RICO Quick Troubleshooting Guide

Curtis 1236E Controller

Table of Contents

Curtis 1236E Manual

*Notes:

1) Not all parameters listed in the "Programmable Features and Descriptions" section have the ability to be changed.
2) Any parameter change should be approved by Rico

Table 3 Programmable Parameter Menus: 1313/1314 Programmer

- **CONTROL MODE SELECT** .... p. 28

- **0 - SPEED MODE EXPRESS** .... p. 29
  - Max Speed
  - Kp
  - Ki
  - Accel Rate
  - Decel Rate
  - Brake Rate
  - Pump Enable

- **1 - SPEED MODE MENU**
  - **Speed Controller** .... p. 30
    - Max Speed
    - Kp
    - Ki LS
    - Ki HS
    - **Vel Feedforward** .... p. 30
      - Kvff
      - Build Rate
      - Release Rate
    - **Acc Feedforward** .... p. 31
      - Kaff
      - Kbff
      - Build Rate
      - Release Rate
  - **Response** .... p. 32
    - Full Accel Rate HS
    - Full Accel Rate LS
    - Low Accel Rate
    - Neutral Decel Rate HS
    - Neutral Decel Rate LS
    - Full Brake Rate HS
    - Full Brake Rate LS
    - Low Brake Rate
    - **Fine Tuning** .... p. 33
      - Partial Decel Rate
      - HS (High Speed)
      - LS (Low Speed)
      - Reversal Soften
      - Max Speed Accel
      - Max Speed Decel
  - **Restraint** .... p. 34
    - Restraint Forward
    - Restraint Back
    - Soft Stop Speed
    - **Position Hold** .... p. 34
      - Position Hold Enable
      - Position Hold Timeout
      - Kp
      - Kd
      - Set Speed Settling Time
      - Set Speed Threshold
      - Entry Rate
      - Exit Rollback Reduction
  - Pump Enable .... p. 35

- **2 - TORQUE MODE MENU**
  - **Speed Limiter** .... p. 36
    - Max Speed
    - Kp
    - Ki
    - Kd
  - **Response** .... p. 37
    - Accel Rate
    - Accel Release Rate
    - Brake Rate
    - Brake Release Rate
    - Neutral Braking
    - Neutral Taper Speed
    - Forward Full Restraint Speed
    - Back Full Restraint Speed
    - **Fine Tuning** .... p. 38
      - Creep Torque
      - Brake Full Creep Cancel
      - Creep Build Rate
      - Creep Release Rate
      - Gear Soften
      - Brake Taper Speed
      - Max Speed Decel

- **CURRENT LIMITS MENU** .... p. 40
  - Drive Current Limit
  - Regen Current Limit
  - Brake Current Limit
  - EMR Current Limit
  - Interlock Brake Current Limit
  - **Power Limiting Map** .... p. 40
    - PL Nominal Speed
    - Delta Speed
    - **Drive Limiting Map** .... p. 41
      - Nominal
      - Plus Delta
      - Plus 2xDelta
      - Plus 4xDelta
      - Plus 8xDelta
    - **Regen Limiting Map** .. p. 42
      - Nominal
      - Plus Delta
      - Plus 2xDelta
      - Plus 4xDelta
      - Plus 8xDelta

- **THROTTLE MENU** .... p. 43
  - Throttle Type
  - Forward Deadband
  - Forward Map
  - Forward Max
  - Forward Offset
  - Reverse Deadband
  - Reverse Map
  - Reverse Max
  - Reverse Offset
  - Throttle Filter
  - HPD/SRO Type
  - Sequencing Delay
  - VCL Throttle Enable

- **BRAKE MENU** .... p. 46
  - Brake Pedal Enable
  - Brake Type
  - Brake Deadband
  - Brake Map
  - Brake Max
  - Brake Offset
  - Brake Filter
  - VCL Brake Enable

Table 3 Programmable Parameter Menus: 1313/1314 Programmer, cont'd

CONTROL MODE SELECT		
PARAMETER	ALLOWABLE RANGE	DESCRIPTION
Control Mode Select PCF *Control_Mode_Select*	0–2 *0–2*	This parameter determines which control method will be in effect when programming motor response: 0 = SPEED MODE EXPRESS 1 = SPEED MODE 2 = TORQUE MODE. Contact Curtis if you are interested in a custom control method. Note: Do not change this parameter while the controller is powering the motor. Any time this parameter is changed a Parameter Change Fault (fault code 49) is set and must be cleared by cycling power; this protects the controller and the operator.

Note: Motor Speed Constraints

The maximum motor speed is a programmable parameter in each control mode. Regardless of which control mode is used, the maximum motor speed the controller will allow is constrained by the number of motor poles, the number of encoder pulses per motor revolution, and the maximum speed constraint imposed by the firmware.

Electrical frequency constraint

The maximum electrical frequency the controller will output is 300 Hz.
To determine how fast this constraint will allow your motor to spin, use the equation

Max Motor RPM = 36000 / Number of Motor Poles

(e.g., a 6-pole motor can run up to 6000 rpm).

Encoder pulses/revolution constraint

The maximum encoder frequency the controller will accept is 10 kHz.
To determine how fast this constraint will allow your motor to spin, use the equation

Max Motor RPM = 600000 / Encoder Size

(e.g., a motor with a 128-pulse encoder can run up to 4687 rpm).

Firmware max speed constraint

The maximum motor speed the controller will allow is 8000 rpm.

☞ **The overall maximum motor speed allowed is the least of these three constraints.**

0 – SPEED MODE EXPRESS — SPEED MODE EXPRESS MENU

PARAMETER	ALLOWABLE RANGE	DESCRIPTION
Max Speed *Max_Speed_SpdMx*	100–8000 rpm *100–8000*	Defines the maximum requested motor rpm at full throttle. Partially-applied throttle is scaled proportionately; e.g., 40% applied throttle corresponds to a request for 40% of the set Max Speed Value. Note: The maximum motor rpm is subject to the constraints on page 28.
Kp *Kp_SpdMx*	0–100 % *0–8192*	Determines how aggressively the speed controller attempts to match the speed of the motor to the commanded speed. Larger values provide tighter control. If the gain is set too high, you may experience oscillations as the controller tries to control speed. If it is set too low, the motor may behave sluggishly and be difficult to control.
Ki *Ki_SpdMx*	5–100 % *50–1000*	The integral term (Ki) forces zero steady state error, so the motor will run at exactly the commanded speed. Larger values provide tighter control. If the gain is set too high, you may experience oscillations as the controller tries to control speed. If it is set too low, the motor may take a long time to approach the exact commanded speed.
Accel Rate *Accel_Rate_SpdMx*	0.1–30.0 s *100–30000*	Sets the rate (in seconds) at which the speed command increases when throttle is applied. Larger values represent slower response.
Decel Rate *Decel_Rate_SpdMx*	0.1–30.0 s *100–30000*	Sets the rate (in seconds) that is used to slow down the vehicle when the throttle is reduced. Larger values represent slower response.
Brake Rate *Brake_Rate_SpdMx*	0.1–30.0 s *100–30000*	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.
Pump Enable *AC_Pump_Enable_SpdM* *AC_Pump_Enable_SpdM_Bit0*	On/Off *On/Off* [Bit 0]	This parameter should be programmed On to operate a pump motor rather than a vehicle drive motor. Speed controller responsiveness and stability are enhanced, and the motor is allowed to turn only in the forward direction.

1 – SPEED MODE SPEED CONTROLLER MENU

PARAMETER	ALLOWABLE RANGE	DESCRIPTION
Max Speed *Max_Speed_SpdM*	100–8000 rpm *100–8000*	Defines the maximum requested motor rpm at full throttle. Partially-applied throttle is scaled proportionately; e.g., 40% applied throttle corresponds to a request for 40% of the set Max Speed Value. If Max_Speed_SpdM is set <100 rpm (through VCL or CAN), the throttle request is zeroed. Note: The maximum motor rpm is subject to the constraints on page 28.
Kp *Kp_SpdM*	0–100 % *0–8192*	Determines how aggressively the speed controller attempts to match the speed of the motor to the commanded speed. Larger values provide tighter control. If the gain is set too high, you may experience oscillations as the controller tries to control speed. If it is set too low, the motor may behave sluggishly and be difficult to control.
Ki LS *Ki_SpdM*	5–100 % *50–1000*	The Ki LS parameter sets the Ki for low vehicle speeds. The integral term (Ki) forces zero steady state error, so the motor will run at exactly the commanded speed. Larger values provide tighter control. If the gain is set too high, you may experience oscillations as the controller tries to control speed. If it is set too low, the motor may take a long time to approach the exact commanded speed.
Ki HS *Ki_HS_SpdM*	5–100 % *50–1000*	The Ki HS parameter sets the integral term (Ki) for high vehicle speeds; see description of Ki LS.

1 – SPEED MODE VELOCITY FEEDFORWARD MENU *[OPTIONAL]*

PARAMETER	ALLOWABLE RANGE	DESCRIPTION
Kvff *Kvff_SpdM*	0–500 A *0–5000*	This velocity feedforward term is designed to improve throttle responsiveness and speed controller performance, especially at low speeds. For traction systems, set it to 50–70% of the current needed to maintain a very low speed, unloaded, on flat ground. For a pump system, set it to the lowest load current (i.e., the current running at the minimum load). Alternatively, the responsiveness of a pump speed control loop can be significantly enhanced by using a VCL program to continuously update this parameter to the appropriate value as each pump load is requested.
Build Rate *Vel_FF_Build_Rate_SpdM*	0.1–5.0 s *100–5000*	Determines how fast the Kvff term builds up. For traction systems, if you feel or hear the mechanical slop pick up abruptly when you move the throttle from neutral to a very small value, slowing the build rate (i.e., setting it to a higher value) will soften the feel. For a pump system, start with this parameter at the minimum setting. Slowing it down (i.e., setting it to a higher value) will reduce speed overshoot if too much feedforward has been commanded.
Release Rate *Vel_FF_Release_Rate_SpdM*	0.1–2.0 s *100–2000*	Determines how fast the Kvff term releases. If the release seems too abrupt, slowing the release rate (i.e., setting it to a higher value) will soften the feel. It should be set fast enough (i.e., at a low enough value) to prevent the vehicle from running on after throttle release.

1 – SPEED MODE **ACCELERATION FEEDFORWARD MENU** *[OPTIONAL]*		
PARAMETER	ALLOWABLE RANGE	DESCRIPTION
Kaff *Kaff_SpdM*	0–500 A *0–5000*	This acceleration feedforward term is designed to improve throttle responsiveness and speed controller performance at all speeds. It can be thought of as a “quick start” function which can enhance responsiveness at all speeds. Using your present accel and decel rates, observe the average current you are running at full throttle at low speeds while accelerating without load on flat ground, and set Kaff to 50–70% of that value. Note: If any accel rate parameters get changed, this parameter will need to be changed also.
Kbff *Kbff_SpdM*	0–500 A *0–5000*	This braking feedforward term is designed to improve braking responsiveness at all speeds. Using your present decel rates, observe the average current you are running at full throttle braking, and set Kbff to that value.
Build Rate *Acc_FF_Build_Rate_SpdM*	0.1–5.0 s *100–5000*	Determines how fast the Kaff and Kbff terms build up. For traction systems, if you feel or hear the mechanical slop pick up abruptly when you move the throttle from neutral to a very small value, slowing the build rate (i.e., setting it to a higher value) will soften the feel. For a pump system, start with this parameter at the minimum setting. Slowing it down (i.e., setting it to a higher value) will reduce speed over-shoot if too much feedforward has been commanded.
Release Rate *Acc_FF_Release_Rate_SpdM*	0.1–2.0 s *100–2000*	Determines how fast the Kaff and Kbff terms release. It should be set fast enough (i.e., at a low enough value) to prevent the vehicle from running on after throttle release.

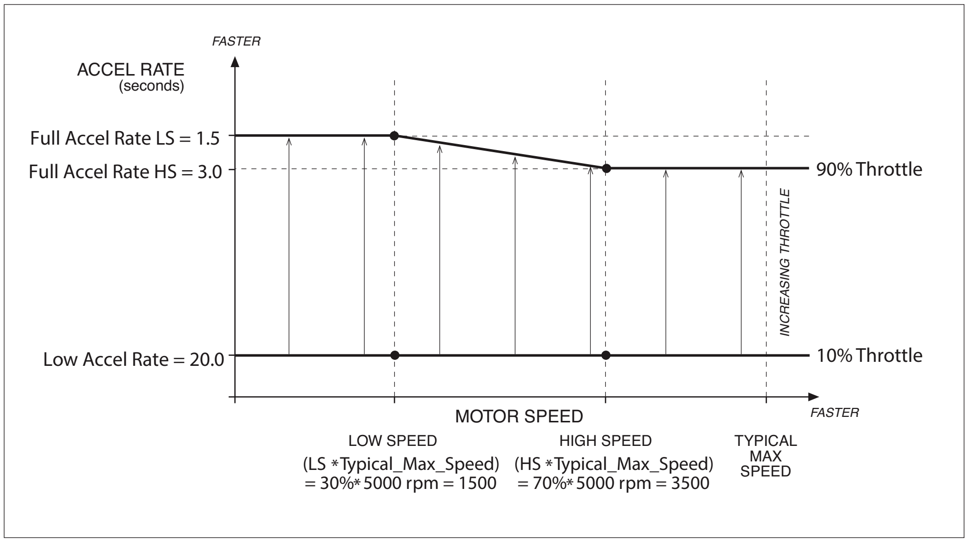
1 – SPEED MODE **RESPONSE MENU**

PARAMETER	ALLOWABLE RANGE	DESCRIPTION
Full Accel Rate HS *Full_Accel_Rate_HS_SpdM*	0.1–30.0 s *100–30000*	Sets the rate (in seconds) at which the speed command increases when full throttle is applied at high vehicle speeds. Larger values represent slower response. See Figure 7 for relationship between Full Accel Rate HS, Full Accel Rate LS, and Low Accel Rate.
Full Accel Rate LS *Full_Accel_Rate_LS_SpdM*	0.1–30.0 s *100–30000*	Sets the rate (in seconds) at which the speed command increases when full throttle is applied at low vehicle speeds.
Low Accel Rate *Low_Accel_Rate_SpdM*	0.1–30.0 s *100–30000*	Sets the rate (in seconds) at which the speed command increases when a small amount of throttle is applied. This rate is typically adjusted to affect low speed maneuverability.
Neutral Decel Rate HS *Neutral_Decel_Rate_HS_SpdM*	0.1–30.0 s *100–30000*	Sets the rate (in seconds) that is used to slow down the vehicle when the throttle is released to neutral at high vehicle speeds.
Neutral Decel Rate LS *Neutral_Decel_Rate_LS_SpdM*	0.1–30.0 s *100–30000*	Sets the rate (in seconds) that is used to slow down the vehicle when the throttle is released to neutral at slow vehicle speeds.
Full Brake Rate HS *Full_Brake_Rate_HS_SpdM*	0.1–30.0 s *100–30000*	Sets the rate (in seconds) at which the vehicle slows down from high speeds when full brake is applied or when full throttle is applied in the opposite direction. See Figure 8 for relationship between Full Brake Rate HS, Full Brake Rate LS, and Low Brake Rate.
Full Brake Rate LS *Full_Brake_Rate_LS_SpdM*	0.1–30.0 s *100–30000*	Sets the rate (in seconds) at which the vehicle slows down from low speeds when full brake is applied or when full throttle is applied in the opposite direction.
Low Brake Rate *Low_Brake_Rate_SpdM*	0.1–30.0 s *100–30000*	Sets the rate (in seconds) at which the vehicle slows down at all speeds when a small amount of brake is applied or when a small amount of throttle is applied in the opposite direction.

