Manual

Model **1220E**

Electric Steering Controller
for Brushed PM Motor

Tecknowledgey Inc.
8 John Walsh Blvd
Peekskill, NY 10566
www.tecknowledgey.com

Read Instructions Carefully!

53226, Rev B February 2019

TABLE OF CONTENTS

CHAPTERS

TABLE OF CONTENTS cont'd

FIGURES

TABLE OF CONTENTS cont'd

TABLES

The Curtis Difference
You feel it when you drive it

1 — OVERVIEW

The Curtis Model 1220E is a EN13849 compliant brushed permanent magnet motor controller for electric power steering (EPS). The 1220E performs as the steering system controller, interpreting the steering command input and wheel position feedback, then driving the steering motor to move the steered wheel(s) to the desired position.

The steering motor must be speed reduced to get the high torque required to rotate the drive wheel. Typically this is done with a gearbox around 50:1 and a chain or gear with an additional reduction of around 4:1. The steering command comes either from a linear potentiometer, an analog voltage sensor, or a quadrature encoder. The command is interpreted as an absolute position or a relative position request. The wheel position feedback comes either from a linear potentiometer, an analog voltage sensor, or quadrature encoder.

Figure 1
Curtis 1220E electric steering controller.

The 1220E works only with Curtis AC traction controllers with embedded VCL. A "handshake" with the traction controller is required at startup to enable operation.

Intended applications are material handling vehicles such as reach trucks, order pickers, stackers, "man up" warehouse trucks, and other similar industrial vehicles.

Advanced Motor Control

- Absolute and relative position control mode.
- 20 kHz PWM switching frequency ensures silent operation.
- Advanced PWM techniques produce low motor harmonics, low torque ripple, and minimized heating losses, resulting in high efficiency.
- Configurable homing methods, center offset, and end-stop protection.
- 24V and 36/48V models available.
- 60A 1-minute current rating with 70A boost for 10 seconds.

Maximum Safety

- Flexible Steer command and position feedback devices: quadrature encoder, analog voltage/potentiometer, or CAN command input.
- Fault output can be used to turn off traction controller's main contactor and EM brake.
- Following error check ensures the wheel position tracks the steering command.
- Power On Self-Test: FLASH, ALU, EEPROM, software watchdog, RAM, etc.
- High level of fault detection with second microprocessor monitoring operation.
- Periodic self-tests (Parameters, Motor Open, Command & Feedback devices, +5V/12V output supply, ALU, RAM, Task period).

Unmatched Flexibility

- Integrated hour meter and diagnostic log functions.
- Curtis 840 Spyglass can be connected to show traction and steering information such as BDI, hour meter, fault, traction speed, and steered wheel angle.
- +5V and +12V low-power supply for input sensors, etc.
- Curtis Software Suite CSS, 1313 handheld programmer and 1314 PC Programming Station provide easy programming and powerful system diagnostic and monitoring capabilities.
- Built-in Status LED gives instant diagnostic indication.

Robust Reliability

- Intelligent thermal cutback and overvoltage/undervoltage protection functions maintain steering while reducing traction speed until severe over/under limits are reached.
- Standard Mini-Fit Molex Jr. and Faston terminals provide proven, robust wiring connections.
- Electronics sealed to IPx4.
- Reverse polarity protection on battery connections.
- Inputs protected against shorts to B+ and B–.

Familiarity with your Curtis controller will help you install and operate it properly. We encourage you to read this manual carefully. If you have questions, please contact your local Curtis representative.

⚠ CAUTION

Working on electrical systems is potentially dangerous. Protect yourself against uncontrolled operation, high current arcs, and outgassing from lead acid batteries:

UNCONTROLLED OPERATION — Some conditions could cause the motor to run out of control. Disconnect the motor or jack up the vehicle and get the drive wheels off the ground before attempting any work on the motor control circuitry.

HIGH CURRENT ARCS — Batteries can supply very high power, and arcing can occur if they are short-circuited. Always open the battery circuit before working on the motor control circuit. Wear safety glasses, and use properly insulated tools to prevent shorts.

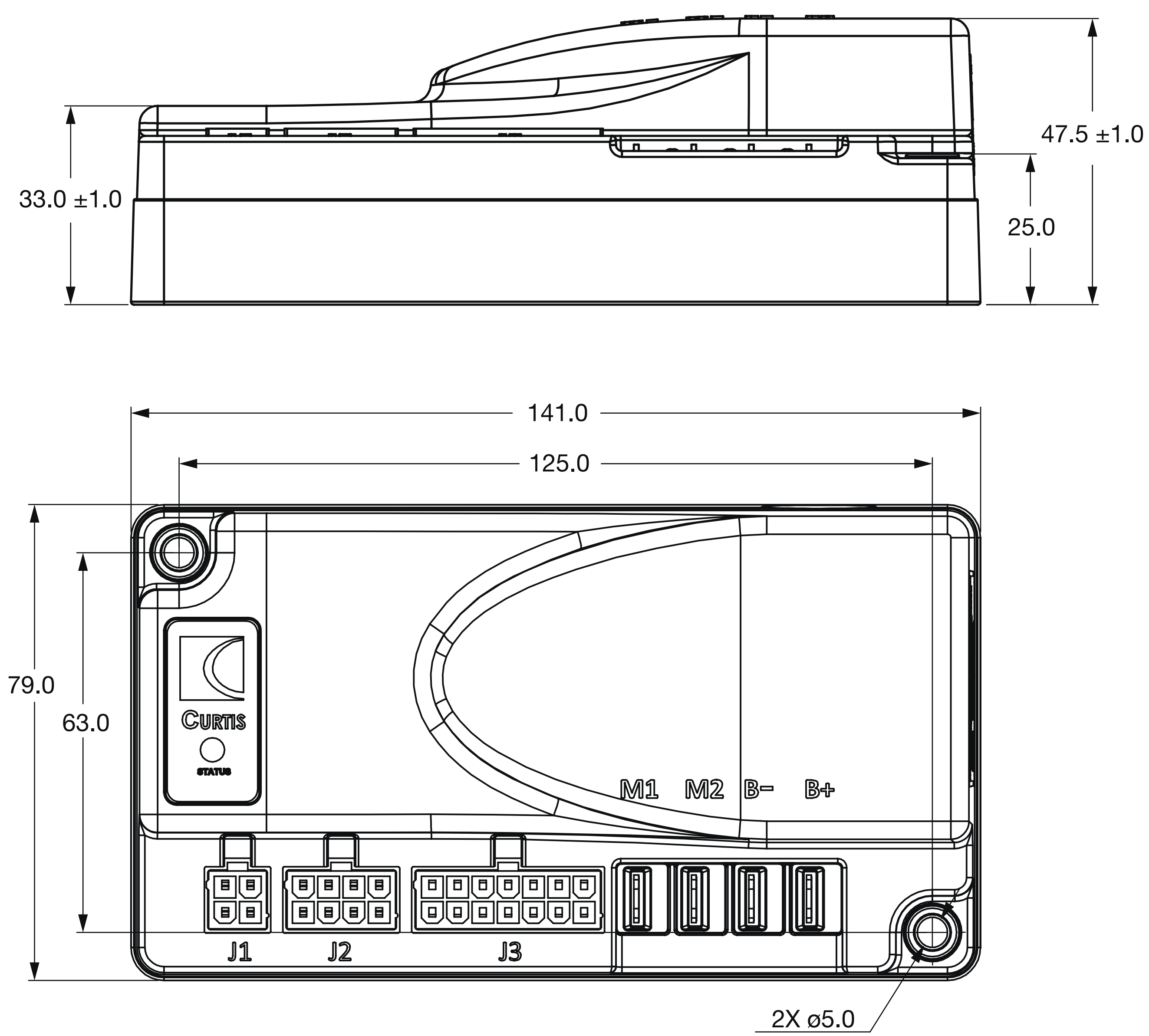
LEAD ACID BATTERIES — Charging or discharging generates hydrogen gas, which can build up in and around the batteries. Follow the battery manufacturer's safety recommendations. Wear safety glasses.

2 — INSTALLATION AND WIRING

MOUNTING THE CONTROLLER

The 1220E controller can be oriented in any position, but **the mounting location should be carefully chosen to keep the controller clean and dry. If a clean, dry mounting location cannot be found, a cover must be used to shield the controller from water and contaminants.**

The outline and mounting hole dimensions are shown in Figure 2. The controller should be mounted by means of the two mounting holes at the opposing corners of the heatsink, using M4 (#8) screws.



Dimensions in millimeters (and inches)

Figure 2

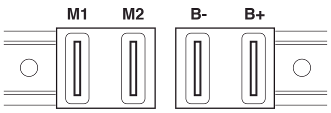
Mounting dimensions, Curtis 1220E motor controller.

You will need to take steps during the design and development of your end product to ensure that its EMC performance complies with applicable regulations; suggestions are presented in Appendix A.

The 1220E controller contains **ESD-sensitive components**. Use appropriate precautions in connecting, disconnecting, and handling the controller. See installation suggestions in Appendix A for protecting the controller from ESD damage.

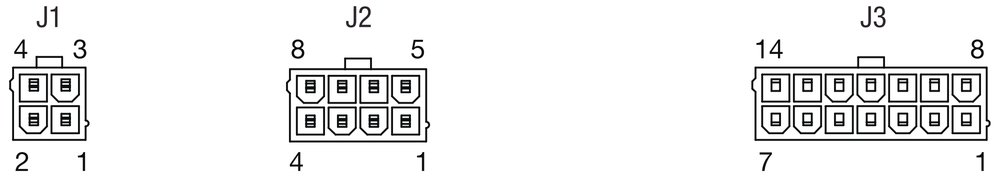
CONNECTIONS: High Current

Four 1/4" Faston terminals are provided for the high current connections. The motor connections (**M1**, **M2**) and battery connections (**B+**, **B–**) have one terminal each.



CONNECTIONS: Low Current

The low current connections are made through three connectors: J1, J2, and J3.



J1-4 Pin Molex:39-28-8040	1	Rx
	2	I/O GND
	3	Tx
	4	+12V
Mating connector: Molex 39-01-2040 with appropriate 45750-series crimp terminals		

J2-8 Pin Molex: 39-28-8080	1	Home Switch 2
	2	Interlock Input 2
	3	Command Encoder 2A
	4	Command Encoder 2B
	5	Steer Motor Encoder 2A
	6	Steer Motor Encoder 2B
	7	CAN TERM H
	8	Auxiliary Analog Input
Mating connector: Molex 39-01-2080 with appropriate 45750-series crimp terminals		

J3-14 Pin Molex: 39-28-8140	1	Fault Output
	2	Steer Motor Encoder 1A/ Position Analog 1
	3	Home Switch 1
	4	Interlock Input 1
	5	KSI
	6	Command Analog 1/ Command Encoder 1A
	7	+5V Supply 1
	8	CANH
	9	Steer Motor Encoder 1B/ Position Analog 2
	10	I/O GND
	11	+5V Supply 2
	12	CANL
	13	Command Analog 2/ Command Encoder 1B
	14	I/O GND
Mating connector: Molex 39-01-2140 with appropriate 45750-series crimp terminals		

CONTROLLER WIRING

As shown in the wiring diagrams (Figures 3a, 3b), the 1220E's keyswitch power must go through the traction controller so that when the keyswitch is turned off both controllers turn off. The fault output (Pin J3-1) must be able to shut down the traction system in the case of a serious fault, in order to meet international safety requirements.

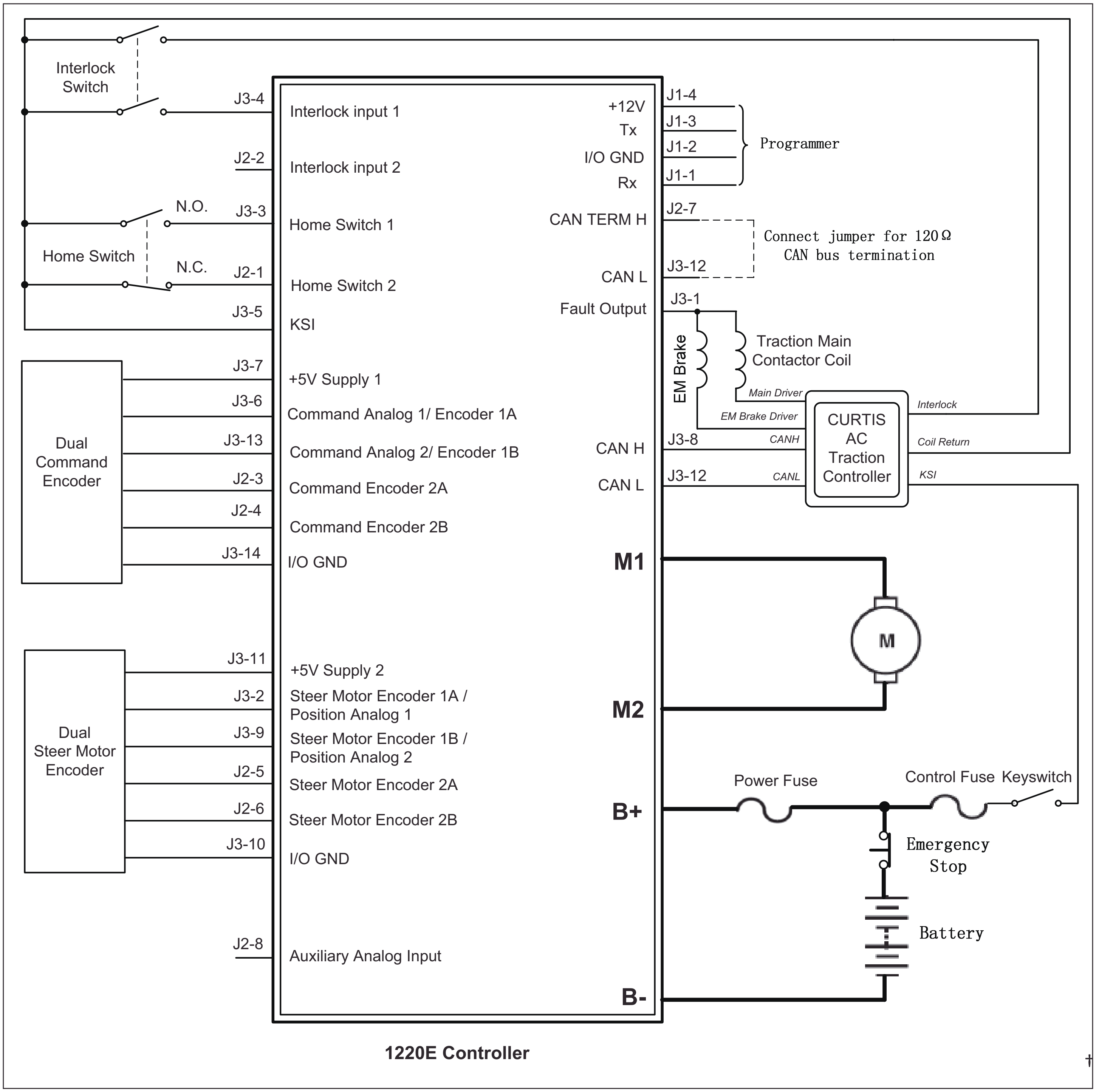


Figure 3a

Basic wiring diagram, Relative Position Mode.

These wiring diagrams (Figures 3a, 3b) show generic applications and may not fully meet the requirements of your system. You may wish to contact your local Curtis representative to discuss your particular application.

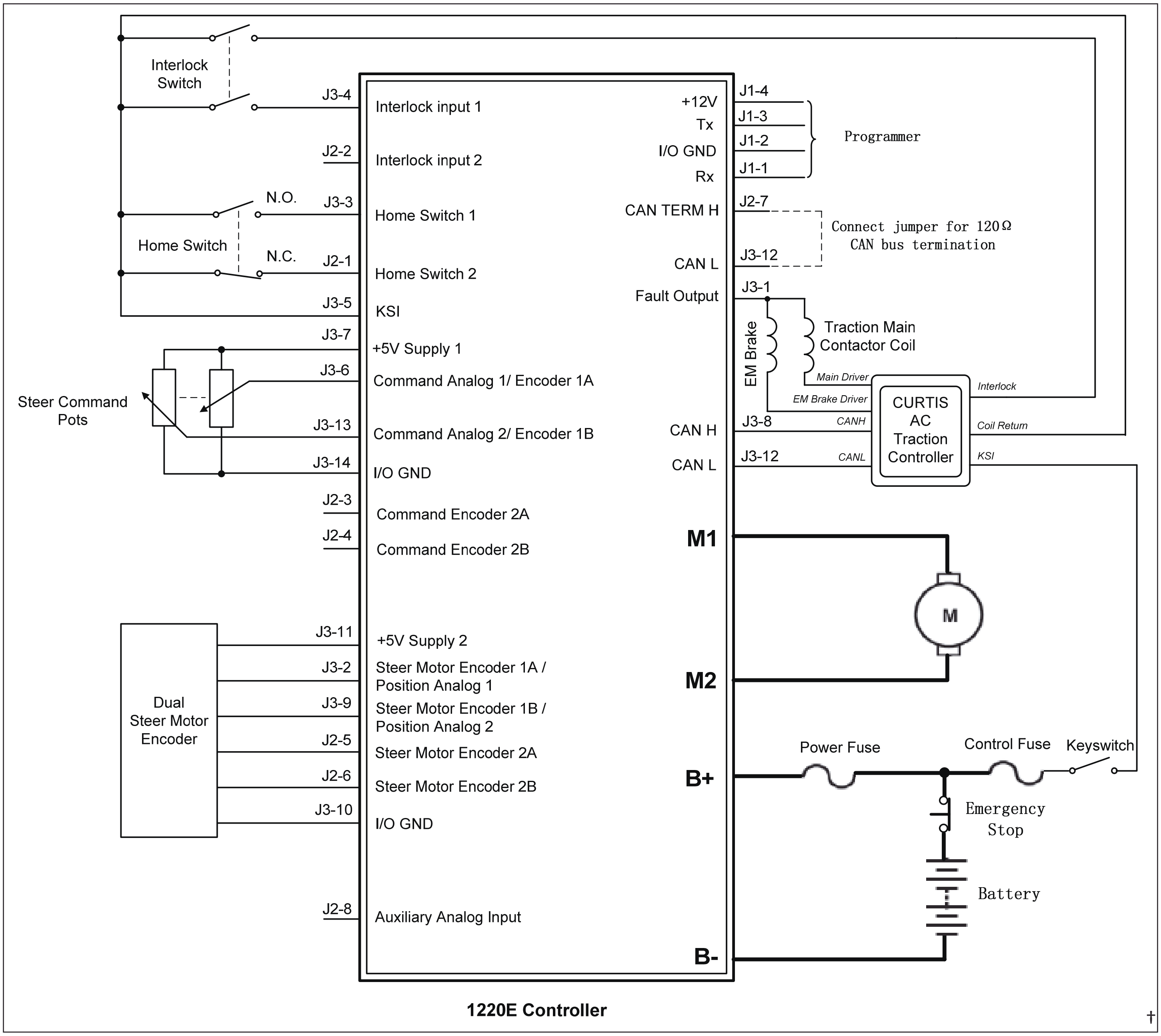


Figure 3b

Basic wiring diagram, Absolute Position Mode.

