables clutch switch)
 - e) **> RPM** (increases set Idle RPM by 10)
 - f) **<RPM** (decreases set idle RPM by 10)
 - g) **ITrq %** (Sets the amount of torque percentage at idle RPM)
 - h) **Save?** (Hold the menu button down, writes the new parameters to the controller)
 - i) **Release** (Release the menu button)
 - j) **Turn Off** (Turn the key switch of the vehicle to off)
- 6) **BMSSetup** (BMS set-up)
- a) **BMS OFF** (Default value, if **BMS ON** is not selected, the program will revert back to **BMSSetup**)
 - b) **BMS ON** (When on can be used with Orion BMS. BMS must have CAN messages configured)
 - c) **> xxx hex** (BMS Address Increase in hexadecimal. Default address is 0x300h with second address +1)
 - d) **< xxx hex** (BMS Address Decrease in hexadecimal)
 - e) **LCB>** (Low Cell Cutback Begin (increase). Sets the voltage of the lowest cell where current limiting will begin. Default= 2.85V)
 - f) **LCB<** (Low Cell Cutback Begin (decrease))
 - g) **LCF>** (Low Cell Full Cutback (increase). Sets the voltage of the lowest cell where full current limiting is in force. Default= 2.40V)
 - h) **LCF<** (Low Cell Full Cutback (decrease))
 - i) **MCF>** (Maximum Current Full Cutback (increase). Sets the maximum current allowed when low voltage full cutback is in force. Default= 20%)
 - j) **MCF<** (Maximum Current Full Cutback (decrease))
 - k) **MCV>** (Maximum Cell Voltage (increase). Sets the voltage at which regen is turned off to prevent over charging. Default= 3.65V)
 - l) **MCV<** (Maximum Cell Voltage (decrease))

- m) **LSC>** (Low SOC Cutback (increase). Set the SOC (state of charge) at which current limiting is in force. Default= 20%)
- n) **LSC<** (Low SOC Cutback (decrease))
- o) **MCL>** (Maximum Current Low SOC (increase). Set the maximum current allowed when SOC is lower than LSC. Default= 20%)
- p) **MCL<** (Maximum Current Low SOC (decrease))

PROGRAM MODE NOTES

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Diagnostic Mode Instructions

- 1) After entering the “Diagnose” mode, “Rdy Diag” will be displayed.
- 2) From here, you can navigate to the five main menus using the menu button but keep in mind that you have a few seconds to make your selection before the software enters the menu item displayed on the Spyglass. The five main menu items are as follows:
 - a) Throttle
 - b) Brake
 - c) Motor
 - d) Power
 - e) Controller

Throttle

- 1) Press the menu button once to view the first diagnostic level, throttle. “Throttle” will be displayed when this menu item is active. Once the Spyglass displays “Throttle”, wait 5 seconds and the Spyglass will toggle to the next menu item that displays the state of the throttle switch. The user will be able to verify settings, throttle switch state and pot voltage.

Throttle Switch ON/OFF

Active only with Throttle Types 2 & 3.

- 1) “Sw ON” will display on the Spyglass if the throttle switch has been tripped and is active.
- 2) Likewise, if the switch is not tripped or is NOT functioning correctly when the throttle is depressed, “Sw OFF” will be displayed.
- 3) Press the menu button once and the next diagnostic level in the throttle menu will be displayed which is the throttle pot voltage.

Throttle Pot

- 1) The Spyglass will display “TPot x.xV” when active; where x= actual voltage value.
- 2) With this display active on the Spyglass, press the throttle pedal and the Spyglass will show the actual voltage reading from the throttle pot.
- 3) Once verified that the throttle pot is working correctly, press the menu button once to toggle to the next menu item.

DeadBand

- 1) The next menu item the Spyglass will display is the throttle deadband (TDB x.xV); where x = actual voltage value that was set by way of the default value, or set by the user through the programming mode.
- 2) Once the deadband has been verified, press the menu button once to toggle to view the next diagnostic level which is throttle max setting.

Throttle Maximum

- 1) The last menu item the Spyglass will display is the throttle maximum (TMax x.xV); where x= actual voltage value that was set by way of the default value or set by the user through the programming mode.
- 2) Once the throttle max has been verified, press the menu button once to toggle back to the top of “Throttle” level.
- 3) To toggle to the next level which is “Brake”, press the menu once more while the Spyglass is displaying “Throttle”.

Brake

Active only with Brake Types 1 & 2.

- 1) Press the menu button twice to view the second diagnostic level, the brake. “Brake” will be displayed when this menu item is active. The user will be able to verify settings and the brake pot voltage.

- 2) Once the Spyglass displays “**Brake**”, wait 5 seconds and the Spyglass will toggle to the next menu item that displays the output voltage of the brake switch.

Brake Pot

- 1) The Spyglass will display “**BPot x.xV**” when active; where x= actual voltage value.
- 2) With “**BPot x.xV**” active on the Spyglass, press the brake pedal and the Spyglass will show the actual voltage reading from the brake pot.
- 3) Once verified that the brake pot is working correctly, press the menu button once to toggle to the next menu item which is brake Deadband (**BDB x.xV**).

DeadBand

- 1) The next menu item the Spyglass will display is the brake deadband (**BDB x.xV**); where x = actual voltage value that was set by way of the default value or set by the user through the programming mode.
- 2) Once the deadband has been verified, press the menu button once to toggle to view the next diagnostic level which is brake max setting (**BMax x.xV**).

Brake Maximum

- 1) The last menu item the Spyglass will display is the brake maximum (**BMax x.xV**); where x = actual voltage value that was set by way of the default value or set by the user through the programming mode.
- 2) Once the brake max has been verified, press the menu button once to toggle back to the top of “**Brake**” level.
- 3) To toggle to the next level which is “**Motor**”, press the menu once more while the Spyglass is displaying “**Brake**”.

Motor

- 1) Press the menu button three times to view the third diagnostic level, motor. “Motor” will be displayed on the Spyglass when this menu item is active. The motor information that will be displayed is the motor RPM, verification that both channels from the encoder are working correctly and the motor temperature.
- 2) Once the Spyglass displays “Motor”, wait 5 seconds and the display will toggle to the next menu item that displays motor RPM (“RPMxxxx”).

RPM

- 1) The first item that the Spyglass will display will be the motor RPM. The Spyglass will display (“RPMxxxx”); where x = a RPM value.
- 2) This diagnostic tool can be used to verify that the encoder is reading the motor RPM.
- 3) Press the menu button to increment to the next level which is to view the signal from encoder A (“EncA”).

