

Hi Performance Electric Vehicle Systems

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## Electrical Schematics and Documentation

FOR CURTIS 1232-1238 "E" AND "SE" VERSION

## CONTROLLERS

## **SOFTWARE VERSIONS 5.30 AND HIGHER**

## FOR SINGLE AND DUAL MOTOR

## **APPLICATIONS**

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## QUICK START GENERIC ELECTRICAL SCHEMATICS 1232-1238 "E" and "SE" CONTROLLERS

The following quick start electrical schematics for both single and dual motor configurations have been generated to assist in quickly getting the drive system connected and running.



Quick Start Electrical Schematic Generic 530 Software Pin Out Specific for 1232-1238 "E" AND "SE" Controllers Single Motor or Primary in Dual Motor Applications

Pin	Name	Function	Terminations	Wire color	Detailed Description		
#							
1	KSI	Keyswitch_Input			Keyswitch input. Provides logic power for the		
				Blue	controller and power for the coil drivers.		
6	Driver 1	Main_Contactor		Orange/White	Main Contactor Coil Driver.		
9	Switch 3	Accel_Switch_Input			Used as safety interlock; switch is open when		
			Active high, connect to 12	Active high, connect to 12	Active high, connect to 12	Green	throttle switch is released. Type 2 & 3 throttle
			volt. See Schematic.		only.		
13	Coil Return	Coil Return	Common to all	Blue/White	This is the coil return pin (at B+ potential) for all		
			relay coils		the contactor and relay coils.		
16	Throttle Pot Wiper	Pot Wiper		Yellow/White	Wiper or throttle input.		
22	Switch 7	Forward_Switch_Input		W/bito	Used by the Motor Control to select forward		
			Active high, connect to 12	white	direction		
			volt. See Schematic.				
25	+12V Out			Red/Blue	Unregulated low power +12V output.		
33	Switch 8	Reverse_Switch_Input	Active high connect to 12		Used by the Motor Control to select reverse		
			volt. See Schematic.	Yellow	direction		
			1				



Qui	Quick Start Electrical Schematic Generic Software Pin Out Specific for 1232-1238 "E" AND "SE" Secondary Controller in Dual Motor Applications								
Din #	Din # Name Eurotian Terminations Wire color Detailed Description								
FIII #	Name	Function	Terminations	wire color					
1	KSI	Keyswitch_Input		Blue	Keyswitch input. Provides logic power for the controller and power for the coil drivers. Connect to primary harness at the Blue KSI wire.				
6	Driver 1	Main_Contactor		Orange/White	Main Contactor Coil Driver.				
13	Coil Return	Coil Return	Common to all relay coils	Blue/White	This is the coil return pin (at B+ potential) for all the contactor and relay coils.				

# FULL ELECTRICAL SCHEMATICS CURTIS 1232-1238 "E" AND "SE" CONTROLLERS



	Generic Software 530 Switch Pin Out Specific for for 1232-1238 "E" AND "SE" Single Motor or Primary in Dual Motor Applications						
Pin #	Name	Function	Terminations	Wire color	Detailed Description		
1	KSI	Keyswitch_Input		Blue	Keyswitch input. Provides logic power for the controller and power for the coil drivers.		
2	Prop. Driver	Tachometer Driver		Orange/Black	Digital output used to drive a tachometer		
3	Driver 4	Brake Light Relay		Orange/Red	Brake light relay driver		
4	N/C						
5	Switch 10	Clutch/Shift Switch		Brown	Switch input is used to reduce neutral braking while shifting		
6	Driver 1	Main_Contactor		Orange/White	Main Contactor Coil Driver.		
7	I/O Ground			Black/Blue	Input and output ground reference.		
8	Analog 2	Motor_Temperature_Sensor		Blue	Used as the motor temperature analog input		
9	Switch 3	Accel_Switch_Input	Active high, connect to 12 volts. See schematic	Green	Used as safety interlock; switch is open when throttle switch is released. Type 2 & 3 throttle only.		
			Active high, connect to 12				
10	Menu	Menu_Button	volts. See schematic	White/Red	Momentary switch: used to scroll through 840 spyglass display		
			Active high, connect to 12		Momentary switch: Enables drive system when Idle function is turned		
11	Switch 5	Start_Switch_Input	volts. See schematic	White/Blue	ON.		
12	Switch 6	Economy Mode Switch Input		Purple	Switch input used to activate Economy Mode.		
13	Coil Return	Coil Return	Common to all relay coils	Blue/White	This is the coil return pin (at B+ potential) for all the contactor and relay coils.		
14	Brake Switch Input	Brake Sw		White/Black	Switch input used for brake rate. USED IN VER 36506 AND UP		
15	Throttle Pot High	Pot High		Black/White	Pot high connection for a 3-wire throttle pot.		
16	Throttle Pot Wiper	Pot Wiper		Yellow/White	Wiper or throttle input.		
17	Pot2 Wiper	Brake Pot Wiper		Yellow/Red	Brake input.		
18	Pot Low	Pot Low		Purple/White	Pot low connection for brake and throttle.		
19	N/C						
20	N/C						
21	CAN Term H	CAN Termination		Black	CAN termination jumper.		
22	Switch 7	Forward_Switch_Input	Active high, connect to 12 volt. See Schematic.	White	Used by the Motor Control to select forward direction		
23	CANH	CAN High		Orange	CAN bus high.		
24	N/C						
25	+12V Out			Red/Blue	Unregulated low power +12V output.		
26	+5V Out			Red/White	Regulated low power +5V output.		
27	N/C						
28	Serial TX			White	Serial transmit line for display or flash update.		
29	Serial RX			Green	Serial receive line for display or flash update.		
30	N/C						
31	Encoder Phase A	MotorspeedA_Input		White	Quadrature encoder input phase A		
32	Encoder Phase B	MotorspeedB_Input		Green	Quadrature encoder input phase B		
33	Switch 8	Reverse_Switch_Input	Active high, connect to 12 volt. See Schematic.	Yellow	Used by the Motor Control to select reverse direction		
34	CAN Term I	CAN Termination		Black	CAN hus termination jumper.		
35	CANI	CAN Low		Grev	CAN bus low.		
	0,	0.0.1000					