INPUT/OUTPUT SIGNAL SPECIFICATIONS

The electrical characteristics of the input/output signals wired to the J1, J2, and J3 connectors are described below.

KSI (pin J3-5)

The keyswitch (KSI) must be connected to B+ via a switch. This pin feeds the internal power supply and can be used for general on/off and for the power supply to the Fault Output pin.

Input current at Nominal Battery Voltage	(50 – 200 mA) + Fault Output current

Digital inputs (pins J2-1, J2-2, J3-3 and J3-4)

The digital inputs must be connected to B+ via a switch, or they can be driven by outputs from other systems.

Input current at Nominal Battery Voltage.	approx 0.2 – 0.7 mA (depending on nominal battery voltage)
Input filter R-C time constant	max 5 ms
Max LOW threshold voltage	4.5 V
Min HIGH threshold voltage	6.5 V
De-bouncing time (in software)	10 – 25 ms

Analog inputs (pins J3-2, J3-6, J3-9, J2-8 and J3-13

The analog inputs are used for analog input commands from any analog input device, e.g., potentiometer, Hall sensor.

Input resistance (to B- ground)	50 kΩ ± 10%
Input current (wheel in center position)	max 100 µA ± 10%
Input filter R-C time constant	max 5 ms
Voltage range	0 – 5.5 V
Minimum resolution	12 bit

Command Encoder Inputs

Encoder 1A, 1B(pins J3-6, J3-13)

These inputs are used for the A and B signals of the Encoder Command input device.

Encoder 2A, 2B(pins J2-3, J2-4)

These inputs are used for the A and B signals of the Redundant Encoder Command input device.

Input current (to Encoder Ground)	1.5 mA ± 20%
Input filter R-C time constant	1 µs
Max LOW threshold voltage	1 V
Min HIGH threshold voltage	4 V

Wheel Position Feedback Encoder Input

Encoder 1A, 1B(pins J3-2, J3-9)

These inputs are the signal inputs for the Steer Motor Encoder.

Encoder 2A, 2B(pins J2-5, J2-6)

These are the signal inputs for the redundant Steered Motor Encoder.

Input current (to Encoder Ground)	1.5 mA ± 20%
Input filter R-C time constant	1 μs
Max LOW threshold voltage	1 V
Min HIGH threshold voltage	4 V

Wheel Position Feedback Analog Input

To sense the position of the steered wheel a single or dual 5 Kohm position feedback potentiometer has to be used.

Position Analog 1 and Redundant position analog 2 (pins J3-2, J3-9)

These are the inputs to the controller wiper(s) of the position feedback potentiometer.

Input resistance (to B- ground)	50 kΩ ± 10%
Input current (wheel in center position)	max 100 μA ± 10%
Input filter R-C time constant	max 5 ms
Voltage range	0 – 5.5 V
Minimum resolution	12 bit

+5V Supplies (pin J3-7, J3-11)

Independent power supply connections to the Command Input Device and the Position Feedback Device.

Command supply voltage	+5 V ± 10%
Maximum current draw	100 mA (per pin)

+12V Supply (pin J1-4)

This pin is the power supply for programmers and 840 displays

Command supply voltage	+12 V ± 10%
Maximum current draw	100 mA

I/O Ground (pins J1-2, J3-10, J3-14)

The Command and Feedback Pot Low pins are connected to I/O GND. They are not protected against short circuits to B+.

Fault Output (pin J3-1)

The Fault Output has independent supervision via the MCU, and can be used for power supply of the traction main contactor coil. This output is protected against short circuit to B-.

Max output current	3A
Max voltage drop (to KSI) at 3 A	1 V
Max short circuit current at max voltage	7A

Programmer connections

The Curtis programmer plugs into the 4-pin connector, J1.

Rx (Pin J1-1)
This is the data input connection to/from the programmer.

Max LOW threshold voltage:	1.50 V
Min HIGH threshold voltage:	3.50 V

Tx (Pin J1-3)
This is the data input connection to/from the programmer.

Logic Level 0:	
Min output sink current	2.8 mA
Max output voltage at current < 2.8 mA	0.6 V
Logic Level 1:	
Min output source current	0.4 mA
Min output voltage at current < 0.4 mA	3.5 V

CAN Communications

Separate CAN ports provide complete communications and programming capability for all user available controller information.

Note: Wiring the CAN TERM H and CAN L together provides a local CAN termination of 120 Ω, 0.25 W. CAN TERM H and CAN L should never be connected to any external wiring. Typically the wiring of the CAN bus nodes is a daisy chain topology with 120 Ω CAN terminating resistors at each end. If the vehicle wiring is done such that the 1220E is the last node in the chain, CAN TERM H and CAN L pins should be connected together.

CANH (Pin J3-8), CANL (Pin J3-12)

Protected voltage: –5V to +58V

Max baud rate: 1Mbps

3 — PROGRAMMABLE PARAMETERS

The 1220E controller has a number of parameters that can be programmed using the Curtis Software Suite CSS, Curtis 1313 handheld programmer or 1314 Programming Station. The programmable parameters allow the steering performance to be customized to fit the needs of specific applications. The programmable parameters are grouped into nested hierarchical menus, as shown in Table 1.

Table 1 Programmable Parameter Menus

COMMAND DEVICE

- COMMAND INPUT DEVICE................ p. 14
- SUPERVISION INPUT DEVICE............ p. 14
- ABSOLUTE MODE........................... p. 14
- COMMAND INPUT GAIN.................. p. 14
- 0 - COMMAND ANALOG 1 AND 2....... p. 16
  - —Command Analog1 Left
  - —Command Analog1 Center
  - —Command Analog1 Right
  - —Command Analog1 Fault Min
  - —Command Analog1 Fault Max
  - —Command Analog2 Left
  - —Command Analog2 Center
  - —Command Analog2 Right
  - —Command Analog2 Fault Min
  - —Command Analog2 Fault Max
- 1 - CAN COMMAND........................ p. 17
  - —CAN Steer Device Type
  - —CAN Steer Center Offset
  - —CAN2 Steer Center Offset
  - —CAN Steer Left Stop to Center
  - —CAN Steer Right Stop to Center
  - —CAN Steer Swap Direction
  - —CAN2 Steer Swap Direction
- 2 - Command Encoder 1 and 2...... p. 18
  - —Left Stop to Center
  - —Right Stop to Center
  - —Left Stop to Center Supervisor
  - —Right Stop to Center Supervisor
  - —Swap Encoder1 Direction
  - —Swap Encoder2 Direction

COMMAND DEVICE, cont'd

- COMMAND MAP...................................... p. 19
  - —Left Stop (deg)
  - —P1 Input
  - —P1 Output (deg)
  - —P2 Input
  - —P2 Output (deg)
  - —P3 Input
  - —P3 Output (deg)
  - —P4 Input
  - —P4 Output (deg)
  - —P5 Input
  - —P5 Output (deg)
  - —P6 Input
  - —P6 Output (deg)
  - —Right Stop (deg)

FEEDBACK DEVICE

- POSITION FEEDBACK DEVICE................ p. 21
- SUPERVISION FEEDBACK DEVICE............ p. 21
- POSITION ANALOG 1 AND 2.................... p. 23
  - —Position Analog1 Left Stop
  - —Position Analog1 Center
  - —Position Analog1 Right Stop
  - —Position Analog1 Fault Min
  - —Position Analog1 Fault Max
  - —Position Analog2 Left Stop
  - —Position Analog2 Center
  - —Position Analog2 Right Stop
  - —Position Analog2 Fault Min
  - —Position Analog2 Fault Max

FEEDBACK DEVICE, cont'd

- POSITION ENCODER 1 AND 2............. p. 24
  - —Encoder1 Steps
  - —Encoder2 Steps
  - —Swap Encoder1 Direction
  - —Swap Encoder2 Direction
  - —Auto Center Type
  - —Center Offset (deg)
  - —Center Compensation
  - HOMING.................................... p. 25
    - —Input Type
    - —Home on Interlock
    - —Homing Direction Method
    - —Homing Speed
    - —Homing Timeout
    - —Homing Compensation (deg)
- VEHICLE CONFIGURATION.................. p. 26
  - —Nominal Voltage
  - —Interlock Type
  - —Fault Steering Timeout
  - —Interlock Enabled Speed
  - —Steering Suspension
  - Main Relay Driver........................... p. 27
    - —Main On Interlock
    - —Pull-In Voltage
    - —Holding Voltage
    - —Main DNC Threshold
    - —Open Delay
    - —Sequencing Delay

⚠ CAUTION

We strongly urge you to read Section 5: Initial Setup, before adjusting any of the parameters. Even if you opt to leave most of the parameters at their default settings, it is imperative that you perform the procedures outlined in Section 5, which set up the basic system characteristics for your application.

COMMAND DEVICE

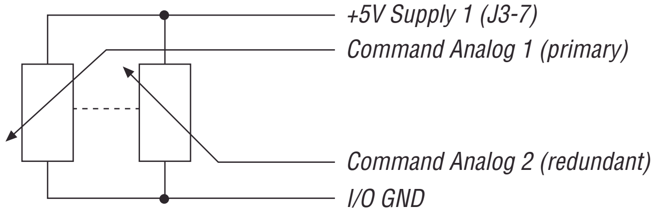
NAME	ALLOWABLE RANGE RAW DATA	DESCRIPTION
Command Input Device (0x334000, 8bits)	0 – 2 0 – 2	This parameter determines input device type which will be used as the steer command for Primary: 0 = Analog Pot 1 = CAN command input 2 = Quadrature encoder input
Supervision Input Device (0x334100, 8bits)	0 – 3 0 – 3	This parameter determines input device type which will be used as the steer command for Supervisor: 0 = Analog Pot 1 = CAN command input 2 = Quadrature encoder input 3 = None (No supervisor device is connected, only a single primary device is used) **Using this setting may make the system non-compliant with EN 13849, and must be evaluated by the OEM.** When the Supervision Command Device is set to 3, steer command supervision is disabled. This option is provided to allow systems not compliant with EN 13849 to be set up without having to supply connections to the supervisory inputs from the single primary input device.
Absolute Mode (0x334700, 8bits)	Off/On 0/1	The sensor is in absolute position mode when this parameter is set to On. The sensor is in relative position mode when this parameter is set to Off. Define the steering work mode only for CAN command input device.
Command Input Gain (0x334200, 16bits)	5 – 1000ms 5 – 1000	Defines the steer command filter time constant. Larger values provide longer filter time constant.

These parameters define which inputs will be used to determine the primary and supervisory steering command input device.

0 = Analog Pot Input, where Analog 1 and Analog 2 inputs are connected to two potentiometers as redundant pots. When analog steering command is used, two channels are required.

NAME	PIN	FUNCTION
Command Analog 1	J3-6	Primary analog input command
Command Analog 2	J3-13	Redundant analog input command

It is best practice to wire the primary and supervisory input signals in an "X" configuration (0–5V and 5V– 0). However, the 1220E has independent maps and will support redundant signals that move in the same direction.



Command Analog Input

1 = CAN command Input, where the input to the 1220E comes via CAN bus message (i.e., "steer-by-wire"). The CAN sensor may be set up as either an absolute or relative position device, using the Absolute Mode parameter.

NAME	CAN INDEX	SUB-INDEX	FUNCTION
CAN Steer Command	0x336200	0x00	Primary CAN Steer Command
CAN2 Steer Command	0x336300	0x00	Redundant CAN Steer Command

To use a CAN input device in an EN13849 compliant system requires that one PDO be sent to the main processor and one to the supervisor. For additional security it is recommended that the PDO sent to the supervisor be the opposite polarity and the swap direction be set for the supervisor only.

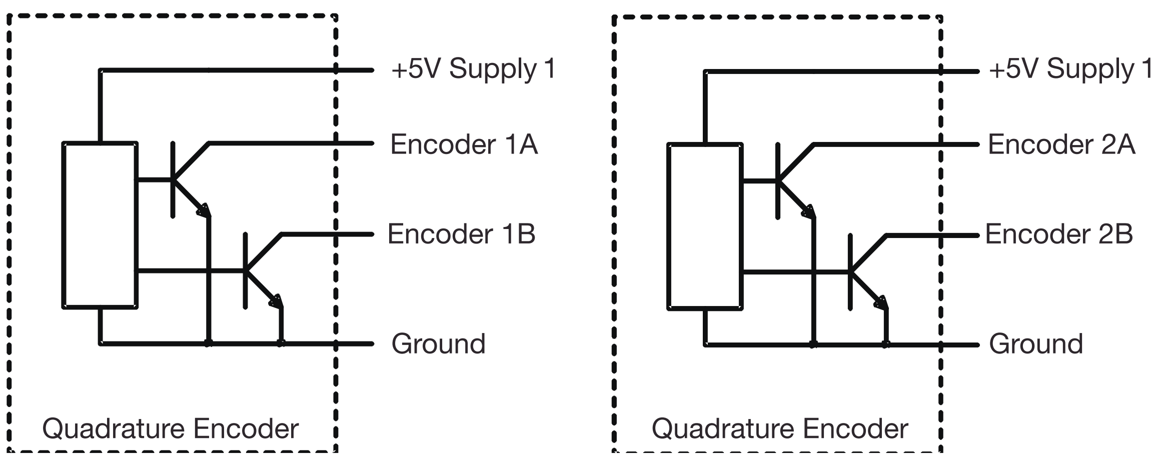
The parameter **CAN Steer Device Type** is used to set the CAN Command sending mode.

0 = Both CAN1 command and CAN2 command to primary.

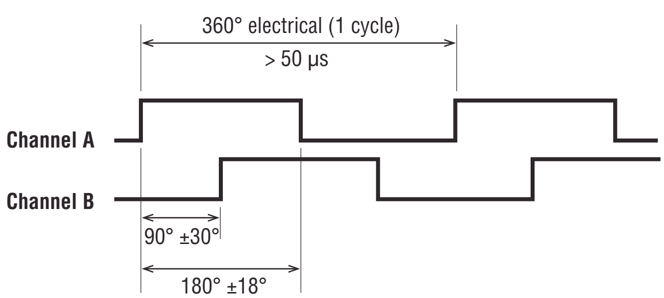
1 = CAN1 command to primary and CAN2 command to supervisor.

2 = Quadrature Encoder Input is a relative input device. In the table below, the + and – denote phase differences found in encoders (– being some amount of phase shift from +). This means that the primary and redundant encoders do not have to have the same alignment.

NAME	PIN	FUNCTION
Command Encoder 1A	J3-6	Primary Quadrature Encoder feedback A+
Command Encoder 1B	J3-13	Primary Quadrature Encoder feedback B+
Command Encoder 2A	J2-3	Redundant Quadrature Encoder feedback A–
Command Encoder 2B	J2-4	Redundant Quadrature Encoder feedback B–



- Below is requirement for quadrature Encoder due to internal RC filter circuit the max allowed input frequency is 20KHz.



0 - COMMAND ANALOG 1 AND 2

NAME	ALLOWABLE RANGE RAW DATA	DESCRIPTION
Command Analog1 Left (0x333000, 16bits)	0 – 5.50V 0 – 3605	Defines the command analog1 wiper voltage required to produce a steer position command of full left. (Steer Command = –100% = Left Stop)
Command Analog1 Center (0x333100, 16bits)	0 – 5.50V 0 – 3605	Defines the command analog1 wiper voltage required to produce a steer position command of center. (Steer Command = 0% = 0°)
Command Analog1 Right (0x333200, 16bits)	0 – 5.50V 0 – 3605	Defines the command analog1 wiper voltage required to produce a steer position command of full right. (Steer Command = 100% = Right Stop)
Command Analog1 Fault Min (0x333300, 16bits)	0 – 5.50V 0 – 3605	Sets the minimum threshold for analog1 pot input. If command wiper voltage goes below this threshold for 60 msec, a fault is issued.
Command Analog1 Fault Max (0x333400, 16bits)	0 – 5.50V 0 – 3605	Sets the maximum threshold for analog1 pot input. If command wiper voltage rises above this threshold for 60 msec, a fault is issued.
Command Analog2 Left (0x333500, 16bits)	0 – 5.50V 0 – 3605	Defines the command analog2 wiper voltage required to produce a steer position command of full left. (Steer Command = –100% = Left Stop)
Command Analog2 Center (0x333600, 16bits)	0 – 5.50V 0 – 3605	Defines the command analog2 wiper voltage required to produce a steer position command of center. (Steer Command = 0% = 0°)
Command Analog2 Right (0x333700, 16bits)	0 – 5.50V 0 – 3605	Defines the command analog2 wiper voltage required to produce a steer position command of full right. (Steer Command = 100% = Right Stop)
Command Analog2 Fault Min (0x333800, 16bits)	0 – 5.50V 0 – 3605	Sets the minimum threshold for analog2 pot input. If command wiper voltage goes below this threshold for 60 msec, a fault is issued.
Command Analog2 Fault Max (0x333900, 16bits)	0 – 5.50V 0 – 3605	Sets the maximum threshold for analog2 pot input. If command wiper voltage rises above this threshold for 60 msec, a fault is issued.

Analog Input Signal Flow Diagram

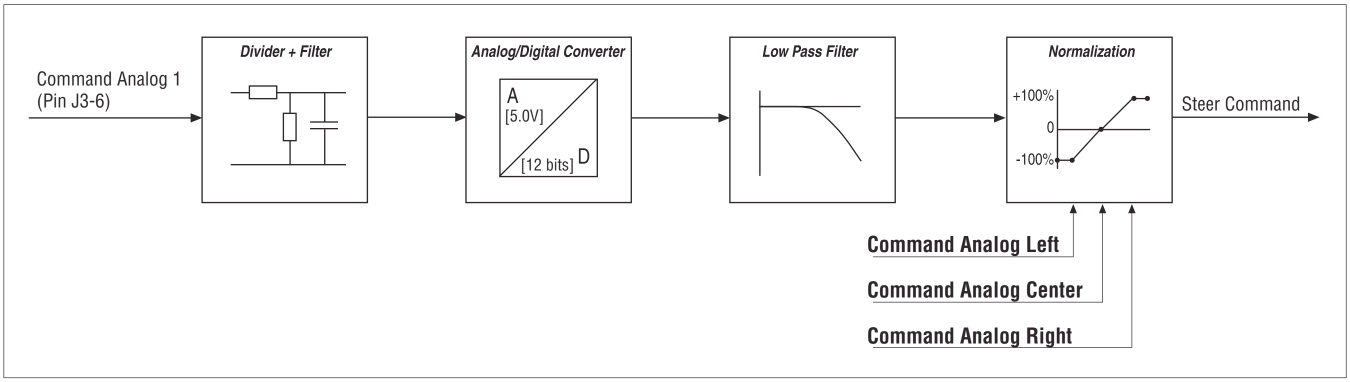


Figure 4
Command signal flow

The normalization map takes Analog 1 in volts and maps it to Steer Command in percent. **Command Analog Left** may be set higher or lower than **Command Analog Right**. **Command Analog Center** must be between **Command Analog Left** and **Command Analog Right**. If **Command Analog Left** is less than **Command Analog Right** then the three points of the map are defined (in order from left to right in the diagram above) as:

X = **Command Analog Left** and Y = –100%
X = **Command Analog Center** and Y = 0%
X = **Command Analog Right** and Y = 100%

1 - CAN COMMAND

NAME	ALLOWABLE RANGE RAW DATA	DESCRIPTION
CAN Steer Device Type (0x336B00, 8bits)	0 – 1 0 – 1	Sets the CAN command data transform type: 0 = Both CAN1 and CAN2 commands to the primary 1 = CAN1 command to the primary and CAN2 command to the supervisor.
CAN Steer Center Offset (0x336500, 16bits)	–32768 – 32767 –32768 – 32767	Defines the position (in counts) required to produce a steer command of center position (Steer Command = 0%). This allows a service technician to recalibrate center without having to physically adjust the sensor.
CAN2 Steer Center Offset (0x336600, 16bits)	–32768 – 32767 –32768 – 32767	Defines the position (in counts) required to produce a steer command2 of center position (Steer Command2 = 0%). This allows a service technician to recalibrate center without having to physically adjust the sensor.
CAN Steer Left Stop to Center (0x336700, 16bits)	–32768 – 0 –32768 – 0	Defines the total CAN steer command sensor counts to produce a steer command from the center position (Steer Command = 0%) to the full left position (Steer Command = –100%). Left Stop to Center is always a negative number.
CAN Steer Right Stop to Center (0x336800, 16bits)	0 – 32767 0 – 32767	Defines the total CAN steer command sensor counts to produce a steer command from the center position (Steer Command = 0%) to the full right position (Steer Command = 100%). Right Stop to Center is always a positive number.
CAN Steer Swap Direction (0x336900, 8bits)	OFF / ON 0 / 1	Changes the direction (left or right) of the CAN steer command input.
CAN2 Steer Swap Direction (0x336A00, 8bits)	OFF / ON 0 / 1	Changes the direction (left or right) of the CAN2 steer command input.