EncA

- 1) The first channel on the encoder is encoder A (“EncA”) is one of the channels that are used. The value that will be displayed as (“EncAxxxx”); where x= a RPM value.
- 2) The diagnostic tool can be used to verify that this channel is reading the motor RPM correctly.
- 3) Press the menu button to increment to the next level in the menu which is view the signal from encoder B (“EncB”).

EncB

- 1) The second channel on the encoder is encoder B (“EncB”). The value that will be displayed as (“EncBxxxx”); where x= a RPM value.
- 2) This diagnostic tool can be used to verify that this channel is reading the motor RPM correctly.

- 3) Press the menu button to increment to the next level in the menu which is viewing the motor temperature ("Temp").

Motor Temperature

- 1) The last menu item within the ("Motor") portion of the diagnostic mode is motor temperature ("Temp").
- 2) The Spyglass will display the motor temperature as ("Tempxxx°C"); where x = a temperature value. The temperature will be displayed in Celsius.
- 3) Once the motor temperature has been viewed, press the menu button once to toggle back to the top of "Motor" level.
- 4) To toggle to the last level which is power ("Power"), press the menu button once more while the Spyglass is displaying "Motor".

Power

- 1) The fourth main menu item in Diagnostic Mode is ("Power") of the system. This section will display Keyswitch voltage, capacitor voltage, the state of the main contactor and finally the RMS current of the controller.

Keyswitch Voltage

- 1) The first item to be displayed within the power section is for the key switch voltage ("KSI").
- 2) The Spyglass will display ("KSIXxx"); where x = a voltage value.
- 3) This diagnostic tool can be used to verify the state of the battery voltage at the keyswitch.
- 4) The next menu to be displayed is capacitor voltage ("Cap"). Press the menu button to increment.

Capacitor Voltage

- 1) The second menu item to be displayed within the power section is for the capacitor voltage ("CAP").
- 2) The Spyglass will display ("CAPxxx"); where x = a voltage value.

- 3) This diagnostic tool can be used to verify the state of the capacitor voltage of the controller's internal capacitor bank at the B+ terminal.
- 4) The next menu item to be displayed checks the main state of the contactor ("Main"). Press the menu button to increment.

Main State

- 1) The third item to be displayed within the power section is the state of the main contactor ("Main x"); where x = the state of the contactor.
- 2) The main contactor state is defined by the following:
 - a) 0 = open
 - b) 1 = precharge
 - c) 2 = weldcheck
 - d) 3 = closingdelay
 - e) 4 = missingcheck
 - f) 5 = closed (Normal Operation)
 - g) 6 = delay
 - h) 7 = arccheck
 - i) 8 = opendelay
 - j) 9 = fault
 - k) 10 = closed (when Main Enable = Off)
- 3) The last menu item to be displayed is the controllers current ("RMS"). Press the menu button to increment.

Controller Current (RMS)

- 1) To view the RMS current of the controller ("RMS") will be displayed on the Spyglass.
- 2) The Spyglass will display ("RMS xxx"); where x = a numerical value for the AC current from the controller to the motor.
- 3) Once the controller current has been viewed, press the menu button once to toggle back to the top of "Power" level.
- 4) To toggle to the last level which is controller ("Cntrlr"), press the menu once more while the Spyglass is displaying "Power".

Controller

- 1) The last of the five main menu items in Diagnostic Mode is for the controller ("Cntrlr").
- 2) This section of software will display the conditions of the controller.
- 3) Once the Spyglass displays "Cntrlr", wait 5 seconds and the Spyglass will toggle to the next menu item that displays the dual drive state.

Dual Drive State

- 1) The first item to be displayed within the controller section is to confirm what state the dual drive parameter is in.
- 2) If the dual drive parameter is on, the Spyglass will display ("DIDrv ON").
- 3) If the dual drive parameter is off, the Spyglass will display ("DIDrvOFF").
- 4) The next menu item to view is the controller temperature (TempxxxC). Press the menu button to increment.

Controller Temperature

- 1) The second menu item to be displayed is the controller temperature.
- 2) The Spyglass will display (TempxxxC); where x= a temperature value. The temperature will be displayed in Celsius.
- 3) The next menu item to view is the operating system (OS xx) that is installed in controller. Press the menu button to increment.

Operating System

- 1) The third menu item to be displayed is the operating system that is installed into the controller.
- 2) The Spyglass will display (OS xx); where x = a numerical value.
- 3) The next menu item to view is the build number (Build xx) that is installed in controller. Press the menu button to increment.

Build Number

- 1) The fourth menu item to be displayed is the build number that is installed into the controller.
- 2) The Spyglass will display (**Build xx**); where x = a numerical value.
- 3) The next menu item to view is the VCL version (**Ver xxxP**) that is installed in controller. Press the menu button to increment.

VCL Version

- 1) The fifth menu item to be displayed is the VCL version number that is installed into the controller.
- 2) The Spyglass will display (**Ver xxxP**); where x = a numerical value. The value of “P” refers to the primary controller.
- 3) The next menu item to view is the manufactured date code (**D/C xxx**). Press the menu button to increment.

Date Code

- 1) The sixth menu item to be displayed is the date code of the controller.
- 2) The Spyglass will display (**D/C xxx**); where x= a numerical value. The date code is the date that the controller was manufactured.
- 3) The last menu item to view is the serial number of the controller. Press the menu button to increment.

Serial Number

- 1) The final menu item to be displayed is the serial number of the controller.
- 2) The Spyglass will display (**S/N xxx**) where x = a numerical value. The serial number is assigned by the manufacturer.
- 3) To exit the diagnostic menu, cycle the key switch from on to off, then turn the key switch back on to return to a run mode.