Fig. 7 *Acceleration response rate diagram.*

In this example,

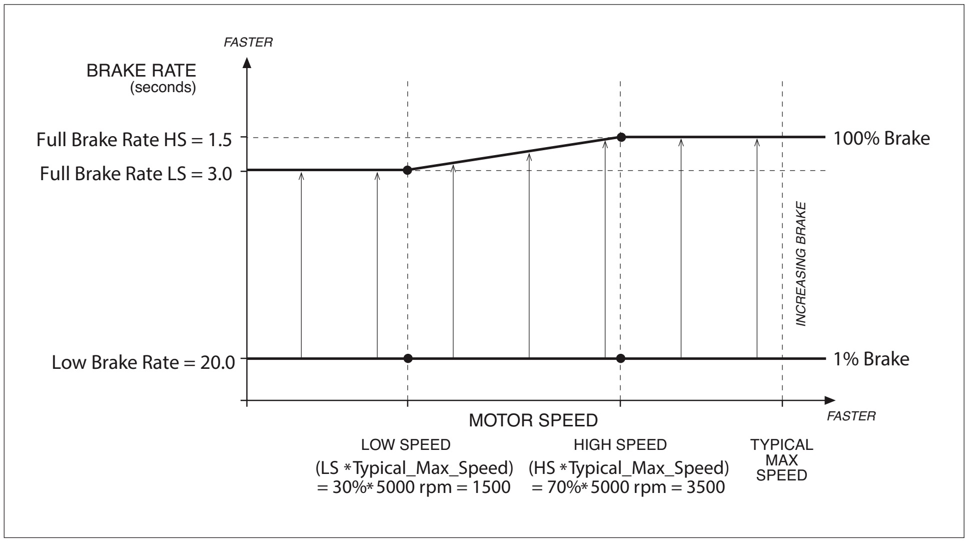
HS = 70%,
LS = 30%,
Typ Max Spd = 5000 rpm.



1 – SPEED MODE FINE TUNING MENU		
PARAMETER	ALLOWABLE RANGE	DESCRIPTION
Partial Decel Rate *Partial_Decel_Rate_SpdM*	0.1–30.0 s *100–30000*	Sets the rate (in seconds) that is used to slow down the vehicle when the throttle is reduced without being released to neutral. Larger values represent slower response.
HS (High Speed) *HS*	0–100 % *0–32767*	Sets the percentage of the Typical Max Speed (page 54) above which the "HS" parameters will be used.
LS (Low Speed) *LS*	0–100 % *0–32767*	Sets the percentage of the Typical Max Speed (page 54) below which the "LS" parameters will be used.
Reversal Soften *Reversal Soften_SpdM*	0–100 % *0–3000*	Larger values create a softer reversal from regen braking to drive when near zero speed. This helps soften the transition when the regen and drive current limits are set to different values.
Max Speed Accel *Max_Speed_Accel_SpdM*	0.1–30.0 s *100–30000*	In some applications, the Max Speed value is changed frequently, through VCL or over the CAN bus. The Max Speed Accel parameter controls the rate at which the maximum speed setpoint is allowed to change when the value of Max Speed is raised. The rate set by this parameter is the time to ramp from 0 rpm to Typical Max Speed rpm. For example, suppose Max Speed is raised from 1000 rpm to 4000 rpm. If Typical Max Speed is 5000 rpm and the rate is 10.0 seconds, it will take 10.0 * (4000–1000) / 5000 = 6.0 seconds to ramp from 1000 rpm to 4000 rpm.
Max Speed Decel *Max_Speed_Decel_SpdM*	0.1–30.0 s *100–30000*	This parameter works like the Max Speed Accel parameter, except that it controls the rate at which the maximum speed setpoint is allowed to change when the value of Max Speed is lowered. For example, suppose you change Max Speed from 4500 rpm to 2500 rpm. If Typical Max Speed is 5000 rpm, and the rate is 5.0 seconds, it will take 5.0 * (4500–2500) / 5000 = 2.0 seconds to ramp from 4500 rpm to 2500 rpm.

Fig. 8 *Braking response rate diagram.*

In this example,
HS = 70%,
LS = 30%,
Typ Max Spd = 5000 rpm.



1 – SPEED MODE **RESTRAINT MENU**

PARAMETER	ALLOWABLE RANGE	DESCRIPTION
Restraint Forward *Restraint_Forward*	0–100 % *0–32767*	Increases torque when on a steep hill in order to limit roll-forward speed. Setting this parameter too high may cause oscillations in the motor as it attempts to limit the roll-forward speed.
Restraint Back *Restraint_Back*	0–100 % *0–32767*	Increases torque when on a steep hill in order to limit roll-back speed. Setting this parameter too high may cause oscillations in the motor as it attempts to limit the roll-back speed.
Soft Stop Speed *Soft_Stop_Speed*	0–500 rpm *0–500*	Defines the speed below which a much slower decel rate is used. A setting of zero disables the function. Note: This parameter works only in Speed Mode and Speed Mode Express. Soft Stop Speed is useful for vehicles that have fast deceleration and vehicles operating on ramps using the Position Hold function. With vehicles that have fast deceleration, the driver may find the final speed reduction to zero rpm uncomfortable; the vehicle may even rock back as a result of tire wind-up. Soft Stop Speed allows the vehicle to slow at the same fast rate until it reaches the set threshold, at which point it changes to a slower (softer) deceleration rate. However, if the threshold is set too high, the vehicle will feel like it is “running on.” When throttle is released on a ramp, the vehicle may roll back before Position Hold (see below) takes control. Soft Speed Stop can be used to reduce the amount of rollback, but shouldn’t be set so high the vehicle drives up the ramp after the throttle is released.

1 – SPEED MODE **POSITION HOLD MENU**

PARAMETER	ALLOWABLE RANGE	DESCRIPTION
Position Hold Enable PCF *Position_Hold_Enable* *Position_Hold_Enable_Bit0* [Bit 0]	On/Off *On/Off*	Allows the Position Hold mode to be entered at zero throttle when the vehicle comes to a stop. Note: EM Brake Type = 2 also enables the Position Hold function.
Position Hold Timeout *Position_Hold_Timeout_Time*	0.0–20.0 s *0–625*	Sets the maximum time the vehicle will stay in Position Hold before releasing the hold and going into Restraint mode. Setting the parameter to zero disables this timeout function, which means the Position Hold will be held. Activating the interlock resets the timer.
Kp *Kp_Position_Hold*	2–100 % *82–2048*	Determines the stiffness with which position is regulated when in Position Hold mode. High Kp will produce less rollback on a ramp, but more bouncing; see Kd below. Too much Kp will cause instability.
Kd *Kd_Position_Hold*	0–100 % *0–8192*	Determines the damping in Position Hold mode. Some damping must be present in the control system to keep the vehicle from oscillating slowly (“bouncing”). High Kd will improve the dynamic response of the Position Hold controller, but too much Kd will cause fast instability.

1 – SPEED MODE **POSITION HOLD MENU, cont'd**

PARAMETER	ALLOWABLE RANGE	DESCRIPTION
Set Speed Settling Time *Set_Speed_Settling_Time*	0–5000 ms *0–156*	This parameter appears twice in the menu structure. For description, see EM Brake Control menu, page 48.
Set Speed Threshold *Set_Speed_Threshold*	5–100 rpm *5–100*	This parameter appears twice in the menu structure. For description, see EM Brake Control menu, page 48.
Entry Rate *Entry_Rate_Position_Hold*	5–100 % *50–1000*	When the vehicle transitions from forward speed to reverse speed or from reverse speed to forward speed (for example, when coming to a stop going up a steep ramp), Position Hold is automatically entered immediately at zero speed—regardless of this parameter. This parameter applies when the vehicle needs to be brought to a stop without the assistance of gravity (for example, when moving forward down a ramp). This rate determines how quickly zero speed is attained after the ramped speed request reaches zero. Setting this parameter too high will make the stop seem very abrupt, and may even cause the vehicle to roll back slightly. When the parameter is set lower, the vehicle take longer to come to a stop and enter Position Hold mode.
Exit Rollback Reduction *Exit_Rollback_Reduction*	0–100 % *0–2048*	This function is applicable only when the Torque Preload function has been disabled (see EM Brake menu), or its timer has expired. It introduces a proportional feedforward term into the speed controller based on the position signal. For example, suppose the vehicle is on a ramp and a forward throttle request is given such that the vehicle rolls back slightly before climbing the ramp (again, assuming the torque preload function is inactive). As the vehicle rolls back a feedforward torque term proportional to the rollback position will be added to the torque request until forward speed is sensed.

1 – SPEED MODE **PUMP ENABLE**

PARAMETER	ALLOWABLE RANGE	DESCRIPTION
Pump Enable *AC_Pump_Enable_SpdM* *AC_Pump_Enable_SpdM_Bit0* [Bit 0]	On/Off *On/Off*	This parameter should be programmed On to operate a pump motor rather than a vehicle drive motor. Speed controller responsiveness and stability are enhanced, and the motor is allowed to turn only in the forward direction.

2 – TORQUE MODE SPEED LIMITER MENU

PARAMETER	ALLOWABLE RANGE	DESCRIPTION
Max Speed *Max_Speed_TrqM*	500–8000 rpm *500–8000*	Defines the maximum allowed motor rpm for torque control mode (independent of throttle position). In torque control mode, full throttle requests 100% of the available torque. Partially-applied throttle is scaled proportionately; e.g., 40% applied throttle corresponds to a request for 40% of the available torque. Note: The maximum motor rpm is subject to the constraints on page 28.
Kp *Kp_TrqM*	0–100 % *0–8192*	Determines how aggressively the speed controller attempts to limit the speed of the motor to Max Speed. Larger values provide tighter control. If Kp is set too high, you may experience oscillations as the controller tries to control speed. Setting Kp too low may result in a top speed much higher than Max Speed.
Ki *Ki_TrqM*	5–100 % *50–1000*	The integral term (Ki) forces zero steady state error, so the motor speed will be limited to Max Speed. Larger values provide faster control. If the gain is set too high, you may experience oscillations as the controller tries to limit speed. If it is set too low, it may take a long time for the motor to approach Max Speed from overspeed.
Kd *Kd_TrqM*	0–100 % *0–8192*	Provides damping as the vehicle approaches top speed, thereby reducing overshoot. If Kd is set too high, the vehicle may take too long to reach top speed. If Kd is set too low, the vehicle may overshoot top speed, especially when traveling downhill.

2 – TORQUE MODE **RESPONSE MENU**

PARAMETER	ALLOWABLE RANGE	DESCRIPTION
Accel Rate *Accel_Rate_TrqM*	0.1–30.0 s *100–30000*	Sets the rate (in seconds) at which the motor torque increases to full when full throttle is applied. Larger values represent slower response.
Accel Release Rate *Accel_Release_Rate_TrqM*	0.1–2.0 s *100–2000*	Determines how quickly deceleration will be initiated when the throttle is released while the vehicle is still accelerating. If the release rate is fast (i.e., set to a low value), the transition is initiated abruptly. The transition is smoother if the release rate is set to a higher value (slower transition); however, setting the rate too high can cause the vehicle to feel uncontrollable when the throttle is released, as it will continue to drive for a short time.
Brake Rate *Brake_Rate_TrqM*	0.1–5.0 s *100–5000*	Adjusts the rate (in seconds) at which braking torque builds as the vehicle transitions from drive to braking when direction is reversed, the brake pedal is applied, or neutral braking begins. Lower values represent faster times and therefore faster braking; gentler braking is achieved by setting the braking rate to a higher value.
Brake Release Rate *Brake_Release_Rate_TrqM*	0.1–2.0 s *100–2000*	Adjusts the rate (in seconds) at which braking torque releases as as the vehicle transitions from braking to drive.
Neutral Braking *Neutral_Braking_TrqM*	0–100 % *0–32767*	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 (see Current Limits menu, page 40).
Neutral Taper Speed *Neutral_Taper_Speed_TrqM*	200–6000 rpm *200–6000*	Determines the motor speed below which neutral braking current is adjusted when throttle is reduced; see Figure 9. The neutral braking current is linearly reduced from Neutral Braking * Regen Current Limit at the Neutral Taper Speed to the Creep Torque current at zero rpm motor speed. Note: Setting the taper speed too low may cause oscillations in the motor.
Forward Full Restraint Speed *Forward_Full_Restraint_Speed*	0–32000 rpm *0–32000*	Sets the speed point at which the full regen current will be applied to restrain the vehicle from rolling forward. Although this speed is never actually reached, it does set the slope of the restraint strength and can be thought of as a gain; see Figure 9. Setting this parameter too low can cause oscillations.
Back Full Restraint Speed *Back_Full_Restraint_Speed*	0–32000 rpm *0–32000*	Sets the speed point at which the full regen current will be applied to restrain the vehicle from rolling in reverse (backward). Although this speed is never actually reached, it does set the slope of the restraint strength and can be thought of as a gain; see Figure 9. Setting this parameter too low can cause oscillations.

2 – TORQUE MODE FINE TUNING MENU

PARAMETER	ALLOWABLE RANGE	DESCRIPTION
Creep Torque *Creep_Torque_TrqM*	0–100 % *0–32767*	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; see Figure 9. ***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 (see page 46), creep torque is progressively disabled as brake is applied so as to prevent the motor from driving into the brakes and thus wasting energy. Creep Torque and Neutral Taper Speed interact to create the slope of the torque response as the vehicle approaches zero speed; see Figure 9. If the vehicle oscillates as it coasts down toward zero speed, try lowering Creep Torque or increasing Neutral Taper Speed.
Brake Full Creep Cancel *Brake_Full_Creep_Cancel_TrqM*	25–100 % *8192–32767*	Determines the amount of brake pedal input that will fully cancel the . creep torque. Amount of cancellation is proportional to the brake input.
Creep Build Rate *Creep_Build_Rate_TrqM*	0.1–5.0 s *100–5000*	Determines how fast the programmed creep torque builds when a direction is selected.
Creep Release Rate *Creep_Release_Rate_TrqM*	0.1–5.0 s *100–5000*	Determines how fast the programmed creep torque releases when the brake is cancelling the creep torque or when the direction switches are cleared (neutral).
Gear Soften *Gear_Soften_TrqM*	0–100 % *0–5000*	Adjusts the throttle take-up from linear (0% setting) to an S curve. Larger values create softer throttle take-up, in forward and reverse. Softening is progressively reduced at higher speeds; see Figure 10.
Brake Taper Speed *Brake_Taper_Speed_TrqM*	200–6000 rpm *200–6000*	Determines the motor speed below which the maximum braking current is linearly reduced from 100% to 0% at zero speed; see Figure 11. Setting the taper speed too low for the braking current will cause oscillations in the motor as it attempts to brake the vehicle to a stop on very steep slopes. Taper speed is applicable only in response to brake pedal input; it does not affect direction reversal braking or neutral braking. If the vehicle is in restraint when the brake is pressed, the applied braking torque is affected by both Brake Taper Speed and Forward (or Back) Full Restraint Speed. If the vehicle oscillates in this mode, it may be necessary to increase one or more of these parameters.
Max Speed Decel *Max_Speed_Accel_TrqM*	0.1–30.0 s *100–30000*	In some applications, the Max Speed value is changed frequently, through VCL or over the CAN bus. The Max Speed Accel parameter controls the rate at which the maximum speed setpoint is allowed to change when the value of Max Speed is lowered. The rate set by this parameter is the time to ramp from Typical Max Speed rpm to 0 rpm. For example, suppose you change Max Speed from 3000 rpm to 1000 rpm. If Typical Max Speed is 5000 rpm, and the rate is 5.0 seconds, it will take 5.0 * (3000–1000) / 5000 = 2.0 seconds to ramp from 3000 rpm to 1000 rpm.

