1310 Manual

MANUAL

1310

VEHICLE SYSTEM CONTROLLER with VCL

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OVERVIEW

The Curtis 1310 vehicle system controller provides unprecedented flexibility and ease-of-use. It contains a powerful microcontroller, FLASH memory, and a wide range of inputs and outputs—which means it can be custom-programmed to provide complex and unique functions for your specific application.

Custom software for the 1310 is written with VCL (Vehicle Control Language), an innovative programming language developed by Curtis.

The 1310 controller integrates and expands systems through its industry standard CAN bus communication port. The 1310 works seamlessly in conjunction with the Curtis CAN-based SepEx and AC motor controllers, such as the 1243, 1244, 1234/36/38, and 1298, as well as with the 1352 eXm expansion module.

The 1310 controller can be applied to electric vehicles, non-electric vehicles, and stationary control systems.

Fig. 1 *Curtis 1310 Vehicle System Controller.*

Features include:

- ✔ The powerful VCL programming language allows custom software to be quickly and easily developed by OEMs for unique applications.
- ✔ CAN bus port allows customized vehicle systems and control.
- ✔ FLASH memory allows easy field upgrades and customization on the assembly line.
- ✔ CANopen-compatible communication protocol provides control and feedback to Curtis CAN-based motor controllers, as well as many other CAN-based products.

More Features ☞

- ✔ Extended software functions of VCL simplify the integration of OEM requirements (BDI, hourmeters, PID, ramp, pot, CAN, etc.).
- ✔ Comprehensive Input and Output selection.
- ✔ Two analog outputs (0–10 V at up to 20 mA).
- ✔ Serial port for communication with the Curtis programmer or Curtis Model 840 “Spyglass” display.
- ✔ Two quadrature encoder inputs.
- ✔ Up to 22 digital switch inputs and up to 16 output channels (at up to 3 amps sink per channel) are available for a maximum input/output combination of 22 channels.
- ✔ Two proportional valve control outputs are available (on 16-output models only).
- ✔ Four software-configurable analog input channels available for any combination of 2- and 3-wire pot inputs or 0–5V inputs.
- ✔ Real-Time Clock with battery back-up (optional).
- ✔ Built-in coil flyback diodes.
- ✔ Software and hardware watchdog circuits ensure proper software operation.
- ✔ Rugged aluminum housing.

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 the Curtis office nearest you.

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INSTALLATION AND WIRING

MOUNTING THE CONTROLLER

The outline and mounting hole dimensions for the 1310 controller are shown in Figure 2. It is recommended that the controller be fastened securely to a clean, flat metal surface with four #8 or M4 screws, using the holes provided. Care should be taken to prevent water from splashing or resting on the connector area. If possible, the controller should be mounted with the connector area facing downward and **guarded from water and dust-born contaminants** which can degrade the electrical connections.

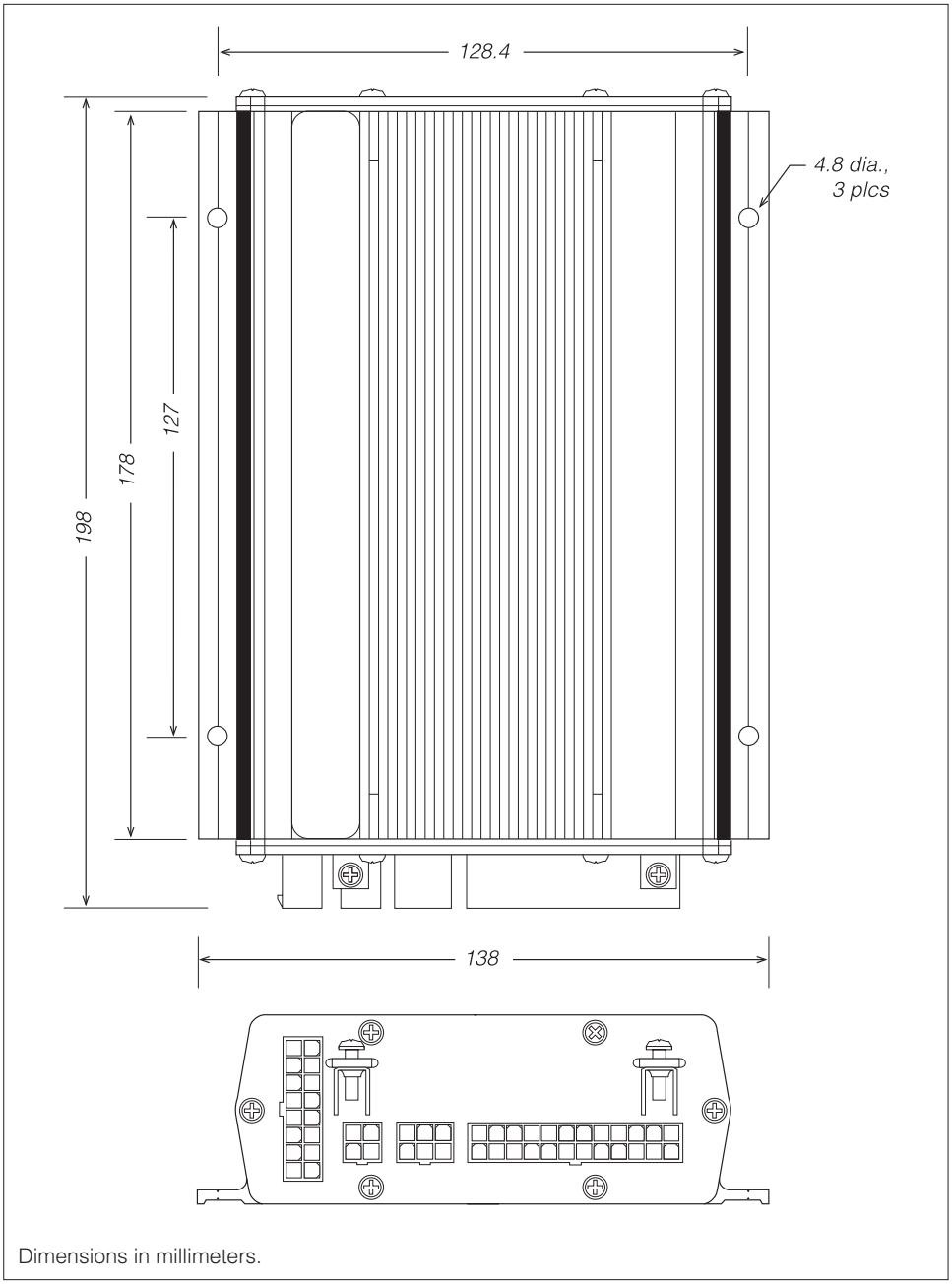


Fig. 2 *Mounting dimensions, Curtis 1310 vehicle system controller.*

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; see Appendix A for suggestions on managing EMC.

The Curtis 1310 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.

CAUTION

Working on electrical systems is potentially dangerous. You should 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.

HIGH CURRENT CONNECTIONS

There are two options for supplying power to the 1310 controller: using pins 23 and 24 on the J1 connector, or using the B- and B+ connection tabs.

Since the controller has many outputs, it is possible for it to draw a considerable load from the battery. If more than 3 amps current is expected in the total system, the **B-** connection tab must be used as the controller ground reference. Likewise, if the system could draw more than 3 amps from B+, the **B+** connection tab must be used to power the controller.

If the driven loads are inductive, the load's power must be connected to the **B+** connection tab, and the the **B+** connection tab must be connected to the battery; see wiring shown in Fig. 3, page 11.

When using the high current connection tabs, be careful not to bend or break the tab while tightening the bolt. For best results, use a pressure washer (convex side up) under the bolt head. This will help prevent the joint from loosening over time.

To avoid overheating the joint, make sure the wire cable gage is sufficient to carry the continuous and maximum loads that will be seen by the controller.

Table 1 High Current Connections

NAME	DESCRIPTION
B+	Battery Positive connection tab, internally connected to J1-24; see Table 2.
B-	Battery Negative connection tab.

LOW CURRENT CONNECTIONS

Low current connections are made through four Molex Mini-Fit Jr. connectors.

J1 is a 24-pin connector containing most of the standard inputs/outputs.

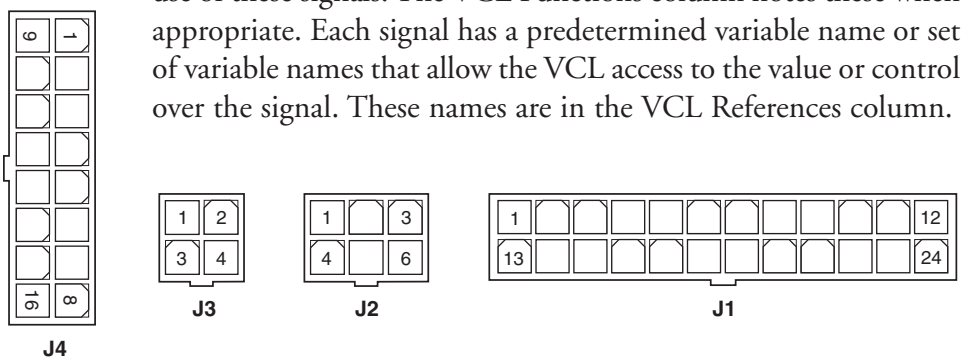
J2 is a 6-pin connector dedicated to the CAN bus.