Diagnostic Mode Quick Reference

In Diagnostic mode, you will be allowed to verify functionality of the system, verify settings of the controller as well as pertinent controller information. The following list is the menu items for Diagnostic Mode:

- 1) **Throttle**
 - a) **Sw OFF** (The throttle switch is deactivated, Throttle Types 2 & 3 only)
 - b) **Sw ON** (The throttle switch is activated, Throttle Types 2 & 3 only)
 - c) **TPot** (Checks and displays throttle pot wiper voltage. As the throttle is depressed, the voltage displayed will increase)
 - d) **TMax** (Displays throttle max setting parameter)
- 2) **Brake** (Only if equipped with brake pot or pressure transducer)
 - a) **BMax** (Checks and displays brake input voltage. As the brake is pressed, the voltage displayed will increase)
 - b) **BDB** (Displays brake deadband)
 - c) **BMax** (Displays brake max setting)
- 3) **Motor**
 - a) **RPM** (Displays motors current speed in RPM)
 - b) **EncA** (Displays Encoder A signal)
 - c) **EncB** (Displays Encoder B signal)
 - d) **Temp C** (Displays motor temperature in Celsius)
- 4) **Power**
 - a) **KSI** (Displays the current key switch voltage)
 - b) **Cap** (Capacitor voltage)
 - c) **Main** (displays the state of the main contactor 0=open, 1=precharge, 2=weldcheck, 3=closingdelay, 4=missingcheck, 5=closed (when Main Enable = ON, 6=delay, 7=arccheck, 8=opendelay, 9=fault, 10=closed (when Main Enable=OFF)
 - d) **RMS** (RMS current of the controller, taking all three phases into account.)
- 5) **Controller** (Controller)
 - a) **Temp** (Displays controller temperature)
 - b) **OS** (Displays operating system version)

- c) **Build** (Displays build number of the operating system software that is loaded into the controller. This variable specifies the minor version number of the controller's operating system)
- d) **Ver** (Version number of the VCL application software that is loaded into the controller)
- e) **D/C** (Date code: Displays the controller manufacture date code)
- f) **S/N** (Displays the controller serial number from the manufacturer)

DIAGNOSE MODE NOTES

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Additional Features

Menu System

When the key switch is first turned on, the system will take a second or two to power up. Depending on if a battery management system (BMS) is being utilized or not will determine what the Spyglass will be displaying at power up. To toggle through the menu items, depress the menu button.

The following is the menu items system list:

1. **Battery Percentage (Batt%)** **ONLY IF A BMS SYSTEM IS BEING UTILIZED**
 - a. **Otherwise: RPM** (motor RPM)
2. **AMPS** (Estimated DC current to the motor)
3. **Vlt** (Keyswitch voltage)
4. **Mtmp** (Motor temperature)
5. **Ctmp** (Controller temperature)

LED (Load Meter)

The LED lights that are located on the bottom of the Spyglass represent how much of a load is exerted on the system.

The following information represents what the system is doing when certain LEDs are illuminated:

1. Regenerative braking: All three green LEDs are illuminated.
2. Very light driving: 2 green LEDs illuminated
3. Good driving: 1 green LED illuminated
4. Moderate driving: 1 yellow LED illuminated
5. Hard acceleration: Red LED illuminated

CAN BUS

The controller transmits over the CAN BUS information pertaining to the controller and the motor. The default addresses of the mailboxes used for transmitting the information are 0x601h and 0x602h. The CAN BUS transmit address can be adjusted, but a handheld programmer or a programming station will be needed.

The following information is transmitted from the controller:

CAN Address 0x601

1. Bytes 0 and 1: Motor RPM – 16 bit
2. Byte 2: Motor Temperature degrees Celsius (-40 degrees to 200 degrees)
3. Byte 3: Controller Temperature degrees Celsius (-40 degrees to 95 degrees)
4. Bytes 4 and 5: RMS Current – 16 bit Scale= 0.1
5. Bytes 6 and 7: Capacitor Voltage – 16 bit Scale= 1.0

CAN Address 0x602

1. Bytes 0 and 1: Frequency – 16 bit (Controller electrical frequency)
Scale= 1.0
2. Byte 2: Primary Controller Fault
3. Byte3: Secondary Controller Fault
4. Bytes 4-7: NOT USED

CAN BUS NOTES

Diagnostics

Diagnostics information can be obtained by observing the fault codes issued by the Status LED's or as displayed on the Spyglass. See Table below for a summary of LED display formats.

The 1311 programmer will display all faults that are currently set as well as a history of the faults that have been set since the history log was last cleared. The 1311 displays the faults by name.

Summary of LED display formats

The two LEDs have four different display modes, indicating the type of information they are providing.

Display	Status
Neither LED Illuminated	Controller is not powered on; or vehicle has dead battery; or severe damage
Yellow LED flashing	Controller is operating normally.
Yellow and red LEDs both on solid	Controller is in Flash program mode
Red LED on solid	Watchdog failure or no software loaded. Cycle KSI to restart, and if necessary load software.
Red LED and yellow LED flashing alternately	Controller has detected a fault. 2-digit code flashed by yellow LED identifies the specific fault; one or two flashes by red LED indicate whether first or second code digit will follow.

The pair of LEDs built into the controller (one red, one yellow) produce flash codes displaying all the currently set faults in a repeating cycle. Each code consists of two digits. The red LED flashes once to indicate that the first digit of the code will follow; the yellow LED then flashes the appropriate number of times for the

first digit. The red LED flashes twice to indicate that the second digit of the code will follow; the yellow LED flashes the appropriate number of times for the second digit.

Example: Battery Undervoltage (code 23).

In the Fault menu of the 1311 programmer, the words Undervoltage Cutback will be displayed; the real-time battery voltage is displayed in the Monitor menu ("Keyswitch Voltage"). The controller's two LEDs will display this repeating pattern:

RED	YELLOW	RED	YELLOW
	 	 	  
(first digit)	(2)	(second digit)	(3)

With this software package, not all of the codes below will be displayed on the Spyglass. We have only utilized faults that are pertinent to our software package.

Troubleshooting

The troubleshooting chart below provides the following information on all the controller faults:

- fault code
- fault name as displayed on the programmer's LCD
- the effect of the fault
- possible causes of the fault
- fault set conditions
- fault clear conditions

Whenever a fault is encountered and no wiring or vehicle fault can be found, shut off KSI and turn it back on to see if the fault clears. If it does not, shut off KSI and remove the 35-pin connector. Check the connector for corrosion or damage, clean it if necessary, and re-insert it.