When setting up a steering command CAN device, for the system to be EN 13849 compliant, one PDO must be sent to the main processor and one to the supervisor. For additional security, it is recommended that the PDO sent to the supervisor be the opposite polarity and that Swap Direction be set for the supervisor only. Contact Curtis technical support for help with setting up PDOs.

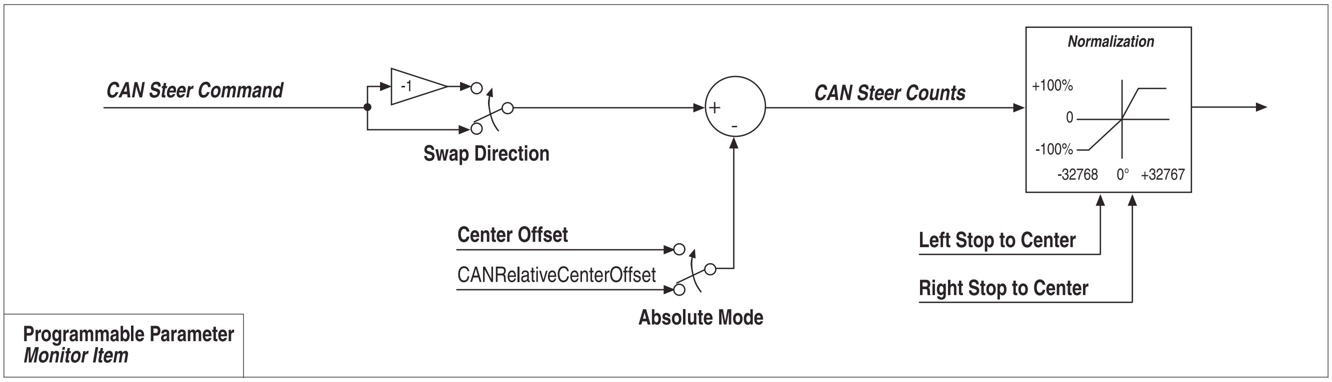


Figure 5
Command input device CAN

2 - COMMAND ENCODER 1 AND 2

NAME	ALLOWABLE RANGE RAW DATA	DESCRIPTION
Left Stop to Center (0x333A00, 16bits)	–32768 – 0 –32768 – 0	Defines the total steer command encoder counts to produce a steer command from the center position (Steer Command = 0%) to the full left position (Steer Command = –100%). Left Stop to Center is always a negative number.
Right Stop to Center (0x333B00, 16bits)	0 – 32767 0 – 32767	Defines the total steer command encoder counts to produce a steer command from the center position (Steer Command = 0%) to the full right position (Steer Command = 100%). Right Stop to Center is always a positive number.
Left Stop to Center Supervisor (0x333C00, 16bits)	–32768 – 0 –32768 – 0	Defines the total steer command encoder counts to produce a steer command from the center position (Steer Command = 0%) to the full left position (Steer Command = –100%) for the supervisor. Left Stop to Center is always a negative number.
Right Stop to Center Supervisor (0x333D00, 16bits)	0 – 32767 0 – 32767	Defines the total steer command encoder counts to produce a steer command from the center position (Steer Command = 0%) to the full right position (Steer Command = 100%) for the supervisor. Right Stop to Center is always a positive number.
Swap Encoder1 Direction (0x334500, 8bits)	OFF / ON 0 / 1	Change the encoder1's effective direction of rotation. The parameters must be set such that when the tiller head is turning right, the steer motor speed is positive.
Swap Encoder2 Direction (0x334600, 8bits)	OFF / ON 0 / 1	Change the encoder2's effective direction of rotation. The parameters must be set such that when the tiller head is turning right, the steer motor speed is positive.

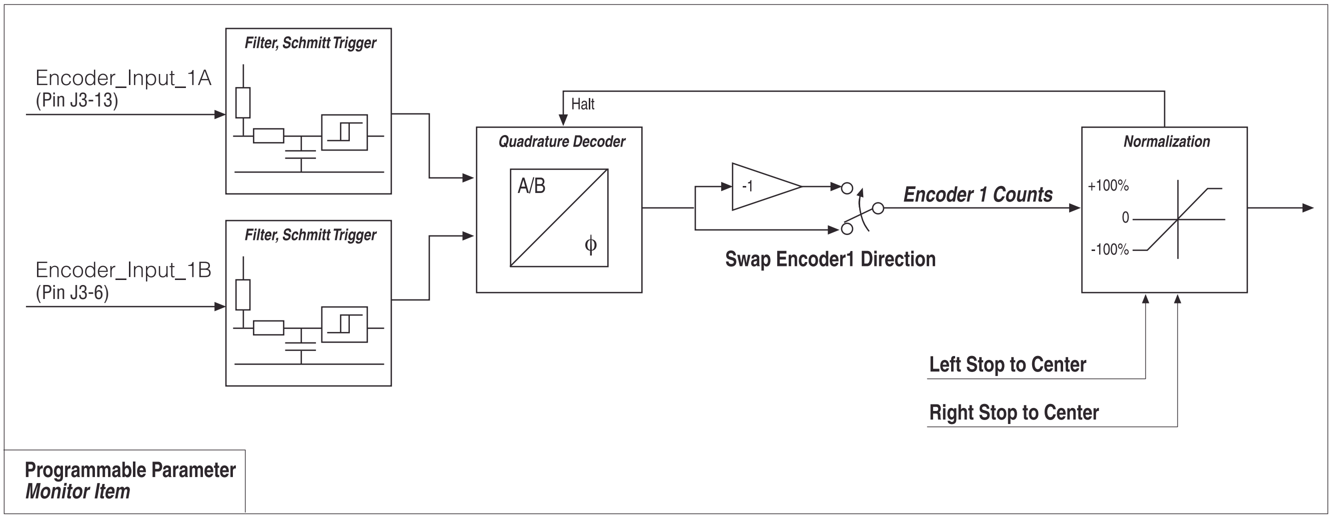


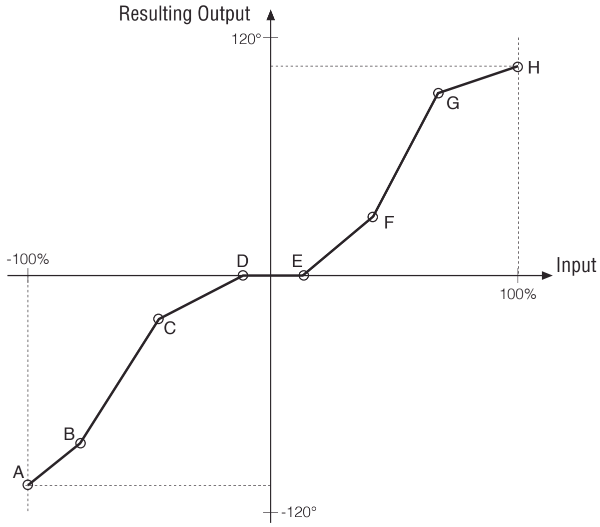
Figure 6

Command input device 2 signal flow (Encoder 1 shown; Encoder 2 is similar.

A command map is used in the input command signal flow to compensate for steering geometry differences between vehicles (steered wheel on the left side, middle, or right side). The command map menu contains 14 parameters defining an 8-point map that modifies the steer command input. The first point (Left Stop (deg)) always defines the steer command input of -100% and the last point (Right Stop deg)) always defines the steer command input of 100%.

COMMAND MAP

NAME	ALLOWABLE RANGE RAW DATA	DESCRIPTION
Left Stop (0x335000, 16bits)	–120.0° – 0° –21845 – 0	Defines the steer command output of full left.
P1 Input (0x335100, 16bits)	–100.0% – 0% –16384 – 0	Defines the steer command input in % for P1 Input.
P1 Output (0x335200, 16bits)	–120.0° – 0° –21845 – 0	Defines the steer command output in degree for P1 Output.
P2 Input (0x335300, 16bits)	–100.0% – 0% –16384 – 0	Defines the steer command input in % for P2 Input.
P2 Output (0x335400 16bits)	–120.0° – 0° –21845 – 0	Defines the steer command output in degree for P2 Output.
P3 Input (0x335500, 16bits)	–100.0% – 0% –16384 – 0	Defines the steer command input in % for P3 Input.
P3 Output (0x335600, 16bits)	–120.0° – 0° –21845 – 0	Defines the steer command output in degree for P3 Output.
P4 Input (0x335700, 16bits)	0% – 100.0% 0 – 16383	Defines the steer command input in % for P4 Input.
P4 Output (0x335800, 16bits)	0° – 120.0° 0 – 21844	Defines the steer command output in degree for P4 Output.
P5 Input (0x335900, 16bits)	0% – 100.0% 0 – 16383	Defines the steer command input in % for P5 Input.
P5 Output (0x335A00, 16bits)	0° – 120.0° 0 – 21844	Defines the steer command output in degree for P5 Output.
P6 Input (0x335B00, 16bits)	0% – 100.0% 0 – 16383	Defines the steer command input in % for P6 Input.
P6 Output (0x335C00, 16bits)	0° – 120.0° 0 – 21844	Defines the steer command output in degree for P6 Output.
Right Stop (0x335D00, 16bits)	0° – 120.0° 0 – 21844	Defines the steer command output of full right.



The steer command map is shaped by points A – H.

	X	Y
A	–100%	Left Stop (deg)
B	P1 input	P1 Output (deg)
C	P2 input	P2 Output (deg)
D	P3 input	P3 Output (deg)
E	P4 input	P4 Output (deg)
F	P5 input	P5 Output (deg)
G	P6 input	P6 Output (deg)
H	100%	Right Stop (deg)

The map in this example is set up to provide a deadband in the center (points D and E) and less sensitivity at the ends (between A and B, and between G and H).

Figure 7

Command input device 1 signal flow (Encoder 1 shown; Encoder 2 is similar.

Although any map shape can be set up, **it is recommended that the map always be set so that a Steer Command of zero % equals a Steer Command (deg) of zero.**

FEEDBACK DEVICE

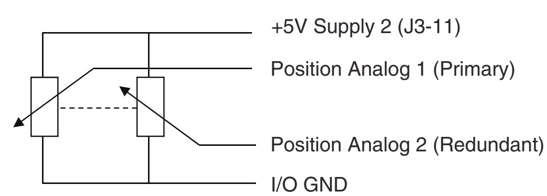
NAME	ALLOWABLE RANGE RAW DATA	DESCRIPTION
Position Feedback Device (0x34F000, 8bits)	0 – 1 0 – 1	Set this parameter to match the type of device you will be using for position feedback: 0 = Analog Sensor 1 = Quadrature Encoder
Supervision Feedback Device (0x34F200, 8bits)	0 – 2 0 – 2	This parameter determines the device type which will be used as position 2 feedback: 0 = Analog Sensor 1 = Quadrature Encoder 2 = None (No supervisor device is connected, only a single primary device is used)

These parameters define which inputs will be used to determine the primary and supervisory steer position feedback.

0 = Analog sensor steer pot position feedback, where Analog 1 and Analog 2 inputs are connected to two potentiometers as redundant feedback pots. When analog position feedback is used, two channels are required.

NAME	PIN	FUNCTION
Position Analog 1	J3-2	Primary Analog Feedback
Position Analog 2	J3-9	Redundant Analog Feedback

It is best practice to wire the primary and supervisory input signals in an "X" configuration (0–5V and 5V–0). However, the 1220E has independent maps and will support redundant signals that move in the same direction.



Position Analog Feedback

1 = Encoder position feedback. The quadrature encoder and a home switch are required, and It must have a minimum of 16 PPR. Position Encoder 2 may be connected anywhere in the drive train, e.g. directly at the steered wheel or on the motor shaft. If Position Encoder 2 is connected directly at the steered wheel, the encoder PPR should be greater than the minimum data (16 times of Steer Motor Gearbox Ratio) to ensure the position accuracy, *please see* below examples for detail.

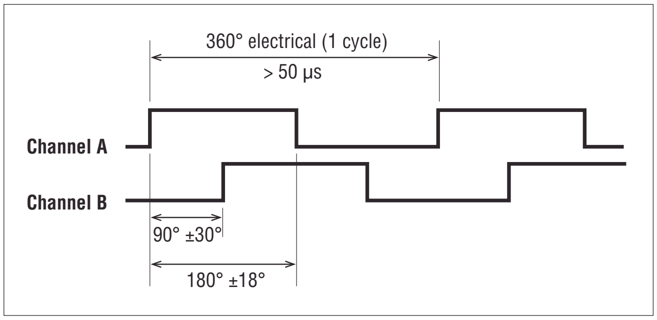
In the table below, the + and – denote phase differences found in encoders (– being some amount of phase shift from +). This means that the primary and redundant encoders do not have to have the same alignment.

NAME	PIN	FUNCTION
Position Encoder 1A	J3-2	Primary Quadrature Encoder feedback A+
Position Encoder 1B	J3-9	Primary Quadrature Encoder feedback B+
Position Encoder 2A	J2-5	Redundant Quadrature Encoder feedback A–
Position Encoder 2B	J2-6	Redundant Quadrature Encoder feedback B–

FEEDBACK DEVICE, cont'd

NAME	ALLOWABLE RANGE RAW DATA	DESCRIPTION

- Below is requirement for quadrature Encoder PPR(pulse per revolution) due to internal RC filter circuit and different installation of encoder, the max allowed input frequency is 20KHz.



1. = If the encoder is installed before the motor gearbox(attach to the steer motor rotor).

   Encoder Single Pulse Period = 60*10^6/(Max Steer Motor RPM*Encoder PPR) should > 50us(20KHz)

Example: Max Steer Motor RPM = 3000.

*60 * 10^6 / (3000 * Encoder PPR) > 50*

Encoder PPR < 400

We recommend encoder PPR > 8 to avoid possible sampling error which will lead to poor steering(following) accuracy.

2. = If the encoder is installed after the motor gearbox.

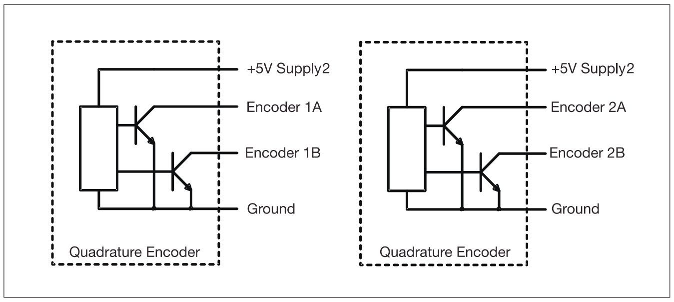
   Encoder Single Pulse Period = Gearbox Ratio*60*10^6/(Max Steer Motor RPM*Encoder PPR) should > 50us.

Example: Max Steer Motor RPM = 3000.
Steer Motor Gearbox Ratio = 40:1

*40 * 60 * 10^6 / (3000 * Encoder PPR) > 50*

Encoder PPR < 16000

We recommend encoder PPR > 8*40 to avoid possible sampling error which will lead to poor steering (following) accuracy.



2 = None. No supervisory position feedback device is connected. Only a single position feedback device (the primary) is used.

This option is available only for the Supervision Feedback Device parameter.

⚠ CAUTION **Using this setting may make the system noncompliant with EN 13849, and must be evaluated by the OEM.**

When the Supervision Feedback Device is set to 2, wheel position supervision is disabled. This option is provided to allow systems not compliant with EN 13849 to be set up without having to supply connections to the supervisory inputs from the single primary feedback device.

POSITION ANALOG 1 AND 2

NAME	ALLOWABLE RANGE RAW DATA	DESCRIPTION
Position Analog1 Left Stop (0x34F300, 16bits)	0 – 5.50V 0 – 3605	Defines the position analog 1 wiper voltage when the steer position feedback is at the Left Stop. (Wheel Position = Left Stop)
Position Analog1 Center (0x34F400, 16bits)	0 – 5.50V 0 – 3605	Defines the position analog 1 wiper voltage when the steer position feedback is at the center position. (Wheel Position = 0°)
Position Analog1 Right Stop (0x34F500, 16bits)	0 – 5.50V 0 – 3605	Defines the position analog 1 wiper voltage when the steer position feedback is at the Right Stop. (Wheel Position = Right Stop)
Position Analog1 Fault Min (0x34F600, 16bits)	0 – 5.50V 0 – 3605	Sets the minimum threshold for analog 1 pot of position feedback. If the position wiper voltage goes below this threshold for 60 msec. a fault is issued.
Position Analong1 Fault Max (0x34F700, 16bits)	0 – 5.50V 0 – 3605	Sets the maximum threshold for analog 1 pot of position feedback. If the position wiper voltage rises above this threshold for 60 msec. a fault is issued.
Position Analog2 Left Stop (0x34F800, 16bits)	0 – 5.50V 0 – 3605	Defines the position analog 2 wiper voltage when the steer position feedback is at the Left Stop. (Wheel Position = Left Stop)
Position Analog2 Center (0x34F900, 16bits)	0 – 5.50V 0 – 3605	Defines the position analog 2 wiper voltage when the steer position feedback is at the center position. (Wheel Position = 0°)
Position Analog2 Right Stop (0x34FA00, 16bits)	0 – 5.50V 0 – 3605	Defines the position analog 2 wiper voltage when the steer position feedback is at the Right Stop. (Wheel Position = Right Stop)
Position Analog2 Fault Min (0x34FB00, 16bits)	0 – 5.50V 0 – 3605	Sets the minimum threshold for analog 2 pot of position feedback. If the position wiper voltage goes below this threshold for 60 msec. a fault is issued.
Position Analong2 Fault Max (0x34FC00, 16bits)	0 – 5.50V 0 – 3605	Sets the maximum threshold for analog 2 pot of position feedback. If the position wiper voltage rises above this threshold for 60 msec. a fault is issued.