	Generic Software 530 Switch Pin Out Specific for for 1232-1238 "E" AND "SE" Secondary Controller in Dual Motor Applications							
Pin #	Name	Function	Terminations	Wire color	Detailed Description			
1	KSI	Keyswitch_Input		Blue	Keyswitch input. Provides logic power for the controller and power for the coil drivers. Connect to primary harness at the Blue KSI wire.			
2	N/C							
3	N/C							
4	N/C							
5	N/C							
6	Driver 1	Main_Contactor		Orange/White	Main Contactor Coil Driver.			
7	I/O Ground			Black	Input and output ground reference.			
8	Analog 2	Motor_Temperature_Sensor		Blue	Used as the motor temperature analog input			
9	N/C							
10	N/C							
11	N/C							
12	N/C							
13	Coil Return	Coil Return	Common to all relay coils	Blue/White	This is the coil return pin (at B+ potential) for all the contactor and relay coils.			
14	N/C							
15	N/C							
16	N/C							
17	N/C							
18	N/C							
19	N/C							
20	N/C							
21	CAN Term H	CAN Termination		Black	CAN termination jumper.			
22	N/C							
23	CANH	CAN High		Orange	CAN bus high.			
24	N/C							
25	+12V Out			Red/Blue	Unregulated low power +12V output.			
26	+5V Out			Red	Regulated low power +5V output.			
27	N/C							
28	Serial TX			White	Serial transmit line for display or flash update.			
29	Serial RX			Green	Serial receive line for display or flash update.			
30	N/C							
31	Encoder Phase A	MotorspeedA_Input		White	Quadrature encoder input phase A			
32	Encoder Phase B	MotorspeedB_Input		Green	Quadrature encoder input phase B			
33	N/C							
34	CAN Term L	CAN Termination		Black	CAN bus termination jumper.			
35	CANL	CAN Low		Grey	CAN bus low.			

### THROTTLE CONFIGURATION

Depending on the type of throttle used for the application, the different types of throttle configurations are listed within the table below. Electrical schematics are also included within the following pages.

THROTTLE CONFIGURATION	ТҮРЕ
ELECTRONIC without SWITCH CURTIS ET-126/ET-134 ELECTRONIC THROTTLE ASSEMBLY without SWITCH	TYPE 1
2 WIRE with SWITCH 0-5k $\Omega$	TYPE 2
3 WIRE with SWITCH 0-5k $\Omega$	TYPE 3 Default
CURTIS PB8 THROTTLE ASSEMBLY	TYPE 3
CURTIS ET-126/ET-134 ELECTRONIC THROTTLE ASSEMBLY WITH SWITCH	TYPE 3













#### THROTTLE INTERLOCK CONNECTION

The throttle interlock connection is required for both 2 and 3 wire throttle pot assemblies. The Green wire is connected to the Normally Closed tab. The red/blue wire is connected to the common tab. See picture below.

NOTE: when the throttle <u>IS ENGAGED</u> the interlock switch is released to its <u>NORMAL</u> position (switch not activated) thus completing the circuit since its green wire is connected to the normally closed (NC) connection.



#### BRAKE INPUT CONFIGURATION

Depending on the type of brake input used for the application, the different types of brake input configurations are listed in the table below. Electrical schematics are also included within the following pages.

BRAKE INPUT CONFIGURATION	ТҮРЕ
PRESSURE TRANSDUCER/ ELECTRONIC 0-5V INPUT or 3-WIRE POT	TYPE 2
2 WIRE 0-5k Ω POT	TYPE 3
SWITCH	TYPE 5





### OPTIONAL ACTIVE BRAKE LIGHT CONFIGURATIONS

These optional brake light configurations are used to activate the brake lights during regenerative braking or when the vehicle brakes are applied. Based on the brake type configuration that is being utilized in the application, use one of the following wiring configurations.











Program Entries Generic 530 (Parameters)									
Level 1	Parameter	Level 2	Parameter	Units	Parameter Range	Default Setting	Notes		
User Settings									
		Speed Settings				1			
			Forward Speed	RPM	200 to 8500	6500	Defines the maximum requested motor rpm at full throttle with forward selected.		
			Reverse Speed	RPM	200 to 8500	6500	Defines the maximum requested motor rpm at full throttle with reverse selected.		
			Econo Speed	RPM	200 to 8500	6500	Defines the maximum requested motor rpm at full throttle with econo mode on.		
		Accel Rates							
			Normal Accel Rate	Seconds	0.1 to 5.0	0.4	Sets the rate (in seconds) at which the speed command increases when throttle is applied. Larger values represent slower response.		
			Econo Accel Rate	Seconds	0.1 to 5.0	0.5	Sets the rate (in seconds) at which the speed command increases in econo mode when throttle is applied. Larger values represent slower response.		
		Throttle Settings							
			Throttle Type	N/A	1 to 3	3	The Curtis controllers accept a variety of throttle inputs. The throttle type parameter can be programmed as follows: 1= Electronic throttle (NO switch, 0-5 volt). 2: 2-wire rheostat, 0–5kΩ input 3: single-ended 3-wire 0-5kΩ potentiometer, or 0–5V voltage source or Electronic (Default)		
			Deadband	Volt	0.00 to 5.00	.30	Defines the wiper voltage at the throttle deadband threshold. Increasing		
			Throttle Max	Volt	0.00 to 5.00	3.5	Defines the wiper voltage required to produce 100% controller output. Decreasing the throttle max setting reduces the wiper voltage and therefore the full stroke necessary to produce full controller output.		
			Mapped Throttle	%	0 to 100	50	Modifies the vehicle's response to the throttle input. Setting the throttle map at 50% provides a linear output response to throttle position. Values below 50% reduce the controller output at low throttle settings, providing enhanced slow speed maneuverability. Values above 50% give the vehicle a faster, more responsive feel at low throttle settings.		
		Brake Pedal Settings							
			Brake Type		0 to 3	0	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. d) Type 3= Switch		
			Brake Deadband	Volt	0.00 to 5.00	0.30	Defines the wiper voltage at the brake deadband threshold. Increasing the brake deadband setting will increase the neutral range		
			Brake Max	Volt	0.00 to 5.00	3.50	Defines the wiper voltage required to produce 100% controller output. Decreasing the brake max setting reduces the wiper voltage and therefore the full stroke necessary to produce full controller output.		
			Regen Brake Light Threshold	AMP	0 to 400	50	Allows for turning on the brake lamp based on the amount of regenerative braking that is taking place when off of the throttle. A higher number to this parameter means that there has to be a high amount of regen to be taking place to turn on the brake lamp		
		Current Limits							
			Normal Neutral Braking	%	0 to 100	15	This parameter will allow for adjustment to Neutral Braking.		
			Econo Neutral Braking	%	0 to 100	25	This parameter will allow for adjustment to Neutral Braking in economy mode.		
			Shift Neutral Braking	%	0 to 100	7	Adjustment to neutral braking while pressing the clutch to shift a manual transmission		
			Normal Drive Current Limit	%	5 to 100	100	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.		
			Econo Drive Current Limit	%	5 to 100	60	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.		
			Brake Current Limit	%	5 to 100	10	Sets the maximum RMS regen current during braking when a brake command is given, as a percentage of the controller's full rated current. Typically the brake current limit is set equal to the regen current limit. The brake current limit overrides the regen current limit when the brake input is active.		