Troubleshooting Chart

Code	Programmer Display (Effect or Fault)	Possible Cause	Set/Clear Conditions
12	Controller Overcurrent	1) External short of phase U, V, or W motor connections 2) Motor parameters are mis-tuned 3) Controller defective	Set: Phase current exceeded the current measurement limit Clear: Cycle KSI
13	Current Sensor Fault	1) Leakage to vehicle frame from phase U, V, or W (short in motor stator) 2) Controller defective	Set: Controller current sensors have invalid reading Clear: Cycle KSI
14	Precharge Failed	1) External load on capacitor bank (B+ connection terminal) that prevents the capacitor bank from charging 2) See Monitor menu >> Battery: Capacitor Voltage	Set: Precharge failed to charge the capacitor bank to KSI voltage Clear: Cycle Interlock input or use VCL function <i>Precharge()</i>
17	Severe Undervoltage	1) Battery Menu parameters are misadjusted 2) Non-controller system drain on battery 3) Battery resistance 4) Battery disconnected while driving 5) See Monitor Menu >> Battery: Capacitor voltage 6) Blown B+ fuse or main contactor did not close	Set: Capacitor bank voltage dropped below the Severe Undervoltage limit with FET bridge enabled Clear: Bring capacitor voltage above Severe Undervoltage limit
18	Severe Overvoltage	1) See Monitor menu >> Battery: Capacitor Voltage 2) Battery menu parameters are misadjusted 3) Battery resistance too high for given regen current 4) Battery disconnected while regen braking	Set: Capacitor bank voltage exceeded the Severe Overvoltage limit with FET bridge enabled Clear: Bring capacitor voltage below Severe Overvoltage limit and then cycle KSI

22	Controller Overtemp Cutback	1) See Monitor menu >> Controller: Temperature 2) Controller is performance-limited at this temperature 3) Controller is operating in an extreme environment 4) Excessive load on vehicle 5) Improper mounting of controller	Set: Heatsink temperature exceeded by 85°C Clear: Bring heatsink temperature below 85°C
23	Undervoltage Cutback	1) Normal operation. Fault shows that the batteries need recharging. Controller performance is limited at this voltage. 2) Battery parameters are misadjusted 3) Non-controller system drain on battery 4) Battery resistance too high 5) Battery disconnected while driving 6) See Monitor Menu >> Battery: Capacitor voltage 7) Blown B+ fuse or main contactor did not close	Set: Capacitor bank voltage dropped below the Undervoltage limit with the FET bridge enabled Clear: Bring capacitor voltage below the undervoltage limit
24	Overvoltage cutback	1) Normal operation. Fault shows that regen braking currents elevated the battery voltage during regen braking. Controller is performance limited at this voltage. 2) Battery parameters are misadjusted 3) Battery resistance too high for given regen current 4) Battery disconnected while regen braking 5) See Monitor Menu >> Battery: Capacitor voltage	Set: Capacitor bank voltage exceeded the Overvoltage limit with the FET bridge enabled Clear: Bring capacitor voltage below the Overvoltage limit

25	(+) 5V Supply Failure	1) External load impedance on the +5V supply (pin 26) is too low 2) See Monitor menu >> outputs: 5 Volts and Ext Supply Current	Set: +5V supply (pin 26) outside the +5V +/- 10% range Clear: Bring voltage within range
28	Motor Temp Hot Cutback	1) Motor temperature is at or above the programmed Temperature Hot setting, and the requested current is being cut back 2) Motor Temperature Control Menu parameters are mis-tuned 3) See Monitor Menu >> Motor: Temperature and >> Inputs: Analog2 4) If the application doesn't use a motor thermistor, Temp Compensation and Temp Cutback should be programmed Off.	Set: Motor temperature is at or above the Temperature Hot parameter setting. Clear: Bring the motor temperature within range
29	Motor Temp Sensor Fault	1) Motor thermistor is not connected properly 2) If the application doesn't use a motor thermistor. Motor Temp Sensor Enable should be programmed OFF 3) See Monitor Menu >> Motor: Temperature and >> Inputs: Analog2	Set: Motor thermistor input (pin 8) is at the voltage rail (0 or 10V) Clear: Bring the motor thermistor input voltage within range
31	Coil1 Driver Open/Short	1) Open or short on driver load 2) Dirty connector pins 3) Bad crimps or faulty wiring	Set: Driver 1 (pin 6) is either open or shorted. This fault can be set only when Main Enable = OFF Clear: Correct open or short and cycle driver

31	Main Open/Short	1) Open or short on driver load 2) Dirty connector pins 3) Bad crimps or faulty wiring	Set: Main contactor driver (pin 6) is either open or shorted. This fault can be set only when Main Enable = ON Clear: Correct open or short, and cycle driver
36	Encoder Fault	1) Motor encoder failure 2) Bad crimps or faulty wiring 3) See Monitor menu >> Motor: Motor RPM	Set: Motor encoder phase failure detected. Clear: Cycle KSI
37	Motor Open	1) Motor phase is open 2) Bad crimps or faulty wiring	Set: Motor phase U, V or W detected open Clear: Cycle KSI
38	Main Contactor Welded	1) Main contactor tips are welded closed 2) Motor phase U or V is disconnected or open 3) An alternative voltage path (such as an external precharge resistor) is providing a current to the capacitor bank (B+ connection terminal)	Set: Just prior to the main contactor closing, the capacitor bank voltage (B+ connection terminal) was loaded for a short time and the voltage did not discharge Clear: Cycle KSI
39	Main Contactor Did Not Close	1) Main contactor did not close 2) Main contactor tips are oxidized, burned, or not making good contact 3) External load on capacitor bank (B+ connection terminal) that prevents capacitor bank from charging 4) Blown B+ fuse	Set: With the main contactor commanded closed, the capacitor bank voltage (B+ connection terminal) did not charge to B+ Clear: Cycle KSI

41	Throttle Wiper High	1) See Monitor Menu >> Inputs: Throttle Pot 2) Throttle pot wiper voltage too high	Set: Throttle pot wiper (pin 16) voltage is higher than the high fault threshold (can be changed with the VCL function <i>Setup_Pot_Faults()</i>) Clear: Bring throttle pot wiper charge below the fault threshold
42	Throttle Wiper Low	1) See Monitor Menu >> Inputs: Throttle Pot 2) Throttle pot wiper voltage too low	Set: Throttle pot wiper (pin 16) voltage is lower than the low fault threshold (can be changed with the VCL function <i>Setup_Pot_Faults()</i>) Clear: Bring throttle pot wiper charge above the fault threshold
43	Pot2 Wiper High	1) See Monitor Menu >> Inputs: Pot2 Raw 2) Pot2 wiper voltage too high	Set: Pot2 wiper (pin 17) voltage is higher than the high fault threshold (can be changed with the VCL function <i>Setup_Pot_Faults()</i>) Clear: Bring Pot2 wiper voltage below the fault threshold
44	Pot2 Wiper Low	1) See Monitor Menu >> Inputs: Pot2 Raw 2) Pot2 wiper voltage too low	Set: Pot2 wiper (pin 17) voltage is lower than the low fault threshold (can be changed with the VCL function <i>Setup_Pot_Faults()</i>) Clear: Bring Pot2 wiper voltage above the fault threshold
45	Pot Low Overcurrent	1) See Monitor Menu >> Outputs: Pot Low 2) Combined pot resistance connected to pot low is too low	Set: Pot low (pin 18) current exceeds 10mA Clear: Clear pot low overcurrent condition and cycle KSI