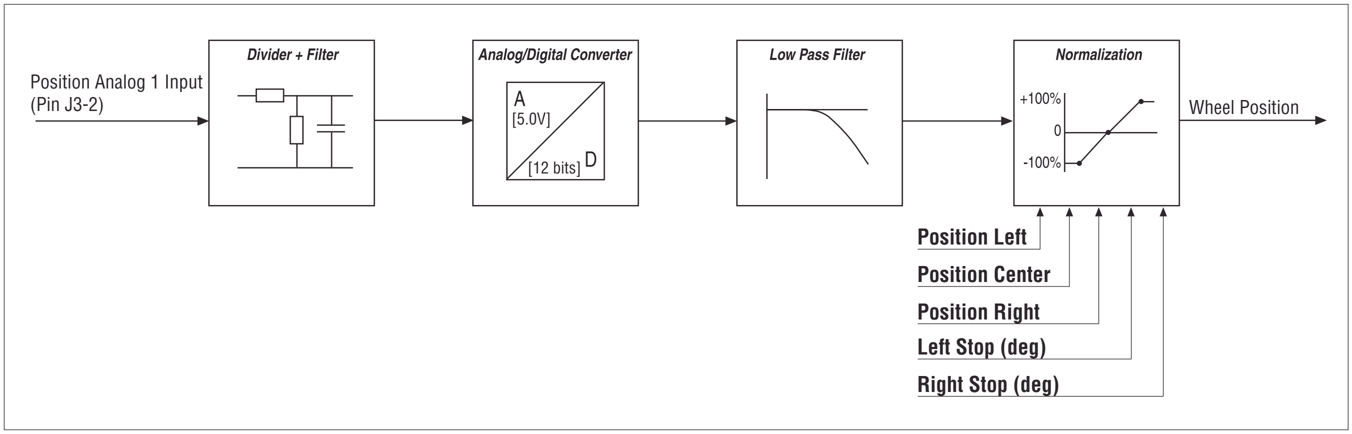
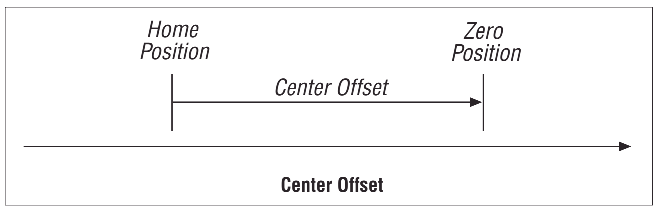


Figure 8

Position Feedback Device "0" signal flow (Analog 1 shown; Analog 2 is similar).

POSITION ENCODER 1 AND 2

NAME	ALLOWABLE RANGE RAW DATA	DESCRIPTION
Encoder1 Steps (0x34E700, 16bits)	8 – 256 80 – 2560	Sets the number of the encoder pulses per revolution of rotor of steering motor encoder 1. Adjusting this parameter can be hazardous; setting it improperly may cause vehicle malfunction, including uncommanded steer motor drive.
Encoder2 Steps (0x34E900, 16bits)	8 – 256 80 – 2560	Sets the number of the encoder pulses per revolution of rotor of steering motor encoder 2. Adjusting this parameter can be hazardous; setting it improperly may cause vehicle malfunction, including uncommanded steer motor drive.
Swap Encoder1 Direction (0x34EA00, 8bits)	OFF / ON 0 / 1	This parameter changes the encoder1 effective direction of rotation. It must be set such that when the tiller head is turning right, the steer motor speed is positive.
Swap Encoder2 Direction (0x34EB00, 8bits)	OFF / ON 0 / 1	This parameter changes the encoder2 effective direction of rotation. It must be set such that when the tiller head is turning right, the steer motor speed is positive.
Auto Center Type (0x34ED00, 8bits)	0 / 1 0 / 1	Defines which event will trigger the controller to center the steered wheel. 0 = Auto Center after homing. 1 = Auto Center after homing and every interlock.
Center Offset (0x34EE00, 16bits)	–180.0° – 180° –32768 – 32767	The Center Offset is the difference between the zero position (center) for the application and the home reference position (found during homing). During homing, the home position is found and once the homing is completed the zero position is offset from the home position by adding the Center Offset to the home position. All subsequent absolute moves shall be taken relative to this new zero position, including Auto Center. If the home switch is at the same position as center, set Center Offset to zero.  **Center Offset**
Center Compensation (0x4E6700, 8bits)	OFF / ON 0 / 1	Enables/disables the center auto compensation feature. In case of losing pulses or incorrectly pulse counting issue happens to position feedback encoder, the position error will be accumulated and cannot be recovered until recycling KSI. The optional home auto calibration feature is used to eliminate the position error accumulation for position encoder, turn on the **Center Compensation,** to enable the home auto calibration feature.

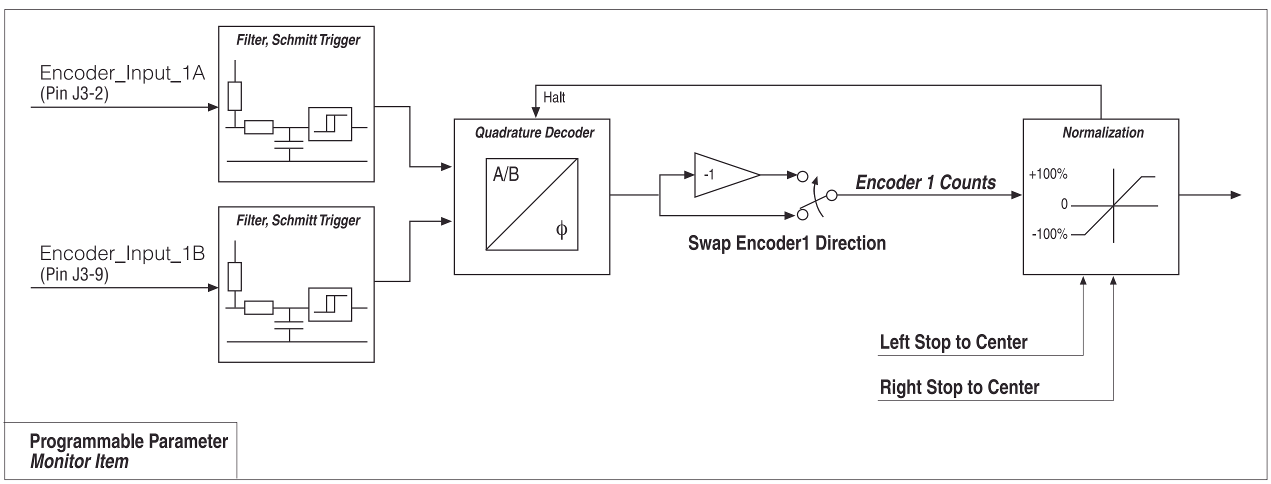
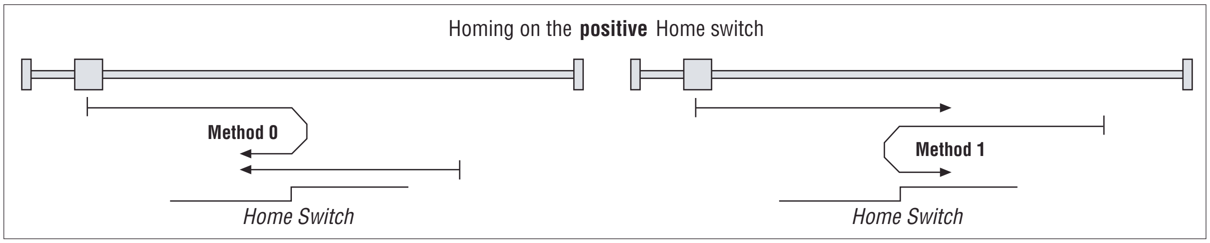


Figure 9

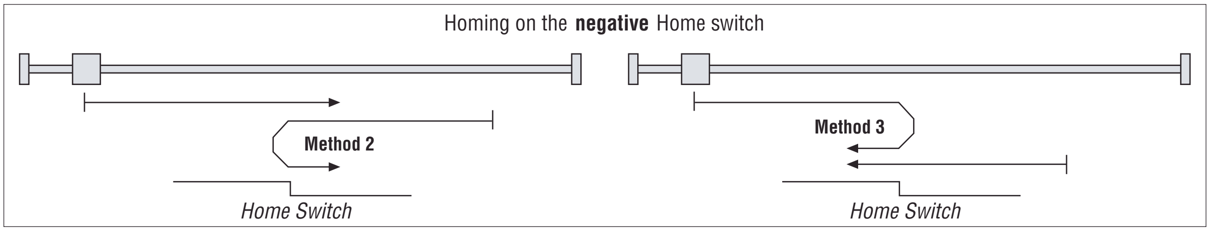
Position Feedback Device "1" signal flow (Encoder 1 shown; Encoder 2 is similar).

HOMING

NAME	ALLOWABLE RANGE RAW DATA	DESCRIPTION
Input Type (0x378600, 8bits)	0 – 2 0 – 2	This parameter defines which inputs will be used to determine Home position. 0 = Single NO switch 1 = Single switch with NO and NC contacts 2 = Two switches with the same NO polarity
Home on Interlock (0x378800, 8bits)	OFF / ON 0 / 1	This parameter defines when the homing function is activated. OFF: Home when keyswitch is turned on ON: Homing on first interlock. If the interlock signal is turned off during homing, the homing procedure is paused and will resume when the interlock gets active again.
Homing Direction Method (0x378A00, 8bits)	0 – 4 0 – 4	This parameter defines which method is use to find Home position. 0 = Left of positive Home switch 1 = Right of positive Home switch 2 = Right of negative Home switch 3 = Left of negative Home switch 4 = Center of positive Home switch Methods 0 and 1 use a Home switch that is On if the wheel is to the right of it and Off if the wheel is to the left of it. At the start of homing the wheel will move to the left if the Home switch is On and to the right if it is Off. The home position is just to the left of the switch transition in method 0 and just to the right of the switch transition in method 1.

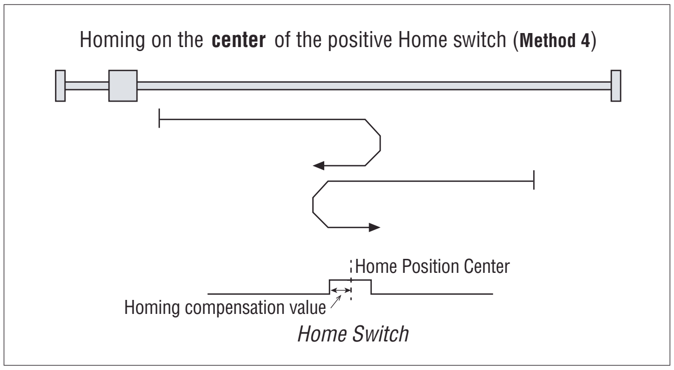


Methods 2 and 3 use a Home switch that is On if the wheel is to the left of it and Off if the wheel is to the right of it. At the start of homing the wheel will move to the right if the Home switch is On and to the left if it is Off. The home position is just to the right of the switch transition in method 2 and just to the left of the switch transition in method 3.



Method 4 uses a Home switch that is On if the wheel is just on it and Off if the wheel is not on it. At the start of homing the wheel will move in the direction saved in EEPROM at the last shutdown. The home position is just at the switch transition period. Only single feedback quadrature encoder and single home switch are supported for this method.

HOMING, cont'd

NAME	ALLOWABLE RANGE RAW DATA	DESCRIPTION
		
Homing Speed (0x378900, 16bits)	0 – 100% 0 – 32767	Defines the speed of the steering motor during the homing function, as a percentage of the steer motor Max Speed. The lower the set value of Homing Speed, the more accurate the homing will be; it is therefore recommended that Homing Speed be set as low as tolerable. Although higher values will allow the homing function to be completed more quickly, the results will be less consistent than with lower values.
Homing Timeout (0x378B00, 16bits)	0 – 20.0s 0 – 200	This parameter defines the allowable time for homing to find home. A Home Position Not Found fault is issued if the homing exceeds the Homing Timeout setting without finding home.
Homing Compensation (deg) (0x378C00, 16bits)	–10.0° – 10.0° –1820 – 1820	This parameter is active only when the Homing Direction Method = 4. It compensates for homing to zero position from either direction.

VEHICLE CONFIGURATION

NAME	ALLOWABLE RANGE RAW DATA	DESCRIPTION
Nominal Voltage (0x33AA00, 16bits)	24.0 – 60.0V 2400 – 6000	Sets the vehicle's nominal battery voltage.
Interlock Type (0x34B000, 8bits)	0 – 4 0 – 4	Defines which inputs will be used to determine an interlock. 0 = KSI (interlock turns on with keyswitch) 1 = Single NO Interlock Switch 1 2 = Interlock turns on with NO Interlock Switch 1 and NC Interlock switch 2 3 = Interlock turns on with NO Interlock Switch 1 and NO Interlock Switch 2 4 = From CAN bus message
Fault Steering Timeout (0x381F00, 16bits)	0 – 8.0s 0 – 80	This parameter applies only when a steer fault action of either "Warning then Shutdown" or "Hold then Shutdown" is triggered. It sets a delay from when either of these fault actions is set to when the fault output turns off.
Interlock Enable Speed (0x34B500, 16bits)	0 – 2000rpm 0 – 2000	This parameter sets the traction motor speed above which interlock will automatically be enabled, thus enabling steering. Set of zero disables this function.
Steering Suspension (0x339200, 8bits)	OFF / ON 0 / 1	When programmed ON the steering suspension feature will shut down the steering PWM if the traction speed is zero and no further steering command is applied for 5 seconds to save battery energy.

MAIN RELAY DRIVER

NAME	ALLOWABLE RANGE RAW DATA	DESCRIPTION
Main on Interlock (0x34C200, 8bits)	OFF / ON 0 / 1	Determines when the main relay is activated. OFF: Main relay is activated when keyswitch is turned on ON: Main relay is activated when interlock is on
Pull-In Voltage (0x34C600, 16bits)	60.0% – 100.0% 2457 – 4095	The relay pull-in voltage parameter allows a high initial voltage when the relay driver first turns on, to ensure contactor closure. After 1 second, the pull-in voltage drops to the holding voltage. The voltage is a percentage of the nominal voltage.
Holding Voltage (0x34C800, 16bits)	60.0% – 100.0% 2457 – 4095	The relay holding voltage parameter allows a reduced average voltage to be applied to the relay coil once it has closed. The voltage is a percentage of the nominal voltage. This parameter must be set high enough to hold the relay closed under all shock and vibration conditions the vehicle will be subjected to.
Main DNC Threshold (0x34C300, 16bits)	0 – 10.0V 0 – 1000	Sets the threshold used for the ongoing check that ensures the main contactor remains closed while in operation. The Main DNC Threshold is the maximum voltage difference between the Keyswitch and Capacitor voltages. Setting this parameter = 0 V will disable the Main Did Not Close fault check.
Open Delay (0x34CA00, 16bits)	0 – 40.0s 0 – 400	The open delay can be set to allow the steer relay to remain closed for a period of time (the open delay) after the interlock is turned off. The delay is useful for preventing unnecessary cycling of the relay.
Sequencing Delay (0x34B700, 16bits)	0 – 1000ms 0 – 1000	Allows the interlock switch to be cycled within a set time, thus preventing inadvertent deactivation of the steering control.

SUPERVISION

NAME	ALLOWABLE RANGE RAW DATA	DESCRIPTION
Steer Command Tolerance (0x336400, 16bits)	2.0° – 90.0° 364 – 16383	This parameter defines the maximum difference allowed between the two steer command inputs (Command Analog 1 and Command Analog 2). If the programmed tolerance is exceeded, a fault is issued. A setting of 90.0° turns off this fault check.
Wheel Position Tolerance (0x379000, 16bits)	2.0° – 90.0° 364 – 16383	This parameter defines the maximum difference allowed between the two position feedback outputs (Analog Position 1 and Analog Position 2). If the programmed tolerance is exceeded, a fault is issued. A setting of 90.0° turns off this fault check.
Home Reference Tolerance (0x379100, 16bits)	2.0° – 90.0° 364 – 16383	This parameter defines the maximum difference allowed between the two home reference inputs (Home Switch 1 and Home Switch 2). A setting of 90.0° turns off this fault check.
Encoder Fault Check (0x570400, 8bits)	OFF / ON 0 / 1	This parameter defines when the encoder fault detection is activated.
5V Supply 1 Current Min (0x36A800, 16bits)	0 – 100mA 0 – 100	This parameter defines the minimum current threshold of external 5V supply 1 for the '5V Supply failure' fault detection. A value of 0mA turns off the minimum current check.
5V Supply 2 Current Min (0x36A900, 16bits)	0 – 100mA 0 – 100	This parameter defines the minimum current threshold of external 5V supply 2 for the '5V Supply failure' fault detection. A value of 0mA turns off the minimum current check.
Stall Steering Speed (0x352A00, 16bits)	0 – 500rpm 0 – 500	This parameter defines the speed below which the steer motor will be considered stalled if it remains below this speed for the length of time defined by the Stall Timeout parameter. When this condition is detected, the Motor Stalled fault is issued. A setting of Stall Speed = 0 turns off this fault check.
Stall Timeout (0x352B00, 16bits)	0 – 2500ms 0 – 2500	This parameter defines the timeout time for the motor stalled fault check.
Stall PWM (0x352C00, 16bits)	25% – 100% 4096 – 16383	This parameter clamps the PWM of the steer controllers output if a steer motor stalled fault is declared and the target PWM is greater than the stall PWM value or the motor current is greater than 95% of the drive current limit.

FOLLOWING ERROR

NAME	ALLOWABLE RANGE RAW DATA	DESCRIPTION
Error Tolerance (0x379200, 16bits)	2.0° – 90.0° 364 – 16383	Defines the maximum difference allowed between Steering Command (deg) and Wheel Position (deg). The difference can be seen in the monitor variable Following Error (deg). If the programmed Error Tolerance (deg) is exceeded for the programmed Error Time while the wheel speed is less than the programmed Speed Tolerance, a Following Error fault is issued. A setting of Error Tolerance (deg) = 90.0° turns off this fault check.
Speed Tolerance (0x382400, 16bits)	0 – 500rpm 0 – 500	This parameter defines the minimum allowed speed for the steered wheel. This is a second condition for the Following Error check. By checking the velocity of the steered wheel (first derivative of Wheel Position) this check ensures that the steered wheel is moving in the correct direction at or above the minimum allowed speed. The wheel speed can be seen in the monitor variable Motor RPM. A setting of Speed Tolerance = 0.0 removes the influence of steered wheel speed from the Following Error check. Setting Speed Tolerance to a value greater than zero (thus enabling the influence of wheel speed in the Following Error check) should allow the Error Tolerance (deg) and Error Time parameters to be set lower without false fault trips. Setting Error Time lower allows the Following Error fault to be detected more quickly.
Error Time (0x379700, 16bits)	0.1 – 10.0s 25 – 2500	Defines how long Error Tolerance (deg) can be exceeded if the steered wheel is not moving in the right direction with a Wheel Speed equal to or greater than the Speed Tolerance. Since the first derivative (Wheel Speed) is inherently noisy, the timer is implemented as a count-up/count-down timer (Following Error Time accumulated) where the fault time is set by the parameter Error Time. Example: If Error Tolerance (deg) = 5 and Speed Tolerance = 10, the Following Error Time Accumulated will count *up* when the Error Tolerance is >5 **and** the Wheel Speed <10. Following Error Time Accumulated will count *down* if either the Error Tolerance ≤ 5 or the Wheel Speed ≥10. Error Time must be set long enough for the steered wheel to reverse direction and reach the minimum speed (Speed Tolerance) under the worst case conditions.