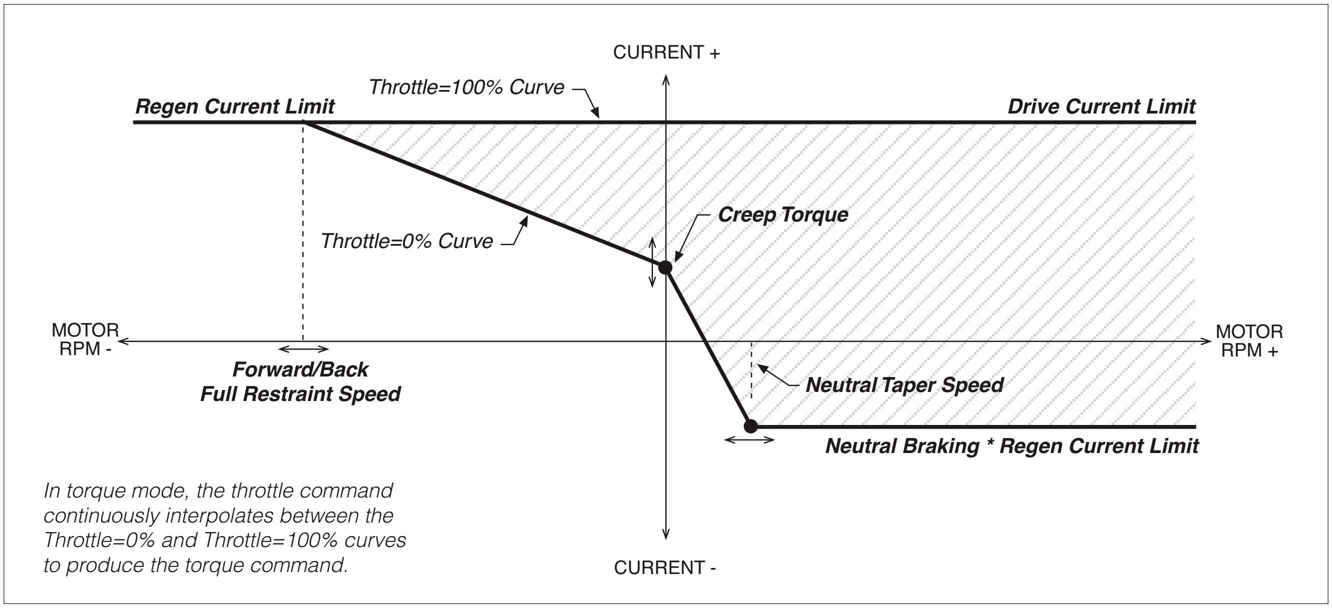


Fig. 9 *Throttle mapping (torque control mode).*

Fig. 10 *Effect of Gear Soften parameter (torque control mode).*

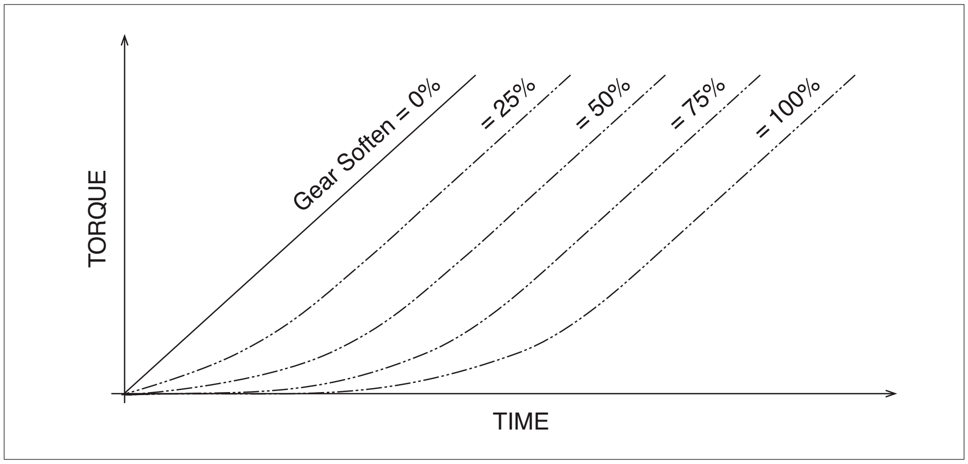
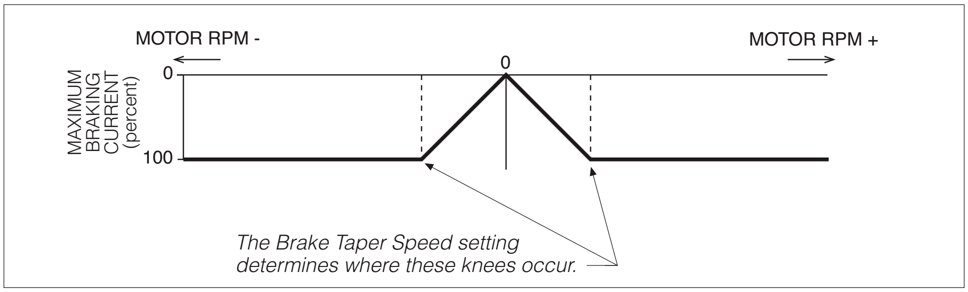


Fig. 11 *Effect of Brake Taper Speed parameter (torque control mode).*



CURRENT LIMITS MENU		
PARAMETER	ALLOWABLE RANGE	DESCRIPTION
Drive Current Limit *Drive_Current_Limit*	5–100 % *1638–32767*	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.* Reducing this value will reduce the maximum drive torque.
Regen Current Limit *Regen_Current_Limit*	5–100 % *1638–32767*	Sets the maximum RMS regen current, as a percentage of the controller's full rated current.* The regen current limit applies during neutral braking, direction reversal braking, and speed limiting when traveling downhill.
Brake Current Limit *Brake_Current_Limit*	5–100 % *1638–32767*	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.
EMR Current Limit *EMR_Current_Limit*	5–100 % *1638–32767*	Sets the maximum RMS current allowed for braking and drive when in emergency reverse. The emergency reverse current limit is a percentage of the controller's full rated current.*
Interlock Brake Current Limit *Interlock_Brake_Current_Limit*	5–100 % *1638–32767*	Sets the maximum RMS regen current during interlock braking, as a percentage of the controller's full rated current.*

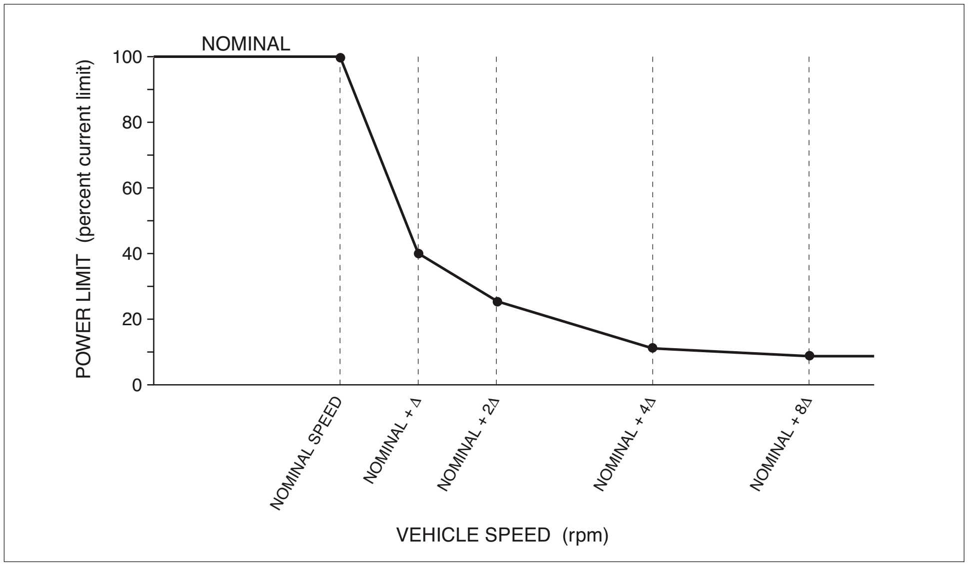
* The full rated current depends on the controller model; see specifications in Table E-1 for the rated current of your model.

POWER LIMITING MAP MENU		
PARAMETER	ALLOWABLE RANGE	DESCRIPTION
Nominal Speed *PL_Nominal_Speed*	100–4000 rpm *100–4000*	Sets the base speed that will be used in the drive limiting map and regen limiting map.
Delta Speed *PL_Delta_Speed*	50–1000 rpm *50–1000*	Sets the width of the delta increment that will be used in the drive limiting map and regen limiting map.

DRIVE LIMITING MAP MENU

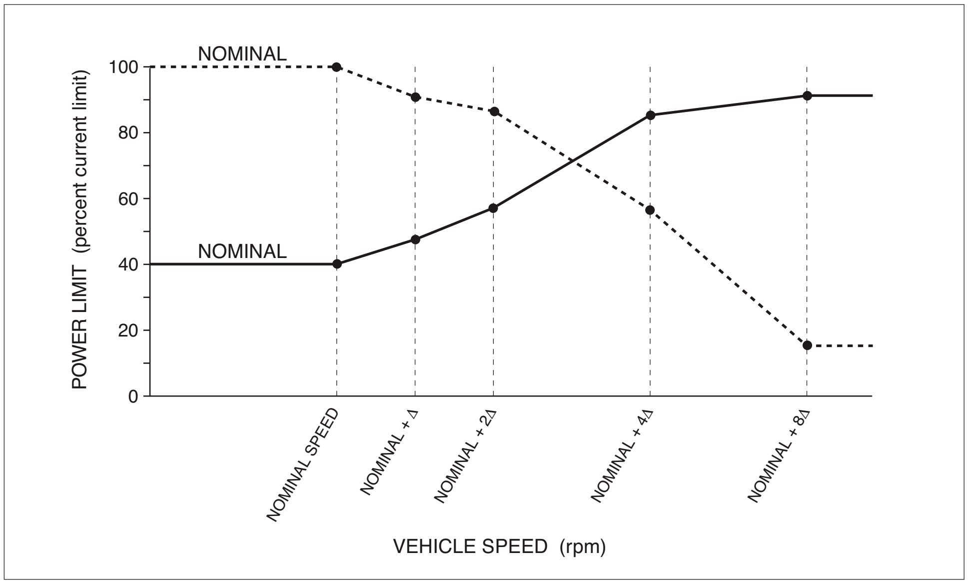
PARAMETER	ALLOWABLE RANGE	DESCRIPTION
Nominal *PL_Drive_Nominal*	0–100 % *0–32767*	These parameters define the percentage of drive current limit that will be applied at the speeds defined by the nominal speed and delta speed parameters. The resulting map allows the controller to reduce the drive current as a function of speed. Reducing the power requirements at certain speeds restricts performance. This can be useful for reducing motor heating. It can also be used to keep consistent vehicle power with changing battery state-of-charge.
Plus Delta *PL_Drive_Nominal_Plus_Delta*	0–100 % *0–32767*	
Plus 2xDelta *PL_Drive_Nominal_Plus_2xDelta*	0–100 % *0–32767*	
Plus 4xDelta *PL_Drive_Nominal_Plus_4xDelta*	0–100 % *0–32767*	
Plus 8xDelta *PL_Drive_Nominal_Plus_8xDelta*	0–100 % *0–32767*	

Fig. 12 *Drive current limiting map (typical example).*



REGEN LIMITING MAP MENU		
PARAMETER	ALLOWABLE RANGE	DESCRIPTION
Nominal *PL_Regen_Nominal*	0–100 % *0–32767*	These parameters define the percentage of regen current limit or braking current limit that will be applied at the speeds defined by the nominal speed and delta speed parameters. The curve can be shaped to limit the available torque at various speeds. One possible use is to compensate for the torque-speed characteristic of the motor.
Plus Delta *PL_Regen_Nominal_Plus_Delta*	0–100 % *0–32767*	
Plus 2xDelta *PL_Regen_Nominal_Plus_2xDelta*	0–100 % *0–32767*	
Plus 4xDelta *PL_Regen_Nominal_Plus_4xDelta*	0–100 % *0–32767*	
Plus 8xDelta *PL_Regen_Nominal_Plus_8xDelta*	0–100 % *0–32767*	

Fig. 13 *Regen current limiting map (two examples).*



THROTTLE MENU		
PARAMETER	ALLOWABLE RANGE	DESCRIPTION
Throttle Type PCF *Throttle_Type*	1–5 *1–5*	The 1232E/34E/36E/38E controllers accept a variety of throttle inputs. The throttle type parameter can be programmed as follows: 1 2-wire rheostat, 5kΩ–0 input 2 single-ended 3-wire 1kΩ–10kΩ potentiometer, or 0–5V voltage source 3 2-wire rheostat, 0–5kΩ input 4 wigwag 3-wire 1kΩ–10kΩ potentiometer, or 0–5V voltage source 5 VCL input (*VCL_Throttle*) Note: Do not change this parameter while the controller is powering the motor. Any time this parameter is changed a Parameter Change Fault (fault code 49) is set and must be cleared by cycling power; this protects the controller and the operator.
Forward Deadband *Forward_Deadband*	0–5.00 V *0–32767*	Defines the wiper voltage at the throttle deadband threshold. Increasing the throttle deadband setting will increase the neutral range. This parameter is especially useful with throttle assemblies that do not reliably return to a well-defined neutral point, because it allows the deadband to be defined wide enough to ensure that the controller goes into neutral when the throttle mechanism is released.
Forward Map *Forward_Map*	0–100 % *0–32767*	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. The map value is the percentage of controller output at half throttle ((deadband + max)/2).
Forward Max *Forward_Max*	0–5.00 V *0–32767*	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. This parameter allows reduced-range throttle assemblies to be accommodated.
Forward Offset *Forward_Offset*	0–100 % *0–32767*	Defines the initial controller output generated when the throttle is first rotated out of the neutral deadband. For most vehicles, a setting of 0 is appropriate. For heavy vehicles, however, increasing the offset may improve controllability by reducing the amount of throttle required to start the vehicle moving.

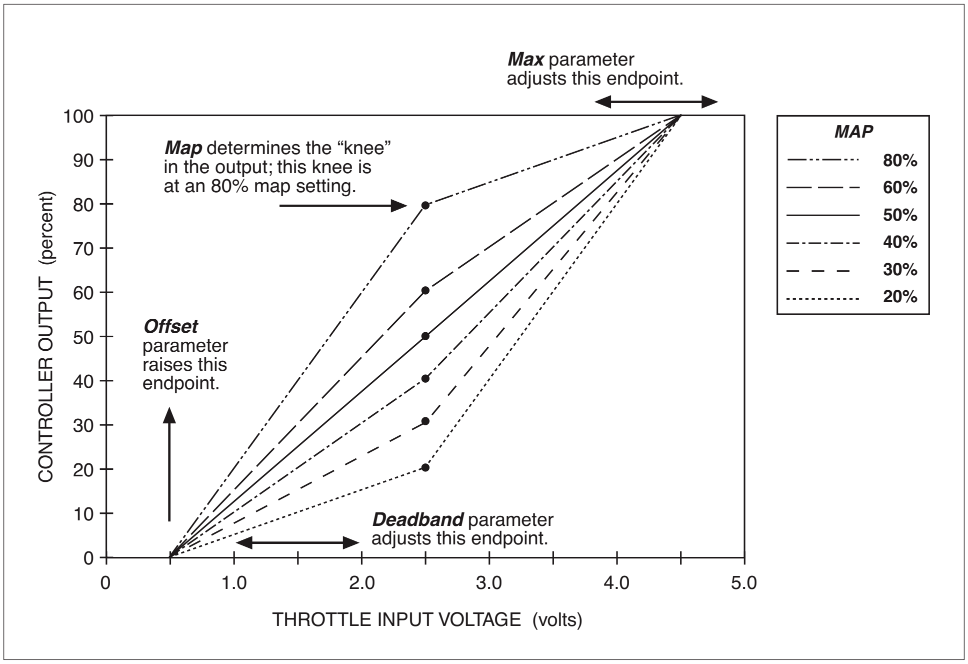
☞ Note: All four throttle adjustment parameters — Deadband, Map, Max, Offset — condition the raw throttle voltage into a single % throttle command, as shown in Figure 14.

THROTTLE MENU, cont'd		
PARAMETER	ALLOWABLE RANGE	DESCRIPTION
Reverse Deadband *Reverse_Deadband*	0–5.00 V *0–32767*	The four Throttle Reverse parameters are the same as their Throttle Forward counterparts, and apply when the throttle direction is reversed.
Reverse Map *Reverse_Map*	0–100 % *0–32767*	
Reverse Max *Reverse_Max*	0–5.00 V *0–32767*	
Reverse Offset *Reverse_Offset*	0–100 % *0–32767*	
Throttle Filter *Throttle_Filter*	2.0–125.0 Hz *524–32767*	Sets the low pass filter cutoff frequency for the throttle pot wiper input. Higher values will make the throttle more responsive to quick changes. Lower values will make the throttle less responsive to electrical noise.