46	EEPROM Failure	1) Failure to write to EEPROM memory. This can be caused by EEPROM memory writes initiated by VCL, by the CAN bus, by adjusting parameters with the programmer, or by loading new software into the controller	Set: Controller operating system tried to write to EEPROM memory and failed. Clear: Download the correct software (OS) and matching parameter default settings into the controller and cycle KSI
49	Parameter Change Fault	1) This is a safely fault caused by a change in certain parameter settings so that the vehicle will not operate until KSI is cycled. For example, if a user changes the Throttle Type this fault will appear and require cycling KSI before the vehicle can operate.	Set: Adjustment of a parameter setting that requires cycling of KSI Clear: Cycle KSI
51	No CAN Communication from Primary	1) Broken wire in the CAN BUS wiring. 2) Faulty primary controller. 3) No power to primary controller	Set: Primary controller not powered. Broken wire on within the CAN BUS wiring harness. Faulty secondary controller. Clear: Check wiring and the fuse. Check the CAN BUS wiring for continuity. Replace the Primary controller.
52	Fault from Secondary	1) The secondary controller that is used in a dual motor configuration has a fault.	Set: Fault from Secondary Clear: Check and clear fault that exists on secondary controller

54	No CAN BUS traffic from Secondary controller	1) No power to secondary controller. 2) Broken wire in the CAN BUS wiring. 3) Faulty secondary controller.	Set: Secondary controller not powered. Broken wire on within the CAN BUS wiring harness. Faulty secondary controller. Clear: Check wiring and the fuse. Check the CAN BUS wiring for continuity. Replace the secondary controller.
55	BMS Communication Fault	1) Faulty BMS 2) Broken wire 3) No power to the BMS 4) CAN BUS isolation issue 5) Faulty motor controller	Set: BMS not communicating on the CAN BUS Clear: Check the BMS for functionality, replace bad wiring, restore power to the BMS, make sure that the CAN BUS is isolated from the vehicles ground, Replace the secondary controller.
56	Program Mode	1) The controller is in Program mode. This code is set to advise and is not an actual controller fault.	Set: Menu button was depressed when the keyswitch was turned to the ON position to enter program/diagnose mode. Clear: Cycle keyswitch.
57	Diagnostic Mode	1) The controller is in Diagnostic mode. This code is set to advise and is not an actual controller fault.	Set: Menu button was depressed when the keyswitch was turned to the ON position to enter program/diagnose mode. Clear: Cycle keyswitch.

58	Charger plugged in	1) The charger is plugged into the vehicle. This code is set to advise and is not an actual controller fault.	Set: The charger is plugged into the vehicle. Clear: Remove plug.
68	VCL Run Time Error	1) VCL code encountered a runtime VCL error 2) See Monitor Menu >> Controller: VCL Error Module and VCL Error. This error can then be compared to the runtime VCL module ID and error code definitions found in the specific OS system information file.	Set: Runtime VCL code error condition Clear: Edit VCL application software to fix this error condition; flash the new complied software and matching parameter defaults; cycle KSI
69	External Supply Out of Range	1) External load on the 5V and 12V supplies draws either too much or too little current 2) Fault Checking Menu parameters Ext Supply Max and Ext Supply Min are mis-tuned 3) See Monitor Menu >> Options: Ext Supply Current	Set: The external supply current (combined current used by the 5V supply [pin 26] and the 12V supply [pin 25]) is either greater than the upper current threshold or lower than the lower current threshold. Clear: Bring the external supply current within range

76	Insulation Resistance Low <i>Isolation monitor will open circuit its connection between the high power circuit and the vehicle chassis. Driving is still allowed.</i>	1. See Monitor menu » Battery: Insulation Resistance. 2. Insulation Resistance Fault threshold set too high. 3. Electrical fault path between high power battery terminals and chassis. 4. Insulation breakdown in motor. 5. Short circuit to chassis fault in high power system wiring. 6. Internal 1239E controller failure.	Set: Insulation Resistance dropped below Insulation Resistance Fault threshold. Clear: Remove insulation fault; cycle KSI.
93	Encoder LOS (Limited Operating Strategy)	1) Limited Operating Strategy (LOS) control mode has been activated, as a result of either an Encoder Fault (Code 36) or Stall Detect Fault (Code 73) 2) Motor encoder failure 3) Bad crimps or faulty wiring 4) Vehicle is stalled	Set: Encoder Fault (Code 36) or Stall Detect Fault (Code 73) was activated, and Brake or Interlock has been applied to activate LOS control mode, allowing limited motor control Clear: Cycle KSI, or if LOS mode was activated by the Stall Fault, clear by ensuring encoder senses proper operation, Motor RPM = 0 and Throttle Command = 0

Keywords

1. **Accel Rate:** sets the rate (in seconds) at which the motor torque increases to full when full throttle is applied. Larger values represent slower response.
2. **Baud rate:** a unit used to measure the speed of electronic code transmission, equal to one unit interval per second
3. **BMS:** Battery Management System
4. **Brake Current Limit:** Sets the maximum RMS regen current during braking when a brake command is given, as a percentage of the controller's full rated current. The full rated current depends on the controller model.
5. **Brake Maximum:** Defines the input voltage required to produce 100% braking torque. Decreasing the brake max setting reduces the amount of voltage necessary to produce full braking torque.
6. **Brake Type:** Defines the brake input for the controller:
 - a. **Type 0**= No Brake input used (Default)
 - b. **Type 1**= 3-wire pot or an electronic (includes transducer or hall sensor.)
 - c. **Type 2**= 2 wire 0 to 5k pot.
7. **CAN:** Controller Area Network. A vehicle bus standard designed to allow microcontrollers and devices to communicate with each other within a vehicle. All controllers on the CAN bus need to have the Baud Rate set the same.
8. **Creep Torque:** Determines the amount of torque applied to the vehicle at a stop with no throttle input, to emulate the feel of an automatic transmission automobile. WARNING! When interlock is engaged, creep torque allows vehicle propulsion if a direction is selected even though no throttle is applied. Care should be taken when setting up this parameter. If pedal braking is enabled, creep torque is progressively disabled as brake is applied so as to prevent the motor from driving into the brakes and thus wasting energy.
9. **Deadband:** is an area of a signal range or band where no action occurs (the system is dead).
10. **Diagnose Mode:** Mode for which the user can observe conditions of certain devices within the system to ascertain the cause or nature of a symptom.
11. **EncA & B:** two signals from the encoder for which the controller determines direction of rotation and speed of the motor.
12. **Field Weakening Rate:** Determines the control loop gains for field weakening. Setting the rate too low may create surging in the vehicle as it accelerates at mid

to high speeds. Setting the rate too high may create high frequency oscillations (usually audible) when the vehicle accelerates at mid to high speeds.