CURRENT

NAME	ALLOWABLE RANGE RAW DATA	DESCRIPTION
Drive Current Limit (0x343B00, 16bits)	10 – 60 A 40 – 240	Defines the maximum current the controller will supply to the steer motor during drive state.
Regen Current Limit (0x344100, 16bits)	10 – 60 A 40 – 240	Defines the maximum current the controller will supply to the steer motor during regen state.
Boost Enable (0x343300, 8bits)	OFF / ON 0 / 1	Enable/Disable the boost feature. When enabled the current limit will be increased 10A above the current settings (**Drive Current Limit and Regen Current Limit**), the max boost current is 70A. Note: The controller heatsink temperature is less than 75°C,
Boost Time (0x343500, 16bits)	0 – 10.0s 0 – 625	Set the maximum time that the boost current is allowed.

MOTOR

NAME	ALLOWABLE RANGE RAW DATA	DESCRIPTION
Max Speed (0x352300, 16bits)	0 – 8000rpm 0 – 8000	Defines the maximum allowed steer motor RPM.
Gear Ratio (0x368600, 16bits)	0 – 500.0 0 – 8000	Defines the total gear ratio of gear box, including its speed reducing mechanism.
Current Rating (0x368300, 16bits)	0 – 50A 0 – 200	This parameter should be set to the motor current rating provided by the motor manufacturer.
Max Current Time (0x368400, 16bits)	0 – 120s 0 – 120	Defines the maximum time the motor is allowed to run at the drive current limit.
Cutback Gain (0x368500, 16bits)	0 – 100% 0 – 255	When the motor overheats, the drive current is cut back until it reaches the programmed Current Rating. The Cutback Gain determines how quickly this cutback will be initiated once the programmed Max Current Time has expired. A higher setting provides faster cutback.

CANopen

NAME	ALLOWABLE RANGE RAW DATA	DESCRIPTION
CAN Required (0x32BA00, 8bits)	OFF / ON 0 / 1	This parameter enables the CAN Not Operational fault detection. When programmed On, a fault check is made to verify that the steering controller is set (via the CAN bus) to CAN NMT State = Operational within 80ms of the interlock being applied.
Baud Rate (0x200101, 16bits	0 – 4 0 – 4	Sets the CAN baud rate for the CANopen Slave system: 0 = 125 Kbps 1 = 250 Kbps 2 = 500 Kbps 3 = 800 Kbps 4 = 1 Mbps
Node ID (0x200001, 16bits)	1 – 127 1 – 127	Sets the Node ID of the Primary.
Node ID Supervisor (0x32A700, 16bits)	1 – 127 1 – 127	Sets the Node ID of the Supervisor.
Heartbeat Rate (0x101700, 16bits)	16 – 200ms 4 – 50	Sets the rate at which the CAN heartbeat messages are sent from the 1220E controller.

PDO SETUPS

NAME	ALLOWABLE RANGE RAW DATA	DESCRIPTION
RPDO1 Event Time (0x140005, 16bits)	0 – 65535ms 0 – 65535	Defines the RPDO1 Event Time and the time threshold for the PDO1 Time-out fault.
RPDO1 COB ID (0x140001, 32bits)	0 – 0xFFFFFFFF 0 – 0xFFFFFFFF	Defines RPDO1 COB-ID Value.
RPDO1 Mapping(see sub menu below)		
TPDO1 Event Time (0x180005, 16bits)	0 – 65535ms 0 – 65535	Defines the TPDO1 Event time.
TPDO1 COB ID (0x180001, 32bits)	0 – 0xFFFFFFFF 0 – 0xFFFFFFFF	Defines TPDO1 COB-ID Value.
TPDO1 Mapping(see sub menu below)		
RPDO2 Event Time (0x140105, 16bits)	0 – 65535ms 0 – 65535	Defines the RPDO2 Event Time.
RPDO2 COB ID (0x140101, 32bits)	0 – 0xFFFFFFFF 0 – 0xFFFFFFFF	Defines RPDO2 COB-ID Value.
RPDO2 Mapping(see sub menu below)		
TPDO2 Event Time (0x180105, 16bits)	0 – 65535ms 0 – 65535	Defines the TPDO2 Event time.
TPDO2 COB ID (0x180101, 32bits)	0 – 0xFFFFFFFF 0 – 0xFFFFFFFF	Defines TPDO2 COB-ID Value.
TPDO2 Mapping(see sub menu below)		

RPDO1 MAPPING

NAME	ALLOWABLE RANGE RAW DATA	DESCRIPTION
Length (0x160000, 8bits)	0 – 8 0 – 8	Defines the maximum supported sub-index.
Map 1 (0x160001, 32bits)	0 – 0xFFFFFFFF 0 – 0xFFFFFFFF	Mapping to Traction Motor Speed.
Map 2 (0x160002, 32bits)	0 – 0xFFFFFFFF 0 – 0xFFFFFFFF	Mapping to Traction is Ready.
Map 3 (0x160003, 32bits)	0 – 0xFFFFFFFF 0 – 0xFFFFFFFF	Mapping to CAN Interlock.
Map 4 (0x160004, 32bits)	0 – 0xFFFFFFFF 0 – 0xFFFFFFFF	Mapping to CAN Command 1.
Map 5 (0x160005, 32bits)	0 – 0xFFFFFFFF 0 – 0xFFFFFFFF	Mapping to CAN Command 2.
Map 6 (0x160006, 32bits)	0 – 0xFFFFFFFF 0 – 0xFFFFFFFF	No mapping.
Map 7 (0x160007, 32bits)	0 – 0xFFFFFFFF 0 – 0xFFFFFFFF	No mapping.
Map 8 (0x160008, 32bits)	0 – 0xFFFFFFFF 0 – 0xFFFFFFFF	No mapping.

RPDO2 MAPPING

NAME	ALLOWABLE RANGE RAW DATA	DESCRIPTION
Length (0x160100, 8bits)	0 – 8 0 – 8	Defines the maximum supported sub-index.
Map 1 (0x160101, 32bits)	0 – 0xFFFFFFFF 0 – 0xFFFFFFFF	Mapping to Sypglass data 1 for gage 840.
Map 2 (0x160102, 32bits)	0 – 0xFFFFFFFF 0 – 0xFFFFFFFF	Mapping to Sypglass data 2 for gage 840.
Map 3 (0x160103, 32bits)	0 – 0xFFFFFFFF 0 – 0xFFFFFFFF	Mapping to Sypglass data 3 for gage 840.
Map 4 (0x160104, 32bits)	0 – 0xFFFFFFFF 0 – 0xFFFFFFFF	Mapping to Sypglass data 4 for gage 840.
Map 5 (0x160105, 32bits)	0 – 0xFFFFFFFF 0 – 0xFFFFFFFF	Mapping to Sypglass data 5 for gage 840.
Map 6 (0x160106, 32bits)	0 – 0xFFFFFFFF 0 – 0xFFFFFFFF	Mapping to Sypglass data 6 for gage 840.
Map 7 (0x160107, 32bits)	0 – 0xFFFFFFFF 0 – 0xFFFFFFFF	Mapping to Sypglass data 7 for gage 840.
Map 8 (0x160108, 32bits)	0 – 0xFFFFFFFF 0 – 0xFFFFFFFF	Mapping to Sypglass data 8 for gage 840.

TPDO1 MAPPING

NAME	ALLOWABLE RANGE RAW DATA	DESCRIPTION
Length (0x1A0000, 8bits)	0 – 8 0 – 8	Defines the maximum supported sub-index.
Map 1 (0x1A0001, 32bits)	0 – 0xFFFFFFFF 0 – 0xFFFFFFFF	Mapping to the steering wheel position.
Map 2 (0x1A0002, 32bits)	0 – 0xFFFFFFFF 0 – 0xFFFFFFFF	Mapping to the present flashing fault code.
Map 3 (0x1A0003, 32bits)	0 – 0xFFFFFFFF 0 – 0xFFFFFFFF	Mapping to the traction cutback data.
Map 4 (0x1A0004, 32bits)	0 – 0xFFFFFFFF 0 – 0xFFFFFFFF	Mapping to the traction fault action.
Map 5 (0x1A0005, 32bits)	0 – 0xFFFFFFFF 0 – 0xFFFFFFFF	Mapping to enable traction.
Map 6 (0x1A0006, 32bits)	0 – 0xFFFFFFFF 0 – 0xFFFFFFFF	Mapping to steer command.
Map 7 (0x1A0007, 32bits)	0 – 0xFFFFFFFF 0 – 0xFFFFFFFF	No mapping.
Map 8 (0x1A0008, 32bits)	0 – 0xFFFFFFFF 0 – 0xFFFFFFFF	No mapping.

TPDO2 MAPPING

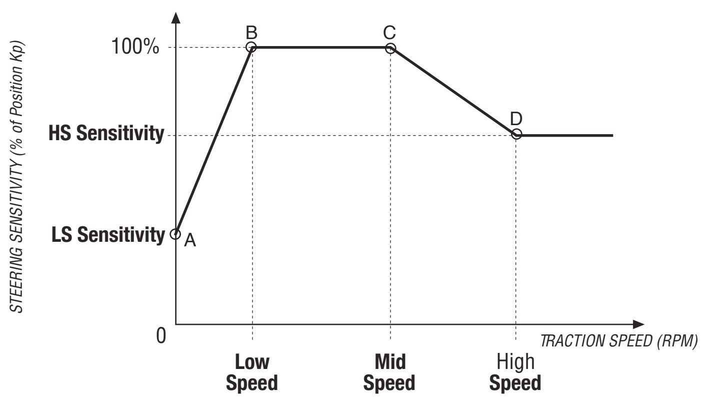
NAME	ALLOWABLE RANGE RAW DATA	DESCRIPTION
Length (0x1A0100, 8bits)	0 – 8 0 – 8	Defines the maximum supported sub-index.
Map 1 (0x1A0101, 32bits)	0 – 0xFFFFFFFF 0 – 0xFFFFFFFF	Mapping to the inverted enable traction.
Map 2 (0x1A0102, 32bits)	0 – 0xFFFFFFFF 0 – 0xFFFFFFFF	Mapping to the inverted traction cutback.
Map 3 (0x1A0103, 32bits)	0 – 0xFFFFFFFF 0 – 0xFFFFFFFF	Mapping to the switches state.
Map 4 (0x1A0104, 32bits)	0 – 0xFFFFFFFF 0 – 0xFFFFFFFF	Mapping to the switches state of supervisor.
Map 5 (0x1A0105, 32bits)	0 – 0xFFFFFFFF 0 – 0xFFFFFFFF	Mapping to the command analog input 2.
Map 6 (0x1A0106, 32bits)	0 – 0xFFFFFFFF 0 – 0xFFFFFFFF	Mapping to the auxiliary analog input of supervisor.
Map 7 (0x1A0107, 32bits)	0 – 0xFFFFFFFF 0 – 0xFFFFFFFF	No mapping.
Map 8 (0x1A0108, 32bits)	0 – 0xFFFFFFFF 0 – 0xFFFFFFFF	No mapping.

MOTOR CONTROL TUNING

NAME	ALLOWABLE RANGE RAW DATA	DESCRIPTION
Position Kp (0x378000, 16bits)	0 – 100.0% 0 – 32767	Determines how aggressively the steer controller attempts to match the steer position to the commanded steer position. Larger values provide tighter control. If the gain is set too high, you may experience oscillations as the controller tries to control position. If it is set too low, the motor may behave sluggishly and be difficult to control. Position Kp can be fine-tuned using the Steering Sensitivity parameters.
Velocity Kp (0x382B00, 16bits)	0 – 100.0% 0 – 32767	Determines how aggressively the steer controller attempts to match the steer velocity to the determined velocity to reach the desired position. Larger values provide tighter control. If the gain is set too high, you may experience oscillations as the controller tries to control velocity. If it is set too low, the motor may behave sluggishly and be difficult to control.
Velocity Ki (0x382A00, 16bits)	0 – 100.0% 0 – 32767	The integral term (Ki) forces zero steady state error in the determined velocity, so the motor will run at exactly the determined velocity. Larger values provide tighter control. If the gain is set too high, you may experience oscillations as the controller tries to control velocity. If it is set too low, the motor may take a long time to approach the exact commanded velocity

SENSITIVITY MAP

NAME	ALLOWABLE RANGE RAW DATA	DESCRIPTION
LS Sensitivity (0x380000, 16bits)	0 – 100% 0 – 16383	Defines the steering sensitivity at very low traction speeds (i.e., near zero traction rpm), as a percentage of the programmed Position Kp. Sensitivity is typically reduced at low speeds to prevent excessive hunting for the commanded position.
HS Sensitivity (0x380100, 16bits)	0 – 100% 0 – 16383	Defines the steering sensitivity at high traction speeds, as a percentage of the programmed Position Kp. Sensitivity is typically reduced at high speeds to make the vehicle easier to drive.
Low Speed (0x380200, 16bits)	0 – 8000rpm 0 – 8000	Defines the percentage of Traction Motor Max Speed at which 100% sensitivity will start to be applied as the vehicle accelerates.
Mid Speed (0x380300, 16bits)	0 – 8000rpm 0 – 8000	Defines the percentage of Traction Motor Max Speed at which 100% sensitivity will start to decrease as the vehicle decelerates.
High Speed (0x380400, 16bits)	0 – 8000rpm 0 – 8000	Defines the percentage of Traction Motor Max Speed at and above which the programmed HS Sensitivity value will be applied.



The steering sensitivity map is shaped by the settings of the five parameters in the Steering Sensitivity menu, with the two sensitivity parameters along the Y axis and the three speed parameters along the X axis.

	X (RPM)	Y (%)
A	0	**LS Sensitivity**
B	**Low Speed**	100%
C	**Mid Speed**	100%
D	**High Speed**	**HS Sensitivity**

The map adjusts the proportional gain (Position Kp) as a function of traction speed.

Figure 10

Steering Sensitivity Map.

Table 2 Functions Menu

FUNCTIONS

NAME	ALLOWABLE RANGE RAW DATA	DESCRIPTION
Reset hour meter (0x4E6600, 16bits)	OFF / ON 0 / 1	When set to Yes, will set the hour meter to zero hours.
Restore Parameters (0x4E4600, 8bits)	OFF / ON 0 / 1	When set to Yes, will reset all programmable parameters to their factory default settings.

4 — MONITOR MENU

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

Table 3 Monitor Menu

MONITOR DEVICE

COMMAND INPUT .... p. 35
- —Target Speed
- —Target Position (deg)
- —Target Position 2 (deg)
- —Steer Command
- —Steer Command 2
- —Speed Request
- —Command Analog 1 Input
- —Command Analog 2 Input
- —CAN Steer Command
- —CAN2 Steer Command

POSITION FEEDBACK .... p. 35
- —Wheel Position (deg)
- —Wheel Position2 (deg)
- —Stop Position Reached
- —Position Analog 1 Input
- —Position Analog 2 Input
- —Position Encoder1 Counts from Home
- —Position Encoder2 Counts from Home

SUPERVISION .... p. 36
- —Following Error (deg)
- —Steer Command Error
- —Wheel Position Error (deg)
- —Home Reference Error (deg)

INPUTS .... p. 36
- —Interlock State
- —Interlock Switch 1
- —Interlock Switch 2
- —Home Switch 1
- —Home Switch 2
- —Fault Output Feedback
- —Auxiliary Analog Input

OUTPUTS .... p. 36
- —Fault Output
- —Fault Output Supervisor
- —Main Driver

BATTERY AND SUPPLY .... p. 37
- —Battery Voltage
- —Capacitor Voltage
- —Keyswitch Voltage
- —Motor Voltage
- —External 5V Supply 1
- —External 5V Supply 2
- —External 12V Supply
- —5V Supply 1 Current
- —5V Supply 2 Current

CONTROLLER .... p. 37
- —Temperature
- —Motor RPM
- —Motor RPM 2
- —Motor Current
- —Motor Temp Cutback
- —Hour Meter
- —Status
  - —Boost
  - —Supervision Fault Type
  - —Traction Connected

CAN STATUS .... p. 38
- —CAN NMT State
- **From Traction Controller** .... p. 38
  - —Traction Motor RPM
  - —Traction Is Ready
  - —CAN Interlock
- **To Traction Controller** .... p. 38
  - —Enable Traction
  - —Traction Cutback
  - —Traction Fault Action

COMMAND INPUT

PARAMETER	ALLOWABLE RANGE	DESCRIPTION
Target Speed (0x384000, 16bits)	8000 – 8000rpm 8000 – 8000	Steer motor speed target for the position control loop.
Target Position (0x336100, 16bits)	–120.0° – 120° –21845 – 21844	Wheel position target for the position control loop (in degrees).
Target Position 2 (0x334900, 16bits)	–120.0° – 120° –21845 – 21844	Wheel position target for the position 2 control loop (in degrees).
Steer Command 1 (0x336000, 16bits)	–100% – 100% –16384 – 16383	The Operator's Steer Command1 (in percent) that is the input into the command map. The output of the command map is the Target Position (deg)
Steer Command 2 (0x337000, 16bits)	–100% – 100% –16384 – 16383	The Operator's Steer Command2 (in percent) that is the input into the command map. The output of the command map is the Target Position (deg)
Speed Request (0x384100, 16bits)	–100% – 100% –16384 – 16383	This monitor value indicates the calculated speed PWM command
Command Analog 1 Input (0x3B2400, 16bits)	0 – 5.50V 0 – 3605	Command Analog 1 input voltage.
Command Analog 2 Input (0x3B4600, 16bits)	0 – 5.50V 0 – 3605	Command Analog 1 input voltage.
CAN Steer Command (0x336200, 16bits)	–16384 – 16383 –16384 – 16383	The incoming CAN steering command 1 communicated on CAN bus. The CAN object is mapped into PDO1 message in default.
CAN2 Steer Command (0x336300, 16bits)	–16384 – 16383 –16384 – 16383	The incoming CAN steering command 2 communicated on CAN bus. The CAN object is mapped into PDO1 message in default.