Fig. 14 *Effect of throttle adjustment parameters. Together these four generic parameters determine the controller's response to throttle demand (in forward or reverse) and to brake demand.*

In the examples shown in this figure,

Deadband = 0.5V
Max = 4.5V
Offset = 0.



THROTTLE MENU, cont'd		
PARAMETER	ALLOWABLE RANGE	DESCRIPTION
HPD/SRO Type PCF *HPD_SRO_Type* *OptionBits1* [Bit 4]	0–3 *0–3*	Determines the type of HPD (High Pedal Disable) / SRO (Static Return to Off) protection. One type of checks is available for material-handling vehicles, and two types for golf-style vehicles. If any of the HPD/SRO checks finds an input sequencing problem, an HPD/Sequencing Fault (flash code 47) is set. 0 HPD/SRO feature is disabled. 1 HPD/SRO enabled for material-handling vehicles. *HPD:* If throttle input is received before interlock input. *SRO:* If direction input is received before interlock input. The HPD/SRO check is made when the interlock input changes from Off to On. If the throttle input >25% or a direction input is On, an HPD/Sequencing Fault is set. The HPD/Sequencing Fault is cleared by returning the throttle input to <25% and the direction inputs to Off. 2 Golf-style HPD that allows direction reversal while driving. *HPD:* If throttle input is received before interlock or direction input while vehicle is stationary. *SRO:* None. The HPD check is made when the interlock input or direction inputs are Off and the vehicle is stationary. If the throttle input >25%, an HPD/Sequencing Fault is set. No SRO check is made with this type, so the order of the interlock and direction inputs does not matter The HPD/Sequencing Fault is cleared by returning the throttle input to <25% and the direction inputs to Off. 3 Golf-style HPD that prevents direction reversal while driving. *HPD:* If throttle input is received before interlock or direction input. *SRO:* None. HPD check is made when the interlock input or direction inputs are Off. If the throttle input >25%, an HPD/Sequencing Fault is set. The check is done regardless of vehicle speed, so reversing direction with throttle input >25% will result in a fault. No SRO check is made with this type, so the order of the interlock and direction inputs does not matter The HPD/Sequencing Fault is cleared by returning the throttle input to <25% and the direction inputs to Off.
Sequencing Delay *Sequencing_Delay*	0.0–5.0 s *0–1250*	Typically the sequencing delay feature allows the interlock switch to be cycled within a set time (the defined sequencing delay), thus preventing inadvertent activation of HPD/SRO. This feature is especially useful in applications where the interlock switch may bounce or be momentarily cycled during operation.
VCL Throttle Enable *VCL_Throttle_Enable* *VCL_Throttle_Enable_Bit0* [Bit 0]	On/Off *On/Off*	When programmed On, the throttle processing with fault detection will operate normally; however, the throttle command (see Figure 15, page 95) will require VCL to define the connection between the OS_Throttle and VCL_Throttle variables. This allows VCL flexibility and customization of throttle processing, while still allowing Throttle_Type 1–4 with throttle fault detection.

BRAKE MENU		
PARAMETER	ALLOWABLE RANGE	DESCRIPTION
Brake Pedal Enable *Brake_Pedal_Enable* *OptionBits1* [Bit 3]	On/Off *On/Off*	Determines whether the brake input and algorithm are enabled, making the brake throttle part of the motor control command.
Brake Type *Brake_Type*	1–5 *1–5*	The 1232E/34E/36E/38E controllers accept a variety of brake inputs. The brake type parameter can be programmed as follows: 1 2-wire rheostat, 5kΩ–0 input 2 single-ended 3-wire 1kΩ–10kΩ potentiometer, 0–5V voltage source, or current source 3 2-wire rheostat, 0–5kΩ input 4 (not applicable) 5 VCL input (*VCL_Brake*) Note: Do not change this parameter while the controller is powering the motor. Any time this parameter is changed a Parameter Change Fault (fault code 49) is set and must be cleared by cycling power; this protects the controller and the operator.
Brake Deadband *Brake_Deadband*	0–5.00 V *0–32767*	The four Brake throttle adjustment parameters are the same as their Drive throttle counterparts; see descriptions and Figure 14.
Brake Map *Brake_Map*	0–100 % *0–32767*	
Brake Max *Brake_Max*	0–5.00 V *0–32767*	
Brake Offset *Brake_Offset*	0–100 % *0–32767*	
Brake Filter *Brake_Filter*	2.0–125.0 Hz *524–32767*	Sets the low pass filter cutoff frequency for the pot2 wiper input. Higher values will make the brake more responsive to quick changes. Lower values will make the brake less responsive to electrical noise.
VCL Brake Enable *VCL_Brake_Enable* *VCL_Brake_Enable_Bit0* [Bit 0]	On/Off *On/Off*	When programmed On, the brake processing with fault detection will operate normally; however, the brake command (see Figure 15, page 95) will require VCL to define the connection between the OS_Brake and VCL_Brake variables. This allows VCL flexibility and customization of throttle processing, while still allowing Brake_Type 1–3 with brake fault detection.

EM BRAKE CONTROL MENU

PARAMETER	ALLOWABLE RANGE	DESCRIPTION
Brake Type PCF *EM_Brake_Type*	0–2 *0–2*	The brake type parameter determines how the EM brake responds to the interlock input, throttle, and vehicle motor speed. 0 EM brake function disabled. The EM brake driver (PWM2) is released to general I/O use with VCL. 1 EM brake controlled by interlock. The controller will command the EM brake to release whenever the interlock is closed (Interlock = On). If interlock braking is enabled and the interlock opens when the vehicle is moving at motor speed greater than EM_Brake_Set_Speed_Threshold, the controller will brake the vehicle to a stop (with interlock braking) and then command the EM brake to set. If the vehicle motor speed is less than this threshold, the EM brake will engage after the Sequencing_Delay has expired. If interlock braking is disabled, the EM brake will engage after the Sequencing_Delay has expired. 2 EM brake controlled by interlock and neutral. The controller will command the EM brake to set whenever the throttle command is zero and motor speed is less than EM_Brake_Set_Speed_Threshold. Position Hold will be enabled automatically.
Pull In Voltage *EM_Brake_Pull_In_Voltage*	0–100 % *0–32767*	The EM brake pull-in voltage allows a high initial voltage when the EM brake first turns on, to ensure brake release. After 1 second, this peak voltage drops to the EM brake holding voltage. Note: The Battery Voltage Compensated parameter controls whether the pull-in and holding voltages are battery voltage compensated.
Holding Voltage *EM_Brake_Holding_Voltage*	0–100 % *0–32767*	The EM brake holding voltage allows a reduced average voltage to be applied to the brake coil once the brake has been released. This parameter must be set high enough to hold the brake released under all shock and vibration conditions the vehicle will be subjected to. Note: The Battery Voltage Compensated parameter controls whether the pull-in and holding voltages are battery voltage compensated.
Battery Voltage Compensated *EM_Brake_Battery_Voltage_Compensated* *EM_Brake_Battery_Voltage_Compensated_Bit0* [Bit 0]	On/Off *On/Off*	This parameter determines whether the EM brake pull-in and holding voltages are battery voltage compensated. When set On, the pull-in and holding voltages are compensated relative to the set Nominal Voltage (see Battery Menu, page 58). In other words, the output voltage is adjusted to compensate for swings in battery voltage, so the percentage is relative to the set Nominal Voltage—not to the actual voltage. For example, suppose Nominal Voltage is set to 48V and Holding Voltage is set to 75% (36V) to the output driver. Now suppose the bus voltage dips to 40V. If Battery Voltage Compensated = On, the output will still be 36V (Nominal Voltage × Holding Voltage) to the coil. If Battery Voltage Compensated = Off, the output will be 30V (Actual Voltage × Holding Voltage) to the coil.
Set EM Brake On Fault *EM_Brake_Set_Upon_Fault* *EM_Brake_Set_Upon_Fault_Bit0* [Bit 0]	On/Off *On/Off*	When programmed On, the controller's operating system will drop the electromagnetic brake when a fault occurs that has a fault action of ShutdownEMBrake. See Section 8 for a list of all the faults that have a fault action of ShutdownEMBrake.

EM BRAKE CONTROL MENU, cont'd		
PARAMETER	ALLOWABLE RANGE	DESCRIPTION
Set Speed Threshold *Set_Speed_Threshold*	5–100 rpm *5–100*	Determines the speed below which the EM brake will be commanded to set. Setting this speed too high may cause a jerky stop when the EM brake sets and stops the motor.
Release Delay *EM_Brake_Release_Delay*	40–2000 ms *5–250*	Estimated time for the EM brake to physically release after the pull-in voltage is applied. This is used to ensure the position hold torque buildup is complete before the brake releases. When set too low, the vehicle may experience rollback on EM brake release.
Set Speed Settling Time *Set_Speed_Settling_Time*	0–5000 ms *0–156*	Determines how long the position hold function is allowed to operate before the EM brake is set. This time should be set long enough for the position hold to settle. *Note* *
Torque Preload Delay *EM_Brake_Torque_Preload_Delay*	0–800 ms *0–100*	Estimated worst-case time to build up the torque required to hold the vehicle stationary on a hill prior to EM brake release. This is used in conjunction with Release Delay to determine when to release the brake and allow the speed request to slew away from zero. *Note* *
Torque Preload Enable *EM_Brake_Torque_Preload_Enable* *EM_Brake_Torque_Preload_Enable_Bit0* [Bit 0]	On/Off *On/Off*	When enabled, this function eliminates rollback when the throttle is re-engaged on a ramp by forcing the vehicle to first enter position-hold before setting the EM brake, and then "remembering" the amount of torque that was necessary to hold it on the ramp. When throttle is re-engaged, this value is loaded in the motor before the EM brake is released. The torque value is cleared automatically when KSI power is cycled. Off = When a valid throttle input is received, the speed controller will start with no torque preload as soon as the Release Delay expires. This will allow some rollback when the EM brake releases. On = When a valid throttle input is received, the speed controller will start with a pre-set torque as measured by position-hold when the vehicle came to a stop. *Note* *
Torque Preload Cancel Delay *EM_Brake_Torque_Preload_Cancel_Delay*	0–120 s *0–15000*	The timer starts after the EM brake is set. If the timer expires before the throttle is re-engaged, the torque preload memory will be cleared. Setting this parameter to zero disables the timer, i.e., the preload is never cancelled. The purpose of this delay is to prevent the vehicle from lunging forward if it is unloaded on a hill such that the torque measured by position-hold is no longer valid. *Note: This parameter is applicable only when Torque Preload Enable = On (see conditions above).*
EM Brake Fault Motor Revs *EM_Brake_Fault_Motor_Revs*	1.0–20.0 *10–200*	Defines the allowable number of motor revolutions after the EM brake is set before an EM Brake Failed to Set fault is issued (fault code 92).

***** *This parameter is applicable only when Speed Mode or Speed Mode Express is selected* ***and*** *either Position Hold Enable = On or EM Brake Type = 2.*

MAIN CONTACTOR MENU

PARAMETER	ALLOWABLE RANGE	DESCRIPTION
Main Enable *Main_Enable* *OptionBits1* [Bit 0]	On/Off *On/Off*	When programmed On, the controller's native software controls the main contactor when the interlock is enabled; when programmed Off, the contactor is controlled by VCL. Note: With Main Enable programmed Off, the controller will not be able to open the main contactor in serious fault conditions and the system will therefore not meet EEC safety requirements.
Main Interlock Type *Main_Interlock_Type*	0–1 *0–1*	When set to 0, the main contactor and interlock each work as determined by their respective parameters. When set to 1, the main contactor will pull in with KSI (like a Type 2 interlock) but the interlock enables/disables drive and engages interlock braking (like a Type 0 or Type 1 interlock).
Pull In Voltage *Main_Pull_In_Voltage*	0–100 % *0–32767*	The main contactor pull-in voltage parameter allows a high initial voltage when the main contactor driver first turns on, to ensure contactor closure. After 1 second, this peak voltage drops to the contactor holding voltage. Note: The Battery Voltage Compensated parameter (below) controls whether the pull-in and holding voltages are battery voltage compensated.
Holding Voltage *Main_Holding_Voltage*	0–100 % *0–32767*	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 under all shock and vibration conditions the vehicle will be subjected to. Note: The Battery Voltage Compensated parameter (below) controls whether the pull-in and holding voltages are battery voltage compensated.
Battery Voltage Compensated *Main_Driver_Battery_Voltage_Compensated* *Main_Driver_Battery_Voltage_Compensated_Bit0* [Bit 0]	On/Off *On/Off*	This parameter determines whether the main pull-in and holding voltages are battery voltage compensated. When set On, the pull-in and holding voltages are set relative to the set Nominal Voltage (see Battery Menu, page 55). In other words, the output voltage is adjusted to compensate for swings in battery voltage, so the percentage is relative to the set Nominal Voltage—not to the actual voltage. For example, suppose Nominal Voltage is set to 48V and Holding Voltage is set to 75% (36V) to the output driver. Now suppose the bus voltage dips to 40V. If Battery Voltage Compensated = On, the output will still be 36V (Nominal Voltage × Holding Voltage) to the coil. If Battery Voltage Compensated = Off, the output will be 30V (Actual Voltage × Holding Voltage) to the coil.
Interlock Type *Interlock_Type*	0–2 *0–2*	Three interlock options are available: 0 = interlock turns on with switch 3. 1 = interlock controlled by VCL functions. 2 = interlock turns on with KSI.
Open Delay *Open_Delay*	0–40 s *0–10000*	Applicable only when Interlock Type = 0 or 1. The delay can be set to allow the contactor to remain closed for a period of time (the delay) after the interlock switch is opened. The delay is useful for preventing unnecessary cycling of the contactor and for maintaining power to auxiliary functions that may be used for a short time after the interlock switch has opened.

MAIN CONTACTOR MENU, cont'd		
PARAMETER	ALLOWABLE RANGE	DESCRIPTION
Weld Check Enable *Weld_Check_Enable* *OptionBits1* [Bit 2]	On/Off *On/Off*	When programmed On, the controller performs a test to make sure the main contactor is open (not welded shut) before it is commanded to close. This test is not performed if this parameter is Off. The main contactor driver, however, is always protected from short circuits.
Main DNC Check Enable *Main_DNC_Check_Enable* *OptionBits4* [Bit 7]	On/Off *On/Off*	When programmed On, the controller performs a test immediately after the main contactor is commanded to close, to make sure the contactor has in fact closed. The test is not performed if this parameter is programmed Off. The main contactor driver, however, is always protected from short circuits.
Main DNC Runtime Threshold *Main_DNC_Runtime_Threshold*	0–200 V *0–12800*	Sets the threshold used for the ongoing check that ensures the main contactor remains closed while in operation. The Main DNC Runtime Threshold is the maximum voltage difference between the Keyswitch and Capacitor voltages. When the voltage difference is above this threshold, and the battery current is low, a Main Did Not Close fault will be set. Setting this parameter lower will increase the sensitivity of the fault detection. Setting this parameter too low may cause false fault trips due to normal voltage drops between the keyswitch and capacitor voltages. Setting this parameter = 0 V will disable the Main Did Not Close fault check.
Precharge Enable *Precharge_Enable* *OptionBits2* [Bit 6]	On/Off *On/Off*	Turns the precharge feature on and off. Precharge provides a limited current charge of the controller's internal capacitor bank before the main contactor is closed. This decreases the arcing that would otherwise occur when the contactor is closed with the capacitor bank discharged.