J3 is a 4-pin connector dedicated to the Curtis serial bus port, used with the 1311 and 1314 programmers and the 840 Spyglass.

J4 is a 16-pin connector for the analog inputs/outputs and encoder connections.

The 60 individual pins are characterized in Tables 2–5.

Often special VCL functions can be used to access or setup or use of these signals. The VCL Functions column notes these when appropriate. Each signal has a predetermined variable name or set of variable names that allow the VCL access to the value or control over the signal. These names are in the VCL References column.



Low current wiring recommendations

Encoders

All four encoder wires should be bundled together as they run between the motor and controller logic connector. These can often be run with the rest of the low current wiring harness. The encoder cables should not be run near the motor cables. In applications where this is necessary, shielded cable should be used with the ground shield connected to the I/O ground (pin 7) at only the controller side. In extreme applications, common mode filters (e.g. ferrite beads) could be used.

CAN bus

It is recommended that the CAN wires be run as a twisted pair. However, many successful applications at 125 kBaud are run without twisting, simply using two lines bundled in with the rest of the low current wiring. CAN wiring should be kept away from the high current cables and cross it at right angles when necessary.

All other low current wiring

The remaining low current wiring should be run according to standard practices. Running low current wiring next to the high current wiring should always be avoided.

Table 2 Connector J1: Inputs/Outputs

PIN	NAME	DESCRIPTION	RELATED VCL	
			FUNCTIONS	REFERENCES
1	Input/Output 1	A digital input with an open collector high-frequency PWM output. This output also provides output current feedback. Signal is pulled to B- when output is on.	Put_PWM Automate_PWM Get_ADC	SW_1 SW_1_UP SW_1_Down PWM1 ADC15_Output
2	Input/Output 2	A digital input with an open collector high-frequency PWM output. This output also provides output current feedback. Signal is pulled to B- when output is on.	Put_PWM Automate_PWM Get_ADC	SW_2 SW_2_UP SW_2_Down PWM2 ADC16_Output
3	Input/Output 3	A switch to B+ digital input with an open collector high-frequency PWM output. Signal is pulled to B- when output is on.	Put_PWM Automate_PWM	SW_3 SW_3_UP SW_3_Down PWM3
4	Input/Output 4	A switch to B+ digital input with an open collector high-frequency PWM output. Signal is pulled to B- when output is on.	Put_PWM Automate_PWM	SW_4 SW_4_UP SW_4_Down PWM4
5	Input/Output 5	A switch to B+ digital input with an open collector high-frequency PWM output. Signal is pulled to B- when output is on.	Put_PWM Automate_PWM	SW_5 SW_5_UP SW_5_Down PWM5
6	Input/Output 6	A switch to B+ digital input with an open collector high-frequency PWM output. Signal is pulled to B- when output is on.	Put_PWM Automate_PWM	SW_6 SW_6_UP SW_6_Down PWM6
7	Input/Output 7	A switch to B+ digital input with an open collector high-frequency PWM output. Signal is pulled to B- when output is on.	Put_PWM Automate_PWM	SW_7 SW_7_UP SW_7_Down PWM7
8	Input/Output 8	A switch to B+ digital input with an open collector high-frequency PWM output. Signal is pulled to B- when output is on.	Put_PWM Automate_PWM	SW_8 SW_8_UP SW_8_Down PWM8
9	Input/Output 9	A switch to B+ digital input with an open collector high-frequency PWM output. Signal is pulled to B- when output is on.	Put_PWM Automate_PWM	SW_9 SW_9_UP SW_9_Down PWM9
10	Input/Output 10	A switch to B+ digital input with an open collector high-frequency PWM output. Signal is pulled to B- when output is on.	Put_PWM Automate_PWM	SW_10 SW_10_UP SW_10_Down PWM10
11	Input/Output 11	A switch to B+ digital input with an open collector high-frequency PWM output. Signal is pulled to B- when output is on.	Put_PWM Automate_PWM	SW_11 SW_11_UP SW_11_Down PWM11
12	Input/Output 12	A switch to B+ digital input with an open collector high-frequency PWM output. Signal is pulled to B- when output is on.	Put_PWM Automate_PWM	SW_12 SW_12_UP SW_12_Down PWM12

Table 2 Connector J1: Inputs/Outputs, cont'd

PIN	NAME	DESCRIPTION	RELATED VCL FUNCTIONS	RELATED VCL REFERENCES
13	Input/Output 13	A switch to B+ digital input with an open collector high-frequency PWM output. Signal is pulled to B- when output is on.	Put_PWM Automate_PWM	SW_13 SW_13_UP SW_13_Down PWM13
14	Input/Output 14	A switch to B+ digital input with an open collector high-frequency PWM output. Signal is pulled to B- when output is on.	Put_PWM Automate_PWM	SW_14 SW_14_UP SW_14_Down PWM14
15	Input/Output 15	A switch to B+ digital input with an open collector high-frequency PWM output. Signal is pulled to B- when output is on.	Put_PWM Automate_PWM	SW_15 SW_15_UP SW_15_Down PWM15
16	Input/Output 16	A switch to B+ digital input with an open collector high-frequency PWM output. Signal is pulled to B- when output is on.	Put_PWM Automate_PWM	SW_16 SW_16_UP SW_16_Down PWM16
17	Input 17	A switch to B+ digital input (pulled low to B-). Switch this pin to B+ to read as ON.		SW_17 SW_17_UP SW_17_Down
18	Input 18	A switch to B+ digital input (pulled low to B-). Switch this pin to B+ to read as ON.		SW_18 SW_18_UP SW_18_Down
19	Input 19	A switch to ground digital input (pulled high to +15V). Switch this pin to B- to read as OFF.		SW_19 SW_19_UP SW_19_Down
20	Input 20	A switch to ground digital input (pulled high to +15V). Switch this pin to B- to read as OFF.		SW_20 SW_20_UP SW_20_Down
21	Input 21	A switch to ground digital input (pulled high to +15V). Switch this pin to B- to read as OFF.		SW_21 SW_21_UP SW_21_Down
22	Input 22	A switch to ground digital input (pulled high to +15V). Switch this pin to B- to read as OFF.		SW_22 SW_22_UP SW_22_Down
23	B-	CAN be used as a low power (<2 amp) ground reference or for switch inputs 12–22 B- reference.		
24	B+	Can be used to power the system (<2 amps) or for B+ reference for switches, etc.	Setup_BDI	ADC13_Output KSI_Filtered KSI_Raw

Note: Model 1310-5210 is not fully "stuffed." This model has Outputs 9–16 available, and Inputs 1–13, 16, and 19–22. Outputs 14 and 15 have over 200kΩ output impedance.

Table 3 Connector J2: CAN Bus

PIN	NAME	DESCRIPTION	RELATED VCL	
			FUNCTIONS	REFERENCES
1	CAN Hi	Positive CAN Bus rail.	Setup_CAN Setup_Mailbox Send_Mailbox etc...	
2	CAN Lo	Negative CAN Bus rail.	Setup_CAN Setup_Mailbox Send_Mailbox etc...	
3	GND	Ground reference.		
4	+5V	+5V for remote module(s).		
5	Term H	Connect Term H to Term L to create an end-of-bus termination (adds a 120Ω resistor across CAN Hi and CAN Lo).		
6	Term L	See Term H description above.		

Table 4 Connector J3: Serial Port

PIN	NAME	DESCRIPTION	RELATED VCL	
			FUNCTIONS	REFERENCES
1	RxD	Serial Receive line for programmer and Spyglass communications.	Setup_Serial Put_Spy_Message	
2	GND	Communications ground.		
3	TxD	Serial Transmit line for programmer and Spyglass communications.	Setup_Serial Put_Spy_Message	
4	PWR	+12V power; the output current of this pin and +5V (J4-15) is combined and monitored at ADC12.		ADC12_Output

Table 5 Connector J4: Specialty I/O

PIN	NAME	DESCRIPTION	RELATED VCL FUNCTIONS	RELATED VCL REFERENCES
1	Encoder 1A	Pulse count input, or encoder channel A.	Setup_Encoder Get_Enc_Count Get_Enc_Dir Get_Enc_Vel Get_Enc_Error	ENC1 ENC1_Count ENC1_Dir ENC1_Vel ENC_Error SW_23
2	Encoder 1B	Encoder channel B.		SW_24
3	Encoder 2A	Pulse count input or encoder channel B.	Setup_Encoder Get_Enc_Count Get_Enc_Dir Get_Enc_Vel Get_Enc_Error	ENC2 ENC2_Count ENC2_Dir ENC2_Vel ENC_Error SW_25
4	Encoder 2B	Encoder channel B.		SW_26
5	Pot High	The high voltage reference for the four potentiometer inputs.	Get_Pot Get_ADC	POT_High ADC1 ADC_Output
6	Wiper 1	A generic 0–5V input which can also be set up as a potentiometer wiper input.	Get_Pot Setup_Pot Setup_Pot_Filtered Get_ADC	POT1_Output ADC2_Output
7	Wiper 2	A generic 0–5V input which can also be set up as a potentiometer wiper input.	Get_Pot Setup_Pot Setup_Pot_Filtered Get_ADC	POT2_Output ADC3_Output
8	Wiper 3	A generic 0–5V input which can also be set up as a potentiometer wiper input.	Get_Pot Setup_Pot Setup_Pot_Filtered Get_ADC	POT3_Output ADC4_Output
9	Wiper 4	A generic 0–5V input which can also be set up as a potentiometer wiper input.	Get_Pot Setup_Pot Setup_Pot_Filtered Get_ADC	POT4_Output ADC5_Output
10	Pot Low	The low voltage reference for the four potentiometer inputs.	Get_Pot Get_ADC	POT_Low ADC6_Output
11	Analog Output 1	0–10V analog output.	Put_DAC Automate_DAC	DAC1
12	Analog Output 2	0–10V analog output.	Put_DAC Automate_DAC	DAC2
13	Not used			
14	PWR_UP	B+ input that can be used to to power up the 1310 controller.	Get_ADC	ADC7_Output
15	+5V	+5V to power sensors. Can supply up to 200 mA. The output current is monitored at ADC11.	Get_ADC	ADC11_Output
16	GND	Ground reference.		