13. **Generic CAN Message:** CAN message containing general information regarding the status of the motor and controller.
14. **Idle Torque:** Torque load delivered by the motor at idle. If the Idle for the motor is enabled, idle torque will equal creep torque.
15. **Load Meter:** The LED lights that are located on the bottom of the Spyglass represent how much of a load is exerted on the system.
16. **Neutral Braking:** Neutral braking occurs progressively when the throttle is reduced toward the neutral position or when no direction is selected. The neutral braking parameter is adjustable from 0 to 100% of the regen current limit.
17. **Program Mode:** Mode for which the user can enter change parameter settings within the controller's software.
18. **Regenerative Braking:** Regenerative braking is used on electric vehicles to recoup some of the energy lost during stopping. This energy is saved to the batteries and used later to power the motor to put the car in motion.
19. **SOC:** State of charge.
20. **Spyglass:** Name given by Curtis Instruments to the 8 segment LCD, 5-LED display.
21. **Throttle Maximum:** Defines the input voltage required to produce 100% controller output. Decreasing the throttle max setting reduces the amount of voltage necessary to produce full controller output.
22. **Throttle Type:** Defines the throttle input for the controller:
 - a. **Type 1**= Electronic throttle (NO switch, 0-5 volt).
 - b. **Type 2**= 0-5K ohm 2 wire pot with switch.
 - c. **Type 3**= 5K ohm 3-wire pot with switch.

Orion BMS Custom Messages for use with HPEVS

		ADDRESS ID	
		0x300	0x301
Length in bytes		8	8
Byte0		Low Cell Voltage	Pack SOC
Byte1		Low Cell Voltage High Byte	High Temperature
Byte2		High Cell Voltage	Low Temperature
Byte3		High Cell Voltage High Byte	12v Supply
Byte4		Pack Current	12v Supply High Byte
Byte5		Pack Current High Byte	*Custom Flag
Byte6		Pack Amphours	n/a
Byte7		Pack Amphours High Byte	n/a

*Custom Flag	
Bit #1	Charge Interlock
Bit #2	DTC: Internal Comm Fault
Bit #3	DTC: Low Cell Voltage Fault
Bit #4	DTC: Current Sensor Fault
Bit #5	DTC: Internal Memory Fault
Bit #6	DTC: Internal Logic Fault
Bit #7	DTC: High Voltage Isolation Fault
Bit #8	Error (Mil) Output

Notes:

CAN Bus Baud rate	Message setting transmit speed for mailboxes 0x300 and 0x301	byte order
250 kbps	104 ms	Big Endian

Address 0x300	
Byte0:	low cell voltage set by multiply by 1 then divide by 10
Byte1:	low cell voltage high byte
Byte2:	high cell voltage set by multiply by 1 then divide by 10
Byte3:	high cell voltage high byte
Byte4:	Pack current set by multiplying by 1 then divide by 1; signed value
Byte5:	Pack current high byte
Byte6:	Pack Amphours set by multiplying by 1 then divide by 1
Byte7:	Pack Amphours high byte

Address 0x301	
Byte0:	Pack SOC value set by multiplying by 1 then divide by 2
Byte1:	High Temperature set by multiplying by 1 then divide by 1
Byte2:	Low Temperature set by multiplying by 1 then divide by 1
Byte3:	12 volt supply set by multiplying by 1 then divide by 1
Byte4:	12 volt supply, high byte.
Byte5:	Custom Flag #2
Byte6:	not used
Byte7:	not used

Secondary Controller

Scope: Just like the primary controller the secondary controller will have new generic software that allows for programming of the Curtis controller utilizing the Spyglass. Unlike the primary controller, the secondary controller only has a couple of settings that need to be adjusted to allow for communication to the primary controller, or if the user has a second gauge that needs a tachometer signal, the secondary controller can provide that signal. The motor kit when installed will be drivable, but the following instructions allow for tuning. Some adjustments may be required before operating the vehicle the first time.

Instructions for Secondary Program and Diagnose Modes

- 1) Have the vehicle turned off.
- 2) Press and hold the menu button for the primary controller.
- 3) While holding down the menu button, turn the vehicle's ignition switch to ON.
- 4) While holding the menu button down, the Spyglass will state "Ready". Once you release the menu button, you will have the opportunity to toggle between "Program" and "Diagnose".
- 5) If you want to enter into the "Program" mode, leave the word "Program" on the Spyglass, and after 5 seconds the Spyglass will change to "Rdy Prog". At this point the controller is ready for programming.
- 6) Likewise, if you want to enter the diagnostic mode, toggle the menu button so that the word "Diagnose" is displayed on the Spyglass. After 5 seconds the Spyglass will change to "Rdy Diag".

Secondary Program Mode

Program Mode Instructions

- 1) After entering the “Program” mode, “Rdy Prog” will be displayed.
- 2) From here, you can navigate to the one main menu using the menu button but keep in mind that you have a few seconds to make your selection before the software enters the menu item displayed on the Spyglass. The two main menu items are as follows:
 - a) Baud Tac

Baud Tac

- 1) Press the menu button once to display the programmable menu item; in this case, “Baud Tac”. If you do nothing else with the menu button, the Spyglass will display the first programmable selection for the “Baud Tac” menu which is Baud rate of the controller. “BR Kbs” (CAN bus baud rate)

CAN BUS Baud Rate

- 1) The baud rate of the CAN bus can be changed in this section. When the Spyglass displays “BR Kbs”, the baud rate can be changed.
- 2) The default baud rate is set to 250 Kbs. The available selections are 125 Kbs, 250 Kbs and 500 Kbs. The factory baud rate setting for the Orion BMS is set to 250 Kbs.
- 3) Press the menu button to toggle the change between the three available selections.
- 4) If a change to the baud rate is not needed, wait 5 seconds and the program will then toggle to the next programmable function. (Tach frequency set-up)

Tachometer Frequency Set-Up

- 1) Tachometer frequency allows the user to set-up the vehicles tachometer to work correctly based on the number of cylinders the original internal combustion engine had that was removed from the vehicle. NOTE: This set-up will only work for digitally controlled tachometers and may or may not work with tachometers that use pulses from a distributor. **Optional Isolation module** required.
- 2) The following set-up parameters are the target frequency levels:
 - a) **4 cylinder engine= 266 Hz** (Default)
 - b) **6 cylinder engine= 400 Hz**
 - c) **8 cylinder engine= 532 Hz**
- 3) If the frequency output has already been set or does not need to be changed, wait 5 seconds and the program will then toggle to the next programmable function or the header of ("**Baud Tac**"); otherwise...
- 4) When this parameter is available to change, the Spyglass will display the following: (**T>xHz**); where x= a value between 0 and 3999. Use the menu button to adjust the value to the desired level. This process will INCREASE the value by 1.
- 5) Adjusting the value is done by pressing the menu button. Holding down the menu button will increment the number as well. After adjusting the parameter, wait 5 seconds and the program will then toggle to the next menu item allowing for a decrease in the value (**T<xHz**).
- 6) The program will allow you to decrease the frequency if you need to for any reason. The Spyglass will display (**T<xHz**); where x= a value between 0 and 3999. Use the menu button to adjust the value to the desired level. This process will DECREASE the value by 1.
- 7) After the parameter is set to the desired value, release the menu button.