Level 1	Parameter	Level 2	Parameter	Units	Parameter Range	Default Setting	Notes
		Idle Setup		•			• •
			Idle Enable		On/Off	Off	on = motor idle will be turned on
			Clutch Start Enable		On/Off	Off	Enables clutch switch so that clutch needs to be depressed to start vehicle
			Idle Speed	RPM	300 to 1000	600	motor idle speed
			Idle Torque	%	0 to 100	50	percentage of available torque at idle speed
			Creep Torque	%	0 to 100	0	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
		Motor Tuning		I	1	1	
			Motor Type		9 to 77	Based on motor type	Input motor type
			Base Speed	RPM	200 to 6000	3500	The speed set point for which the motor goes into field weakening.
			Field Weakening	%	0 to 100	50	Determines the amount of high speed power the controller will allow, while still maintaining maximum effficiency at the allowed power. Reducing this parameter effectively reduces controller current at high speeds, which can reduce energy consumption and motor heating, but at the expense of reduced available torque from the motor.
			Econo Field Weakening	%	0 to 100	0	Determines the amount of high speed power the controller will allow while in econo mode, while still maintaining maximum efficiency at the allowed power. Reducing this parameter effectively reduces controller current at high speeds, which can reduce energy consumption and motor heating, but at the expense of reduced available torque from the motor.
			Weakening Rate	%	0 to 100	36	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.
		Main Contactor					
			Main Contactor Voltage	Volt	12 to 96	24	Main contactor voltage that is used in the system
			Main Holding %	%	0 to 100	80	The main contactor holding voltage parameter allows a reduced average voltage to be applied to the contactor coil once it has closed. This parameter must be set high enough to hold the contactor closed
		Display Menu Items					
			Auto Scroll	N/A	On/Off	Off	Turn on auto scroll function on 840 display to show monitored items listed below
			Scroll Delay Time	Seconds	1 to 10	4	Time that delays scroll function displaying the menu items below on the Spyglass 840
			Display SOC	N/A	On/Off	Off	When turned on the State Of Charge (SOC) of battery pack will be displayed. Acuity required.
			Display Motor RPM	N/A	On/Off	On	When turned on the Motor RPM will be displayed
			Display Battery Amps	N/A	On/Off	On	When turned on, battery pack current will be displayed
			Display Voltage	N/A	On/Off	On	When turned on, battery pack voltage will be displayed
			Display Motor Temp	N/A	On/Off	On	When turned on, motor temperature will be displayed
			Display Controller Temp	N/A	On/Off	On	When turned on, controller temperature will be displayed
			Display Minimum Voltage	N/A	On/Off	On	When turned on, minimum voltage during operation will be displayed
			Display Maximum Current	N/A	On/Off	On	When turned on, maximum current during operation will be displayed
		BMS			•		•
			BMS Installed		On/Off	Off	When on can be used with Orion BMS. BMS must have CAN messages configured.
			BMS Address		768 to 1536	768	BMS Address range in decimal. Hex range = 0x300 to 0x600
			User Undervoltage	%	50 to 90	80	The value of this parameter is a percentage of the Nominal Voltage setting. The User Undervoltage parameter can be used to adjust the undervoltage threshold, which is the voltage at which the controller will cut back drive current to prevent damage to the electrical system.
			Low Cell Begin Cutback	Volt	0.000 to 4.000	2.800	Low cell cutback begin sets the voltage of the lowest cell where current limiting will begin
			Low Cell Full Cutback	Volt	0.000 to 4.000	2.300	Low Cell Full Cutback parameter sets the voltage of the lowest cell where full current limiting is in force
			Max Current at Full Cutback	%	0 to 100	50	Maximum Current Full Cutback parameter sets the maximum current allowed when low voltage full cutback is in force
			Maximum Cell Voltage	Volt	2.000 to 4.000	3.700	Maximum cell voltage parameter sets the voltage at which regen is turned off to prevent overcharging
			Low SOC Cutback	%	0 to 100	20	Low SOC (State of Charge) Cutback parameter sets the SOC at which current limiting is in force
			Max Current at Low	%	0 to 100	30	Maximum Current Low SOC (State of Charge) parameter sets the maximum current allowed when SOC is lower
	L		SOC	1			Itnan Low SUC Cutback

Level 1	Parameter	Level 2	Parameter	Units	Parameter Range	Default Setting	Notes
		Dual Drive					
			Dual Drive Mode		On/Off	Based on using either single motor or dual motor	This parameter turns dual drive off or on. Turn on for a dual motor.
			Response Timeout	ms	50 to 1000	200	Time alloted for the secondary controller(s) to respond to the primary controller
		Misc					
			Max Output Frequency	Hz	0 to 4000	266	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
			Prg Mode Step Timer	Seconds	1.0 to 10.0	4.0	The time in seconds that the program steps through program mode.
			Generic CAN Message ID Dec		1537 to 1616	1537	CAN ID that the controller transmits. Hex range = 0x601 to 0x650
		Software Version					
			VCL Version		0 to 32767	Based on VCL software version	Software Version
			OS Version		0 to 32767	Based on Operating system installed	Version number of the operating system software that is loaded into the controller. This variable specifies the major version number of the controller's operating system.
			OS Build Number		0 to 32767	Based on software OS Build system	Build number of the operating system software that is loaded into the controller.