CONTROLLER WIRING

Because the 1310 controller is so versatile, there is no "standard" wiring configuration. The diagram shown as Figure 3 illustrates some of the possibilities for the various inputs and outputs. The power and battery connections shown are fairly standard, although other configurations are possible. The following paragraphs walk through the diagram.

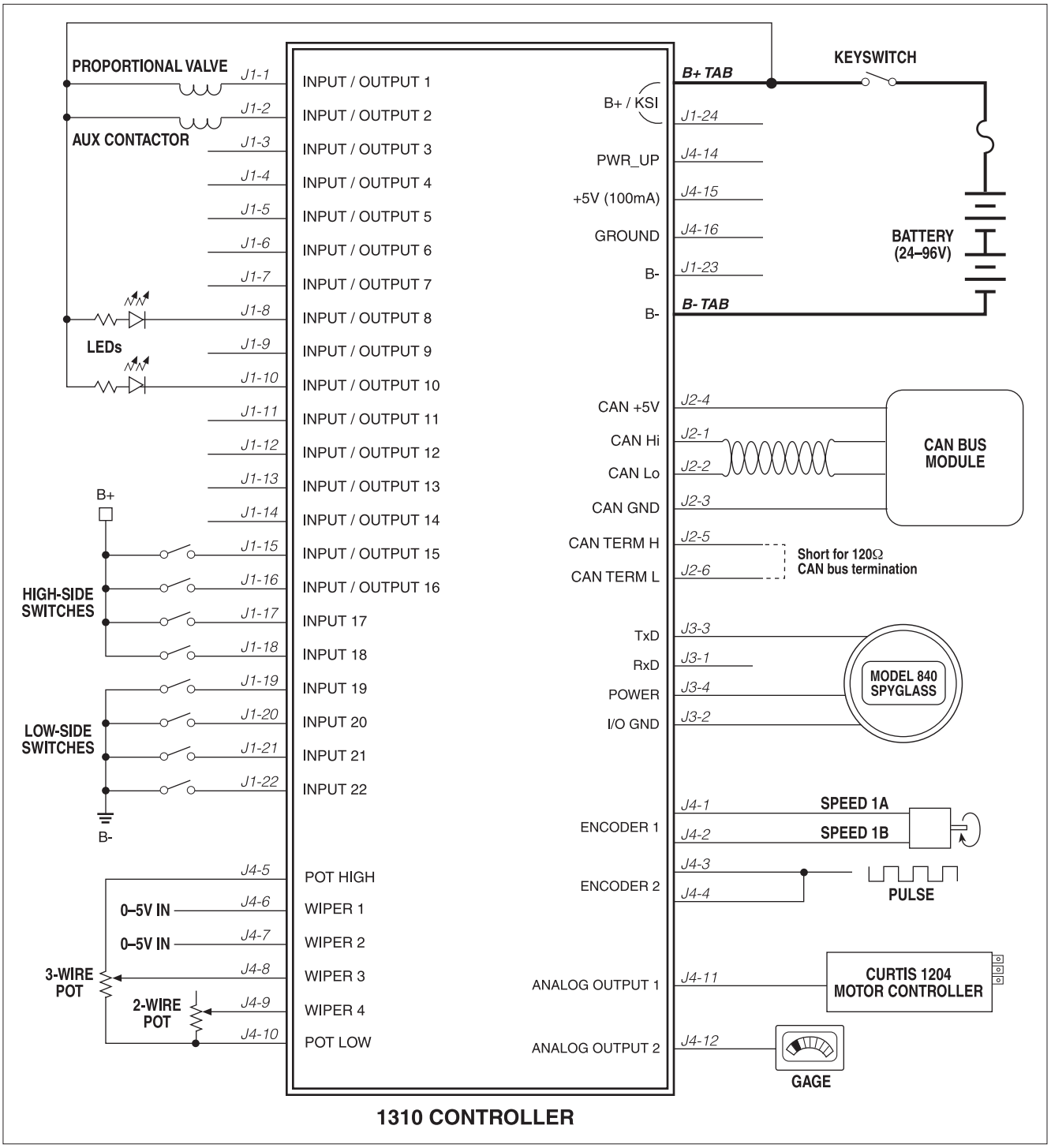


Fig. 3 *Wiring diagram, Curtis 1310 vehicle system controller.*

Power connection

The battery is connected to the 1310 controller's power tabs through a fuse and a keyswitch. The power tabs are used because there are inductive loads on the system (Aux Contactor and Proportional Valve coils) which could cause the current to exceed 3 amps. The fuse is required to protect the wiring, as the controller could draw significant power if there were a short or failure in the unit.

The keyswitch is used to "start" the system. Both the B+ power tab and the B+ signal at J1-24 are used as the Keyswitch Input. When the keyswitch is closed, the B+/KSI input goes high, the controller powers up, and the BDI functions are enabled.

Outputs

The system shown in Figure 3 has two high-power outputs and two LEDs that run off keyswitch power.

The first power output drives a proportional valve coil. Outputs 1 and 2 are special in that they have internal current feedback lines. VCL can use this signal in a PID loop to regulate current, which is necessary to properly control the position (and flow) in a proportional valve. Outputs 1 through 4 also run at a higher frequency and thus can provide a smoother current (less ripple).

The second power output drives a basic contactor coil. It is connected to Output 2, which has a current feedback signal. In this case, VCL can use the current feedback signal to ensure that the coil is connected and drawing the proper current when on. In this way, enhanced fault diagnostics can be performed.

Using the PWM outputs to drive the LEDs allows the the brightness of the LEDs to be varied. The frequency is too high for the human eye to see any flickering. Note that a dropping resistor must be used because even low duty cycle PWM applies full battery voltage is short bursts, and this will destroy the LED without a dropping resistor limiting the current. Note that the internal impedance to ground of the driver will cause **leakage current** to flow through the LEDs even when the output driver is off. Refer to the Digital Output Specifications (page 15) when calculating the leakage current. This leakage current can be enough (> 2 mA) to light high efficiency LEDs. Model 1310-5210 provides two output drivers (Outputs 14 and 15) that do not have leakage current issues and may therefore be the best suited for driving LEDs.

Switch inputs

All the outputs can be used as active high inputs (On when connected to B+). There are four special inputs that are active low (On when connected to B-).

If an output is used as an input (see, for example, Input/Output 15 in the wiring diagram), VCL must take care not to turn on that output or a direct short to B+ could be established through the switch and the internal FET driver.

Analog inputs

Three types of analog inputs are used. The first two inputs use a 0–5V input. The next is a 3-wire connection for a potentiometer using both Pot High and Pot Low and the third is a 2-wire potentiometer or rheostat.

Note that in all cases, the VCL code must be written to provide the necessary wiring and potentiometer fault checking. To accomplish this, the 1310 provides the measured voltage readings of Pot High and Pot Low connections. Monitoring these values can indicate if there is a short to B+ or B-. Using the Pot High and Pot Low connections for the potentiometer or rheostat will also provide a small lower and (when using Pot High) upper bound to the analog input. Knowing this, proper range checking in VCL can be performed for additional fault diagnostics.

Encoder and pulse inputs

The 1310 has two quadrature encoder inputs. Using A and B channels with a quadrature encoder allows velocity, position (count), and direction detection. Tying the A and B channels together, as shown on Encoder 2, allows the input to measure a single pulse train. In this configuration, the 1310 will either count (ENC_Count mode) or measure speed magnitude (Enc_Velocity mode); the ENC2_DIR variable is not valid in this configuration.

Power for the encoder can be derived from the +5V output and Ground pins found on J4. The +5V output has an output current measurement. VCL can use this value to determine if the encoder and/or any other sensors are connected and drawing the proper current. This can be used to provide additional fault diagnostics.

Note: If the encoder inputs are set up in velocity mode, the **direction flag will not be accurate** below a low speed threshold. The direction bit may stay in the last direction and may not return to 0 when the speed is at zero. The VCL code must be written to read the velocity variable and doublecheck the direction bit in this case; see page 36.