PROPORTIONAL DRIVER MENU		
PARAMETER	ALLOWABLE RANGE	DESCRIPTION
PD Enable PCF *PD_Enable* *OptionBits1* [Bit 6]	On/Off *On/Off*	Determines how the PWM of the proportional driver is controlled. When programmed On, it is controlled by the controller's PD current control software. When programmed Off, it is controlled by the VCL function *Put_PWM* (PWM5, value); see Figure 17, page 100.
Hyd Lower Enable *Hyd_Lower_Enable* *OptionBits1* [Bit 7]	On/Off *On/Off*	When programmed On, lowering is controlled by throttle position. When programmed Off, lowering is controlled by the VCL variable *VCL_PD_Throttle*; see Figure 17, page 100.
PD Max Current *PD_Max_Current*	0.0–2.0 A *0–607*	* The Lower speed is determined by the aperture of the proportional valve. This parameter sets the maximum allowed current through the valve, which in turn defines its aperture.
PD Min Current *PD_Min_Current*	0.0–2.0 A *0–607*	* Sets the minimum allowed current through the proportional valve. Most proportional valves need a non-zero closed current in order to start opening immediately when Lower is requested.
PD Dither % *PD_Dither_Percent*	0–100 % *0–32767*	* Dither provides a constantly changing current in the coil to produce a rapid back-and-forth motion of the valve; this keeps the valve lubricated and allows low-friction, precise movement. The PD Dither % parameter specifies the amount of dither as a percentage of the PD max current, and is applied in a continuous cycle of add%-subtract%.
PD Dither Period *PD_Dither_Period*	16–112 ms *1–7*	* Sets the period for proportional valve dither.
PD Kp *PD_Kp*	1–100 % *82–8192*	* Sets the proportional gain of the current feedback controller. Higher gains force the control loop to respond quickly but may cause oscillations.
PD Ki *PD_Ki*	1–100 % *327–32767*	* Sets the integral gain of the current feedback controller. Integral gain tries to force the error to zero. Higher gains force the control loop to respond quickly but may cause oscillations.

* These parameter descriptions assume the proportional driver is being used to drive a proportional valve, and that the PD current control software is active (PD_Enable = On).

DRIVER 3 MENU		
PARAMETER	ALLOWABLE RANGE	DESCRIPTION
Contactor Enable *Hydraulic_Contactor_Enable* *OptionBits4* [Bit 1]	On/Off *On/Off*	When programmed On, VCL functions control Driver 3 as the hydraulic pump contactor. On: The VCL function Start_Pump() will close the pump contactor according to the defined pull-in and holding voltages. The VCL function Stop_Pump() will open the pump contactor. Off: Driver 3 will be available for general VCL usage. Start_Pump() and Stop_Pump() will not have any effect.
Pull In Voltage *Hydraulic_Pull_In_Voltage*	0–100 % *0–32767*	The hydraulic contactor pull-in voltage parameter allows a high initial voltage when the hydraulic contactor driver first turns on, to ensure contactor closure. After 1 second, this peak voltage drops to the contactor holding voltage. Note: This voltage will be battery voltage compensated.
Holding Voltage *Hydraulic_Holding_Voltage*	0–100 % *0–32767*	The hydraulic 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 under all shock and vibration conditions the vehicle will be subjected to. Note: This voltage will be battery voltage compensated.

FAULT CHECKING MENU

PARAMETER	ALLOWABLE RANGE	DESCRIPTION
Driver1 Checks Enable *Driver1_Checks_Enable* *OptionBits2* [Bit 1]	On/Off *On/Off*	The five Checks Enable parameters are used to enable driver and coil fault detection at the five individual drivers (at Pins J1-6, J1-5, J1-4, J1-3, and J1-2). When a Checks parameter is enabled, the associated driver, driver wiring, and driver load are checked to verify that the driver correctly drives the load both high and low. The checks will occur regardless of the PWM output of the driver. The checks will detect both open and shorted conditions. When a fault is detected, the controller opens the driver and issues a fault code. If nothing is connected to a driver, its Checks Enable parameter should be set Off. Note: Short circuit protection is always active at these five drivers, regardless of how Checks Enable is set.
Driver2 Checks Enable *Driver2_Checks_Enable* *OptionBits2* [Bit 2]	On/Off *On/Off*	
Driver3 Checks Enable *Driver3_Checks_Enable* *OptionBits2* [Bit 3]	On/Off *On/Off*	
Driver4 Checks Enable *Driver4_Checks_Enable* *OptionBits2* [Bit 4]	On/Off *On/Off*	
PD Checks Enable *PD_Checks_Enable* *OptionBits2* [Bit 5]	On/Off *On/Off*	
External Supply Max *External_Supply_Max*	0–200 mA *0–800*	Sets the upper threshold of the combined current of the 5V and 12V external supplies. At or above this threshold a fault will be created that can be read by VCL.
External Supply Min *External_Supply_Min*	0–200 mA *0–800*	Sets the lower threshold of the combined current of the 5V and 12V external supplies. At or below this threshold a fault will be created that can be read by VCL.

PWM FREQUENCY PARAMETER

PARAMETER	ALLOWABLE RANGE	DESCRIPTION
PWM Frequency *PWM_Frequency*	120–1000 Hz *120–1000*	This single parameter defines the frequency of Drivers 1 through 4.

MOTOR MENU

PARAMETER	ALLOWABLE RANGE	DESCRIPTION
Typical Max Speed *Typical_Max_Speed*	500–8000 rpm *500–8000*	Set this parameter to the typical maximum motor speed of the vehicle. This value does not need to be set precisely; an estimate will do. All of the vehicle response rates are normalized to Typical Max Speed. For example, suppose Typical_Max_Speed is fixed at 6000 rpm, and Full_Accel_Rate_LS_SpdM = 3.0 seconds: If Max_Speed_SpdM = 6000 rpm, it will take 3.0 seconds to accelerate from zero to top speed (6000 rpm). If Max_Speed_SpdM = 3000 rpm, it will take 1.5 seconds to accelerate from zero to top speed (3000 rpm). If Max_Speed_SpdM = 1000 rpm, it will take 0.5 seconds to accelerate to accelerate from zero to top speed (1000 rpm).
Swap Encoder Direction PCF *Swap_Encoder_Direction* *OptionBits3* [Bit 0]	On/Off *On/Off*	Changes the motor encoder's effective direction of rotation. The encoder provides data used to calculate motor position and speed. This parameter must be set such that when the motor is turning forward, the controller reports back a positive motor speed. **Positive motor speed must be in the forward direction in order for the emergency reverse feature to operate properly.** Note: Do not change this parameter while the controller is powering the motor. Any time this parameter is changed a Parameter Change Fault (fault code 49) is set and must be cleared by cycling power; this protects the controller and the operator. ☞ ***Adjusting this parameter can be hazardous. For instructions, see Section 5, Step ⑩ (page 81).***
Swap Two Phases PCF *Swap_Two_Phases* *OptionBits3* [Bit 3]	On/Off *On/Off*	If, after Swap Encoder Direction has been set correctly, the vehicle drives in the wrong direction (i.e., drives forward when in reverse, and vice versa), try changing the setting of the Swap Two Phases parameter. This parameter has the same effect as physically swapping the cables on any two of the three motor phase connections. **Positive motor speed must be in the forward direction in order for the emergency reverse feature to operate properly.** Note: Do not change this parameter while the controller is powering the motor. Any time this parameter is changed a Parameter Change Fault (fault code 49) is set and must be cleared by cycling power; this protects the controller and the operator. ☞ ***Adjusting this parameter can be hazardous. For instructions, see Section 5, Step ⑩ (page 81).***
Encoder Steps PCF *Encoder_Steps*	32–256 *32–256*	Sets the number of encoder pulses per revolution. This must be set to match the encoder; see motor nameplate. Note: Do not change this parameter while the controller is powering the motor. Any time this parameter is changed a Parameter Change Fault (fault code 49) is set and must be cleared by cycling power; this protects the controller and the operator. ☞ ***Adjusting this parameter can be hazardous; setting it improperly may cause vehicle malfunction, including uncommanded drive. For instructions, see Section 5, Step ① (page 78).***

ENCODER FAULT SETUP MENU

PARAMETER	ALLOWABLE RANGE	DESCRIPTION
Fault Detection Enable *Encoder_Fault_Detection_Enable* *Encoder_Fault_Detection_Enable_ Bit0* [Bit 0]	On/Off *On/Off*	When programmed On, encoder fault checking is enabled. Three fault conditions are checked: Encoder Fault (fault code 36, Stall Detected (fault code 73), and Encoder Pulse Error (fault code 88).
Encoder Pulse Fault Detect Time *Encoder_Pulse_Fault_Detect_Time*	0–3 s *0–94*	Defines the minimum time it takes for the controller, while the vehicle is in motion, to detect that the encoder and the Encoder Steps parameter do not match. When the Encoder Steps setup is incorrect, the motor controller cannot properly calculate AC motor field orientation. The loss of field orientation can cause the motor to spin up toward full speed once any throttle is applied. This parameter sets a timer that starts once the throttle has been moved and then released, the drive current is significant, and the motor is still accelerating. Note that the motor can spin at high rpm for several seconds before conditions allow the controller to properly detect a fault. An Encoder Pulse Error (fault code 88) is declared when this fault is detected. Setting the parameter to zero will disable this fault detection.
Fault Stall Time *Enc_Fault_Stall_Time*	0–10 s *0–5000*	Sets a timer when no motor encoder movement is detected. If no motor encoder movement is detected for the programmed Fault Stall time, with maximum throttle applied, a Stall Detected fault (fault code 73) is issued.
LOS Upon Encoder Fault *LOS_Upon_Encoder_Fault* *LOS_Upon_Encoder_Fault_ Bit0* [Bit 0]	On/Off *On/Off*	Limited Operating Strategy (LOS) is typically used to drive the vehicle back to a repair center at very low speeds in the event the motor encoder fails. Following an encoder failure ((either Encoder Fault (fault code 36) or Stall Detected (fault code 73)), and after the Interlock is cycled, the vehicle enters LOS mode thus allowing drive without motor encoder feedback. In LOS mode, the ability to achieve maximum torque—even for a very short time—is considered more important than smoothness. When LOS mode is entered, the Encoder LOS fault (fault code 93) becomes active and the encoder fault ((either Encoder Fault (fault code 36) or Stall Detected (fault code 73)) is cleared. When this parameter is programmed On, LOS mode will be entered in the event of an encoder fault followed by an Interlock cycle. When programmed Off, in the event of an encoder fault the encoder fault remains and drive is disabled.
LOS Max Speed *Enc_LOS_Max_Speed*	100–2000 rpm *100–2000*	This parameter indirectly defines the maximum speed for LOS mode by setting the maximum frequency that corresponds to LOS Max Speed. In LOS mode the throttle commands a frequency that is interpolated linearly between zero (at Throttle Command = 0%) and the programmed LOS Max Speed (at Throttle Command = 100%).
LOS Max Current *Enc_LOS_Max_Current*	100–650 A *1000–6500*	In LOS mode, a partial or full throttle command will result in the maximum current set by this parameter. This current setting is clamped by the controller's rated current.

ENCODER FAULT SETUP MENU, cont'd		
PARAMETER	ALLOWABLE RANGE	DESCRIPTION
LOS Max Mod Depth *Enc_LOS_Max_Mod_Depth*	15–100 % *177–1182*	In LOS mode, the maximum modulation depth acts to limit the current at higher speeds. This parameter should be set such that the modulation depth limit is reached prior to the LOS Max Speed limit, so that the motor current will fall off from LOS Max Current at higher speeds. This may allow the vehicle to drive longer in LOS mode, as it lessens the chance of the motor or controller overheating.
LOS Accel Rate *Enc_LOS_Accel_Rate*	2.0–15.0 s *2000–15000*	Defines the rate (in seconds) at which the frequency increases when full throttle is applied, while operating in LOS mode. This parameter should be set to a slow rate (high parameter value) so the frequency command has a very slow slew rate to ensure that the max torque point is hit for a reasonable period of time; this decreases the probability of going over the slip curve, and allows ramps or obstacles to be overcome.
LOS Decel Rate *Enc_LOS_Decel_Rate*	2.0–15.0 s *2000–15000*	Defines the rate (in seconds) at which the frequency decreases when throttle is released, while operating in LOS mode.

MOTOR TEMPERATURE CONTROL MENU

PARAMETER	ALLOWABLE RANGE	DESCRIPTION
Sensor Enable *MotorTemp_Sensor_Enable* *OptionBits3* [Bit 1]	On/Off *On/Off*	When programmed On, the motor temperature cutback and the motor temperature compensation features are enabled. This parameter can be used only if a temperature sensor has been properly configured. The motor temperature cutback feature will linearly cut back the current from 100% to 0% between the Temperature Hot and Temperature Max temperatures. The motor temperature compensation feature will adapt the motor control algorithms to varying motor temperatures, for improved efficiency and more consistant performance.
Sensor Type *MotorTemp_Sensor_Type*	1–5 *1–5*	Five sensor types are predefined in the software:. Type 1 KTY83–122 Type 2 2× Type 1, in series Type 3 KTY84–130 or KTY84–150 Type 4 2× Type 3, in series Type 5 PT1000. Custom sensor types can be set up easily, if none of the five predefined types is appropriate for your application. Please contact your Curtis customer support engineer. ☞ Note: The industry standard KTY temperature sensors are silicon temperature sensors with a polarity band; **the polarity band of a KTY sensor must be the end connected to I/O Ground** (pin 7).
Sensor Temp Offset *MotorTemp_Sensor_Offset*	-20 – 20 °C *-200–200*	Often the sensor is placed in the motor at a location with a known offset to the critical temperature; the offset can be corrected with this parameter. The parameter can also be used to correct a known offset in the sensor itself.
Braking Thermal Cutback Enable *BrakingThermalCutback_Enable* *BrakingThermalCutback_Enable_Bit0* [Bit0]	On/Off *On/Off*	When programmed On, drive current and regen braking current will be cut back based on motor temperature. When programmed Off, only drive current (and not regen braking current) will be cut back based on motor temperature. If the vehicle has mechanical brakes, setting this parameter to Off may help reduce motor heating.
Temperature Hot *MotorTemp_Hot*	0–250 °C *0–2500*	Defines the temperature at which current cutback begins.
Temperature Max *MotorTemp_Max*	0–250 °C *0–2500*	Defines the temperature at which current is cut back to zero.
MotorTemp LOS Max Speed *MotorTemp_LOS_Max_Speed*	100–3000 rpm *100–3000*	When a Motor Temp Sensor Fault (fault code 29) is set, a LOS (Limited Operating Strategy) mode is engaged. The maximum speed is reduced to the programmed Max Speed in the operating mode (Max_Speed_SpdMx, Max_Speed_SpdM, Max_Speed_TrqM) ***or*** to the MotorTemp_LOS_Max_Speed, whichever is lower.

BATTERY MENU

PARAMETER	ALLOWABLE RANGE	DESCRIPTION
Nominal Voltage *Nominal_Voltage*	24–96 V *1536–6144*	Must be set to the vehicle's nominal battery pack voltage. This parameter is used in determining the overvoltage and undervoltage protection thresholds for the electronic system. Overvoltage protection cuts back regen braking to prevent damage to batteries and other electrical system components due to overvoltage. Undervoltage protection prevents systems from operating at voltages below their design thresholds. The four threshold points are calculated from the Nominal Voltage, Undervoltage Kp and Ki, User Overvoltage, and User Undervoltage parameter settings and the controller's minimum voltage and maximum voltage ratings. <u>Overvoltage</u> = Either Max Voltage (see Table E-1) *or* User Overvoltage × Nominal Voltage, whichever is lower. <u>Severe Overvoltage</u> = Overvoltage (see previous item) + 10V. <u>Undervoltage</u> = Either Min Voltage (see Table E-1) *or* User Undervoltage × Nominal Voltage, whichever is higher. <u>Severe Undervoltage</u> = Either drive current cut back to 0% for 64 ms *or* Brownout Voltage* (see Table E-1) is reached, whichever comes first. * The Brownout Voltage is determined by the controller base type and cannot be changed. When the capacitor voltage falls below the Brownout voltage the bridge is switched off (i.e., motor current is switched off). If the capacitor voltage stays below the Brownout voltage for > 64 milliseconds the controller will reset (equivalent to cycling the keyswitch). If the capacitor voltage rises above the Brownout voltage before 64 ms have passed the bridge will be reenabled. The Severe Undervoltage point cannot be set lower than the Brownout voltage.
Kp UV *Batt_Kp_UV*	0–100 %/V *0–1024*	When the battery voltage goes below the undervoltage threshold (as set above), a closed loop PI (Proportional/Integral) controller is enabled in an attempt to keep the battery voltage from drooping. It accomplishes this by cutting back the drive current, thereby reducing the load on the battery. The Kp term is the proportional gain and is set in units of % cutback per volt; for example, a setting of 25 would provide full current cutback with 4 V of droop. The Ki term is the integral gain. Integral gain will accumulate the voltage droop and attempt to bring the battery droop back to 0 V. Higher gains will react more strongly and quickly. Typically, Kp UV and Ki UV are used together to provide the best response. If the linear response of the previous AC controllers is preferred, set Ki UV = 0.
Ki UV *Batt_Ki_UV*	0–100 % *0–16384*	

BATTERY MENU, cont'd

PARAMETER	ALLOWABLE RANGE	DESCRIPTION
User Overvoltage *User_Overvoltage*	105–200 % *269–512*	The value of this parameter is a percentage of the Nominal Voltage setting. The User Overvoltage parameter can be used to adjust the overvoltage threshold, which is the voltage at which the controller will cut back regen braking to prevent damage to the electrical system. Typically this parameter is changed only when the controller is being used in an application at the low end of the controller's range: such as a 48–80V controller being used in a system with a 48V battery pack. In this case, the overvoltage threshold can be raised by setting the User Overvoltage to a higher value. The overvoltage threshold can never be raised above the controller's power base maximum voltage rating.
User Undervoltage *User_Undervoltage*	0–95 % *0–242*	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. Typically this parameter is changed only when the controller is being used in an application at the high end of the controller's range: such as a 24–36V controller being used in a system with a 36V battery pack. In this case, the undervoltage threshold can be lowered by setting the User Undervoltage to a lower value. The undervoltage threshold can never be lowered below the controller's power base minimum voltage rating.