SAVE

- 1) After the changes have been made, the Spyglass will ask if you want to "**Save?**" the changes. If the parameters were set incorrectly, while the "**Save?**" is displayed do NOT press the menu button. The program will then cycle to the

top of the menu, which in this case is “Baud Tac” and you can start from the beginning. All the changes that were made will be ignored until the changes are saved.

- 2) To save the new parameters while the “Save?” is displayed, press the menu button and the new parameters will be saved.
- 3) After which the Spyglass will ask you to “Release” the menu button.
- 4) Release the menu button.
- 5) Then the Spyglass will instruct you to “Turn OFF” the system by turning the key switch to the off position.
- 6) To exit the program menu, cycle the key switch from on to off, then turn the key switch back on to return to a run mode.

Program Mode Quick Reference

- 1) **Baud Tac**
 - a) **BR Kbs** (Adjusts Baud Rate of CAN communication. 125KBAUD, 250KBAUD, 500KBAUD)
 - b) **T> Hz** (Increases Tach Frequency Hz)
 - c) **T< Hz** (Decreases Tach Frequency Hz)
 - d) **Save?** (Hold the menu button down, writes the new parameters to the controller)
 - e) **Release** (Release the menu button)
 - f) **Turn Off** (Turn the key switch of the vehicle to off)

[illegible]

This image shows a blank sheet of white paper with horizontal ruling lines. The lines are evenly spaced and run across the width of the page. There are no margins, text, or other markings on the paper.

Secondary Diagnostic Mode

Diagnostic Mode Instructions

- 1) After entering the “Diagnose” mode, “Rdy Diag” will be displayed.
- 2) From here, you can navigate to the five main menus using the menu button but keep in mind that you have a few seconds to make your selection before the software enters the menu item displayed on the Spyglass. The five main menu items are as follows:
 - a) Throttle
 - b) Brake
 - c) Motor
 - d) Power
 - e) Controller

Throttle

- 1) Press the menu button once to view the first diagnostic level, throttle. “Throttle” will be displayed when this menu item is active. Once the Spyglass displays “Throttle”, wait 5 seconds and the Spyglass will toggle to the next menu item that displays the state of the throttle switch. The user will be able to verify settings, throttle switch state and pot voltage.

Throttle Switch ON/OFF

Active only with Throttle Types 2 & 3.

- 1) “Sw ON” will display on the Spyglass if the throttle switch has been tripped and is active.
- 2) Likewise, if the switch is not tripped or is NOT functioning correctly when the throttle is depressed, “Sw OFF” will be displayed.
- 3) Press the menu button once and the next diagnostic level in the throttle menu will be displayed which is the CAN BUS throttle signal.

Throttle Signal

- 1) The Spyglass will display “TSigxxx%” when active; where x= CAN BUS throttle signal percentage from the primary controller.
- 2) With this display active on the Spyglass, press the throttle pedal and the Spyglass will display CAN BUS throttle signal percentage from the primary controller.
- 3) Once the CAN BUS throttle signal has been verified, press the menu button once to toggle back to the top of “Throttle” level.
- 4) To toggle to the next level which is “Brake”, press the menu once more while the Spyglass is displaying “Throttle”.

Brake

- 1) Press the menu button twice to view the second diagnostic level, “Brake”. Brake will be displayed when this menu item is active. The user will be able to verify that the CAN BUS signal for the brake is active.
- 2) Once the Spyglass displays “Brake”, wait 5 seconds and the Spyglass will toggle to the menu item that displays the CAN BUS signal that the secondary controller receives from the primary controller.

Brake Signal

- 1) The Spyglass will display “BSigxxx%” when active; where x=CAN BUS brake signal percentage from the primary controller.
- 2) With this display active on the Spyglass, press the throttle pedal and the Spyglass will display CAN BUS brake signal percentage from the primary controller.
- 3) Once the CAN BUS brake signal has been verified, press the menu button once to toggle back to the top of “Brake” level.
- 4) To toggle to the next level which is “Motor”, press the menu once more while the Spyglass is displaying “Brake”.

Motor

- 1) Press the menu button three times to view the third diagnostic level, motor. “Motor” will be displayed on the Spyglass when this menu item is active. The motor information that will be displayed is the motor RPM, verification that both channels from the encoder are working correctly and the motor temperature.
- 2) Once the Spyglass displays “Motor”, wait 5 seconds and the display will toggle to the next menu item that displays motor RPM (“RPMxxxx”).

RPM

- 1) The first item that the Spyglass will display will be the motor RPM. The Spyglass will display (“RPMxxxx”); where x = a RPM value.
- 2) This diagnostic tool can be used to verify that the encoder is reading the motor RPM.
- 3) Press the menu button to increment to the next level which is to view the signal from encoder A (“EncA”).

EncA

- 1) The first channel on the encoder is encoder A (“EncA”) is one of the channels that are used. The value that will be displayed as (“EncAxxxx”); where x= a RPM value.
- 2) The diagnostic tool can be used to verify that this channel is reading the motor RPM correctly.
- 3) Press the menu button to increment to the next level in the menu which is view the signal from encoder B (“EncB”).

EncB

- 1) The second channel on the encoder is encoder B (“EncB”). The value that will be displayed as (“EncBxxxx”); where x= a RPM value.
- 2) This diagnostic tool can be used to verify that this channel is reading the motor RPM correctly.

- 3) Press the menu button to increment to the next level in the menu which is viewing the motor temperature ("Temp").

Motor Temperature

- 5) The last menu item within the ("Motor") portion of the diagnostic mode is motor temperature ("Temp").
- 6) The Spyglass will display the motor temperature as ("Tempxxx°C"); where x = a temperature value. The temperature will be displayed in Celsius.
- 7) Once the motor temperature has been viewed, press the menu button once to toggle back to the top of "Motor" level.
- 8) To toggle to the last level which is power ("Power"), press the menu button once more while the Spyglass is displaying "Motor".