Analog outputs

The two analog outputs can be used to interface to various analog devices. Here, Analog Output 1 is used to control the throttle input of a Curtis 1204 motor controller. Note that most throttle inputs are 0–5 V while the 1310 can provide up to 10 volts.

Analog Output 2 is being used to drive a gage, such as a Curtis enGage 2 or simple voltmeter. VCL code can use this output to display a wide range of data—for example, the state of the battery charge, position of the potentiometer wipers, or speed of the encoder.

INPUT/OUTPUT SIGNAL SPECIFICATIONS

The input/output signals wired to the J1, J2, J3, and J4 connectors can be grouped by type as follows; their electrical characteristics are discussed below.

— digital inputs
— digital outputs
— analog inputs
— analog output
— power
— communications.

Digital inputs

These signal lines can be used as digital (on/off) inputs. Normally, the On signal is made by a connection direct to B+ and Off is direct to B-. Inputs 1 through 18 will pull low (Off) if no connection is made. Inputs 19 through 22 and the encoder inputs will pull high (On) if no connection is made.

Inputs 1 through 18 are associated with driver outputs. Inputs 19 through 22 and the encoder inputs are low voltage "TTL" level inputs and can be used when connecting to other low voltage (5V) logic circuits or sensors. The encoder channels are normally used for pulse count inputs from quadrature (2-channel) encoders, but they may also be used as 5V logic-level digital inputs. Take careful note of their much lower voltage range.

DIGITAL INPUT SPECIFICATIONS

SIGNAL NAME	PIN	LOGIC THRESHOLDS	INPUT IMPEDANCE	VOLTAGE RANGE	ESD TOLERANCE
Input/Output 1–16	J1-1 thru J1-16	*24–48V models:* Low = 7.5 V High = 15.8 V *48–96V models:* Low = 14.1 V High = 29.7 V	*24–48V models:* about 5.4 kΩ *48–96V models:* about 22 kΩ * see note below	*24–48V models:* -0.5 to 64 V *48–96V models:* -0.5 to 124 V	±8 kV (air discharge)
Input 17–18	J1-17 thru J1-18	*24–48V models:* Low = 7.5 V High = 15.8 V *48–96V models:* Low = 14.1 V High = 29.7 V	*24–48V models:* about 5.4 kΩ *48–96V models:* about 22 kΩ	*24–48V models:* -0.5 to 64 V *48–96V models:* -0.5 to 124 V	±8 kV (air discharge)
Input 19–22	J1-19 thru J1-22	*All models:* High = 3.8 V Low = 1.8 V	*All models:* about 4.5 kΩ	*24–48V models:* -0.5 to 64 V *48–96V models:* -0.5 to 124 V	±8 kV (air discharge)
Encoder 1A,1B,2A,2B	J4-1 thru J4-4	Rising edge= 3.0 V Falling edge= 2.0 V	*All models:* about 4.7 kΩ	*All models:* -0.5 to 5.5 V	±8 kV (air discharge)

Tolerance of above values ±5%.

* Outputs 14 and 15 on Model 1310-5210 have over 200 kΩ output impedance.

Digital outputs

These signal lines can be used as digital (on/off) or Pulse Width Modulated (PWM) outputs. Each driver is active low, meaning the output will pull low (to B-) when commanded On. The PWM is at a fixed frequency (~9.7kHz for Outputs 1–4 and ~400Hz for Outputs 5–16), but can vary duty cycle from 0% (Off = 0) to 100% (On = 32767). Digital Outputs 1 and 2 are special as these have internal current feedback signals that can be used by VCL to create current sources or check the output load, etc.

If the digital outputs are connected to inductive loads, the B+ tab must be connected to the battery source. This connection provides a path for the internal freewheel diodes to clamp the turn-off spike. Failure to make this connection with inductive loads can cause permanent damage to the controller as well as propagate failures of other electronics in the system due to the high voltage spike caused when an inductive load turns off without a freewheel path.

DIGITAL OUTPUT SPECIFICATIONS						
SIGNAL NAME	PIN	PWM	FREQUENCY	OUTPUT CURRENT	PROTECTED VOLTAGE	ESD TOLERANCE
Input/Output 1–16	J1-1 thru J1-16	0 to 100% duty cycle	*Outputs 1–4:* ~9.7 kHz *Outputs 5–16:* ~400 Hz	Sink 3 amps	*24–48V models:* -0.5 to 64 V *48–96V models:* -0.5 to 124 V	±8 kV (air discharge)

Analog inputs

The four analog inputs can easily be configured for use with potentiometers. VCL allows each input to be independently set up as a voltage input or as a 2-wire or 3-wire resistance input. Voltage inputs can be connected directly to the Wiper input (with B- or GND for the return line). Rheostats (2-wire) are connected between the Pot Wiper and Pot Low, and a 3-wire potentiometer has the resistance element connected between the Pot High and Pot Low signals and the wiper connected to the Wiper signal. The corresponding VCL setup must be used to allow the 1310 to properly detect and scale the signal.

Although designed to be used with potentiometers, Pot High and Pot Low signals are monitored by analog pins in the 1310 and thus have a limited use as analog inputs. Note that these pins have a low input impedance (~680Ω) which could be damaged by moderate voltages from a low impedance source.

ANALOG INPUT SPECIFICATIONS					
SIGNAL NAME	PIN	OPERATING VOLTAGE	INPUT IMPEDANCE	PROTECTED VOLTAGE	ESD TOLERANCE
Wiper 1–4	J4–6 thru J4-9	0 to 5 V	5 kΩ	-1 V to 30 V	±8 kV (air discharge)
Pot High	J4-5	0 to 5 V	680 Ω to +5 V	-1 V to 30 V	±8 kV (air discharge)
Pot Low	J4-10	0 to 5 V	680 Ω to ground	-1 V to 8 V	±8 kV (air discharge)

Analog outputs

Two signals provide low power analog outputs. These outputs are generated from filtered PWM signals and have about 1% ripple. The settling time (within 2% of final output) is about 30 ms for a 0–10V step. The Analog Outputs are protected against shorts to B+ or B-.

CAUTION

During a FLASH software download, the DAC output voltages will float up and can reach as high as 10 volts. Make sure that your vehicle system is safe and can tolerate this event.

If the battery system droops below 20 volts, the DAC outputs will not reach the 10V output specification and will start dropping as the battery voltage drops below 20 volts.

ANALOG OUTPUT SPECIFICATIONS					
SIGNAL NAME	PIN	OUTPUT VOLTAGE	OUTPUT IMPEDANCE	PROTECTED VOLTAGE	ESD TOLERANCE
Analog Output 1–2	J4-11 & J4-12	0 to 10 V	about 33 kΩ	-1 V to 124 V	±8 kV (air discharge)

Power

Group A: These signals provide power for the various sensors and communication systems that might be connected to the 1310. The PWR signal is normally only used for powering the 1311 handheld programmer or the Curtis 840 Spyglass, but can be used to power other small sensors or electronics. These three power supply signals are current limited. The limited supply current can be split between these power pins as long as the combined total does not exceed 200 mA.

POWER SPECIFICATIONS: Group A				
SIGNAL NAME	PIN	OUTPUT VOLTAGE	OUTPUT CURRENT	ESD TOLERANCE
+5 Volts	J4-15	5 V ±5%	200 mA max*	±8 kV (air discharge)
CAN +5V	J2-4	5 V ±5%	200 mA max*	±8 kV (air discharge)
PWR (Serial Port)	J3-4	13.75 V ±5%	200 mA max*	±8 kV (air discharge)

* The combined current of +5 Volts, CAN +5V, and PWR cannot exceed 200 mA.

Group B: These connections are used to supply power to the 1310 itself. Depending on the power requirements, the 1310 can be powered up through the B+ and B- power tabs or through the Mini-Fit Jr. pins listed.

POWER SPECIFICATIONS: Group B			
SIGNAL NAME	PIN	MAX CURRENT	ESD TOLERANCE
B+/KSI	J1-24	3 A*	±8 kV (air discharge)
	B+ TAB	40 A	
B-	J1-23	3 A*	±8 kV (air discharge
	B- TAB	40 A	
PWR_UP	J4-14	3 A	±8 kV (air discharge)

* The B+ and B- power tabs must be used if more than 3A is expected in the system, or if the driven loads are inductive.

Communications

Separate CAN and serial ports provide complete communications and programming capability.

The Curtis 1311 handheld programmer plugs into a 4-pin connector wired to pins J3-1 and J3-3, along with ground (pin J3-2) and the +12V power supply (pin J3-4); see wiring diagram, Figure 3. The Curtis Model 840 Spyglass can plug into the same 4-pin connector.

Wiring the CAN Term H and CAN Term L pins together provides a local CAN termination of 120 Ω, 0.5 W; keep the length of these wires short. CAN Term H and CAN Term L should never be connected to any external wiring.