BDI Algorithm

The BDI (battery discharge indicator) algorithm continuously calculates the battery state-of-charge whenever KSI is on. The result of the BDI algorithm is the variable BDI Percentage, which is viewable in the programmer's Monitor » Battery menu. When KSI is turned off, the present BDI Percentage is stored in nonvolatile memory.

The standard values for volts per cell are as follows, for flooded lead acid and sealed maintenance-free batteries.

	BATTERY TYPE	
	FLOODED	SEALED
Reset Volts Per Cell	2.09	2.09
Full Volts Per Cell	2.04	2.04
Empty Volts Per Cell	1.73	1.90

Use the standard values for your type of batteries as the starting point in setting the reset, full, and empty volts-per-cell parameters.

BATTERY MENU, cont'd		
PARAMETER	ALLOWABLE RANGE	DESCRIPTION
Reset Volts Per Cell *BDI_Reset_Volts_Per_Cell*	0.90–3.00 V *900–3000*	The reset voltage level is checked only once, when KSI is first turned on. Note that the BDI Reset Percent parameter also influences the algorithm that determines whether BDI Percentage is reset to 100%. Reset Volts Per Cell should always be set higher than Full Volts Per Cell. Reset Voltage Level = Reset Volts Per Cell × number of cells in the battery pack.*
Full Volts Per Cell *BDI_Full_Volts_Per_Cell*	0.90–3.00 V *900–3000*	The full voltage level sets the Keyswitch Voltage that is considered to be 100% state-of-charge; when a loaded battery drops below this voltage, it begins to lose charge. Keyswitch Voltage is viewable in the programmer's Monitor » Battery menu. Full Voltage Level = Full Volts Per Cell × number of cells in the battery pack.*
Empty Volts Per Cell *BDI_Empty_Volts_Per_Cell*	0.90–3.00 V *900–3000*	The empty voltage level sets the Keyswitch_Voltage that is considered to be 0% state-of-charge. Empty Voltage Level = Empty Volts Per Cell × number of cells in the battery pack.*
Discharge Time *BDI_Discharge_Time*	0–600 minutes *0–600*	Sets the minimum time for the BDI algorithm to count down the BDI Percentage from 100% to 0%. The BDI algorithm integrates the time the filtered keyswitch voltage is below the state of charge voltage level. When that cumulative time exceeds the Discharge Time / 100, the BDI Percentage is decremented by one percentage point and a new state of charge voltage level is calculated. State of Charge Level = ((Full Voltage Level - Empty Voltage Level) × BDI Percentage / 100) + Empty Voltage Level.
BDI Reset Percent *BDI_Reset_Percent*	0–100 % *0–100*	When a battery has a high BDI percentage, its float voltage at KSI On can sometimes cause false resets. The BDI Reset Percent parameter addresses this problem by allowing the user to define a BDI Percentage value above which the BDI Percentage variable will not reset. When KSI is first powered on, the BDI Percentage variable will reset to 100% only if ((Keyswitch Voltage > Reset Voltage Level) and (BDI Percentage < BDI Reset Percent)).

* To determine the number of cells in your battery pack, divide your Nominal Voltage setting (page 58) by 2.

DUAL DRIVE MENU
FOR DUAL DRIVE PARAMETERS, SEE THE DUAL DRIVE ADDENDUM, P/N 37022-DD.

VEHICLE MENU

PARAMETER	ALLOWABLE RANGE	DESCRIPTION
Metric Units *Metric_Units* *OptionBits3* [Bit 5]	On/Off *On/Off*	When this parameter is programmed On, the distance variables (Vehicle Odometer, Braking Distance Captured, Distance Since Stop, Distance Fine, and the Capture Distance variables) will accumulate and display in metric units (km, meters, or decimeters). When programmed Off, the distance variables will accumulate and display in English units (miles, feet, or inches). Distance variables are displayed in the Monitor » Vehicle menu, page 74.
Speed to RPM *Speed_to_RPM*	10.0–3000.0 *100–30000*	This parameter affects the vehicle speed displayed in the Monitor » Motor menu (see page 71), and also modifies the VCL variable *Vehicle_Speed*; it does not affect actual vehicle performance. The value entered for Speed to RPM is a conversion factor that scales motor speed to vehicle speed. KPH to RPM: (G/d)*5305, where G = gear ratio, d = tire diameter [mm]. MPH to RPM: (G/d)*336.1, where G = gear ratio, d = tire diameter [in].
Capture Speed 1 *Capture_Speed_1*	0–8000 rpm *0–8000*	The controller captures the time it takes the motor to go from 0 rpm to the programmed Capture Speed. The result is stored as “Time to Speed 1” in the Monitor » Vehicle menu (page 74). This timer starts every time the motor accelerates from zero speed.
Capture Speed 2 *Capture_Speed_2*	0–8000 rpm *0–8000*	This parameter allows a second capture speed to be defined, and works identically to Capture Speed 1. The result is stored as “Time to Speed 2” in the Monitor » Vehicle menu (page 74).
Capture Distance 1 *Capture_Distance_1*	1–1320 *1–1320*	The controller captures the time it takes the vehicle to travel from 0 rpm to the programmed Capture Distance. The result is stored as “Time to Dist 1” in the Monitor » Vehicle menu (page 74). This timer starts every time the vehicle accelerates from zero speed. Note: For accurate distance measuring, the Speed to RPM parameter must be set correctly. With the Metric Units parameter programmed Off, distance is in units of feet. With Metric Units programmed On, distance is in units of meters.
Capture Distance 2 *Capture_Distance_2*	1–1320 *1–1320*	This parameter allows a second capture distance to be defined, and works identically to Capture Distance 1. The result is stored as “Time to Dist 2” in the Monitor » Vehicle menu.
Capture Distance 3 *Capture_Distance_3*	1–1320 *1–1320*	This parameter allows a third capture distance to be defined, and works identically to Capture Distance 1. The result is stored as “Time to Dist 3” in the Monitor » Vehicle menu.

EMERGENCY REVERSE MENU **[SPEED MODE & SPEED MODE EXPRESS only]**

PARAMETER	ALLOWABLE RANGE	DESCRIPTION
EMR Enable *EMR_Enable* *OptionBits1* [Bit 1]	On/Off *On/Off*	Determines whether the emergency reverse function is active. On = emergency reverse is enabled. Off = emergency reverse is disabled.
EMR Type *EMR_Type*	0–3 *0–3*	Determines where the input comes from for emergency reverse. 0 = emergency reverse activated by switch 1 (pin 24). 1 = emergency reverse is activated by VCL functions Enable_Emer_Rev() and Disable_Emer_Rev(). 2 = emergency reverse activated by switch 1 (pin 24), but only if the vehicle is moving forward (forks trailing) when emergency reverse is activated. 3 = emergency reverse is activated by VCL functions Enable_Emer_Rev() and Disable_Emer_Rev(), but only if the vehicle is moving forward (forks trailing) when emergency reverse is activated.
EMR Dir Interlock *EMR_Dir_Interlock* *EMR_Dir_Interlock_Bit0* [Bit 0]	On/Off *On/Off*	Determines whether the interlock switch must be turned off after emergency reverse before the vehicle can be driven again. On = Interlock and throttle and direction must all be cleared. Off = Only throttle and direction must be cleared.
EMR Time Limit *EMR_Time_Limit*	0–30 s *0–3750*	Defines how long emergency reverse is allowed to be active after the vehicle is moving in the reverse direction. This timer will restart if the vehicle ever goes forward while emergency reverse is still active. The allowable range is 0–30 seconds, where 30 seconds is a special case of no time out. When emergency reverse times out, the Emer Rev Timeout fault is set. Cycling the emergency reverse input will clear the Emer Rev Timeout fault. To stop the vehicle after an EMR event (not move in reverse direction), set this parameter to 0.
EMR Speed *EMR_Speed*	50–6000 rpm *50–6000*	Defines the maximum reverse speed of the motor (in motor rpm), when emergency reverse is active.
EMR Accel Rate *EMR_Accel_Rate*	0.1–3.0 s *100–3000*	Sets the rate (in seconds) at which the vehicle accelerates in the opposite direction after it has been brought to a stop. If the vehicle is already traveling in the reverse direction below the EMR Speed, the EMR Accel Rate will bring the vehicle to the EMR Speed.
EMR Decel Rate *EMR_Decel_Rate*	0.1–3.0 s *100–3000*	Sets the rate (in seconds) at which the vehicle brakes to a stop when emergency reverse is activated and the vehicle is moving forward. If the vehicle is already traveling in the reverse direction above the EMR Speed, the EMR Decel Rate will bring the vehicle down to the EMR Speed.

INTERLOCK BRAKING MENU		
PARAMETER	ALLOWABLE RANGE	DESCRIPTION
Enable *Interlock_Brake_Enable* *OptionBits3* [Bit 7]	On/Off *On/Off*	Determines whether the interlock braking function is active. On = The controller will attempt to bring the vehicle to a stop using regen braking when the interlock signal is removed. Off = The controller will disable the bridge after Sequencing Delay expires and allow the vehicle to roll freely when the interlock signal is removed. This option is typically used only when there is a user controlled mechanical or hydraulic brake system.
Decel Rate HS *Interlock_Brake_Decel_Rate_HS*	0.1–30.0 *100–30000*	Sets the rate (in seconds) that is used to slow down the vehicle when the interlock is released at high vehicle speeds. Larger values represent slower response.
Decel Rate LS *Interlock_Brake_Decel_Rate_LS*	0.1–30.0 *100–30000*	Sets the rate (in seconds) that is used to slow down the vehicle when the interlock is released at low vehicle speeds. Larger values represent slower response.
Interlock Brake Timeout *Interlock_Brake_Timeout*	0–8.0 s *0–1000*	Controls the maximum allowable duration of an interlock braking event. The timer starts as soon as the interlock signal is removed. If the time expires before the vehicle has slowed below the Set_Speed_Threshold, the EM brake will engage automatically. This timeout allows parallel usage of regen braking and the EM brake to reduce stopping distance. If Interlock Brake Timeout expires and the motor is still moving, regen braking will continue to retard vehicle motion in conjunction with the EM brake. *Note: This parameter is only applicable when EM_Brake_Type = 1 or 2 (see page 47).*

CAN INTERFACE MENU		
PARAMETER	ALLOWABLE RANGE	DESCRIPTION
CANopen Interlock *CANopen_Interlock_Enable* *OptionBits3* [Bit 2]	On/Off *On/Off*	When programmed On, CAN NMT State must = 5 (operational state) in order for the interlock to be set; see Monitor » CAN Status menu, page 76.
Node ID 1 *Node_ID_1*	0–127 *0–127*	The Node ID for the primary microprocessor is determined by the state of switches 5 and 6 at KSI turn on: Node_ID_1 is selected when Sw 6 = Off and Sw 5 = Off Node_ID_2 is selected when Sw 6 = Off and Sw 5 = On Node_ID_3 is selected when Sw 6 = On and Sw 5 = Off Node_ID_4 is selected when Sw 6 = On and Sw 5 = On. If the selected parameter has a Node ID of zero, this ID is invalid and the Node_ID_1 parameter is used. If the Node_ID_1 parameter is also zero, a default ID of 38 is used.
Node ID 2 *Node_ID_2*	0–127 *0–127*	See description of Node ID 1.
Node ID 3 *Node_ID_3*	0–127 *0–127*	See description of Node ID 1.
Node ID 4 *Node_ID_4*	0–127 *0–127*	See description of Node ID 1.
Supervisor Node ID *Supervisor_Node_ID*	1–127 *1–127*	Sets the Node ID for the supervisor microprocessor. The Node ID is the first 7 bits of the 11-bit identifier (the COB ID).
Baud Rate *CAN_Baud_Rate*	-3 – 4 *-3 – 4*	Sets the CAN baud rate for the CANopen Slave system: -3=20Kbps, -2=50Kbps, -1=100Kbps, 0=125Kbps, 1=250Kbps, 2=500Kbps, 3=800Kbps, 4=1000Kbps.
Heartbeat Rate *CANopen_Heart_Beat_Rate*	16–200 ms *4–50*	Sets the rate at which the CAN heartbeat messages are sent from the CANopen Slave system.
PDO Timeout Period *CAN_PDO_Timeout_Period*	0–200 ms *0–50*	Sets the PDO timeout period for the CANopen Slave system. After the slave controller has sent a PDO MISO, it will declare a PDO Timeout Fault if the master controller has not sent a reply PDO MOSI message within the set time. Either PDO1 MOSI or PDO2 MOSI will reset the timer. Setting the PDO Timeout Period = 0 will disable this fault check.
Emergency Message Rate *CANopen_Emergency_ Message_Rate*	16–200 ms *4–50*	Sets the minimum rate between CAN emergency messages from the CANopen Slave system. This prevents quickly changing fault states from generating so many emergency messages that they flood the CAN bus.
Suppress CANopen Init *Suppress_CANopen_Init*	0–1 *0–1*	When Suppress CANopen Init is set = 1, at KSI On the initialization of the CANopen system is suppressed. Typically this is done so that the VCL program can make changes to the CANopen system before enabling it (by setting the variable Suppress_CANopen_Init = 0 and running the Setup_ CAN() function).

MOTOR CHARACTERIZATION TESTS MENU		
PARAMETER	ALLOWABLE RANGE	DESCRIPTION
		Contact your Curtis customer support engineer if you will be running the motor characterization tests yourself. See Initial Setup, step ⑪, page 82.

FIELD WEAKENING CONTROL MENU		
PARAMETER	ALLOWABLE RANGE	DESCRIPTION
FW Base Speed *FW_Base_Speed*	200–6000 rpm *200–6000*	This parameter needs to be reset each time the Motor Type is changed or the low speed current limit is changed. For example, if you lower Drive_Current_Limit (page 40) or PL_Drive_Nominal (page 41), you should consider adjusting this parameter. To determine the correct value, perform this tuning test. The test should be run with batteries that have a reasonable charge. In either Torque Control Mode or Speed Control Mode, set your accel rates to be fast—so that you'll be accelerating at full current during the test. Next, set the Base Speed parameter to the maximum value (so that it will not interfere with the test result). From a stop, apply full throttle and accelerate to high speed and then stop. After stopping, note the value displayed in Monitor » Controller » Motor Tuning » Base Speed Captured, and enter this value for the Base Speed setting. The test restarts each time the vehicle comes to a stop and the throttle is released, so be sure to note the value before driving away.
Field Weakening Drive *Field_Weakening_Drive*	0–100 % *0–1024*	Sets the amount of field weakening allowed while driving the motor. A setting of 100% will allow full field weakening when needed. A setting of zero will disable field weakening. This parameter is typically set to 100%.
Field Weakening Regen *Field_Weakening_Regen*	0–100 % *0–1024*	Sets the amount of field weakening allowed while regen braking the motor. A setting of 100% will allow full field weakening when needed. A setting of zero will disable field weakening. The default is to allow full regen field weakening, but for some higher speed vehicles a lower setting (e.g., 50%) could provide a more responsive feel.
Weakening Rate *Field_Weakening_Rate*	0–100 % *0–500*	Sets 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.
Min Field Current *Min_Field_Current*	0–800 A *0–8000*	Sets the field current when no torque is requested from the motor. This current pre-fluxes the motor and can improve initial take-off at the expense of some battery consumption.