POSITION FEEDBACK

PARAMETER	ALLOWABLE RANGE	DESCRIPTION
Wheel Position (0x378500, 16bits)	–120.0° – 120° –21845 – 21844	The final wheel position 1 (in degrees).
Wheel Position 2 (0x378E00, 16bits)	–120.0° – 120° –21845 – 21844	The final wheel position 2 (in degrees).
Stop Position Reached (0x379400, 8bits)	OFF / ON 0 / 1	Flag indicating the Stop position has been reached.
Position Analog 1 Input (0x3B2500, 16bits)	0 – 5.50V 0 – 3605	Position feedback Analog 1 input voltage.
Position Analog 2 Input (0x3B4700, 16bits)	0 – 5.50V 0 – 3605	Position feedback Analog 2 input voltage.
Position Encoder1 Counts from Home (0x379500, 32bits)	–2147483648 – 2147483647 –536870912 – 536870911	Encoder1 counts from home position. The steer motor rotating should change the counts; a move left of home position will be negative counts, and a move right of home will be positive counts.
Position Encoder2 Counts from Home (0x379600, 32bits)	–2147483648 – 2147483647 –536870912 – 536870911	Encoder2 counts from home position. The steer motor rotating should change the counts; a move left of home position will be negative counts, and a move right of home will be positive counts.

SUPERVISION

PARAMETER	ALLOWABLE RANGE	DESCRIPTION
Following Error (0x501400, 16bits)	–180° – 180° –32768 – 32767	Following Error = Steer Command minus Wheel Position. If the difference exceeds the programmed Following Tolerance, a fault is issued.
Steer Command Error (0x501600, 16bits)	–180° – 180° –32768 – 32767	Steer Command Error = Steer Command minus Steer Command 2. If the difference exceeds the programmed Steer Command Tolerance, a fault is issued.
Wheel Position Error (0x501500, 16bits)	–180° – 180° –32768 – 32767	Wheel Position Error = Wheel Position minus Wheel Position 2. If the difference exceeds the programmed Wheel Position Tolerance, a fault is issued.
Home Reference Error (0x501800, 16bits)	–180° – 180° –32768 – 32767	Home Reference Error = Home Reference minus Home Reference 2. If the difference exceeds the programmed Home Reference Tolerance, a fault is issued.

INPUTS

PARAMETER	ALLOWABLE RANGE	DESCRIPTION
Interlock State (0x301200, 8bits)	OFF / ON 0 / 1	This monitor value indicates the interlock status.
Interlock Switch 1 (0x332000, 8bits)	OFF / ON 0 / 1	This monitor value indicates the interlock switch 1 status.
Interlock Switch 2 (0x332100, 8bits)	OFF / ON 0 / 1	This monitor value indicates the interlock switch 2 status.
Home Switch 1 (0x332200, 8bits)	OFF / ON 0 / 1	This monitor value indicates the home switch 1 status.
Home Switch 2 (0x323600, 8bits)	OFF / ON 0 / 1	This monitor value indicates the home switch 2 status.
Fault Output Feedback (0x350000, 8bits)	OFF / ON 0 / 1	This monitor value indicates the Fault Output feedback status. If it is unmatched with the fault output status, a fault is issued.
Auxiliary Analog Input (0x3B4400, 16bits)	0 – 5.50V 0 – 3605	This monitor value indicates the Auxiliary Analog input voltage.

OUTPUTS

PARAMETER	ALLOWABLE RANGE	DESCRIPTION
Fault Output (0x340100, 8bits)	OFF / ON 0 / 1	This monitor value indicates the Fault Output status.
Fault Output Supervisor (0x340000, 8bits)	OFF / ON 0 / 1	This monitor value indicates the Supervisor Fault Output status.
Main Driver (0x34CC00, 8bits)	OFF / ON 0 / 1	This monitor value indicates the main relay driver status.

BATTERY AND SUPPLY

PARAMETER	ALLOWABLE RANGE	DESCRIPTION
Battery Voltage (0x339300, 16bits)	0 – 105.00V 0 – 10500	Voltage of battery.
Capacitor Voltage (0x34C100, 16bits)	0 – 105.00V 0 – 10500	Voltage of steer controller's internal capacitors bank.
Keyswitch Voltage (0x339800, 16bits)	0 – 105.00V 0 – 10500	Voltage of key switch.
Motor Voltage (0x368700, 16bits)	0 – 80.00V 0 – 8000	Voltage measured between the steer motor connectors.
External 5V Supply 1 (0x36AA00, 16bits)	0 – 20.00V 0 – 2000	Voltage measured at the +5V output 1
External 5V Supply 2 (0x36AC00, 16bits)	0 – 20.00V 0 – 2000	Voltage measured at the +5V output 2
External 12V Supply (0x36AB00, 16bits)	0 – 20.00V 0 – 2000	Voltage measured at the +12V output
5V Supply 1 Current (0x36A000, 16bits)	0 – 500mA 0 – 500	Current measured at +5V output 1
5V Supply 2 Current (0x36A100, 16bits)	0 – 500mA 0 – 500	Current measured at +5V output 2

CONTROLLER

PARAMETER	ALLOWABLE RANGE	DESCRIPTION
Temperature (0x300000, 16bits)	–50°C – 100°C –500 – 1000	Controller's internal temperature.
Motor RPM (0x384300, 16bits)	–8000 – 8000 rpm –8000 – 8000	Steer motor speed in revolutions per minute.
Motor RPM 2 (0x384400, 16bits)	–8000 – 8000 rpm –8000 – 8000	Steer motor speed 2 in revolutions per minute.
Motor Current (0x308500, 16bits)	–100 – 100A –400 – 400	Current of the steer motor.
Motor Temp Cutback (0x343900, 16bits)	0 – 100% 0 – 4095	Current cutback, as a percentage of max current, during motor over-temperature. 100% = no cutback.
Hour Meter (0x4E1400, 32bits)	0 – 9999999.9h 0 – 99999999	Number of hours KSI has been active.

STATUS

PARAMETER	ALLOWABLE RANGE	DESCRIPTION
Boost (0x343000, 8bits)	OFF / ON 0 / 1	Flag indicates the boost status.
Supervision Fault Type (0x284006, 32bits)	0 – 0xFFFFFFFF 0 – 0xFFFFFFFF	Indicate the Supervision fault type. This menu can only be found on 1313/1314 programmer. See Supervision Fault Type
Traction Connected (0x4E6300, 8bits)	OFF / ON 0 / 1	Indicate the connection between 1220E and traction controller.

CAN STATUS

PARAMETER	ALLOWABLE RANGE	DESCRIPTION
CAN NMT State (0x32A400, 8bits)	0 – 127 0 – 127	Controller NMT state 0 = initialization 4 = stopped 5 = operational 127 = pre-operational

FROM TRACTION CONTROLLER

PARAMETER	ALLOWABLE RANGE	DESCRIPTION
Traction Motor RPM (0x310400, 16bits)	–8000 – 8000 rpm –8000 – 8000	This monitor value indicates the Traction motor speed in revolutions per minute.
Traction is Ready (0x310300, 8bits)	OFF / ON 0 / 1	This monitor value is sent by the traction controller over the CAN bus to indicate whether the traction controller is ready. Typically implemented in the traction controller VCL to indicate that the traction main contactor is closed.
CAN Interlock (0x34B800, 8bits)	OFF / ON 0 / 1	This monitor value is sent by the traction controller over CAN bus to indicate whether the interlock is enable. This flag is used by the 1220E only when Interlock Type = 2.

TO TRACTION CONTROLLER

PARAMETER	ALLOWABLE RANGE	DESCRIPTION
Enable Traction (0x310000,8bits)	OFF / ON 0 / 1	This monitor value is sent from the steer controller to enable the traction controller.
Traction Cutback (0x310100,8bits)	0 – 100% 0 – 100	This monitor variable is sent from the steer controller to cut back the speed of the traction motor.
Traction Fault Action (0x310200,8bits)	0 – 10 0 – 10	This monitor Variable sent from the steer controller to trigger a fault action in the traction controller. 0 = no fault 1 = stop traction 2 = reduce traction speed 3 = no action

5 — COMMISSIONING

The 1220E steer controller can be used in a variety of vehicles, which differ in characteristics and in their input and feedback devices. Before driving the vehicle, it is important that the commissioning procedures be carefully followed to ensure that the controller is set up to be compatible with your application.

The 1220E controller must be used in conjunction with a Curtis AC traction controller with VCL. The Curtis traction controller must implement special software (VCL) to communicate with the 1220E controller, in order to support safe vehicle operation.

A single main contactor can be used to support both traction and steer controllers. **All vehicles must use the Fault Output connection** (J3-1) to allow the 1220E to disable the traction controller's main contactor coil and EM Brake coil during certain fault conditions.

⚠ CAUTION

Before starting the commissioning procedures, jack the vehicle drive wheels up off the ground so that they spin freely and steer freely from stop to stop. Manually disable the Interlock (traction and steer) so that the 1220E will not begin steering and the traction wheel will not turn. Double-check all wiring to ensure it is consistent with the wiring guidelines presented in Section 2. Make sure all connections are tight. Turn on the controller and plug in the handheld programmer.

The commissioning procedures are grouped into four sections, as follows.

The first section covers the initial setting of various parameters, before the actual commissioning begins.

Step 1: Preparation for commissioning

The procedures in the second section set up the steer command. The 1220E interlock and the traction interlock both remain Off.

Step 2: Command Map setup

Step 3: Command Input Device setup

The procedures in the third section require the steer motor to turn, so the 1220E interlock (the steer interlock) must be set to On. The vehicle drive wheels continue to be jacked up off the ground to they can spin freely and steer freely from stop to stop.

Step 4: Position Feedback Device setup

Type 0 — Setup for Pot feedback

Type 1 — Setup for Quadrature Encoder feedback

Step 5: Set the Motor Control Tuning parameters

Step 6: Verify the Position Feedback Setup

Step 7: Resolve any existing faults

Last, the vehicle drive wheels are lowered to the ground and the final procedures are conducted. For these procedures, the traction interlock must also be set to On.

Step 8: Set the Center Offset parameter

Step 9: Set the remaining Motor parameters

Step 10: Adjust the Sensitivity Map.

Step 1: Preparation for commissioning

Lower these five parameter values to force low steering performance and stable response (with the wheel off the ground) while the setup procedures are performed:

Motor

Max Speed = 1000 rpm or lower

Current

Drive Current Limit = 20%

Motor Control Tuning

Position Kp = 5%
Velocity Kp = 5%
Velocity Ki = 5%.

Verify that the 1220E interlock = Off (Monitor » Inputs » Interlock State) and the traction controller interlock = Off. If either interlock is On, either change the interlock input to the controllers or adjust the **Interlock Type** parameter until the interlock variables are both Off. If the interlock is accidentally set to On during commissioning, the steered wheel may turn without warning.

Set the following parameters based on the vehicle configuration and your desired performance characteristics.

Motor

Gear Ratio
Max Speed
Current Rating

Vehicle Configuration

Interlock Type
Interlock Enable Speed
Fault Steering Timeout

Main Relay Driver

Main On Interlock
Pull-In Voltage
Holding Voltage
Open Delay
Sequencing Delay

Sensitivity Map

LS Sensitivity
LS Sensitivity
Low speed
Mid Speed
High Speed

Verify that the correct VCL software is loaded into the Curtis AC traction controller to support the 1220E. Resolve any problems with the traction software before continuing on to the commissioning procedures.

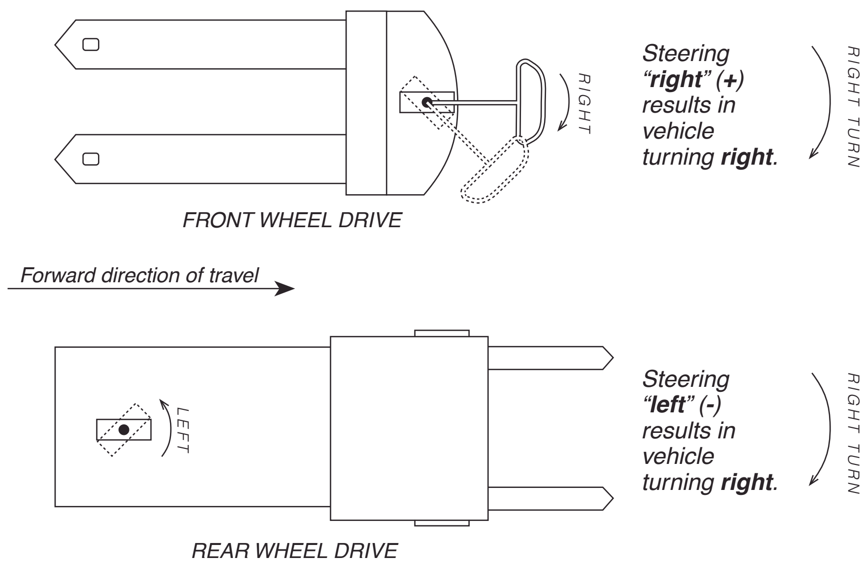
Steer Direction

Parameter and monitor values for wheel position and steer motor speed are signed (i.e., they are positive and negative values).

Right wheel positions (positive values) are such that when traveling in the forward vehicle direction in a vehicle with the steered wheel in the front the steer direction is to the driver's right.

Left wheel positions (negative values) are such that when traveling in the forward vehicle direction in a vehicle with the steered wheel in the front the steer direction is to the driver's left.

In vehicles where the steered wheel is in the back, these directions are reversed.



Step 2: Command Map setup (see page 12)

The fourteen parameters in the Command Map menu define an 8-point map, as described on page 19. The *input* to the Command Map (in units of %) can be observed in Monitor » Command Input » *Steer Command 1 and Steer Command 2*. The *output* to the Command Map (in units of degrees) can be observed in Monitor » Command Input » *Target Position 1 and Target Position 2 (deg)*.

The **Left Stop (deg)** parameter is paired with a value of –100%, and the **Right Stop (deg)** parameter is paired with a value of 100%. The **P1-P6 Output** values fill in the continuum between the two stops; these values should get positive when center is crossed. Similarly, the **P1-P6 Input** parameters should start with negative percent values and increase to positive percent values. The settings of the point pairs can be customized to shape the map according to the needs of the application. In general, starting with a linear command map without any deadband is recommended for vehicles that have the steered wheel in the center.

NOTICE

Setting the **Left Stop (deg)** and **Right Stop (deg)** to the correct angle is critical to the setup of the vehicle as these two parameters set the maximum steering angle. They must be set before continuing on to set up the position feedback. Although any map shape can be set up, it is recommended that the map always be set so that a *Steer Command* 1 and 2 of zero equals a *Target Position 1 and 2 (deg)* of zero.

Step 3: Command Input Device setup (see pages 14–18)

Your steering command input device will be a either a dual potentiometer, using pins J3-6, and J3-13, or a dual encoder in which case you would use J3-6, J3-13 and J2-3 and J2-4. Most applications will have a primary command input device and a supervisory input device. For applications with only a primary command input device, you will need to set the **Supervision Input Device** parameter to 3 (No supervisor device is connected). For applications with a supervisory input device will need to set the **Supervision Input Device** parameter to the type of input you will be using:

Supervision Input Device
0 = Analog Pot
1 = CAN command input
2 = Quadrature encoder input
3 = None (No supervisor device is connected, only a single primary device is used)

Step 0 — Setup for Analog Pot input

Note: The steer motor should not respond to this command input because the Interlock is Off. If the steer motor shows any movement (or if the Interlock is On), stop and resolve the issue; see Preparation for Commissioning, page 39.

a. Move the steer command pots to the Left position (not to the actual physical stop, but a small amount away, to allow for pot tolerance variation) and observe the two voltages shown in the Monitor » Command Input » *Command Analog 1 Input and Command Analog 2 Input* variable. Set the parameters **Command Analog 1 Left** and **Command Analog 2 Left** to the observed voltage.

b. Move the steer command pots to the Center position and observe the two voltage shown in the *Command Analog 1 and Command Analog 2 Input* variable. Set the parameter **Command Analog 1 Center** and **Command Analog 2 Center** to the observed voltages.

c. Move the steer command pots to the Right position (not to the actual physical stop, but a small amount away, to allow for pot tolerance variation) and observe the two voltages shown in the Monitor » Command Input » Command Analog 1 Input and Command Analog 2 Input variable. Set the parameters Command Analog 1 Right and Command Analog 2 Right to the observed voltage.

d. Set the four fault parameters (**Command Analog 1 Fault Min, Command Analog 1 Fault Max, Command Analog 2 Fault Min, Command Analog 2 Fault Max**). Set these to voltages that will not be reached during normal operation, but will be reached when the steer command inputs become faulty (e.g., should there be an open or short circuit).

The **Fault Min** settings must be below the minimum voltage seen on *Command Analog 1 or Command Analog 2 Input* when steered to the maximum left or right positions.

The **Fault Max** setting must be above the maximum voltage seen on *Command Analog 1 or Command Analog 2 Input* when steered to the maximum left or right positions.

Step 1 — Setup for CAN Sensor input (see page 14)

Note: The steer motor should not respond to this command input because the Interlock is Off. If the steer motor shows any movement (or if the Interlock is On), stop and resolve the issue; see Preparation for commissioning, page 39.

a. Decide if the sensor input will be in absolute position mode or relative position mode, and then follow Step "b" or "c" as appropriate.

   Absolute Mode = On is for absolute position mode. The sensor input typically has a range of motion that matches the range of motion of the steered wheel (not multi-turn) and the center, right, and left positions are all defined. Absolute position mode is typically used for walkie and walkie rider material handling applications.

b. For Absolute Position Mode (Absolute Mode = On):

   1. Move the CAN Sensor to the center position and observe the counts shown in the Monitor » Command Input » *CAN Steer Command variable*. Set the **CAN Steer Center Offset** to the observed counts.

   2. With the CAN Sensor still in the center position, observe the counts shown in the Monitor » Command Input » *CAN2 Steer Command variable*. Set the **CAN2 Steer Center Offset** to the observed counts.

   3. Move the CAN Sensor to the Left position (not to the actual physical stop, but a small amount away, to allow for sensor tolerance variation) and observe the counts shown in the Monitor » Command Input » *CAN Steer Command* and *CAN2 Steer Command* variables. The observed *CAN Steer Command* and *CAN2 Steer Command* must both be negative. Change the **CAN Steer Swap Direction** and **CAN2 Steer Swap Direction** as necessary to achieve negative count values for the *CAN Steer Command* and *CAN2 Steer Command variables*. If changes were made to either of the swap parameters, return to the beginning of Step "b" to reset the **CAN Steer Center Offset** and **CAN2 Steer Center Offset parameters**. Set the **CAN Steer Left Stop to center** parameter to the observed count.

   4. Move the CAN Sensor to the Right position (not to the actual physical stop, but a small amount away, to allow for sensor tolerance variation) and observe the counts shown in the Monitor » Command Input » *CAN Steer Command* and *CAN2 Steer Command variables.* Set the **CAN Steer Right stop to Center** parameter to the observed count.

c. For Relative Position Mode (Absolute Mode = Off):

1. Set the **CAN Steer Center Offset** and **CAN2 Steer Center Offset** to zero, as these parameters are not used in relative position mode.
2. Set the **CAN Steer Left Stop to Center** parameter to the number of negative counts required to produce a steer command from center to full left.
3. Set the **CAN Steer Right Stop to Center** parameter to the number of counts required to produce a steer command from center to full right.
4. Verify that turning the CAN sensor to the left results in negative counts for both the *CAN Steer Command* and the *CAN2 Steer Command* variables. Change the **CAN Steer Swap Direction** and **CAN2 Steer Swap Direction** as necessary to achieve negative count values for both the *CAN Steer Command* and the *CAN2 Steer Command* variables.