COMMUNICATIONS PORT SPECIFICATIONS					
SIGNAL NAME	PIN	SUPPORTED PROTOCOL/DEVICES	DATA RATE	PROTECTED VOLTAGE	ESD TOLERANCE
CAN Hi	J2-1	CANopen	up to 1 Mbps	Continuous= -36 V to (MaxV + 10 V) Transient= ±200 V	±8 kV (air discharge)
CAN Lo	J2-2				
CAN Term H	J2-5			(no connection to external wiring)	±8 kV (air discharge)
CAN Term L	J2-6				
TxD	J3-3	Curtis 840 Display, 1311 Handheld Programmer, 1314 PC Programming Station	as required, 9.6 to 56 kbps	-0.3 to 12 V	±8 kV (air discharge)
RxD	J3-1				

3 PROGRAMMABLE PARAMETERS

The Curtis 1310 Vehicle System Controller is designed to be a universal control block, and therefore has only a few "ready-made" standard parameters that can be adjusted via the 1311 handheld programmer. Many custom parameters and menus can be added to meet the needs of the application, using the VCL programming language. Refer to Section 5 of the VCL Programmer's Guide for detailed information on setting up parameter lists and menus that can be read by the Curtis 1311 handheld programmer or Curtis 1314 PC-based programmer. For programmer operation, see Appendix C.

PROGRAMMING MENUS

The standard programmable parameters are grouped these two menus:

BATTERY MENU
- —Nominal Voltage
- —Reset Volts Per Cell
- —Full Volts Per Cell
- —Empty Volts Per Cell
- —Discharge Time
- —BDI Reset Percent

CAN INTERFACE MENU
- —Master ID
- —Slave ID
- —Baud Rate
- —Heartbeat Rate
- —PDO Timeout Period
- —Emergency Message Rate
- —Suppress CANopen Init

Individual parameters are presented as follows in the menu charts:

Parameter name as it appears in the programmer display ⇓	Allowable range in the programmer's units ⇓	Description of the parameter's function and, where applicable, suggestions for setting it ⇓
Nominal Voltage *Nominal_Voltage*	24–48 V *1536–3072*	Must be set to the system's nominal battery voltage. This value is used in determining the number of cells in the battery pack for the BDI parameters.
⇑ *Parameter name in VCL*	⇑ *Allowable range in VCL units*	

Battery Discharge Indicator algorithm

The 1310 controller contains a sophisticated battery state-of-charge algorithm. Set up properly, this algorithm can track the remaining battery charge (in percent) using only a voltage reading from the B+ power tab or J1-24. To achieve any accuracy, it is critical to set the BDI parameters correctly for the vehicle, battery, and normal duty cycle of the application. Note that many of the parameters are in volts per cell. A normal 24V battery has 12 cells.

The remaining battery capacity is automatically updated into the variable *BDI_Percentage*.

BATTERY MENU

PARAMETER	ALLOWABLE RANGE	DESCRIPTION
Nominal Voltage *Nominal_Voltage*	24–48 V *1536–3072*	Must be set to the vehicle's nominal battery pack voltage. This value is used in determining the number of cells in the battery pack for the BDI parameters. How so?
Reset Volts Per Cell *BDI_Reset_Volts_Per_Cell*	0.00–3.00 V *000–3000*	At power up, the BDI is reset to 100% if the battery is measured above this setting. Typical value is 2.09 V. Reset Volts Per Cell must be set higher than Full Volts Per Cell.
Full Volts Per Cell *BDI_Full_Volts_Per_Cell*	0.00–3.00 V *000–3000*	The BDI will output 100% (full) while the average voltage per cell resding is above this setting.
Empty Volts Per Cell *BDI_Empty_Volts_Per_Cell*	0.00–3.00 V *000–3000*	The BDI will output 0% (empty) when the average voltage per cell reading is below this setting.
Discharge Time *BDI_Discharge_Time*	0–600 min. *0–600*	The time it will take the BDI to go from 100% to 0% at maximum current drawl.
BDI Reset Percent *BDI_Reset_Percent*	0–100 % *0–100*	If the previous BDI % value was above this point at power up, the BDI will not reset, even if the battery is measured above the Reset Volts Per Cell level. This will prevent a slightly discharged battery from "floating" and resetting the BDI at every power up.

CANopen interface

The 1310 controller can be easily interfaced to other CANopen modules. The parameters in the CAN Interface menu work with VCL to set up the basic CANopen IDs and rates. Refer to the Section G of the VCL Common Functions Manual for information on setting up CANopen PDO, SDO, and other CAN-related functions.

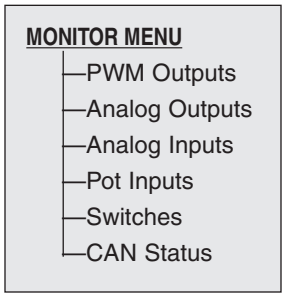
CAN INTERFACE MENU

PARAMETER	ALLOWABLE RANGE	DESCRIPTION
Master ID *CAN_Master_ID*	0 – 3 *0 – 3*	CAN ID for incoming messages to a CANopen Slave system.
CAN Slave ID *CAN_Slave_ID*	0 – 31 *0 – 31*	CAN ID for outgoing messages from a CANopen Slave system. first 7 bits of the 11-bit identifier (the COB ID).
Baud Rate *CAN_BAUD_Rate*	0 – 2 *0 – 2*	Sets the CAN baud rate for the CANopen Slave system: 0=125 kbps, 1=250 kbps, 2=500 kbps.
Heartbeat Rate *Heartbeat_Rate*	16 – 200 ms *4 – 50*	Sets the rate at which the CAN heartbeat messages are sent by the CANopen Slave system.
PDO Timeout Period *CAN_PDO_Timeout_Period*	0 – 200 ms *0 – 50*	Sets the PDO timeout period for the CANopen Slave system. After the slave controller has sent a PDO MISO, it will declare a PDO Timeout Fault if the master controller has not sent a reply PDO MOSI message within the set time. Either PDO1 MOSI or PDO2 MOSI will reset the timer. Setting the PDO Timeout Period = 0 will disable this fault check.
Emergency Message Rate *CANopen_Emergency_ Message_Rate*	16 – 200 ms *4 – 50*	Sets the minimum rate between CAN emergency messages from the CANopen Slave system. This prevents quickly changing fault states from generating so many emergency messages that they flood the CAN bus.
Suppress CANopen Init *Suppress_CANopen_Init*	0 – 1 *0 – 1*	When Suppress CANopen Init is set = 1, at power up the initialization of the CANopen system is suppressed. Typically this is done so that the VCL program can make changes to the CANopen system before enabling it (by setting the variable Suppress_CANopen_Init = 0 and running the Setup_CAN() function).

4a

MONITOR MENU

Through its Monitor menu, the 1311 programmer provides access to many internal variables that are continuously read and updated. This information is helpful during diagnostics and troubleshooting, and also while adjusting programmable parameters.



Monitor Menu: PWM OUTPUTS

VARIABLE	DISPLAY RANGE	DESCRIPTION
Channel # *PWM#_Output*	0–32767 *0–32767*	PWM output value (32767 = 100%) of one of the 16 PWM signals. # = 1 through 16.

Monitor Menu: ANALOG OUTPUTS

VARIABLE	DISPLAY RANGE	DESCRIPTION
Channel # *DAC#_Output*	0–32767 *0–32767*	Analog output value (32767 = 10 V) of one of the 2 DAC channels. # = 1 or 2.

Monitor Menu: ANALOG INPUTS

VARIABLE	DISPLAY RANGE	DESCRIPTION
KSI Filtered *KSI_Filtered*	0–100.0 V *0–10000*	Filtered and calibrated value of the B+ / KSI input signals. 1 volt = 100 counts.
KSI Raw *KSI_Raw*	0–1023 *0–1023*	Unfiltered (raw) value of the B+ / KSI input signals. ~1 volt = 9.5 counts (uncalibrated).
Channel # *ADC#_Input*	0–1023 *0–1023*	Analog input value (~1023 = 5 volts) of one of the 16 ADC channels. # = 1 through 16.

Monitor Menu: POT INPUTS		
VARIABLE	DISPLAY RANGE	DESCRIPTION
Pot # *Pot#_Input*	0–32767 *0–32767*	Analog value of the Pot Wiper input signal. # = 1 through 4.
Pot High *Pot_High*	0–32767 *0–32767*	Analog reading of the Pot High signal
Pot Low *Pot_Low*	0–32767 *0–32767*	Analog reading of the Pot Low signal.

Monitor Menu: SWITCHES		
VARIABLE	DISPLAY RANGE	DESCRIPTION
Switch # *SW_#*	On / Off *0–255*	Switch state. # = 1 through 26. #1 – #22 = the 22 inputs (J1-1 – J1-22); #23 – #26 = the 4 encoder channels (J4-1 – J4-4).