Power

- 1) The next main menu item in Diagnostic Mode is ("Power") of the system. This section will display Keyswitch voltage, capacitor voltage, the state of the main contactor and finally the RMS current of the controller.

Keyswitch Voltage

- 1) The first item to be displayed within the power section is for the key switch voltage ("KSI").
- 2) The Spyglass will display ("KSIxxx"); where x = a voltage value.
- 3) This diagnostic tool can be used to verify the state of the battery voltage at the keyswitch.
- 4) The next menu to be displayed is capacitor voltage ("Cap"). Press the menu button to increment.

Capacitor Voltage

- 1) The second menu item to be displayed within the power section is for the capacitor voltage ("CAP").
- 2) The Spyglass will display ("CAPxxx"); where x = a voltage value.
- 3) This diagnostic tool can be used to verify the state of the capacitor voltage of the controller's internal capacitor bank at the B+ terminal.
- 4) The next menu item to be displayed checks the main state of the contactor ("Main"). Press the menu button to increment.

Main State

- 1) The third item to be displayed within the power section is the state of the main contactor ("Main x"); where x = the state of the contactor.
- 2) The main contactor state is defined by the following:
 - a) 0 = open
 - b) 1 = precharge
 - c) 2 = weldcheck
 - d) 3 = closingdelay
 - e) 4 = missingcheck
 - f) 5 = closed (Normal Operation)
 - g) 6 = delay
 - h) 7 = arccheck
 - i) 8 = opendelay
 - j) 9 = fault
 - k) 10= closed (when Main Enable = Off)
- 3) The last menu item to be displayed is the controllers current ("RMS"). Press the menu button to increment.

Controller Current (RMS)

- 1) To view the RMS current of the controller ("RMS") will be displayed on the Spyglass.
- 2) The Spyglass will display ("RMS xxx"); where x = a numerical value for the AC current from the controller to the motor.
- 3) Once the controller current has been viewed, press the menu button once to toggle back to the top of "Power" level.
- 4) To toggle to the last level which is controller ("Cntrlr"), press the menu once more while the Spyglass is displaying "Power".

Controller

- 1) The last of the five main menu items in Diagnostic Mode is for the controller ("Cntrlr").
- 2) This section of software will display the conditions of the controller.
- 3) Once the Spyglass displays "Cntrlr", wait 5 seconds and the Spyglass will toggle to the next menu item that displays the controller temperature.

Controller Temperature

- 1) The first menu item to be displayed is the controller temperature.
- 2) The Spyglass will display (TempxxxC); where x= a temperature value. The temperature will be displayed in Celsius.
- 3) The next menu item to view is the operating system (OS xx) that is installed in controller. Press the menu button to increment.

Operating System

- 1) The second menu item to be displayed is the operating system that is installed into the controller.
- 2) The Spyglass will display (OS xx); where x = a numerical value.
- 3) The next menu item to view is the build number (Build xx) that is installed in controller. Press the menu button to increment.

Build Number

- 1) The third menu item to be displayed is the build number that is installed into the controller.
- 2) The Spyglass will display (**Build xx**); where x = a numerical value.
- 3) The next menu item to view is the VCL version (**Ver xxxP**) that is installed in controller. Press the menu button to increment.

VCL Version

- 1) The fourth menu item to be displayed is the VCL version number that is installed into the controller.
- 2) The Spyglass will display (**Ver xxxP**); where x = a numerical value. The value of “P” refers to the primary controller.
- 3) The next menu item to view is the manufactured date code (**D/C xxx**). Press the menu button to increment.

Date Code

- 1) The fifth menu item to be displayed is the date code of the controller.
- 2) The Spyglass will display (**D/C xxx**); where x= a numerical value. The date code is the date that the controller was manufactured.
- 3) The last menu item to view is the serial number of the controller. Press the menu button to increment.

Serial Number

- 1) The final menu item to be displayed is the serial number of the controller.
- 2) The Spyglass will display (**S/N xxx**) where x = a numerical value. The serial number is assigned by the manufacturer.
- 3) To exit the diagnostic menu, cycle the key switch from on to off, then turn the key switch back on to return to a run mode.

Diagnostic Mode Quick Reference

In Diagnostic mode, you will be allowed to verify functionality of the system, verify settings of the controller as well as pertinent controller information. The following list is the menu items for Diagnostic Mode:

- 1) **Throttle**
 - a) **Sw OFF** (The throttle switch is deactivated, Throttle Types 2 & 3 only)
 - b) **Sw ON** (The throttle switch is activated, Throttle Types 2 & 3 only)
 - c) **TPot** (Checks and displays throttle pot wiper voltage. As the throttle is depressed, the voltage displayed will increase)
 - d) **TMax** (Displays throttle max setting parameter)
- 2) **Brake** (Only if equipped with brake pot or pressure transducer)
 - a) **BMax** (Checks and displays brake input voltage. As the brake is pressed, the voltage displayed will increase)
 - b) **BDB** (Displays brake deadband)
 - c) **BMax** (Displays brake max setting)
- 3) **Motor**
 - a) **RPM** (Displays motors current speed in RPM)
 - b) **EncA** (Displays Encoder A signal)
 - c) **EncB** (Displays Encoder B signal)
 - d) **Temp C** (Displays motor temperature in Celsius)
- 4) **Power**
 - a) **KSI** (Displays the current key switch voltage)
 - b) **Cap** (Capacitor voltage)
 - c) **Main** (displays the state of the main contactor 0=open, 1=precharge, 2=weldcheck, 3=closingdelay, 4=missingcheck, 5=closed (when Main Enable = ON, 6=delay, 7=arccheck, 8=opendelay, 9=fault, 10=closed (when Main Enable=OFF)
 - d) **RMS** (RMS current of the controller, taking all three phases into account.)
- 5) **Controller** (Controller)
 - a) **Temp** (Displays controller temperature)
 - b) **OS** (Displays operating system version)

- c) **Build** (Displays build number of the operating system software that is loaded into the controller. This variable specifies the minor version number of the controller's operating system)
- d) **Ver** (Version number of the VCL application software that is loaded into the controller)
- e) **D/C** (Date code: Displays the controller manufacture date code)
- f) **S/N** (Displays the controller serial number from the manufacturer)

[illegible]

This image shows a blank sheet of white paper with horizontal ruling lines. The lines are evenly spaced and run across the width of the page. There are no margins, text, or other markings on the paper.