MOTOR TYPE PARAMETER		
PARAMETER	ALLOWABLE RANGE	DESCRIPTION
Motor Type PCF *Motor_Type*	0–248 *0–248*	This parameter references a predefined table of motor parameters for many AC motors. Consult your local Curtis customer support engineer for information on how to set this parameter based on your application and motor.

RESET CONTROLLER PARAMETER		
PARAMETER	ALLOWABLE RANGE	DESCRIPTION
Reset Controller *Reset_Controller*	0–1 *0–1*	Setting this parameter = 1 will reset the controller. This reset is similar to resetting by cycling the keyswitch. Reset Controller has the advantage of resetting without causing the parameter block to be reloaded into the 1313/1314 programmer.

CLONING (for copying parameter settings to multiple controllers)

Once a controller has been programmed to the desired settings, these settings can be transferred as a group to other controllers, thus creating a family of "clone" controllers with identical settings. **Cloning only works between controllers with the same model number and software version.** For example, the programmer can read all the information from a 1236E-5325 controller and write it to other 1236E-5325 controllers; however, it cannot write that same information to 1236E-5324 controllers.

To perform cloning, plug the programmer (1313 or 1314) into the controller that has the desired settings. Select the Program menu; follow the prompts to copy the settings into the programmer.

Plug the programmer into the controller that you want to have these same settings, and follow the Program menu prompts to write these settings into the controller.

Note: For cloning Dual Drive controllers, see the separate Dual Drive addendum, p/n 37022-DD.

4a

MONITOR MENU

Through its Monitor menu, the 1313 handheld and 1314 PC programmers provide access to real-time data during vehicle operation. This information is helpful during diagnostics and troubleshooting, and also while adjusting programmable parameters.

MONITOR MENU

Monitor Menu: INPUTS

VARIABLE	DISPLAY RANGE	DESCRIPTION
Throttle Command *Throttle_Command*	-100–100 % *-32768–32767*	Throttle request to slew rate block.
Mapped Throttle *Mapped_Throttle*	-100–100 % *-32768–32767*	Mapped throttle request.
Throttle Pot *Throttle_Pot_Raw*	0–5.5 V *0–36044*	Voltage at throttle pot wiper (pin 16).
Brake Command *Brake_Command*	0–100 % *0–32767*	Brake request to slew rate block.
Mapped Brake *Mapped_Brake*	0–100 % *0–32767*	Mapped brake request.
Pot2 Raw *Pot2_Raw*	0–5.5 V *0–36044*	Voltage at pot2 wiper (pin 17).
PD Throttle *PD_Throttle*	0–100 % *0–32767*	Proportional driver current request.
Steer Pot *Steer_Pot_Raw*	0–6.25 V *0–32767*	Voltage at steer pot wiper (pin 17) on Dual Drive traction slave.
Steer Angle *Steer_Angle*	-90 – 90 *-90 – 90*	Steer angle degrees calculated in Dual Drive traction master.
Interlock *Interlock_State* *System_Flags1* [Bit 0]	On/Off *On/Off*	Interlock input on or off. The source of the interlock input is determined by the Interlock Type parameter: from Switch 3 (pin 9) if Interlock Type = 0 from VCL function if Interlock Type = 1 from KSI (pin 1) if Interlock Type = 2.

Monitor Menu: INPUTS, cont'd

VARIABLE	DISPLAY RANGE	DESCRIPTION
Emer Rev *EMR_State* *System_Flags1* [Bit 1]	On/Off *On/Off*	Emergency reverse input on or off. The source of the emergency reverse input is determined by the EMR Type parameter: from Switch 1 (pin 24) if EMR Type = 0 from VCL function if EMR Type = 1.
Analog 1 *Analog1_Input*	0–10.0 V *0–1023*	Voltage at analog 1 (pin 24).
Analog 2 *Analog2_Input*	0–10.0 V *0–1023*	Voltage at analog 2 (pin 8).
Switch 1 *Sw_1* *Switches* [Bit 0]	On/Off *On/Off*	Switch 1 on or off (pin 24).
Switch 2 *Sw_2* *Switches* [Bit 1]	On/Off *On/Off*	Switch 2 on or off (pin 8).
Switch 3 *Sw_3* *Switches* [Bit 2]	On/Off *On/Off*	Switch 3 on or off (pin 9).
Switch 4 *Sw_4* *Switches* [Bit 3]	On/Off *On/Off*	Switch 4 on or off (pin 10).
Switch 5 *Sw_5* *Switches* [Bit 4]	On/Off *On/Off*	Switch 5 on or off (pin 11).
Switch 6 *Sw_6* *Switches* [Bit 5]	On/Off *On/Off*	Switch 6 on or off (pin 12).
Switch 7 *Sw_7* *Switches* [Bit 6]	On/Off *On/Off*	Switch 7 on or off (pin 22).
Switch 8 *Sw_8* *Switches* [Bit 7]	On/Off *On/Off*	Switch 8 on or off (pin 33).
Driver 1 Input *Sw_9* *Switches* [Bit 8]	On/Off *On/Off*	Driver 1 input on or off (pin 6).
Driver 2 Input *Sw_10* *Switches* [Bit 9]	On/Off *On/Off*	Driver 2 input on or off (pin 5).

Monitor Menu: INPUTS, cont'd

VARIABLE	DISPLAY RANGE	DESCRIPTION
Driver 3 Input *Sw_11* *Switches* [Bit 10]	On/Off *On/Off*	Driver 3 input on or off (pin 4).
Driver 4 Input *Sw_12* *Switches* [Bit 11]	On/Off *On/Off*	Driver 4 input on or off (pin 3).
PD Input *Sw_13* *Switches* [Bit 12]	On/Off *On/Off*	Proportional driver on or off (pin 2).
DigOut6 Input *Sw_14* *Switches* [Bit 13]	On/Off *On/Off*	Digital Out 6 input on or off (pin 19).
DigOut7 Input *Sw_15* *Switches* [Bit 14]	On/Off *On/Off*	Digital Out 7 input on or off (pin 20).
Switch 16 *Sw_16* *Switches* [Bit 15]	On/Off *On/Off*	Switch 16 on or off (pin 14).

Monitor Menu: OUTPUTS

VARIABLE	DISPLAY RANGE	DESCRIPTION
Analog Out *Analog_Output*	0–10.0 V *0–32767*	Voltage at Analog output (pin 30).
Digital Out 6 *Dig6_Output*	On/Off *On/Off*	Digital Out 6 output on or off (pin 19).
Digital Out 7 *Dig7_Output*	On/Off *On/Off*	Digital Out 7 output on or off (pin 20).
Driver 1 PWM *PWM1_Output*	0–100 % *0–32767*	Driver 1 PWM output (pin 6).
Driver 2 PWM *PWM2_Output*	0–100 % *0–32767*	Driver 2 PWM output (pin 5).
Driver 3 PWM *PWM3_Output*	0–100 % *0–32767*	Driver 3 PWM output (pin 4).
Driver 4 PWM *PWM4_Output*	0–100 % *0–32767*	Driver 4 PWM output (pin 3).
PD PWM *PD_Output*	0–100 % *0–32767*	Proportional driver PWM output (pin 2).
PD Current *PD_Current*	0–2.0 A *0–607*	Current at proportional driver (pin 2).
12 Volts *Twelve_Volts_Output*	0–12.00 V *0–768*	Voltage at +12V output (pin 25).
5 Volts *Five_Volts_Output*	0–6.25 V *0–1023*	Voltage at +5V output (pin 26).
Ext Supply Current *Ext_Supply_Current*	5–200 mA *52–800*	Combined current of the external +12V and +5V voltage supplies (pins 25 and 26).
Pot Low *Pot_Low_Output*	0–6.25 V *0–1023*	Voltage at pot low (pin 18).

Monitor Menu: BATTERY

VARIABLE	DISPLAY RANGE	DESCRIPTION
BDI *BDI_Percentage*	0–100 % *0–100*	Battery state of charge.
Capacitor Voltage *Capacitor_Voltage*	0–105 V *0–6720*	Voltage of controller's internal capacitor bank at B+ terminal.
Keyswitch Voltage *Keyswitch_Voltage*	0–105 V *0–10500*	Voltage at KSI (pin 1).

Monitor Menu: MOTOR

VARIABLE	DISPLAY RANGE	DESCRIPTION
Motor RPM *Motor_RPM_Display*	-12000–12000 rpm *-12000–12000*	Motor speed in revolutions per minute.
Temperature *Motor_Temperature*	-100–300 °C *-1000–3000*	Temperature sensor readout.
MotorSpeed A *MotorspeedA*	0–12000 rpm *0–12000*	Motor encoder phase A speed in revolutions per minute. This can be used to verify that phase A of the encoder is operating correctly. MotorSpeed A should equal MotorSpeed B in a properly operating motor encoder. Note: MotorSpeed A does not indicate direction.
MotorSpeed B *MotorspeedB*	0–12000 rpm *0–12000*	Motor encoder phase A speed in revolutions per minute. This can be used to verify that phase B of the encoder is operating correctly. MotorSpeed B should equal MotorSpeed A in a properly operating motor encoder. Note: MotorSpeed B does not indicate direction.

Monitor Menu: CONTROLLER		
VARIABLE	DISPLAY RANGE	DESCRIPTION
Current (RMS) *Current_RMS*	0–1000 A *0–10000*	RMS current of the controller, taking all three phases into account.
Modulation Depth *Modulation_Depth*	0–100 % *0–1182*	Percentage of available voltage being used.
Frequency *Frequency*	-300–300 Hz *-18000–18000*	Controller electrical frequency.
Temperature *Controller_Temperature*	-100–300 °C *-1000–3000*	Controller internal temperature.
Main State *Main_State*	0–10 *0–10*	Main contactor state: 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).
Regen *Regen_State* *System_Flags1* [Bit 2]	On/Off *On/Off*	On when regen braking is taking place; Off when it is not.
VCL Error Module *Last_VCL_Error_Module* **VCL Error** *Last_VCL_Error*	0–65536 *0–65536* 0–65536 *0–65536*	A VCL Runtime Error (fault code 68) will store additional information about the cause of a VCL runtime error in the VCL Error Module and VCL Error variables. The resulting non-zero values can be compared to the runtime VCL module ID and error code definitions listed in the controller's OS SysInfo file, which should help pinpoint the VCL error that caused the runtime error.
Motor Characterization Error *Motor_Characterization_Error*	0–65536 *0–65536*	A Motor Characterization Error (fault code 87) will store additional information in the Motor Characterization Error variable: 0= none 1= encoder signal seen but unable to determine step size; must set up Encoder Step Size manually 2= motor temp sensor fault 3= motor temp hot cutback fault 4= controller overtemp cutback fault 5= controller undertemp cutback fault 6= undervoltage cutback fault 7= severe overvoltage fault 8= encoder signal not seen, or one or both channels missing 9= motor parameters out of characterization range.

Monitor Menu: CUTBACKS

VARIABLE	DISPLAY RANGE	DESCRIPTION
Motor Temp Cutback *MotorTempCutback*	0–100 % *0–4096*	Displays the current available as a result of the motor temperature cutback function. A value of 100% indicates no cutback in current.
Controller Temp Cutback *ControllerTempCutback*	0–100 % *0–4096*	Displays the current available as a result the controller temperature cutback function. A value of 100% indicates no cutback in current.
Undervoltage Cutback *UndervoltageCutback*	0–100 % *0–4096*	Displays the current available as a result the undervoltage cutback function. A value of 100% indicates no cutback in current.
Overvoltage Cutback *OvervoltageCutback*	0–100 % *0–4096*	Displays the current available as a result the overvoltage cutback function. A value of 100% indicates no cutback in current.

Monitor Menu: MOTOR TUNING

VARIABLE	DISPLAY RANGE	DESCRIPTION
Base Speed Captured *Base_Speed_Captured*	0–8000 rpm *0–8000*	Displays the value of the motor base speed captured in the most recent acceleration. This value is used to set the Base Speed parameter (Program » Motor Control Tuning » Field Weakening Control menu), using the Base Speed set procedure described on page 62.

☞ *Note: All vehicle calculations assume no tire slippage.*

Monitor Menu: VEHICLE

VARIABLE	DISPLAY RANGE	DESCRIPTION
Vehicle Speed *Vehicle_Speed*	-327.7–327.7 *-32768–32767*	Vehicle speed, in units of MPH or KPH, depending on the setting of the Metric Units parameter (see Program » Vehicle menu, page 61). For accurate speed estimates, the Speed to RPM parameter must be set correctly (page 61).
Vehicle Odometer *Vehicle_Odometer*	0–429496729.5 *0–4294967295*	Vehicle distance traveled, in units of miles or km, depending on the setting of the Metric Units parameter (page 61). For accurate distance measurements, the Speed to RPM parameter must be set correctly (page 61).
Vehicle Acceleration *Vehicle_Acceleration*	-10–10 g *-10000–10000*	Vehicle acceleration. The Speed to RPM parameter must be set correctly for accurate measurement.
Time to Speed 1 *Time_to_Capture_Speed_1*	0–128 s *0–32000*	Time taken for the vehicle to go from zero rpm to the programmed Capture Speed 1 (see Program » Vehicle menu, page 61) during its most recent such acceleration.
Time to Speed 2 *Time_to_Capture_Speed_2*	0–128 s *0–32000*	Time taken for the vehicle to go from zero rpm to the programmed Capture Speed 2 (see Program » Vehicle menu, page 61) during its most recent such acceleration.
Time Between Speeds *Time_Between_Capture_Speeds*	0–128 s *0–32000*	Time taken for the vehicle to go from programmed Capture Speed 1 to programmed Capture Speed 2 (see Program » Vehicle menu, page 61) during its most recent such acceleration.
Time to Dist 1 *Time_to_Capture_Dist_1*	0–128 s *0–32000*	Time taken for the vehicle to travel from zero rpm to the programmed Capture Distance 1 (see Program » Vehicle menu, page 61) during its most recent such trip. For accurate distance measurements, the Speed to RPM parameter must be set correctly (page 61).
Time to Dist 2 *Time_to_Capture_Dist_2*	0–128 s *0–32000*	Time taken for the vehicle to travel from zero rpm to the programmed Capture Distance 2 (see Program » Vehicle menu) during its most recent such trip. For accurate distance measurements, the Speed to RPM parameter must be set correctly (page 61).

Monitor Menu: VEHICLE, cont'd

VARIABLE	DISPLAY RANGE	DESCRIPTION
Time to Dist 3 *Time_to_Capture_Dist_3*	0–128 s *0–32000*	Time taken for the vehicle to travel from zero rpm to the programmed Capture Distance 3 (see Program » Vehicle menu, page 61) during its most recent such trip. For accurate distance measurements, the Speed to RPM parameter must be set correctly (page 61).
Braking Distance Captured *Braking_Distance_Captured*	0–1000000.0 *0–400000000*	Distance traveled by the vehicle starting with vehicle braking (initiated by throttle reversal, brake pot, VCL_Brake, or interlock braking) and ending when Motor_RPM = 0. Units are meters or feet, depending on the setting of the Metric Units parameter (page 61). For accurate distance measurements, the Speed to RPM parameter must be set correctly (page 61).
Distance Since Stop *Distance_Since_Stop*	0–1000000.0 *0–400000000*	Distance traveled by the vehicle starting from a stop. In effect, the vehicle is used as a tape measure. (In other words, if you travel 300 feet forward and then 300 feet in reverse, the distance would be 600.) The distance is continuously updated and will stop (and restart) when Motor_RPM = 0. For accurate distance measurements, the Speed to RPM parameter must be set correctly (page 61). Units are meters or feet, depending on the setting of the Metric Units parameter (page 61).
Distance Fine *Distance_Fine_Long*	-214748364.8–214748364.7 *-2147483648–2147483647*	Position measurement. Net distance in both the forward and reverse directions. (In other words, if you travel 20 inches forward and then 20 inches in reverse, the distance would be zero.) The distance is continuously updated and will roll over when the variable goes over the limits. Units are decimeters or inches, depending on the setting of the Metric Units parameter (page 61). For accurate distance measurements, the Speed to RPM parameter must be set correctly (page 61).