Monitor Menu: CAN STATUS		
VARIABLE	DISPLAY RANGE	DESCRIPTION
CAN NMT State *CAN_NMT_State*	0–127 *0–127*	CAN network state: 0=initialization, 4=stopped, 5=operational, 127=pre-operational.
PDO1 MOS1 COB ID	0–65355	Communication object ID for the PDO1 Master Out Slave In message.
PDO1 MOSI Byte Map*	0 – 2^{32}	Mapping objects for PDO1 MOSI's eight bytes.
PDO1 MISO COB ID	0–65355	Communication object ID for the PDO1 Master In Slave Out message.
PDO1 MISO Byte Map*	0 – 2^{32}	Mapping objects for PDO1 MISO's eight bytes.
PDO2 MOS1 COB ID	0–65355	Communication object ID for the PDO2 Master Out Slave In message.
PDO2 MOSI Byte Map*	0 – 2^{32}	Mapping objects for PDO2 MOSI's eight bytes.
PDO2 MISO COB ID	0–65355	Communication object ID for the PDO2 Master In Slave Out message.
PDO2 MISO Byte Map*	0 – 2^{32}	Mapping objects for PDO2 MISO's eight bytes.

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

PDO1 MOSI Byte Map

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

4b

CONTROLLER INFORMATION MENU

This menu provides ID and version numbers for your controller hardware and software.

CONTROLLER INFORMATION MENU

VARIABLE	DISPLAY RANGE	DESCRIPTION
Model Number *Model_Number*	0–4294967295 *0–4294967295*	Model number. For example, if you have a controller with the model number 1310-4501, the Model Number variable will have a value of 13104501.
Serial Number *Serial Number*	0–4294967295 *0–4294967295*	Serial number. For example, if the serial number printed on your controller is 08045L.11493, the Serial Number variable will have the value of 11493.
Mfg Date Code *Manuf_Date*	0–32767 *0–32767*	Controller date of manufacture, with the first two digits indicating the year and the last three indicating the day. For example, if the serial number printed on your controller is 08045L.11493, the Mfg Date Code variable will have the value of 08045 (45th day of 2008).
Hardware Version *Hardware_Ver*	0–32.767 *0–32767*	The hardware version number uniquely describes the combination of electronic assemblies used in the controller.
OS Version *OS_Ver*	0–32767 *0–32767*	Version number of the operating system software that is loaded into the controller. This variable specifies the major version number of the controller's operating system.
Build Number *Build_Number*	0–32767 *0–32767*	Build number of the operating system software that is loaded into the controller. This variable specifies the minor version number of the controller's operating system.
SM Version *SM_Ver*	0–327.67 *0–32767*	Version number of the Start Manager software that is loaded into the controller.
Param Blk Version *Param_Blk_Ver*	0–327.67 *0–32767*	Version number of the parameter block that is loaded into the controller.
VCL App Version *VCL_App_Ver*	0–327.67 *0–32767*	Version number of the VCL application software that is loaded into the controller. This value is set in the VCL program by assigning a value to the *VCL_App_Ver* variable.

5 VEHICLE CONTROL LANGUAGE (VCL)

The Curtis 1310 Vehicle System Controller is similar to other programmable logic controllers with application-specific functions generally found in the vehicle control industry. Key to the flexibility and application of the 1310 is a proprietary software language, VCL (Vehicle Control Language). VCL software provides a fast and easy way to implement unique and complex vehicle control functions.

The VCL programming language will feel very familiar to anyone who has worked with BASIC, Pascal, or C. VCL code can be written using either a code-writing program (such as Code Warrior or UltraEdit) or a non-formatting text program (such as Windows Notepad).

VCL is compiled, managed, and downloaded into the 1310 using the Curtis WinVCL PC program. The install process for WinVCL will also install two manuals on your PC—the VCL Programmer's Guide and the VCL Common Functions Manual. These manuals describe the common portions of the VCL programming language, and include more detailed information about VCL than is included here. They should be your starting point if you are not yet familiar with WCL. A third manual, the WinVCL User's Guide, should also be reviewed prior to starting your VCL programming.

This section of the manual describes additional aspects and functions of VCL that are unique to the 1310, and also provides a basic summary overview of VCL.

Summary of VCL Basics

- VCL is not case-sensitive:
  put_pwm(), Put_PWM(), and PUT_PWM() are identical.
- Spaces in variable and constant names are not allowed in VCL; use underscores in place of spaces.
  Example: SW_1 is the VCL name for switch input #1.
- Functions are followed by parentheses; for example:
  GET_ADC() is a function
  ADC7_Output is a variable.
- Logical statements must be inside parentheses; examples:
  IF (setpoint >50)
  ELSE IF ((setpoint <20) & (temperature >100)).
- Comments are preceded by semicolons; for example:
  ; This is a comment.

VARIABLE TYPES & QUANTITIES

VCL provides dedicated space in which to store custom variables. There are four types of variables, based on their type of storage:

- volatile memory (RAM)
- automatic non-volatile memory (EEPROM)
- non-volatile block memory (EEPROM)
- parameter non-volatile memory (EEPROM).

Volatile memory variables (RAM) are stored only while power is on; they are lost at power-down. This is the memory used to hold temporary calculations, counters, and other variables that are needed only while running. The generic VCL names for these variables are User1–User120. They must be initialized on power-up by explicit VCL assignments (e.g., User1 = 12); otherwise they will be reset to a value of 0.

Automatic non-volatile memory variables (EEPROM) are labeled NVUser1–NVUser15 in VCL. These 15 variables are stored cyclically while running and at power-down. They can be recalled by using the NVM_NVUser_Restore function is used. Thus, they are automatically saved and can then be recalled at the next power-on cycle, which restores their previous values. See the section on non-volatile memory access in the VCL Common Functions manual for more information.

Non-volatile block memory (EEPROM) is 38 blocks of 15 variables (total of 570 variables), which are stored and recalled using the functions NVM_Block_Read and NVM_Block_Write. The 38 blocks are called NVM3–NVM40. The read and write functions will retrieve and store RAM variables (such as User20) from and into the EEPROM blocks. See the section on non-volatile memory access in the VCL Common Functions manual for more information.

Parameter non-volatile variables (EEPROM) are a special type of EEPROM variable that is intended to be used to create OEM-defined 1311/1314 parameters. These parameters can be defined as 16-bit words by using the P_User variables or they can be defined as single bits (On/Off) by using the P_UserBit variables. Parameter variable values are modified and stored through the programmer interface (i.e., when a 1311 user changes a parameter setting using the 1311). They can be read or written to in the VCL code. However, it is important to note that **writing to parameters in VCL will not be stored in EEPROM** nor read by the 1311 or 1314 programmer. At the next power down, the data changes made by VCL will be lost. These variables are intended to be used only for creating and defining 1311/1314 parameters.

TYPE	QUANTITY	RANGE
RAM	120 16-bit variables 160 single-bit variables	User1 – User120 UserBit1 – UserBit10
NVUser EEPROM	15 variables	NVUser1 – NVUser15
Block EEPROM	38 blocks	NVM3 – NVM40 (15 variables each)
Parameters EEPROM	100 16-bit variables 160 single-bit variables	P_User1 – P_User100 P_UserBit1 – P_UserBit10

VCL RUNTIME RATES

VCL is an interpreted language. Each line of VCL code is converted by the WinVCL compiler into an array of pseudo-code which can then be flash loaded into the controller. The controller interprets these pseudo-codes one line at a time while the system is running (powered). The table below lists the service rate at which the VCL interpreter runs each of the various functions, and also lists how many instances of each function are available to the VCL software.

FUNCTION	FUNCTION FULL NAME	INSTANCES	SERVICE RATE
ABS	Absolute Value	2	4 ms
ADC	Analog to Digital Converter Input	2	1 ms
CAN	CAN Communications	15	4 ms
CPY	Copy	8	4 ms
DAC	Digital to Analog Converter Ouput	2	4 ms
DLY	Delay	32	1 ms
FLT	Filter	4	1 ms
LIM	Limit	4	4 ms
MAP	Map	4	4 ms
MTD	Multiply then Divide	4	4 ms
NVM	Non-Volatile Memory	38	2 ms
PID	Proportional Integral Derivative	2	4 ms
POT	Potentiometer Input	2	8 ms
PWM	Pulse Width Modulated Output	6	4 ms
RMP	Ramp	4	1 ms
RTC	Real-Time Clock	1	4 ms
SCL	Scaling	4	4 ms
SEL	Selector, 2-position switch	8	4 ms
SEL_4P	Selector, 4-position switch	8	32 ms
SW	Switch Inputs (all)	1	4 ms
TMR	Timers (hourmeters)	3	1 ms

VCL FUNCTIONS SPECIFIC TO 1310 CONTROLLERS

The VCL functions described in the VCL Common Functions manual are available on 1310 controllers. The 1310 also has the following additional or expanded functions.

Pot wiper inputs

Setup_POT(2)

This function sets the type of input that will be connected to each of the four analog inputs. The system uses the concept of a potentiometer and thus these inputs are called Wiper inputs. The inputs can be set up as one-wire, two-wire, or three-wire, referring to the number of wires connected from the pot to the 1310. A one-wire pot is a voltage input (0–5V), and connects to a Wiper input; a two-wire pot (rheostat) connects with the Wiper and Pot Low signals; and a three-wire pot connects with the Pot High, Wiper, and Pot Low signals. Note that this function does not enable any fault checks. Fault checks must be done by custom VCL code.

Data Values

Pot#_Output Variable that is automatically updated with the value of the wiper input.

Parameters None.

`Pot_ID` Identifies which wiper input is used (POT1 – POT4).