Step 2 — Setup for Encoder input (see page 15)

Note: The steer motor should not respond to this command input because the Interlock is Off. If the steer motor shows any movement (or if the Interlock is On), stop and resolve the issue; see Preparation for commissioning, page 39.

a. Both command encoders must move in the same direction and the values must be positive for the Right direction and negative for the Left direction Observe the Monitor » Command Input » *Steer Command* and *Steer Command 2* variables. While moving the command encoders, verify that these values are both positive (for movements to command Right steer direction) or negative (for movements to command Left steer direction). If so, go on to step "b"

If one or both of the Encoder Counts is incorrect, use the parameters **Swap Encoder1 Direction** and/or **Swap Encoder2 Direction**. Recheck the *Steer Command* and *Steer Command 2* variables and verify that they both move in the same direction with the correct sign. If problems persist, contact your Curtis customer support engineer before continuing.

b. Set the parameters **Left Stop to Center** and **Right Stop to Center**. These parameters determine how many revolutions of the command encoders are required to steer between the Left and Right stops. These values can be calculated based on the encoders' pulses per revolution (ppr) and the desired number of revolutions of the steering wheel (counts = 4 × encoder ppr × number of revolutions). Both encoders must have the same ppr.

Another way to set up these parameters is by observing the *Steer Command* and *Steer Command 2* values and steering while observing the change in the encoder counts during one complete revolution of the steering wheel.

⚠ CAUTION

Continuing with the commissioning procedures will require the steer motor to turn, so you will have to enable the steer interlock (interlock = On). The vehicle drive wheels should continue to be jacked up off the ground so they can spin freely and steer freely from stop to stop. Enabling the steer interlock can result in erratic movement of the steer motor.

Step 4: Position Feedback Device Setup (see pages 21–24)

Manually enable the interlock, so that the 1220E will begin steering; the traction interlock can remain Off. Verify that the 1220E interlock is now On (Monitor » Inputs » *Interlock State*). If *Interlock State* = Off, resolve the fault condition that is causing this, change the interlock input to the steer controller, or adjust the Interlock Type parameter (Vehicle Configuration » **Interlock Type**) until the *Interlock Switch* variable = On.

Your position feedback device will be a dual potentiometer (using pin J3-2 and J3-9) or a dual motor encoder with a Home switch (using pins J3-2, J3-9, J2-5, J2-6 for the motor encoder and J3-3 for the Home switch).

Set the **Position Feedback Device** and **Redundant Input** parameters to match your input type:

Position Feedback Device Type
0 = Analog pot
1 = Quadrature encoder input

Supervision Feedback Device Type
0 = Analog pot
1 = Quadrature encoder input

Use the appropriate setup procedure for the type of device you have chosen.

Step 0 — Setup for Analog Pot input (see page 14)

a. Use the tiller to move the steered wheel to the Left stop and observe the two voltages shown in the Monitor » Position Feedback » *Position Analog 1 Input and position Analog 2 input* variables. Set the **Position Analog1 Left stop and the Position Analog2 stop** parameters to the observed voltage.

b. Similarly, move the steered wheel to the center and observe the two voltages shown in the *Position Analog 1 Input* and Position Analog 2 input variables. Set the parameter **Position Analog1 Center** and the **Position Analog2 Center** parameters to the observed voltage.

c. Finally, move the steered wheel to the Right stop and again observe the voltages shown in the *Position Analog 1 Input* and position Analog 2 input variables. Set the parameter **Position Analog1 Right Stop** and the **Position Analog2 Right Stop** parameters to the observed voltage.

d. Set the four fault parameters (**Position Analog1 Fault Min, Position Analog1 Fault Max, Position Analog2 Fault Min, and Position Analog1 Fault Max**). Set these to voltages that will not be reached during normal operation, but will be reached if the steer position feedback becomes faulty (e.g., should there be an open or short circuit).

   The **Position Analog1 Fault Min** setting must be below the minimum voltage seen on *Position Analog 1 Input* when steered to the maximum left or right positions.

   The **Position Analog1 Fault Max** setting must be above the maximum voltage seen on *Position Analog 1 Input* when steered to the maximum left or right positions.

Step 1 — Setup for Encoder feedback and Home Switch (see pages 18–22)

a. Verify that the feedback position encoder is working in the correct direction. Steer to the right, and observe the Monitor » Controller » *Motor RPM* variable. In a vehicle traveling forward with the steer motor in front, this value should be positive. If necessary, change the Program » Feedback Device » Position Encoder 1 and 2» **Swap Encoder1 Direction** and **Swap Encoder2 Direction** parameter.

b. Set the **Homing Direction Method**, **Home on Interlock**, and **Homing Speed** parameters. **Homing Speed** can be set to a lower speed than required as the final setting will be performed in Step 5.

c. Review the diagrams in the **Homing Direction Method** parameter description on pages 25–26. Then determine the correct **Homing Direction Method** by observing the Monitor » Inputs » *Home Switch1 and Home Switch2* variables while also observing the position of the steered wheel and the Home switch.

If *Home Switch* = On and the steered wheel is to the right of the Home switch (or *Home Switch* = Off and steered wheel is to the left), setting **Homing Direction Method** to either 0 or 1 will result in the correct direction toward the Home switch during homing. Choose 0 or 1 depending on which side of the Home switch you prefer the steered wheel to be when homing is complete.

If *Home Switch* = On and the steered wheel is to the left of the Home switch (or *Home Switch* = Off and steered wheel is to the right), setting **Homing Direction Method** to either 2 or 3 will result in the correct direction toward the Home switch during homing. Choose 2 or 3 depending on which side of the Home switch you prefer the steered wheel to be when homing is complete.

If *Home Switch* = On and the steered wheel is just on the Home switch (and when *Home Switch* = Off when the steered wheel is not on the Home switch), set **Homing Direction Method** to 4. Then set **Homing Compensation (deg)** to the value shown in the Monitor » Command Input » *Target Position (deg)* variable after steering the tiller head and making the steered wheel just on the center of the Home switch.

After setting the **Homing Direction Method**, verify that the homing function works correctly starting from either side of the Home switch.

d. The correct settings for **Encoder Steps** (pulses per revolution, or PPR) can be calculated as follows.

(1) If the encoder is installed *before* the motor gearbox (i.e., attached to the steer motor rotor),

Encoder Single Pulse Period = $60*10^6$/(Max Steer Motor RPM*Encoder PPR)
should be > 50 µs (20 kHz).

Example: Max Steer Motor RPM = 3000.
$60*10^6$/(3000*Encoder PPR) > 50
Encoder PPR < 400

(2) If the encoder is installed *after* the motor gearbox,

Encoder Single Pulse Period = Gearbox Ratio*$60*10^6$/(Max Steer Motor RPM*Encoder PPR)
should be > 50 µs (20 kHz).

Example: Max Steer Motor RPM = 3000.
Gearbox ratio = 40:1.
$40*60*10^6$/(3000*Encoder PPR) > 50
Encoder PPR < 16000

In either case, we recommend setting **Encoder Steps** to a value greater than 8 to avoid possible sampling error which will lead to poor following accuracy.

Step 5: Set the Motor Control Tuning parameters (see page 32)

a. Restore these two parameter values to their desired performance settings:

Motor » **Max Speed**
Current » **Drive Current Limit.**

If **Position Feedback Device** = 2, set **Homing Speed** (which is a percentage of **Max Speed**) to the desired setting.

b. Temporarily set Sensitivity Map » **LS Sensitivity** and **HS Sensitivity** = 100%.

With this setting, and the drive wheels still jacked up off the ground, set the three parameters in the Motor Control Tuning menu (see page 32) to get correct responsiveness to the steer command input.

Note: Setting these values too high will result in unstable responsiveness. Increase these values as high as possible without becoming unstable:

Motor Control Tuning » **Position Kp**
Motor Control Tuning » **Velocity Kp**
Motor Control Tuning » **Velocity Ki.**

After setting these three parameters, return **LS Sensitivity** and **HS Sensitivity** to their proper values.

Step 6: Verify the position feedback setup

To verify the setup thus far, observe Monitor»Position Feedback» *Wheel Position (deg)* while exercising the steer command input device over the entire operational steer range. If the signal gives an undesired output, go back and resolve this problem before continuing.

Step 7: Resolve any existing faults

Cycle the Keyswitch input to reset the vehicle controllers. Check the active faults in the controller and resolve any faults until all have been cleared. All faults must be cleared before lowering the vehicle drive wheels to the ground. Use Section 6 for help in troubleshooting. Contact your Curtis customer support engineer to resolve any remaining issues about faults before continuing.

⚠ CAUTION

Do not take the vehicle down off the blocks until both the steer and traction motors are responding properly. Once the motors are responding properly, lower the vehicle to put the drive wheels on the ground.

Step 8: Set the Center Offset parameter (see page 24)

While driving the vehicle, initiate a homing action and note the home reference position reached. Set the Center Offset to the difference between this value and the true center (zero) position for the application.

Step 9: Set the remaining Motor parameters (see page 27)

Set Supervision » **Stall Steering Speed**, **Stall PWM**, and **Stall Timeout** to appropriate values that will not cause a fault during normal operation, but will trigger a fault during a real stall condition.

Set Motor » **Max Current Time** and **Cutback Gain** as desired.

Step 10: Set the Sensitivity Map parameters (see page 32)

Drive the vehicle through a wide range of turning and speed scenarios, and adjust the Motor Control Tuning » Sensitivity Map » **Low Speed**, **Mid Speed**, and **High Speed** parameters to create the desired sensitivity map.

6 — DIAGNOSTICS & TROUBLESHOOTING

The 1220E controller detects a wide variety of fault conditions. Faults with the steering controller typically affect the traction controller as well, as shown in the troubleshooting chart.

Faults are displayed on the handheld programmer. The numerical codes used by the LED are listed in the troubleshooting chart (Table 4),

The troubleshooting chart, Table 4, provides the following information about each controller fault:

- fault code
- fault name as displayed on the programmer's LCD
- possible causes of the fault
- fault clear conditions
- steer fault action (effect of fault on steering)
- traction fault action (effect of fault on traction)

For each fault, the chart shows one of these six **Steer Fault actions:**

Warning Only — The 1220E still operates normally.

Shutdown — Immediate shutdown of the 1220E and turn-off of the fault output (pin J3-1).

Warning and reduced current limit — Steer motor current is reduced, to protect the controller.

Warning then Shutdown — The 1220E continues to operate until the traction motor comes to a stop or the timer (set by Fault Steering Timeout) expires. After this occurs, the Shutdown action takes place.

Hold then Shutdown — The 1220E tries to hold the existing wheel position regardless of operator input until the traction motor comes to a stop or the timer (set by Fault Steering Timeout) expires. After this occurs, the Shutdown action takes place.

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 J1, J2, and J3 connectors. Check the connectors for corrosion or damage, clean them if necessary, and re-insert them.

Diagnostics and Fault Processing

The fault chart below gives a description of all the diagnostics/faults and details the set and clear conditions

Table 4 TROUBLESHOOTING CHART

FLASH CODE	NAME	POSSIBLE CAUSE	CLEAR CONDITION	STEER FAULT ACTION	TRACTION FAULT ACTION
12	Controller Overcurrent	1. The steer motor wires shorted. 2. Controller defective.	Cycle KSI	Shutdown	1 = Stop
13	Current Sense Fault	1. Controller defective.	Cycle KSI	Shutdown	1 = Stop
14	Precharge Fault	1. Controller defective.	Cycle KSI	Shutdown	1 = Stop
15	Controller Severe Undertemp	1. Controller is operating in extreme low temperature. 2. the temperature sensor is broken.	Heatsink temperature above –35°C.	Warning Only	3 = No Action
16	Controller Severe Overtemp	1. Excessive load on vehicle. 2. Controller is operating in extreme high temperature. 3. Improper mounting of controller.	Cycle KSI	Warning then Shutdown	1 = Stop
17	Severe Undervoltage	1. Battery or battery cables or battery connections defective. 2. Excessive non-controller hydraulic system drain on battery. 3. Battery discharged or improper battery.	Cycle KSI	Shutdown	1 = Stop
18	Severe Overvoltage	1. Battery or battery cable resistance too high for a given regen current. 2. Battery disconnected while regen braking.	Cycle KSI	Shutdown	1 = Stop
23	Motor Polarity Fault	1. The motor polarity is reversed. 2. The position feedback device polarity is reversed.	Cycle KSI	Shutdown	1 = Stop
24	5V Supply Failure	1. Overload for the 5V supply 2. Controller defective 3. Load wiring open for the 5V supply	Cycle KSI	Hold then Shutdown	1= Stop
25	12V Supply Failure	1. Overload for the 12V supply 2. Controller defective	Cycle KSI	Warning then Shutdown	1= Stop
26	Motor Temp Hot Cutback	1. Excessive load on vehicle. 2. Controller is operating in extreme high temperature.	Bring Steering Motor temperature backs to range.	Warning and Reduce Current Limit	2 = Reduce Speed
31	Main Driver Fault	1. Internal relay coil is broken. 2. Internal relay driver is open or shorted.	Cycle KSI	Warning then Shutdown	1 = Stop
33	Motor Short	1. The steer motor wires shorted.	Cycle KSI	Shutdown	1 = Stop
34	Encoder Fault	1. Encoder is broken. 2. Encoder wiring is open. 3. Controller defective.	Cycle KSI	Hold then Shutdown	1 = Stop
35	Fault Output Failure	1. Incorrect Fault Output wiring. 2. Controller defective.	Cycle KSI	Shutdown	1 = Stop
36	Motor Stalled	1. Stalled steer motor. 2. Steer motor encoder failure or wires open. 3. Steer motor wires open. 4. Related parameters do not match with steer motor.	Cycle KSI	Shutdown	1 = Stop

Table 4 TROUBLESHOOTING CHART cont'd

FLASH CODE	NAME	POSSIBLE CAUSE	CLEAR CONDITION	STEER FAULT ACTION	TRACTION FAULT ACTION
37	Motor Open	1. Steer motor wires open. 2. Faulty motor cable wiring. 3. Controller defective.	Cycle KSI	Warning then Shutdown	1 = Stop
38	Relay Welded	1. Internal relay welded. 2. Controller defective.	Cycle KSI	Shutdown	1 = Stop
39	Relay Did Not Close	1. Internal relay was commanded to be close but it did not. 2. Controller defective.	Cycle KSI	Shutdown	1 = Stop
41	Command Analog1 Out of Range	1. Command Analog Input 1 (J3-6) is out of range. 2. Incorrect parameter settings.	Cycle KSI	Hold then Shutdown	1 = Stop
42	Command Analog2 Out of Range	1. Command Analog Input 2 (J3-13) is out of range. 2. The crosscheck on Command Analog Input 1 (J3-6) and Command Analog Input 2 (J3-13) failed. 3. Incorrect parameter settings.	Cycle KSI	Hold then Shutdown	1 = Stop
43	Feedback Analog1 Out of Range	1. Analog Input (J3-2) is out of range. 2. Incorrect parameter settings.	Cycle KSI	Hold then Shutdown	1 = Stop
44	Feedback Analog2 Out of Range	1. Position Analog Input 2 (J3-9) is out of range. 2. The crosscheck on Position Analog Input 1 (J3-2) and Position Analog Input 2 (J3-9) failed. 3. Incorrect parameter settings.	Cycle KSI	Hold then Shutdown	1 = Stop
45	CAN Not Operational	1. 1220E CAN NMT State did not go operational within 80 ms of interlock being applied.	Cycle KSI	Warning then Shutdown	1 = Stop
46	NV Failure	1. Internal Non-Volatile Memory defective.	Cycle KSI	Shutdown	1 = Stop
47	Parameter Change	1. A parameter value was changed that requires a power cycle. 2. Parameters are restored to the default settings.	Cycle KSI	Shutdown	1 = Stop
51	Interlock Switch Supervision	1. A fault is set if the 2 switch inputs are not matched. 2. Interlock switch defective.	Cycle KSI	Interlock = OFF	1 = Stop
52	Home Switch Supervision	1. When the wheel position is not close to home, the redundant home switch inputs are checked and a fault is set if they disagree. 2. Home switch defective.	Cycle KSI	Warning then Shutdowm	1 = Stop
53	Home Position Not Found	1. Home switch defective. 2. Mounting or wiring defective.	Cycle KSI	Shutdown	1 = Stop
54	Home Reference Tolerance Fault	1. Home switch defective.	Cycle KSI	Shutdown	1 = Stop
55	Steer Command Supervision	1. Command input device defective.	Cycle KSI	Hold then Shutdown	1 = Stop
56	Wheel Position Supervision	1. Position feedback device defective.	Cycle KSI	Hold then Shutdown	1 = Stop
71	Software Fault	1. Software defective. 2. Controller defective.	Cycle KSI	Shutdown	1 = Stop
72	PDO1 Timeout	1. Communication between the traction controller and the 1220E has halted.	Cycle KSI	Warning then shutdown	1 = Stop

Table 4 TROUBLESHOOTING CHART cont'd

FLASH CODE	NAME	POSSIBLE CAUSE	CLEAR CONDITION	STEER FAULT ACTION	TRACTION FAULT ACTION
73	Following Error	1. Incorrect parameter settings. 2. Position feedback device defective. 3. Steer motor defective.	Cycle KSI	Shutdown	1 = Stop
74	Hardware Fault	A hardware error has been detected. 1. Power MOSFETs shorted. 2. MODFETs driver defective. 3. Watchdog cross checking defective. 4. Internal +15V defective. 5. Poor connection to battery terminals	Cycle KSI	Shutdown	1 = Stop
75	Parameter Conflict	1. Parameter settings are selected that are in conflict with each other. 2. Parameter setting out of range.	Cycle KSI	Shutdown	1 = Stop
78	CAN Bus Loading	1. CAN bus defective. 2. The message sending is too fast.	Cycle KSI	Warning then Shutdown	1 = Stop
79	PDO Mapping Error	1. Incorrect CAN mapping data.	Cycle KSI	Shutdown	1 = Stop
81	Bad Calibrations	1. Calibration data is out of range	Cycle KSI	Shutdown	1 = Stop
82	Parameter Out of Range	1. Parameter data out of range	Cycle KSI	Shutdown	1 = Stop
84	Supervision	1. Supervisor defective	Cycle KSI	Shutdown	1 = Stop

Supervision Fault Type

The fault type of fault supervision is described as below table. This menu can only be found on 1313/1314 programmer.