Generic 530 Software Monitor Items						
Level 1	Parameter	Level 2	Parameter	Units	Parameter Range	Notes
Dual Drive						
	Dual Drive State				On/Off	On = A secondary controller has been detected in a dual drive system
<b>CAN Communication</b>		-	-		-	
	BMS Communicating				On/Off	On = BMS is communicating to the controller through the CAN Bus
	Charger Communicating				On/Off	On = Charger is communicating to the controller through the CAN Bus
Battery Information		1				
		Peak I&E				F
			Peak RMS Current	AMP	0 to 1000	Peak RMS current reported while the system is under load
			Minimum Voltage	Volt	0 to 170.0	Minimum voltage reported while the system is under load
		General			-	
			Keyswitch Voltage	Volt	0 to 150	Voltage at KSI (Pin 1)
			Measured Current	AMP	-600 to 600	The Measured System Current During Operation
			Remaining Amphours	AMP	0 to 500	Remaining Battery Amphours
			BDI Percentage	%	0 to 100	Battery state of charge.
			Aux Battery Voltage	Volt	0 to 20	Auxiliary battery voltage
		Charging Info		1	ſ	
			Charger Output Current	Ampere	0 to 100	Battery charger output current to the battery pack
			Charger Output Voltage	Volt	0 to 1400	Battery charger output voltage to the battery pack
			Charger Status	N/A	0 to 32	Status of the charger.
		Cell Monitor		1		
			Highest Cell			Identification of the battery with the highest voltage
			Highest Cells Voltage	Volt	0 to 4.500	Highest battery cell voltage
			Lowest Cell			Identification of the battery with the lowest voltage
			Lowest Cells Voltage	Volt	0 to 4.500	lowest battery cell voltage
			Highest Temperature	°C		Highest battery temperature within the battery pack
			Lowest Temperature	°C		Lowest battery temperature within the battery pack

Generic Software "E" Controller Faults								
Code	PROGRAMMER LCD DISPLAY EFFECT OF FAULT	POSSIBLE CAUSE	SET/CLEAR CONDITIONS					
12	Controller Overcurrent ShutdownMotor; ShutdownMainContactor; ShutdownEMBrake; ShutdownThrottle; FullBrake; ShutdownPump.	<ol> <li>1) External short of phase U, V, or W motor connections</li> <li>2) Motor parameters are mis-tuned</li> <li>3) Controller defective</li> <li>4) Speed encoder noise problems.</li> </ol>	Set: Phase current exceeded the current measurement limit Clear: Cycle KSI					
13	Current Sensor Fault ShutdownMotor; ShutdownMainContactor; ShutdownEMBrake; ShutdownThrottle; FullBrake; ShutdownPump.	<ol> <li>Leakage to vehicle frame from phase U, V, or W (short in motor stator)</li> <li>Controller defective</li> </ol>	<b>Set</b> : Controller current sensors have invalid reading <b>Clear</b> : Cycle KSI					
14	Precharge Failed ShutdownMotor; ShutdownMainContactor; ShutdownEMBrake; ShutdownThrottle; FullBrake; ShutdownPump.	1) External load on capacitor bank (B+ connection terminal) that prevents the capacitor bank from charging	Set: Precharge failed to charge the capacitor bank to KSI voltage Clear: Cycle Interlock input or use VCL function Enable_Precharge()					
15	Controller Severe Undertemp ShutdownMotor; ShutdownMainContactor; ShutdownEMBrake; ShutdownThrottle; FullBrake; ShutdownPump.	<ol> <li>See Monitor menu » Controller: Temperature.</li> <li>Controller is operating in an extreme environment.</li> </ol>	Set: Heatsink temperature below -40°C. Clear: Bring heatsink temperature above -40°C, and cycle interlock or KSI.					

Code	PROGRAMMER LCD DISPLAY EFFECT OF FAULT	POSSIBLE CAUSE	SET/CLEAR CONDITIONS
16	Controller Severe Overtemp ShutdownMotor; ShutdownMainContactor; ShutdownEMBrake; ShutdownThrottle; FullBrake; ShutdownPump.	<ol> <li>See Monitor menu » Controller: Temperature.</li> <li>Controller is operating in an extreme environment.</li> <li>Excessive load on vehicle.</li> <li>Improper mounting of controller.</li> </ol>	Set: Heatsink temperature above +95°C. Clear: Bring heatsink temperature below +95°C, and cycle interlock or KSI.
17	Severe B+ Undervoltage Reduced drive torque.	<ol> <li>Battery Menu parameters are misadjusted</li> <li>Non-controller system drain on battery</li> <li>Battery resistance</li> <li>Battery disconnected while driving</li> <li>See Monitor Menu &gt;&gt; Battery: Capacitor voltage</li> <li>Blown B+ fuse or main contactor did not close</li> </ol>	Set: Capacitor bank voltage dropped below the Severe Undervoltage limit with FET bridge enabled Clear: Bring capacitor voltage above Severe Undervoltage limit
18	Severe B+ Overvoltage ShutdownMotor; ShutdownMainContactor; ShutdownEMBrake; ShutdownThrottle; FullBrake; ShutdownPump.	<ol> <li>See Monitor menu &gt;&gt; Battery: Capacitor Voltage</li> <li>Battery menu parameters are misadjusted</li> <li>Battery resistance too high for given regen current</li> <li>Battery disconnected while regen braking</li> </ol>	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 Reduced drive and brake torque.	<ol> <li>See Monitor menu &gt;&gt; Controller: Temperature</li> <li>Controller is performance-limited at this temperature</li> <li>Controller is operating in an extreme environment</li> <li>Excessive load on vehicle</li> <li>Improper mounting of controller</li> </ol>	<b>Set</b> : Heatsink temperature exceeded by 85°C <b>Clear</b> : Bring heatsink temperature below 85°C

Codo	PROGRAMMER LCD DISPLAY		
Code	EFFECT OF FAULT	POSSIBLE CAUSE	SET/CLEAR CONDITIONS
23	<b>B+ Undervoltage Cutback</b> <i>Reduced drive torque.</i>	<ol> <li>Normal operation. Fault shows that the batteries need recharging. Controller performance is limited at this voltage.</li> <li>Battery parameters are misadjusted</li> <li>Non-controller system drain on battery</li> <li>Battery resistance too high</li> <li>Battery disconnected while driving</li> <li>See Monitor Menu &gt;&gt; Battery: Capacitor voltage</li> <li>Blown B+ fuse or main contactor did not close</li> </ol>	Set: Capacitor bank voltage dropped below the Undervoltage limit with the FET bridge enabled Clear: Bring capacitor voltage below the undervoltage limit
24	<b>B+ Overvoltage Cutback</b> <i>Reduced brake torque</i> .	<ol> <li>Normal operation. Fault shows that regen braking currents elevated the battery voltage during regen braking. Controller is performance limited at this voltage.</li> <li>Battery parameters are misadjusted</li> <li>Battery resistance too high for given regen current</li> <li>Battery disconnected while regen braking</li> <li>See Monitor Menu &gt;&gt; Battery: Capacitor voltage</li> </ol>	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 None, unless a fault action is programmed in VCL.	<ol> <li>1) External load impedance on the +5V supply (pin 26) is too low</li> <li>2) See Monitor menu &gt;&gt; outputs: 5</li> <li>Volts and Ext Supply Current</li> </ol>	<b>Set</b> : +5V supply (pin 26) outside the +5V +/- 10% range <b>Clear</b> : Bring voltage within range