Monitor Menu: CAN STATUS		
VARIABLE	DISPLAY RANGE	DESCRIPTION
CAN Node ID	0–127	Displays the controller's Node ID.
CAN NMT State *CAN_NMT_State*	0–127 *0–127*	Controller CAN NMT state: 0=initialization, 4=stopped, 5=operational, 127=pre-operational.
PDO1 MOSI Byte Map*	$0 - 2^{32}$	Mapping objects for PDO1 MOSI's eight bytes.
PDO1 MISO Byte Map*	$0 - 2^{32}$	Mapping objects for PDO1 MISO's eight bytes.
PDO2 MOSI Byte Map*	$0 - 2^{32}$	Mapping objects for PDO2 MOSI's eight bytes.
PDO2 MISO Byte Map*	$0 - 2^{32}$	Mapping objects for PDO2 MISO's eight bytes.

* Each of these byte maps is a submenu containing 8 variables, one for each byte. Each variable is 32 bits. For example, the PDO1 MOSI Byte Map menu looks like this:

PDO1 MOSI Byte Map

1	$0 - 2^{32}$	Mapping object for byte 1 of PDO1 MOSI.
2	$0 - 2^{32}$	Mapping object for byte 2 of PDO1 MOSI.
3	$0 - 2^{32}$	Mapping object for byte 3 of PDO1 MOSI.
4	$0 - 2^{32}$	Mapping object for byte 4 of PDO1 MOSI.
5	$0 - 2^{32}$	Mapping object for byte 5 of PDO1 MOSI.
6	$0 - 2^{32}$	Mapping object for byte 6 of PDO1 MOSI.
7	$0 - 2^{32}$	Mapping object for byte 7 of PDO1 MOSI.
8	$0 - 2^{32}$	Mapping object for byte 8 of PDO1 MOSI.

8 DIAGNOSTICS AND TROUBLESHOOTING

These controllers detect a wide variety of faults or error conditions. Faults can be detected by the operating system or by the VCL code. This section describes the faults detected by the operating system.

Faults detected by VCL code (faults 51–67 in Table 5) cannot be defined here as they will vary from application to application. Refer to the appropriate OEM documentation for information on these faults.

DIAGNOSTICS

Diagnostics information can be obtained in either of two ways: (1) by reading the display on a 1313 handheld or 1314 PC programmer or (2) by observing the fault codes issued by the Status LEDs. See Table 4 for a summary of LED display formats.

The 1313/1314 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 programmer displays the faults by name.

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 1313/1314 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)

The numerical codes used by the yellow LED are listed in the troubleshooting chart (Table 5), which also lists possible fault causes and describes the conditions that set and clear each fault.

Summary of LED display formats

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

Table 4 TYPES OF LED DISPLAY

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	No software loaded, or an internal hardware fault detected by the Supervisor or Primary microprocessor. Cycle KSI to clear. Reload software or replace controller if necessary.
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.

TROUBLESHOOTING

The troubleshooting chart, Table 5, 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.

Table 5 TROUBLESHOOTING CHART

CODE	PROGRAMMER LCD DISPLAY / *EFFECT OF FAULT*	POSSIBLE CAUSE	SET/CLEAR CONDITIONS
12	Controller Overcurrent *ShutdownMotor; ShutdownMainContactor; ShutdownEMBrake; ShutdownThrottle; FullBrake; ShutdownPump.*	1. External short of phase U,V, or W motor connections. 2. Motor parameters are mis-tuned. 3. Controller defective. 4. Speed encoder noise problems.	*Set:* Phase current exceeded the current measurement limit. *Clear:* Cycle KSI.
13	Current Sensor Fault *ShutdownMotor; ShutdownMainContactor; ShutdownEMBrake; ShutdownThrottle; FullBrake; ShutdownPump.*	1. Leakage to vehicle frame from phase U, V, or W (short in motor stator). 2. Controller defective.	*Set:* Controller current sensors have invalid offset reading. *Clear:* Cycle KSI.
14	Precharge Failed *ShutdownMotor; ShutdownMainContactor; ShutdownEMBrake; ShutdownThrottle; FullBrake; ShutdownPump.*	1. See Monitor menu » Battery: Capacitor Voltage. 2. External load on capacitor bank (B+ connection terminal) that prevents the capacitor bank from charging.	*Set:* Precharge failed to charge the capacitor bank to the KSI voltage. *Clear:* Cycle Interlock input or use VCL function *Enable_Precharge()*.
15	Controller Severe Undertemp *ShutdownMotor; ShutdownMainContactor; ShutdownEMBrake; ShutdownThrottle; FullBrake; ShutdownPump.*	1. See Monitor menu » Controller: Temperature. 2. Controller is operating in an extreme environment.	*Set:* Heatsink temperature below -40°C. *Clear:* Bring heatsink temperature above -40°C, and cycle interlock or KSI.
16	Controller Severe Overtemp *ShutdownMotor; ShutdownMainContactor; ShutdownEMBrake; ShutdownThrottle; FullBrake; ShutdownPump.*	1. See Monitor menu » Controller: Temperature. 2. Controller is operating in an extreme environment. 3. Excessive load on vehicle. 4. Improper mounting of controller.	*Set:* Heatsink temperature above +95°C. *Clear:* Bring heatsink temperature below +95°C, and cycle interlock or KSI.
17	Severe Undervoltage *Reduced drive torque.*	1. Battery Menu parameters are misadjusted. 2. Non-controller system drain on battery. 3. Battery resistance too high. 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 (see page 58) with FET bridge enabled. *Clear:* Bring capacitor voltage above Severe Undervoltage limit.

Table 5 TROUBLESHOOTING CHART, cont'd

CODE	PROGRAMMER LCD DISPLAY *EFFECT OF FAULT*	POSSIBLE CAUSE	SET/CLEAR CONDITIONS
18	Severe Overvoltage *ShutdownMotor; ShutdownMainContactor; ShutdownEMBrake; ShutdownThrottle; FullBrake; ShutdownPump.*	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 (see page 58) 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.*	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 85°C. *Clear:* Bring heatsink temperature below 85°C.
23	Undervoltage Cutback *Reduced drive torque.*	1. Normal operation. Fault shows that the batteries need recharging. Controller is performance 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 (see page 58) with the FET bridge enabled. *Clear:* Bring capacitor voltage above the Undervoltage limit.
24	Overvoltage Cutback *Reduced brake torque.* *Note: This fault is declared only when the controller is running in regen.*	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 (see page 58) 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.*	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.
26	Digital Out 6 Open/Short *Digital Output 6 driver will not turn on.*	1. External load impedance on Digital Output 6 driver (pin 19) is too low.	*Set:* Digital Output 6 (pin 19) current exceeded 15 mA. *Clear:* Remedy the overcurrent cause and use the VCL function Set_DigOut() to turn the driver on again.

Table 5 TROUBLESHOOTING CHART, cont'd

CODE	PROGRAMMER LCD DISPLAY / *EFFECT OF FAULT*	POSSIBLE CAUSE	SET/CLEAR CONDITIONS
27	Digital Out 7 Open/Short *Digital Output 7 driver will not turn on.*	1. External load impedance on Digital Output 7 driver (pin 20) is too low.	*Set:* Digital Output 7 (pin 20) current exceeded 15 mA. *Clear:* 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.*	1. Motor temperature is at or above the programmed Temperature Hot setting, and the 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 *MaxSpeed reduced (LOS, Limited Operating Strategy), and motor temperature cutback disabled.*	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 *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.*	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
32	Coil2 Driver Open/Short *ShutdownDriver2.*	1. Open or short on driver load. 2. Dirty connector pins. 3. Bad crimps or faulty wiring.	*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.*	1. Open or short on driver load. 2. Dirty connector pins. 3. Bad crimps or faulty wiring.	*Set:* Electromagnetic brake driver (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.
33	Coil3 Driver Open/Short *ShutdownDriver3.*	1. Open or short on driver load. 2. Dirty connector pins. 3. Bad crimps or faulty wiring.	*Set:* Driver 3 (pin 4) is either open or shorted. *Clear:* Correct open or short, and cycle driver.
34	Coil4 Driver Open/Short *ShutdownDriver4.*	1. Open or short on driver load. 2. Dirty connector pins. 3. Bad crimps or faulty wiring.	*Set:* Driver 4 (pin 3) is either open or shorted. *Clear:* Correct open or short, and cycle driver.

Table 5 TROUBLESHOOTING CHART, cont'd

CODE	PROGRAMMER LCD DISPLAY / *EFFECT OF FAULT*	POSSIBLE CAUSE	SET/CLEAR CONDITION
35	PD Open/Short *ShutdownPD.*	1. Open or short on driver load. 2. Dirty connector pins. 3. Bad crimps or faulty wiring.	*Set:* Proportional driver (pin 2) is either open or shorted. *Clear:* Correct open or short, and cycle driver.
36	Encoder Fault *ShutdownEMBrake;* *ShutdownThrottle.*	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 *ShutdownMotor;* *ShutdownMainContactor;* *ShutdownEMBrake;* *ShutdownThrottle;* *FullBrake;* *ShutdownPump.*	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 *ShutdownMotor;* *ShutdownMainContactor;* *ShutdownEMBrake;* *ShutdownThrottle;* *FullBrake;* *ShutdownPump.*	1. Main contactor tips are welded closed. 2. Motor phase U or V is disconnected or open. 3. An alternate 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 *ShutdownMotor;* *ShutdownMainContactor;* *ShutdownEMBrake;* *ShutdownThrottle;* *FullBrake;* *ShutdownPump.*	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 *ShutdownThrottle.*	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 *Setup_Pot_Faults()*). *Clear:* Bring throttle pot wiper voltage below the fault threshold.
42	Throttle Wiper Low *ShutdownThrottle.*	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 *Setup_Pot_Faults()*). *Clear:* Bring throttle pot wiper voltage above the fault threshold.
43	Pot2 Wiper High *FullBrake.*	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 *Setup_Pot_Faults()*). *Clear:* Bring Pot2 wiper voltage below the fault threshold.

Table 5 TROUBLESHOOTING CHART, cont'd

CODE	PROGRAMMER LCD DISPLAY / *EFFECT OF FAULT*	POSSIBLE CAUSE	SET/CLEAR CONDITIONS
44	Pot2 Wiper Low *FullBrake.*	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 *Setup_Pot_Faults()*). *Clear:* Bring Pot2 wiper voltage above the fault threshold.
45	Pot Low Overcurrent *ShutdownThrottle;* *FullBrake.*	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 *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.*	1. KSI, interlock, direction, and throttle inputs applied in incorrect sequence. 2. Faulty wiring, crimps, or switches at KSI, interlock, direction, or throttle inputs. 3. See Monitor menu » Inputs.	*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.
49	Parameter Change Fault *ShutdownMotor;* *ShutdownMainContactor;* *ShutdownEMBrake;* *ShutdownThrottle;* *FullBrake;* *ShutdownPump.*	1. This is a safety 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.
51–67	OEM Faults *(See OEM documentation.)*	1. These faults can be defined by the OEM and are implemented in the application-specific VCL code. See OEM documentation.	*Set:* See OEM documentation. *Clear:* See OEM documentation.

Table 5 TROUBLESHOOTING CHART, cont'd

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 compiled software and matching parameter defaults; cycle KSI.
69	External Supply Out of Range *None, unless a fault action is programmed in VCL.*	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 » Outputs: Ext Supply Current.	*Set:* The external supply current (combined current used by the 5V supply [pin 26] and 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 (page 53). *Clear:* Bring the external supply current within range.
71	OS General *ShutdownMotor; ShutdownMainContactor; ShutdownEMBrake; ShutdownThrottle; ShutdownInterlock; ShutdownDriver1; ShutdownDriver2; ShutdownDriver3; ShutdownDriver4; ShutdownPD; FullBrake; ShutdownPump.*	1. Internal controller fault.	*Set:* Internal controller fault detected. *Clear:* Cycle KSI.
72	PDO Timeout *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	Stall Detected *ShutdownEMBrake; ShutdownThrottle; Control Mode changed to LOS (Limited Operating Strategy).*	1. Stalled motor. 2. Motor encoder failure. 3. Bad crimps or faulty wiring. 4. Problems with power supply for the motor encoder. 5. See Monitor menu » Motor: Motor RPM.	*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.
74	Fault On Other Traction Controller	Dual Drive fault: see Dual Drive manual.	
75	Dual Severe Fault	Dual Drive fault: see Dual Drive manual.	

Table 5 TROUBLESHOOTING CHART, cont'd

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.*	1. The Supervisor has detected a mismatch in redundant readings. 2. Internal damage to Supervisor microprocessor. 3. Switch inputs allowed to be within upper and lower thresholds for over over 100 milliseconds.	*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.
87	Motor Characterization Fault *ShutdownMotor; ShutdownMainContactor; ShutdownEMBrake; ShutdownThrottle; FullBrake; ShutdownPump.*	1. Motor characterization failed during characterization process. See Monitor menu » Controller: Motor Characterization Error for cause: 0=none 1=encoder signal seen, but step size not determined; set Encoder Step Size manually 2=motor temp sensor fault 3=motor temp hot cutback fault 4= controller overtemp cutback fault 5=controller undertemp cutback fault 6=undervoltage cutback fault 7=severe overvoltage fault 8=encoder signal not seen, or one or both channels missing 9=motor parameters out of characterization range.	*Set:* Motor characterization failed during the motor characterization process. *Clear:* Correct fault; cycle KSI.

Table 5 TROUBLESHOOTING CHART, cont'd

CODE	PROGRAMMER LCD DISPLAY / *EFFECT OF FAULT*	POSSIBLE CAUSE	SET/CLEAR CONDITIONS
88	Encoder Pulse Error *ShutdownMotor; ShutdownMainContactor; ShutdownEMBrake; ShutdownThrottle; ShutdownInterlock; ShutdownDriver1; ShutdownDriver2; ShutdownDriver3; ShutdownDriver4; ShutdownPD; FullBrake; ShutdownPump.*	1. Encoder Steps parameter does not match the actual motor encoder.	*Set:* Motor lost IFO control and accelerated without throttle command. *Clear:* 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.	*Set:* Motor_Type parameter is set to an illegal value. *Clear:* 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.
92	EM Brake Failed to Set *ShutdownEMBrake; ShutdownThrottle.* *Position Hold is engaged when Interlock=On.*	1. Vehicle movement sensed after the EM Brake has been commanded to set. 2. EM Brake will not hold the motor from rotating.	*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	Encoder LOS (Limited Operating Strategy) *Enter LOS control mode.*	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). 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.
94	EMR Rev Timeout *ShutdownEMBrake; ShutdownThrottle.*	1. Emergency Reverse was activated and concluded because the EMR Timeout timer has expired. 2. The emergency reverse input is stuck On.	*Set:* Emergency Reverse was activated and ran until the EMR Timeout timer expired. *Clear:* Turn the emergency reverse input Off.

Table 5 TROUBLESHOOTING CHART, cont'd

CODE	PROGRAMMER LCD DISPLAY *EFFECT OF FAULT*	POSSIBLE CAUSE	SET/CLEAR CONDITIONS
98	Illegal Model Number *ShutdownMotor;* *ShutdownMainContactor;* *ShutdownEMBrake;* *ShutdownThrottle;* *FullBrake;* *ShutdownPump.*	1. 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. 2. Software and hardware do not match. 3. Controller defective.	*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.
99	Dualmotor Parameter Mismatch	Dual Drive fault: see Dual Drive manual.	