TYPE	NAME	POSSIBLE CAUSES	CLEAR CONDITION
4	SUPERVISOR_FAULT_OUTPUT_FAILURE	1. Incorrect Fault Output wiring. 2. Controller defective.	Cycle KSI
9	SUPERVISOR_HOME_POSITION_NOT_FOUND_SUPERVISION	1. Home switch defective. 2. Mounting or wiring defective.	Cycle KSI
14	SUPERVISOR_PDO1_TIMEOUT	1. Communication between the traction controller and the supervisor has halted.	Cycle KSI
16	SUPERVISOR_HARDWARE_FAULT	A hardware error has been detected. 1. Watchdog crosschecking defective.	Cycle KSI
17	SUPERVISOR_CAN_BUS_LOADING	1. CAN bus defective 2. the message sending is too fast.	Cycle KSI
26	PRIMARY_WRITE_TIMEOUT	1. The primary does not received the acknowledge when updating the parameter	Cycle KSI
27	PRIMARY_WRITE_CRC	1. The received parameter crc is error.	Cycle KSI
28	PRIMARY_WRITE_ACK	1. The primary receives an error acknowledge when the primary is updating the supervisor's parameter.	Cycle KSI
29	PRIMARY_TASK_QUEUE_FAIL	1. The task queue cross check of the primary and the supervisor is failed.	Cycle KSI
31	PRIMARY_ALU_FAIL	1. The ALU cross check of the primary and the supervisor is failed.	Cycle KSI
32	PRIMARY_MESSAGE_WATCHDOG	1. The communication between the primary and the supervisor is disordered.	Cycle KSI
33	PRIMARY_FAULT_ACK	1. The primary does not receive the acknowledge when the fault action message is send.	Cycle KSI
34	SUPERVISOR_INIT_CAN_OBJ	1. The received CAN object is not in the supervisor's parameter table in intial phase 2. The received parameter crc is error.	Cycle KSI
35	SUPERVISOR_INIT_ILLEGAL_CAN_SIZE	1. The supervisor' parameter data length send by the primary is illegal.	Cycle KSI
36	SUPERVISOR_INIT_CAN_SIZE	1. The supervisor's parameter data length is different with the length send by the primary in initial phase.	Cycle KSI
37	SUPERVISOR_INIT_TIMEOUT	1. The supervisor does not receive the init acknowledge from the primary.	Cycle KSI
38	SUPERVISOR_WRITE_OJECT	1. The received CAN object is not in the supervisor's parameter table.	Cycle KSI
39	SUPERVISOR_WRITE_SIZE	1. The supervisor's parameter data length is different with the length send by the primary when the parameter is updating.	Cycle KSI
43	SUPERVISOR_TASK_QUEUE_FAIL	1. The task queue cross check of the primary and the supervisor is failed.	Cycle KSI
44	SUPERVISOR_ALU_FAIL	1. The ALU cross check of the primary and the supervisor is failed.	Cycle KSI
45	SUPERVISOR_MESSAGE_WATCHDOG	1. The communication between the primary and the supervisor is disordered.	Cycle KSI
46	SUPERVISOR_KSI	1. KSI switch defective.	Cycle KSI
50	SUPERVISOR_PARAMETER_CHANGE	1. A parameter value was changed that requires a power cycle	Cycle KSI

7 — MAINTENANCE

There are no user serviceable parts in Curtis 1220E controllers. **No attempt should be made to open, repair, or otherwise modify the controller.** Doing so may damage the controller and will void the warranty.

It is recommended that the controller and connections be kept clean and dry, and that the controller's fault history file be checked and cleared periodically.

CLEANING

Periodically cleaning the controller exterior will help protect it against corrosion and possible electrical control problems created by dirt, grime, and chemicals that are part of the operating environment and that normally exist in battery powered systems.

⚠ CAUTION

When working around any battery-powered system, proper safety precautions should be taken. These include, but are not limited to: proper training, wearing eye protection, and avoiding loose clothing and jewelry.

Use the following cleaning procedure for routine maintenance. Never use a high-pressure washer to clean the controller.

1. Remove power by disconnecting the battery.
2. Remove any dirt or corrosion from the power and signal connector areas. The controller should be wiped clean with a moist rag. Dry it before reconnecting the battery.
3. Make sure the connections are tight.

FAULT HISTORY

The handheld programmer can be used to access the controller's fault history file. The programmer will read out all the faults the controller has experienced since the last time the fault history file was cleared. Faults such as contactor faults may be the result of loose wires; contactor wiring should be carefully checked. Faults such as overtemperature may be caused by operator habits or by overloading.

After a problem has been diagnosed and corrected, it is a good idea to clear the fault history file. This allows the controller to accumulate a new file of faults. By checking the new fault history file at a later date, you can readily determine whether the problem was indeed fixed.

APPENDIX A

VEHICLE DESIGN CONSIDERATIONS
REGARDING ELECTROMAGNETIC COMPATIBILITY (EMC)
AND ELECTROSTATIC DISCHARGE (ESD)

ELECTROMAGNETIC COMPATIBILITY (EMC)

Electromagnetic compatibility (EMC) encompasses two areas: emissions and immunity. *Emissions* are radio frequency (RF) energy generated by a product. This energy has the potential to interfere with communications systems such as radio, television, cellular phones, dispatching, aircraft, etc. *Immunity* is the ability of a product to operate normally in the presence of RF energy.

EMC is ultimately a system design issue. Part of the EMC performance is designed into or inherent in each component; another part is designed into or inherent in end product characteristics such as shielding, wiring, and layout; and, finally, a portion is a function of the interactions between all these parts. The design techniques presented below can enhance EMC performance in products that use Curtis motor controllers.

Emissions

Signals with high frequency content can produce significant emissions if connected to a large enough radiating area (created by long wires spaced far apart). Contactor drivers and the motor drive output from Curtis controllers can contribute to RF emissions. Both types of output are pulse width modulated square waves with fast rise and fall times that are rich in harmonics. (Note: contactor drivers that are not modulated will not contribute to emissions.) The impact of these switching waveforms can be minimized by making the wires from the controller to the contactor or motor as short as possible and by placing the wires near each other (bundle contactor wires with Coil Return; bundle motor wires separately).

For applications requiring very low emissions, the solution may involve enclosing the controller, interconnect wires, contactors, and motor together in one shielded box. Emissions can also couple to battery supply leads and throttle circuit wires outside the box, so ferrite beads near the controller may also be required on these unshielded wires in some applications. It is best to keep the noisy signals as far as possible from sensitive wires.

Immunity

Immunity to radiated electric fields can be improved either by reducing overall circuit sensitivity or by keeping undesired signals away from this circuitry. The controller circuitry itself cannot be made less sensitive, since it must accurately detect and process low level signals from sensors such as the throttle potentiometer. Thus immunity is generally achieved by preventing the external RF energy from coupling into sensitive circuitry. This RF energy can get into the controller circuitry via conducted paths and radiated paths.

Conducted paths are created by the wires connected to the controller. These wires act as antennas and the amount of RF energy coupled into them is generally proportional to their length. The RF voltages and currents induced in each wire are applied to the controller pin to which the wire is connected. Curtis controllers include bypass capacitors on the printed circuit board's throttle wires to reduce the impact of this RF energy on the internal circuitry. In some applications, additional filtering in the form of ferrite beads may also be required on various wires to achieve desired performance levels.

Radiated paths are created when the controller circuitry is immersed in an external field. This coupling can be reduced by placing the controller as far as possible from the noise source or by enclosing the controller in a metal box. Some Curtis controllers are enclosed by a heatsink that also provides shielding around the controller circuitry, while others are partially shielded or unshielded. In some applications, the vehicle designer will need to mount the controller within a shielded box on the end product. The box can be constructed of just about any metal, although steel and aluminum are most commonly used.

Most coated plastics do not provide good shielding because the coatings are not true metals, but rather a mixture of small metal particles in a non-conductive binder. These relatively isolated particles may appear to be good based on a dc resistance measurement but do not provide adequate electron mobility to yield good shielding effectiveness. Electroless plating of plastic will yield a true metal and can thus be effective as an RF shield, but it is usually more expensive than the coatings.

A contiguous metal enclosure without any holes or seams, known as a Faraday cage, provides the best shielding for the given material and frequency. When a hole or holes are added, RF currents flowing on the outside surface of the shield must take a longer path to get around the hole than if the surface was contiguous. As more "bending" is required of these currents, more energy is coupled to the inside surface, and thus the shielding effectiveness is reduced. The reduction in shielding is a function of the longest linear dimension of a hole rather than the area. This concept is often applied where ventilation is necessary, in which case many small holes are preferable to a few larger ones.

Applying this same concept to seams or joints between adjacent pieces or segments of a shielded enclosure, it is important to minimize the open length of these seams. Seam length is the distance between points where good ohmic contact is made. This contact can be provided by solder, welds, or pressure contact. If pressure contact is used, attention must be paid to the corrosion characteristics of the shield material and any corrosion-resistant processes applied to the base material. If the ohmic contact itself is not continuous, the shielding effectiveness can be maximized by making the joints between adjacent pieces overlapping rather than abutted.

The shielding effectiveness of an enclosure is further reduced when a wire passes through a hole in the enclosure; RF energy on the wire from an external field is re-radiated into the interior of the enclosure. This coupling mechanism can be reduced by filtering the wire where it passes through the shield boundary.

Given the safety considerations involved in connecting electrical components to the chassis or frame in battery-powered vehicles, such filtering will usually consist of a series inductor (or ferrite bead) rather than a shunt capacitor. If a capacitor is used, it must have a voltage rating and leakage characteristics that will allow the end product to meet applicable safety regulations.

The B+ (and B–, if applicable) wires that supply power to a control panel should be bundled with the other control wires to the panel so that all these wires are routed together. If the wires to the control panel are routed separately, a larger loop area is formed. Larger loop areas produce more efficient antennas which will result in decreased immunity performance.

Keep all low power I/O separate from the motor and battery leads. When this is not possible, cross them at right angles.

ELECTROSTATIC DISCHARGE (ESD)

Curtis motor controllers contain ESD-sensitive components, and it is therefore necessary to protect them from ESD (electrostatic discharge) damage. Most of these control lines have protection for moderate ESD events, but must be protected from damage if higher levels exist in a particular application.

ESD immunity is achieved either by providing sufficient distance between conductors and the ESD source so that a discharge will not occur, or by providing an intentional path for the discharge current such that the circuit is isolated from the electric and magnetic fields produced by the discharge. In general the guidelines presented above for increasing radiated immunity will also provide increased ESD immunity.

It is usually easier to prevent the discharge from occurring than to divert the current path. A fundamental technique for ESD prevention is to provide adequately thick insulation between all metal conductors and the outside environment so that the voltage gradient does not exceed the threshold required for a discharge to occur. If the current diversion approach is used, all exposed metal components must be grounded. The shielded enclosure, if properly grounded, can be used to divert the discharge current; it should be noted that the location of holes and seams can have a significant impact on ESD suppression. If the enclosure is not grounded, the path of the discharge current becomes more complex and less predictable, especially if holes and seams are involved. Some experimentation may be required to optimize the selection and placement of holes, wires, and grounding paths. Careful attention must be paid to the control panel design so that it can tolerate a static discharge.

MOV, transorbs, or other devices can be placed between B- and offending wires, plates, and touch points if ESD shock cannot be otherwise avoided.

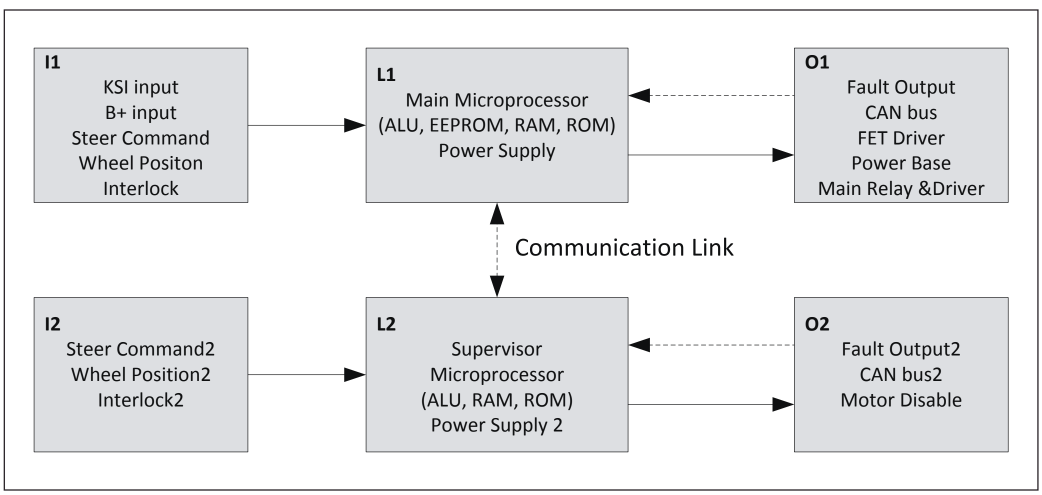
APPENDIX B

EN 13849 COMPLIANCE

Since January 1, 2012, conformance to the European Machinery Directive has required that the Safety Related Parts of the Control System (SRPCS) be designed and verified upon the general principles outlined in EN 13849. EN 13849 supersedes the EN954 standard and expands upon it by requiring the determination of the safety Performance Level (PL) as a function of Designated Architecture plus Mean Time To Dangerous Failure (MTTFd), Common Cause Faults (CCF), and Diagnostic Coverage (DC). These figures are used by the OEM to calculate the overall PL for each of the safety functions of their vehicle or machine.

The OEM must determine the hazards that are applicable to their vehicle design, operation, and environment. Standards such as EN 13849-1 provide guidelines that must be followed in order to achieve compliance. Some industries have developed further standards (called type-C standards) that refer to EN 13849 and specifically outline the path to regulatory compliance. EN 1175-1 is a type-C standard for battery-powered industrial trucks. Following a type-C standard provides a presumption of conformity to the Machinery Directive.

Curtis 1220E Steering Controllers comply with these directives using advanced active supervisory techniques. A Supervisor microcontroller continuously tests the safety related parts of the control system; see the simplified block diagram in the Figure below.



The Supervisor and Primary motor control processors run diagnostic checks at startup and continuously during operation. At startup, the integrity of the code and EEPROM are ensured through CRC checksum calculations. RAM is pattern checked for proper read, write, and addressing. During operation, the arithmetic and logic processing unit of each micro is cyclically tested through dynamic stimulus and response. The operating system timing and task sequencing are continuously verified. Redundant input measurements are crosschecked, and operational status information is passed between microprocessors to keep the system synchronized. Any faults in these startup tests, communication timing, crosschecks, or responses will be detected within 100 ms.The Type C standards of EN 1175 define the hazards that must be analyzed. Four of the listed hazards are relevant to the Curtis 1220E Steering Controller: (1) crushing, due to unintended or uncontrolled movement; (2) loss of stability, due to uncontrolled movement at speed, (3) failure of energy supply, resulting in unintended steering or loss of steering; and (4) failure of control system, resulting in unintended steering or loss of steering. The mitigating Safety Function for these four hazards is "Prevention of Unintended Steering or Loss of Steering."

Curtis has analyzed each hazard and calculated its Mean Time To Dangerous Failure (MTTFd) and Diagnostic Coverage (DC), and designed them against Common Cause Faults (CCF). The safety-related performance of the Curtis 1220E is summarized as follows:

Safety Function	Designated Architure	MTTFd	DC	CCF Score	PL
Prevention of unintended steering or loss of steering	Category 3	>22 yrs	>90%	≥65	d

EN 1175 specifies that electronic steer control systems must use Designated Architecture Category 3 or greater. This design employs input, logic, and output circuits that are monitored and tested by independent circuits and software to ensure a high level of safety performance.

Mean Time To Dangerous Failure (MTTFd) is related to the expected reliability of the safety related parts used in the controller. Only failures that can result in a dangerous situation are included in the calculation.

Diagnostic Coverage (DC) is a measure of the effectiveness of the control system's self-test and monitoring measures to detect failures and provide a safe shutdown.

Common Cause Faults (CCF) are so named because some faults within a controller can affect several systems. EN 13849 provides a checklist of design techniques that should be followed to achieve sufficient mitigation of CCFs. All circuits used by a safety function must be designed in such a way as to score 65 or better on the CCF score sheet as provided by EN 13849 table F.1.

Performance Level (PL) categorizes the quality or effectiveness of a safety channel to reduce the potential risk caused by dangerous faults within the system with "a" being the lowest and "e" being the highest achievable performance.

Contact Curtis technical support for more details.

APPENDIX C

PROGRAMMING DEVICES

Curtis programmers provide programming, diagnostic, and test capabilities for the 1220E controller. The power for operating the programmer is supplied by the host controller via a 4-pin connector. When the programmer powers up, it gathers information from the controller.

Three types of programming devices are available: the Curtis Software suite CSS, 1314 PC Programming Station and the 1313 handheld programmer. The Programming Station has the advantage of a large, easily read screen; on the other hand, the hand-held programmer (with its 45×60mm screen) has the advantage of being more portable and hence convenient for making adjustments in the field.

Both programmers are available in User, Service, Dealer, and OEM versions. Each programmer can perform the actions available at its own level and the levels below that—a User-access programmer can operate at only the User level, whereas an OEM programmer has full access.

PC PROGRAMMING STATION (1314)

The Programming Station is an MS-Windows 32-bit application that runs on a standard Windows PC. Instructions for using the Programming Station are included with the software.

HANDHELD PROGRAMMER (1313)

The handheld programmer is functionally equivalent to the PC Programming Station; operating instructions are provided in the 1313 manual.

PROGRAMMER FUNCTIONS

Programmer functions include:

Parameter adjustment — provides access to the individual programmable parameters.

Monitoring — presents real-time values during vehicle operation; these include all inputs and outputs.

Diagnostics and troubleshooting — presents diagnostic information, and also a means to clear the fault history file.

Programming — allows you to save/restore custom parameter settings files and also to update the system software.

Favorites — allows you to create shortcuts to your frequently-used adjustable parameters and monitor variables.

APPENDIX D

SPECIFICATIONS

Table C-1 SPECIFICATIONS: 1220E CONTROLLERS

Nominal Input Voltage:	**24V 36/48V**
PWM operating frequency:	20 kHz
Electrical isolation to heatsink:	500 V (minimum)
Storage ambient temperature range:	–40°C to 85°C (–40°F to 185°F)
Operating ambient temperature range:	–40°C to 50°C (–40°F to 122°F)
Package environmental rating:	IPx4 for electronics
Weight:	0.4 kg (0.88 lbs)
Dimensions, W×L×H:	79 × 141 × 47.5 mm (3.1'' × 5.6'' × 1.9'')
EMC:	Designed to the requirements of EN 12895:2015
Safety:	Designed to the requirements of EN 1175-1:1998+A1:2010 and EN ISO 13849-1:2015 category 3
UL:	UL recognized component per UL583 (Pending)

Note: Regulatory compliance of the complete vehicle system with the controller installed is the responsibility of the vehicle OEM.

MODEL NUMBER	NOMINAL BATTERY VOLTAGE (V)	1 MIN RATING (Arms)	1 HOUR RATING (Arms)	BOOST (Arms)
1220E-24XX	24	60	30	70
1220E-54XX	36-48	60	30	70

NOTE:

Conditions for thermal ratings are as follows: Controller mounted on 150 mm square, 6 mm thick aluminum plate, with 5 km/h perpendicular air flow. Initial heatsink temperature = 25°C. Motor current held at rating being tested for a minimum of 120% of rated time before start of thermal limiting.