Code	PROGRAMMER LCD DISPLAY EFFECT OF FAULT	POSSIBLE CAUSE	SET/CLEAR CONDITIONS
26	Digital Out 6 Overcurrent Digital Output 6 driver will not turn on.	1. External load impedance on Digital Output 6 driver (pin 19) is too low.	<b>Set:</b> Digital Output 6 (pin 19) current exceeded 15 mA. <b>Clear:</b> Remedy the overcurrent cause and use the VCL function Set_DigOut() to turn the driver on again.
27	Digital Out 7 Overcurrent Digital Output 7 driver will not turn on.	1) External load impedance on Digital Output 7 driver (pin 20) is too low.	<b>Set:</b> Digital Output 7 (pin 20) current exceeded 15 mA. <b>Clear:</b> Remedy the overcurrent cause and use the VCL function Set_DigOut() to turn the driver on again.
28	Motor Temp Hot Cutback Reduced drive torque.	<ol> <li>Motor temperature is at or above the programmed Temperature Hot setting, and the requested current is being cut back</li> <li>Motor Temperature Control Menu parameters are mis-tuned</li> <li>See Monitor Menu &gt;&gt; Motor: Temperature and &gt;&gt; Inputs: Analog2</li> <li>If the application doesn't use a motor thermistor, Temp Compensation and Temp Cutback should be programmed Off.</li> </ol>	Set: Motor temperature is at or above the Temperature Hot parameter setting. Clear: Bring the motor temperature within range
29	<b>Motor Temp Sensor Fault</b> MaxSpeed reduced (LOS, Limited Operating Strategy), and motor temperature cutback disabled.	<ol> <li>Motor thermistor is not connected properly</li> <li>If the application doesn't use a motor thermistor. Motor Temp Sensor Enable should be programmed OFF</li> <li>See Monitor Menu &gt;&gt; Motor: Temperature and &gt;&gt; Inputs: Analog2</li> </ol>	<b>Set</b> : Motor thermistor input (pin 8) is at the voltage rail (0 or 10V) <b>Clear</b> : Bring the motor thermistor input voltage within range

Code	PROGRAMMER LCD DISPLAY		
Code	EFFECT OF FAULT	POSSIBLE CAUSE	SET/CLEAR CONDITIONS
31	Coil1 Driver Open/Short ShutdownDriver1.	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 ShutdownMotor; ShutdownMainContactor; ShutdownEMBrake; ShutdownThrottle; FullBrake; ShutdownPump.	<ol> <li>1) Open or short on driver load</li> <li>2) Dirty connector pins</li> <li>3) Bad crimps or faulty wiring</li> </ol>	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
32	Coil2 Driver Open/Short ShutdownDriver2.	<ol> <li>1) Open or short on driver load.</li> <li>2) Dirty connector pins.</li> <li>3) Bad crimps or faulty wiring.</li> </ol>	Set: Driver 2 (pin 5) is either open or shorted. This fault can be set only when EM Brake Type = 0. Clear: Correct open or short, and cycle driver.
32	EMBrake Open/Short ShutdownEMBrake; ShutdownThrottle; FullBrake.	<ol> <li>1) Open or short on driver load.</li> <li>2) Dirty connector pins.</li> <li>3) Bad crimps or faulty wiring.</li> </ol>	<b>Set:</b> Electromagnetic brake driver (pin 5) is either open or shorted. This fault can be set only when EM Brake Type > 0. <b>Clear:</b> Correct open or short, and cycle driver.

Code	PROGRAMMER LCD DISPLAY	POSSIBLE CAUSE	SET/CLEAR CONDITIONS
33	Coil3 Driver Open/Short ShutdownDriver3.	<ol> <li>1) Open or short on driver load.</li> <li>2) Dirty connector pins.</li> <li>3) Bad crimps or faulty wiring.</li> </ol>	Set: Driver 3 (pin 4) is either open or shorted. Clear: Correct open or short, and cycle driver.
34	Coil4 Driver Open/Short ShutdownDriver4.	<ol> <li>1) Open or short on driver load.</li> <li>2) Dirty connector pins.</li> <li>3) Bad crimps or faulty wiring.</li> </ol>	<b>Set:</b> Driver 4 (pin 3) is either open or shorted. <b>Clear:</b> Correct open or short, and cycle driver.
35	PD Open/Short ShutdownPD.	<ol> <li>1) Open or short on driver load.</li> <li>2) Dirty connector pins.</li> <li>3) Bad crimps or faulty wiring.</li> </ol>	Set: Proportional driver (pin 2) is either open or shorted. Clear: Correct open or short, and cycle driver.
36	Encoder Fault ShutdownEMBrake; ShutdownThrottle.	<ol> <li>Motor encoder failure</li> <li>Bad crimps or faulty wiring</li> <li>See Monitor menu &gt;&gt; Motor: Motor RPM</li> </ol>	<b>Set</b> : Motor encoder phase failure detected. <b>Clear</b> : Cycle KSI
36	Sin/Cos Sensor Fault ShutdownEMBrake; ShutdownThrottle.	<ol> <li>SPMSM motor characterization not completed or poorly matched to motor.</li> <li>Sin/cos feedback sensor failure.</li> <li>Bad crimps or faulty wiring.</li> <li>See Monitor menu » Motor: Sin Input A and Sin Input B.</li> <li>See Monitor menu » Motor: Motor RPM.</li> </ol>	<b>Set:</b> Sin/cos sensor output failure detected. <b>Clear:</b> Cycle KSI.
37	Motor Open ShutdownMotor; ShutdownMainContactor; ShutdownEMBrake; ShutdownThrottle; FullBrake; ShutdownPump.	1) Motor phase is open 2) Bad crimps or faulty wiring	<b>Set</b> : Motor phase U, V or W detected open <b>Clear</b> : Cycle KSI