`Type` Identifies which type of pot is connected (ONE_WIRE, TWO_WIRE, or THREE_WIRE).

Returns

0 – Setup did not execute.

1 – Setup successful.

Error Codes None.

Examples

```
Setup_Pot(POT1,ONE_WIRE)
;refer to wiring diagram pin J4-6

Setup_Pot(POT3,THREE_WIRE)
;refer to wiring diagram pins J4-8, J4-5, J4-10

Setup_Pot(POT4,TWO_WIRE)
;refer to wiring diagram pins J4-9, J4-10
```

Analog inputs

Get_ADC(1)

This function retrieves the present input value of the selected ADC (Analog to Digital Converter) channel. Although there are only 4 dedicated analog inputs (called Wiper 1–4), the 1310 actually monitors 12 channels of analog values. Many of these analog signals are internal to the 1310 hardware but can nevertheless be used in VCL. It is **not** necessary to use the Get_ADC() function, as the ADC channels are constantly monitored and automatically placed in the corresponding ADC#_Output variable, but when programming you may wish to use this function to ensure that the most recent value is read or simply for clarity in the program. Note that **all ADC channels are read as 10 bit** and therefore have a range of 0 to 1023:

Data Values

`ADC#_Output` Variable that is automatically updated with the value of the ADC channel.

Parameters None.

`ADC#` Identifies which ADC channel is to be read (ADC1 – ADC16).

- ADC1 Common Pot High
- ADC2 Pot 1 wiper input
- ADC3 Pot 2 wiper input
- ADC4 Pot 3 wiper input
- ADC5 Pot 4 wiper input
- ADC6 Common Pot Low
- ADC7 Pwr_Up Input (~9.5 counts/volt)
- ADC8, 9, 10 not connected
- ADC11 +5V output current monitor
- ADC12 +5V and +12V combined current (~4.21 counts/mA)
- ADC13 B+/KSI input (~9.5 counts/volt)*
- ADC14 not connected
- ADC15 PWM1 drive current (~310 counts/amp)
- ADC16 PWM2 drive current (~310 counts/amp)

* We recommend using the variable KSI_Filtered instead of ADC_13 since it is factory calibrated for 100 counts/volt). ADC13 is uncalibrated.

Returns

0 – 1023 The value of the ADC channel.

Error Codes Bad_ID ADC channel is out of range (>16).

Examples

```
User1=Get_ADC(ADC11)
;put the current reading of +5V into User1
```

Analog outputs

Put_DAC(2)

This function outputs an analog voltage on the selected DAC (Digital to Analog Converter) channel. A constant or a variable may be used as the output value.

Parameters

`DAC#` Identifies which DAC channel is to be read (DAC1 or DAC2).

`Value` The digital value of the output voltage;
the scale is 0–32767 = 0.0–10.0 volts.

Returns

0 – New value did not go out.

1 – New value output on DAC.

Error Codes Bad_ID Incorrect DAC ID was used.

Auto_Run Trying to access an automated DAC is not allowed.

Examples

```
Put_DAC(DAC1,16383) ;Output 5V on DAC 1 signal
```

or

```
User1=16383
Put_PWM(PWM1,User1)
;a 50% pulse wave is output on Analog Output 1
```

Automate_DAC(2)

This function is used to automatically update the DAC output voltage. This function only needs to be called once. After this function is called, the DAC output will run continuously. Note that in this function, the output value **must be a variable**.

Parameters

`DAC#` Identifies which DAC channel is to be read (DAC1 or DAC2).

`Variable` The variable that holds the desired output voltage;
the scale is 0–32767 = 0.0–10.0 volts.

Returns

0 – Setup did not execute.

1 – Setup successful.

Error Codes Bad_ID Incorrect DAC ID was used.

PT_Range The variable used is not acceptable.

Example

```
User1=0
Automate_DAC(DAC1,User1)

Loop:
User1=User1+1
;this will create a 0-10V ramp wave on DAC1
If User1=32767
    {
    User1=0
    }
;add some delay or code here
Goto Loop
```

Digital outputs

Put_PWM(2)

This function outputs an Pulse Width Modulated voltage on the selected output pin. This function is used to control the state of the active low output FET drivers. A value of 0 is Off (the output is open). A value of 32767 is fully On (the output is closed to ground). Intermediate values provide a pulse train. A value of 16383 provides a 50% output (square wave). This can be useful to provide "average" voltages and regulate current in an inductive load. A constant or a variable may be used as the output value.

Parameters

`PWM#` Identifies which PWM channel is to be read (PWM1–PWM16).

`Value` The digital value of the output voltage;
the scale is 0–32767 = 0–100% On (switched to ground).

Returns

0 – New value did not go out.

1 – New value output on DAC.

Error Codes Bad_ID Incorrect PWM ID was used.

Auto_Run Trying to access an automated PWM is not allowed.

Examples

```
Put_PWM(PWM1,16383)
;a 50% pulse wave is output on Output 1
```

or

```
User1=16383
Put_PWM(PWM1,User1)
;a 50% pulse wave is output on Output 1
```

Automate_PWM(2)

This function is used to automatically update the PWM output. This function only needs to be called once. After this function is called, the PWM output will run continuously. Note that in this function, **the output value must be a variable**.

Parameters

`PWM#`	Identifies which PWM channel is to be read (PWM1–PWM16).
`Variable`	The variable that holds the desired output voltage; the scale is 0–32767 = 0–100% On.

Returns

0 – Setup did not execute.

1 – Setup successful.

Error Codes

Bad_ID	Incorrect PWM ID was used.
PT_Range	The variable used is not acceptable.

Example

```
User1=0
Automate_PWM(PWM1,User1)

Loop:
User1=User1+1
;this will create a 0-100% PWM ramp on Output 1
If User1=32767
   {
   User1=0
   }
;add some delay or code here
Goto Loop
```

Encoder outputs

There are two quadrature encoder inputs. These inputs can detect direction, position, and velocity from a pulse train of two channels, offset 90 degrees from each other. Each encoder input must first be set up for use as a position counter or as a velocity measurement. After the encoders are set up, the VCL uses special functions to retrieve the count or velocity (in RPM) of the incoming pulse train. The setup also allows enabling error detection.

Setup_Encoder(4)

VCL must set up the encoders before they can be used. The Setup_Encoder function sets the mode, conversion factor, and error detection parameters for the encoder VCL functions.

Parameters

`Enc#` Identifies which encoder is to be read (ENC1 or ENC2).

`Mode` Sets the encoder to Velocity or Count mode, using the predefined constant ENC_COUNT or ENC_VELOCITY.

`Max_PPR` Sets either the Pulses Per Revolution or the maximum pulse error count.

If the mode is ENC_VELOCITY, the value sets the pulses that are seen in one revolution of the encoder; used to convert to RPM.

If the mode is ENC_COUNT, the value sets the number of counts on Channel A that can be tolerated without a count on Channel B before an error is declared; a setting of 0 disables error checking.

`Max_Time` Sets the time limit within which the count error (in Max_PPR) must be reached for an error to be declared. This parameter is used only in ENC_COUNT mode. Setting Max_Time to 0 means there is no time limit. Time limit = Max_Time × 16ms.

Returns

0 – Setup did not execute.
1 – Setup successful.

Error Codes Bad_ID Incorrect ENC ID was used.

Examples

```
Setup_Encoder(ENC1,ENC_VELOCITY,64,0)
;velocity mode where 64 pulses = 1 revolution
;note the last parameter is don't care,
;but must be filled with some value.

Setup_Encoder(ENC2,ENC_COUNT,10,10)
;count mode
;if more than 10 counts on one channel without
;any on the other in under 160ms = Error!
```

Get_Encoder_Count(1)

This function retrieves the current position (count) of the encoder. Note that this function is not required to get the current count as it is continuously updated in the *ENC#_Count* variable.

Data Values

ENC#_Count Variable that is updated with the value of the encoder count.

Parameters

`Enc#` Identifies which encoder is to be read (ENC1 or ENC2).

Returns

N – Encoder count (0–32767).

Error Codes Bad_ID Incorrect ENC ID was used.

Examples

```
User1=Get_Encoder_Count(ENC1)
```

or

```
User1=ENC1_Count
```

Get_Encoder_Vel(1)

This function retrieves the current velocity (RPM) of the encoder. The output is the speed in Revolutions Per Minute as scaled by the Setup_Encoder() function. Note that this function is not required to get the current velocity as it is continuously updated in the *ENC#_Vel* variable.

Data Values

ENC#_Vel Variable that is updated with the encoder velocity in RPM.

Parameters

`Enc#` Identifies which encoder is to be read (ENC1 or ENC2).

Returns

N – Encoder velocity (0–32767).

Error Codes Bad_ID Incorrect ENC ID was used.

Examples

```
User1=Get_Encoder_Vel(ENC1)
```

or

```
User1=ENC1_Vel
```

Get_Encoder_Dir(1)

This function retrieves the current direction (CW or CCW) of the encoder. Note that this function is not required to get the current direction as it is continuously updated in the *ENC#_Dir* variable. However, if the encoder speed (*ENC#_Vel*) is zero, the direction signal is not valid.

Data Values

ENC#_Dir Variable that is updated with the value of the encoder count.