Code	PROGRAMMER LCD DISPLAY	POSSIBLE CAUSE	SET/CLEAR CONDITIONS
	EFFECT OF FAULT		
38	Main Contactor Welded ShutdownMotor; ShutdownMainContactor; ShutdownEMBrake; ShutdownThrottle; FullBrake; ShutdownPump.	<ol> <li>Main contactor tips are welded closed</li> <li>Motor phase U or V is disconnected or open</li> <li>An alternative voltage path (such as an external precharge resistor) is providing a current to the capacitor bank (B+ connection terminal)</li> </ol>	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 ShutdownMotor; ShutdownMainContactor; ShutdownEMBrake; ShutdownThrottle; FullBrake; ShutdownPump.	<ol> <li>Main contactor did not close</li> <li>Main contactor tips are oxidized, burned, or not making good contact</li> <li>External load on capacitor bank (B+ connection terminal) that prevents capacitor bank from charging</li> <li>Blown B+ fuse</li> </ol>	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 ShutdownThrottle.	<ol> <li>See Monitor Menu &gt;&gt; Inputs: Throttle Pot</li> <li>Throttle pot wiper voltage too high</li> </ol>	Set: Throttle pot wiper (pin 16) voltage is higher than the high fault threshold (can be changed with the VCL function Setup_Pot_Faults() ) Clear: Bring throttle pot wiper voltage below the fault threshold
42	Throttle Wiper Low ShutdownThrottle.	<ol> <li>See Monitor Menu &gt;&gt; Inputs: Throttle Pot</li> <li>Throttle pot wiper voltage too low</li> </ol>	Set: Throttle pot wiper (pin 16) voltage is lower than the low fault threshold (can be changed with the VCL function Setup_Pot_Faults()) Clear: Bring throttle pot wipervoltage above the fault threshold

Codo	PROGRAMMER LCD DISPLAY		
Code	EFFECT OF FAULT	POSSIBLE CAUSE	SET/CLEAR CONDITIONS
43	Pot2 Wiper High FullBrake.	<ol> <li>See Monitor Menu &gt;&gt; Inputs: Pot2 Raw</li> <li>Pot2 wiper voltage too high</li> </ol>	Set: Pot2 wiper (pin 17) voltage is higher than the high fault threshold (can be changed with the VCL function Setup_Pot_Faults()) Clear: Bring Pot2 wiper voltage below the fault threshold
44	Pot2 Wiper Low FullBrake.	<ol> <li>See Monitor Menu &gt;&gt; Inputs: Pot2 Raw</li> <li>Pot2 wiper voltage too low</li> </ol>	Set: Pot2 wiper (pin 17) voltage is lower than the low fault threshold (can be changed with the VCL function Setup_Pot_Faults()) Clear: Bring Pot2 wiper voltage above the fault threshold
45	Pot Low Overcurrent ShutdownThrottle; FullBrake.	<ol> <li>See Monitor Menu &gt;&gt; Outputs: Pot Low</li> <li>Combined pot resistance connected to pot low is too low</li> </ol>	<b>Set</b> : Pot low (pin 18) current exceeds 10mA <b>Clear</b> : Clear pot low overcurrent condition and cycle KSI

Code	PROGRAMMER LCD DISPLAY EFFECT OF FAULT	POSSIBLE CAUSE	SET/CLEAR CONDITIONS
46	EEPROM Failure ShutdownMotor; ShutdownMainContactor; ShutdownEMBrake; ShutdownThrottle; ShutdownInterlock; ShutdownDriver1; ShutdownDriver2; ShutdownDriver3; ShutdownDriver4; ShutdownPD; FullBrake; ShutdownPump.	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
47	HPD/Sequencing Fault ShutdownThrottle.	<ol> <li>KSI, interlock, direction, and throttle inputs applied in incorrect sequence.</li> <li>Faulty wiring, crimps, or switches KSI, interlock, direction, or throttle inputs.</li> </ol>	Set: HPD (High Pedal Disable) or sequencing fault caused by incorrect sequence of KSI, interlock, direction, and throttle inputs. Clear: Reapply inputs in correct sequence.
47	Emer Rev HPD ShutdownThrottle; ShutdownEMBrake.	1) Emergency Reverse operation has concluded, but the throttle, forward and reverse inputs, and interlock have not been returned to neutral.	Set: At the conclusion of Emergency Reverse, the fault was set because various inputs were not returned to neutral. Clear: If EMR_Interlock = On, clear the interlock, throttle, and direction inputs. If EMR_Interlock = Off, clear the throttle and direction inputs.

Code	PROGRAMMER LCD DISPLAY EFFECT OF FAULT	POSSIBLE CAUSE	SET/CLEAR CONDITIONS
49	Parameter Change Fault ShutdownMotor; ShutdownMainContactor; ShutdownEMBrake; ShutdownThrottle; FullBrake; ShutdownPump.	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.	<b>Set:</b> Adjustment of a parameter setting that requires cycling of KSI <b>Clear:</b> Cycle KSI
51	Motor Type Parameter Change ShutdownMotor; ShutdownMainContactor; ShutdownEMBrake; ShutdownThrottle; FullBrake; ShutdownPump.	1) Motor Type was changed when the system was up and running.	<b>Set</b> : Motor Type Change <b>Clear</b> : Cycle KSI
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; Cycle KSI
53	Software License Violation	1)The software that has been installed violates the license agreement between the software and the controller	Set: The license of the installed software package does not match the license of the controller. Clear: Contact HPEVS
54	Secondary Communication Error	<ol> <li>No power to secondary controller.</li> <li>Broken wire in the CAN BUS wiring.</li> <li>Faulty secondary controller.</li> </ol>	Set: Secondary controller not powered. Broken wire within the CAN BUS wiring harness. Faulty secondary controller. Clear: Check wiring and make sure that controller is powering up. Check the CAN BUS wiring to secondary controller for continuity. Replace the secondary controller.
55	Program Mode	1) Primary controller in program mode	Set: Primary controller in program mode by user Clear: Complete program functions in primary controller and cycle KSI

Code	PROGRAMMER LCD DISPLAY EFFECT OF FAULT	POSSIBLE CAUSE	SET/CLEAR CONDITIONS
56	Diagnostic Mode	1) Primary controller in diagnostic mode	Set: Primary controller in diagnostic mode by user Clear: Complete diagnostic mode functions in primary controller and cycle KSI
57	BMS Fault	1) BMS has reported a fault	<b>Set:</b> BMS fault detected <b>Clear</b> : Determine and fix BMS fault; cycle KSI
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.	<b>Set:</b> The charger is plugged into the vehicle. <b>Clear:</b> Remove plug.

Code	PROGRAMMER LCD DISPLAY EFFECT OF FAULT	POSSIBLE CAUSE	SET/CLEAR CONDITIONS
68	VCL Run Time Error ShutdownMotor; ShutdownMainContactor; ShutdownEMBrake; ShutdownThrottle; ShutdownInterlock; ShutdownDriver1; ShutdownDriver2; ShutdownDriver3; ShutdownDriver4; ShutdownPD; FullBrake; ShutdownPump.	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	<ol> <li>1) External load on the 5V and 12V supplies draws either too much or too little current</li> <li>2) Fault Checking Menu parameters Ext Supply Max and Ext Supply Min are mis-tuned</li> <li>3) See Monitor Menu &gt;&gt; Options: Ext Supply Current</li> </ol>	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. The two thresholds are defined by the External Supply Max and External Supply Min parameter settings. Clear: Bring the external supply current within range

Code	PROGRAMMER LCD DISPLAY EFFECT OF FAULT	POSSIBLE CAUSE	SET/CLEAR CONDITIONS
71	OS General ShutdownMotor; ShutdownMainContactor; ShutdownEMBrake; ShutdownThrottle; ShutdownInterlock; ShutdownDriver1; ShutdownDriver2; ShutdownDriver3; ShutdownDriver4; ShutdownPD; FullBrake; ShutdownPump.	1) Internal controller fault.	<b>Set:</b> Internal controller fault detected. <b>Clear:</b> Cycle KSI.
72	<b>PDO Timeout</b> ShutdownThrottle; CAN NMT State set to Pre-operational.	1) Time between CAN PDO messages received exceeded the PDO Timeout Period.	Set: Time between CAN PDO messages received exceeded the PDO Timeout Period. Clear: Cycle KSI or receive CAN NMT message.
73	<b>Stall Detected</b> ShutdownEMBrake; Control Mode changed to LOS (Limited Operating Strategy).	<ol> <li>Stalled Motor</li> <li>Motor encoder failure</li> <li>Bad crimps or faulty wiring</li> <li>Problems with power supply for the motor encoder</li> <li>See Monitor Menu &gt;&gt; Motor: Motor RPM</li> </ol>	Set: No motor encoder movement detected Clear: Either cycle KSI or detect valid motor encoder signals while operating in LOS mode and return Throttle Command = 0 and Motor RPM = 0

Code	PROGRAMMER LCD DISPLAY EFFECT OF FAULT	POSSIBLE CAUSE	SET/CLEAR CONDITIONS
77	Supervisor Fault ShutdownMotor; ShutdownMainContactor; ShutdownEMBrake; ShutdownThrottle; ShutdownInterlock; ShutdownDriver1; ShutdownDriver2; ShutdownDriver3; ShutdownDriver4; ShutdownPD; FullBrake; ShutdownPump.	<ol> <li>The Supervisor has detected a mismatch in redundant readings.</li> <li>Internal damage to Supervisor microprocessor.</li> <li>Switch inputs allowed to be within upper and lower thresholds for over over 100 milliseconds.</li> </ol>	Set: Mismatched redundant readings; damaged Supervisor; illegal switch inputs. Clear: Check for noise or voltage drift in all switch inputs; check connections; cycle KSI.
78	Supervisor Incompatible ShutdownMotor; ShutdownMainContactor; ShutdownEMBrake; ShutdownThrottle; ShutdownInterlock; ShutdownDriver1; ShutdownDriver2; ShutdownDriver3; ShutdownDriver4; ShutdownPD; FullBrake; ShutdownPump.	1) The main OS is not compatible with the Supervisor OS.	Set: Incompatible software. Clear: Load properly matched OS code or update the Supervisor code; cycle KSI.
82	Bad Calibrations ShutdownMotor; ShutdownMainContactor; ShutdownEMBrake; ShutdownThrottle; FullBrake; ShutdownPump.	1) Internal controller fault.	<b>Set:</b> Internal controller fault detected. <b>Clear:</b> Correct fault; cycle KSI.

Code	PROGRAMMER LCD DISPLAY EFFECT OF FAULT	POSSIBLE CAUSE	SET/CLEAR CONDITIONS
83	Driver Supply Fault ShutdownMotor; ShutdownMainContactor; ShutdownEMBrake; ShutdownThrottle; FullBrake; ShutdownPump.	1) Internal controller fault in the voltage supply for the driver circuits.	<b>Set:</b> Internal controller fault detected. <b>Clear:</b> Cycle KSI.
84	Following Error Fault ShutdownMotor; ShutdownMainContactor; ShutdownEMBrake; ShutdownThrottle; FullBrake; ShutdownPump.	<ol> <li>Motor speed was detected not following the commanded speed trajectory within the programmed limits.</li> <li>See Program menu » 1-Speed Mode » Speed Controller »Following Error Limit and Following Error Time.</li> <li>See Monitor menu » Motor Tuning » Speed Error.</li> </ol>	Set: With Control Mode Select = 0 or 1 Speed Mode Express or Speed Mode), motor speed error detected outside the the programmed limits. Clear: Cycle KSI.

Code	PROGRAMMER LCD DISPLAY EFFECT OF FAULT	POSSIBLE CAUSE	SET/CLEAR CONDITIONS
87	Motor Characterization Fault ShutdownMotor; ShutdownMainContactor; ShutdownEMBrake; ShutdownThrottle; FullBrake; ShutdownPump.	<ol> <li>Motor characterization failed during characterization process. See Monitormenu » Controller: Motor Characterization Error for cause:</li> <li>0=none</li> <li>1=encoder signal seen, but step size not determined; set Encoder Step Size manually</li> <li>2=motor temp sensor fault</li> <li>3=motor temp hot cutback fault</li> <li>4= controller overtemp cutback fault</li> <li>5=controller undertemp cutback fault</li> <li>6=undervoltage cutback fault</li> <li>8=encoder signal not seen, or one or both channels missing</li> <li>9=motor parameters out of characterization range.</li> <li>20=sin/cos sensor not found.</li> <li>21=phasing not detected.</li> <li>22=sin/cos sensor characterization failure.</li> <li>23=started characterization procedure while motor rotating.</li> </ol>	Set: Motor characterization failed during the motor characterization process. Clear: Correct fault; cycle KSI. Notes: Errors 1 and 8 apply to ACIM motors only. Errors 20, 21, and 23 apply to SPMSM motors only. Errors indicate the motor characterization data is invalid, except in the case of Error 1.

Code	PROGRAMMER LCD DISPLAY		
	EFFECT OF FAULT		
88	Encoder Steps Count Fault ShutdownMotor; ShutdownMainContactor; ShutdownEMBrake; ShutdownThrottle; ShutdownInterlock; ShutdownDriver1; ShutdownDriver2; ShutdownDriver3; ShutdownDriver4; ShutdownPD; FullBrake; ShutdownPump.	1) Encoder Steps parameter does not match the actual motor encoder.	<b>Set:</b> Motor lost IFO control and accelerated without throttle command. <b>Clear:</b> Ensure the Encoder Steps parameter matches the actual encoder; cycle KSI.
89	Motor Type Fault ShutdownMotor; ShutdownMainContactor; ShutdownEMBrake; ShutdownThrottle; FullBrake; ShutdownPump.	1) The Motor_Type parameter value is out of range.	<b>Set:</b> Motor_Type parameter is set to an illegal value. <b>Clear:</b> Set Motor_Type to correct value and cycle KSI.
91	VCL/OS Mismatch ShutdownMotor; ShutdownMainContactor; ShutdownEMBrake; ShutdownThrottle; ShutdownInterlock; ShutdownDriver1; ShutdownDriver2; ShutdownDriver3; ShutdownDriver4; ShutdownPD; FullBrake; ShutdownPump.	1) The VCL software in the controller does not match the OS software in the controller.	Set: VCL and OS software do not match; when KSI cycles, a check is made to verify that they match and a fault is issued when they do not. Clear: Download the correct VCL and OS software into the controller.

Code	PROGRAMMER LCD DISPLAY EFFECT OF FAULT	POSSIBLE CAUSE	SET/CLEAR CONDITIONS
92	EM Brake Failed to Set ShutdownEMBrake; ShutdownThrottle; Position Hold is engaged when Interlock=On.	<ol> <li>1) Vehicle movement sensed after the EM Brake has been commanded to set.</li> <li>2) EM Brake will not hold the motor from rotating.</li> </ol>	Set: After the EM Brake was commanded to set and time has elapsed to allow the brake to fully engage, vehicle movement has been sensed. Clear: Activate the throttle.
93	<b>Encoder LOS (Limited Operating Strategy)</b> Enter LOS control mode.	<ol> <li>1) Limited Operating Strategy (LOS) control mode has been activated, as a result of either an Encoder Fault (Code 36) or a Stall Detect Fault (Code 73).</li> <li>2) Motor encoder failure.</li> <li>3) Bad crimps or faulty wiring.</li> <li>4) Vehicle is stalled.</li> </ol>	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.
94	EMR Rev Timeout ShutdownEMBrake; ShutdownThrottle;	<ol> <li>Emergency Reverse was activated and concluded because the EMR Timeout timer has expired.</li> <li>The emergency reverse input is stuck On.</li> </ol>	Set: Emergency Reverse was activated and ran until the EMR Timeout timer expired. Clear: Turn the emergency reverse input Off.
98	Illegal Model Number ShutdownMotor; ShutdownMainContactor; ShutdownEMBrake; ShutdownThrottle; FullBrake; ShutdownPump.	<ol> <li>Model_Number variable contains illegal value. For 1234E/36E/38E models, a value other than 1234, 1236, 1238, or 1298 is illegal. For 1232E models, a value other than 1232 is illegal.</li> <li>Software and hardware do not match.</li> <li>Controller defective.</li> </ol>	Set: Illegal Model_Number variable; when KSI cycles, a check is made to confirm a legal Model_Number, and a fault is issued if one is not found. Clear: Download appropriate software for your controller model.

Code	PROGRAMMER LCD DISPLAY EFFECT OF FAULT	POSSIBLE CAUSE	SET/CLEAR CONDITIONS
99	Parameter Mismatch Fault ShutdownMotor; ShutdownMainContactor; ShutdownEMBrake; ShutdownThrottle; FullBrake; ShutdownPump.	<ol> <li>Dual Motor Enable parameter set On and Control Mode Select parameter not set to 1 (Speed Mode Express) or 2 (Speed Mode).</li> <li>Motor Technology and Feedback Type parameters do not match.</li> </ol>	Set: When the Dual Drive software is enabled, the controller must be set to either Speed Mode Express or Speed Mode; otherwise this fault is set. Motor Technology=0 must be paired with Feedback Type=1, and Motor Technology=1 must be paired with Feedback Type=2; otherwise this fault is set. Clear: Adjust parameters to appropriate values and cycle KSI.

### **GLOSSARY OF TERMS**

- 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 Input Rate**: Sets the rate (in seconds) at which the vehicle slows down when brake is applied or when throttle is applied in the opposite direction. Larger values represent slower response.
- 6. **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.
- 7. Brake Type: Defines the brake input for the controller:
  - a. Type 2= 3 wire 0 to 5kohm pot or electronic 0-5v input or pressure transducer.
  - b. Type 3=2 wire with switch; 0 to 5kohm.
  - c. Type 5= switch.
- 8. **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.
- 9. **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.
- 10. Deadband: is an area of a signal range or band where no action occurs (the system is dead).
- 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. Nominal Voltage: Battery pack voltage; not to exceed controller voltage ratings.
- 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. **Shift Neutral Braking:** Adjustment to neutral braking while pressing the clutch to shift a manual transmission
- 20. **SOC**: State of charge.
- 21. Spyglass: Name given by Curtis Instruments to the 8 segment LCD, 5-LED display.
- 22. **Throttle Maximum**: Defines the wiper input voltage required to produce 100% controller output. Decreasing the throttle max setting reduces the amount of voltage necessary to produce full controller output.
- 23. Throttle Type: Defines the throttle input for the controller:
  - a. Type 1= Electronic without switch
  - b. Type 2 = 0-5K ohm 2 wire pot with switch.
  - c. Type 3= 0-5K ohm 3-wire pot with switch. Electronic with switch.