Parameters

`Enc#` Identifies which encoder is to be read (ENC1 or ENC2).

Returns

Encoder direction:

0 = stopped
1 = reverse
2 = forward

Error Codes Bad_ID Incorrect ENC ID was used.

Examples

```
User1=Get_Encoder_Dir(ENC1)
```

or

```
User1=ENC1_Dir
```

Get_Encoder_Error(1)

This function retrieves the current error status of the encoder. Note that this function is not required to get the current status as it is continuously updated in the *ENC#_Error* variable.

Data Values

ENC#_Error Variable that is updated with the value of the encoder channel.

Parameters

`Enc#` Identifies which encoder is to be read (ENC1 or ENC2).

Returns

Error status:

0 = OK
1 = Channel A error
2 = Channel B error

Error Codes Bad_ID Incorrect ENC ID was used.

Examples

```
User1=Get_Encoder_Error(ENC1)
```

or

```
User1=ENC1_Error
```

Real-Time Clock (RTC)

The 1310 controller contains a real-time clock with battery backup. The clock keeps accurate date and time for use by VCL (time stamping errors, clock display, timed events, etc). When first used, the RTC may need to be updated. If so, the *RTC_Needs_Update* variable will be set. The Setup_RTC function can be used to set the day and time.

If the RTC stops working, the battery may need to be replaced; it should last for many years. Open the end cap (the one with the LED status window) by removing the six screws. Slide out the button Lithium battery. Replace the battery and end cap. You will need to run a VCL program to update the RTC time and day parameters. See the example following.

After it is set, the RTC continuously updates the following variables:

Hours_24	Actual Hour in 24h format (0...23)
Hours_12	Actual Hour in 12h format (1...12)
Am_Pm	0 => AM, 1 => PM
Minutes	Actual Minute (0...59)
Seconds	Actual Seconds (0...59)
Day	Actual Day (1...31)
Month	Actual Month (1...12)
Year	Year (00...99)
Day_of_Week	Actual Day of Week (MONDAY...SUNDAY).*

A few other variables of importance when using the RTC

RTC_Needs_Update	Set to 1 when the RTC has to be updated
RTC_Disabled	Set to 1 when RTC is disabled.

* When setting up the RTC or reading the *Day_of_Week* variable, VCL must use the predefined constants:

MONDAY
TUESDAY
WEDNESDAY
THURSDAY
FRIDAY
SATURDAY
SUNDAY

Setup_RTC(7)

This function sets up the date and time on the Real-Time Clock. Note that the 24-hour format must be used to set the time.

Parameters

`Hours`	Actual Hour in 24h format (0...23)
`Minutes`	Actual Minute (0...59)
`Seconds`	Actual Seconds (0...59)
`Day`	Actual Day (1...31)
`Month`	Actual Month (1...12)
`Year`	Year (00...99)
`DayofWeek`	Actual Day of Week (MONDAY...SUNDAY).

Returns

0 – Setup did not execute.

1 – Setup successful.

Error Codes Param_Range A parameter is out of range.

Examples

```
If(RTC_Needs_Update=1)
  {
  Setup_RTC(14,35,00,11,6,12,MONDAY)
  ;June 11, 2012 at 2:35:00pm
  }
```

Hold_RTC(0) and **Release_RTC(0)**

These functions stop and start the updating of the Date and Time variables. Note that the internal clock continues to run independent of these functions; only the VCL variables are not updated after a Hold_RTC is called. This can be useful when writing the time out to a display or time stamping a fault into EEPROM, as the time will not tick forward unexpectedly during the process.

Use Release_RTC() to allow the automatic update of the the correct time and date VCL variables to continue.

Hold_RTC() will set the *RTC_Disabled* variable (=1) and Release_RTC() will clear it (=0)

These functions have no parameters and no errors, and return nothing.

Examples

```
Hold_RTC()
Release_RTC()
```

UNIQUE I/O & VCL USAGE

The Curtis 1310 Vehicle System Controller is designed to be extremely flexible, which means there is really no "standard configuration" or "standard wiring." Because of its wide ranging application and large array of inputs and outputs, many features and possible uses of the 1310 may not be readily apparent. This section will introduce the unique features and uses of some of the 1310's I/O and associated VCL. Examples cover such concepts as:

- Switch input usage with rising and falling edge detection (interfacing to push buttons)
- Output 1 & 2 used as current source drivers (interfacing to proportioning valves)
- Using arrays of text in VCL (advanced interfacing to the Spyglass)
- Single channel pulse/frequency counters
- Sensor fault detection (using the measured voltage and load on +5 and +12V).

I/O CONTROL WITH VCL

Digital Inputs

The 1310 controller can have up to 26 digital inputs; see the model selection chart in Appendix D.

18 switch-to-B+ inputs (SW_1 through SW_18); sensed ON when switched to B+ and OFF when left open.

8 switch-to-ground inputs (SW_19 though SW_26).
SW_19 – SW_22 will be sensed ON when left open and OFF when switched to ground.
SW_23 – SW_26 are associated with the encoders and are sensed ON when closed to ground and OFF when left open.

To address a digital input in a VCL program, use the desired input label (SW_1 through SW_26). **You must use the predefined constants ON or OFF** in the code when determining a switch state; using true/false or 1/0 will give erroneous results.

```
If (SW_1 = ON)
   {
   ;put code here to run when switch 1 is On
   }
If (SW_16 = OFF)
   {
   ;put code here to run when switch 16 is Off
   }
```

All switch inputs are automatically debounced by the VCL operating system. This prevents noisy contacts or contact bounce from causing erroneous events in your VCL code. The debounce time can be varied from 0 to 32 milliseconds in 4ms steps, using this function:

```
Setup_Switches(5); 20 milliseconds
```

If this line is not in the VCL code, the default debounce time is set at 16 ms.

The previous example "polls" the switch inputs at the the time the statement VCL is run. If there is a need to read fast inputs, the VCL will need to poll these inputs very often in order not to miss a correct reading. Sometimes it is not possible to run the VCL fast enough. Big programs or push buttons cause the switch state to be easily missed.

SW_#_UP and SW_#_DOWN variables (where # = 1 through 26) give VCL a better way to catch fast transients on the inputs. The "up" and "down" terms are based on the action of a pushbutton that is pushed down to turn something "on." The 1310 samples the switch states 250 times per second. Any input that has changed state from Off to On will set the corresponding SW_#_DOWN variable. Any switch that has changed state from On to Off will set the corresponding SW_#_UP variable. It is vital to note that once the bit is set, it is not cleared by the corresponding variable. An input going off (released) will not clear the SW_#_DOWN bit and likewise a switch being pushed down (on) will not clear the SW_#_UP bit. It is this feature that allows the VCL code to run less often and still detect input changes, even after the event occurs. Once the VCL code has detected the change, it can clear the bit to allow the next detection. The example below illustrates a push button interface.

```
If (SW_1_UP = ON)
   {
   ;put code here to run when switch 1 is OFF (up & released)
   SW_1_UP = OFF
   ;clear the bit so we can detect the button release
   }
If (SW_1_DOWN = ON)
   {
   ;put code here to run when switch 1 is ON (down & pressed)
   SW_1_DOWN = OFF
   ;clear the bit so we can detect the next button press
   }
```

Note that these bits are always checked to be ON, even for the switch off state. Think of it not as the state of the input, but as the transition of the input. In the first line, the VCL checks to see if it is true that the button went Off (up). Normally, software is written to clear it (OFF) after reading it so that the next state can be caught. Also note that it is entirely possible that both the SW_#_UP and SW_#_DOWN bits are set. This simply means that the input went both On and Off within the time it took for the VCL code to return to these lines of code.

Digital Outputs

All 16 outputs on the 1310 are Pulse Width Modulated active low FET drivers. They are not simply turned On or Off but must be set to a duty cycle between 0% and 100%. Setting the PWM value to 0 will turn the output off completely (open output) while a setting of 32767 will set it completely on (always pulled to B-). A setting of 16383 provides nearly 50% duty cycle. The Put_PWM and Automate_PWM functions are used for all digital outputs. The variable PWM#_Output (where # is 1 through 16) can be used by VCL to read the present state of any output driver.

Each output also has an associated input. This input goes on and off with the PWM and senses the actual state of the FET driver and wiring. Using the input function on an output can allow the wiring of a circuit to be fault checked. Using the wiring configuration shown in Fig. 3, the Aux Contactor on Output 2 can be checked for proper connection before and after engaging it.

```
If (PWM2_Output = 0)  ;check if Aux Contactor is open (off)
   {
   If (SW_2 = ON) ; check if the input is high
      {
      ;the PWM is off and B+ is getting to the pin,
      ;so the coil must be connected
      Put_PWM(PWM2, 32767) ;close the Aux Contactor
      }
   Else ;there is a fault!
      {
      ;the input sense was low, so the coil
      ;must be disconnected or open.
      ;put your fault detect code HERE....
      }
   }

If (PWM2_Output = 32767)
   ;check if the Aux Contactor is closed (on)
   {
   If (SW_2 = ON)
   ;the input should be low, check if it is high
      {
      ;the PWM is full on but B+ is getting to the pin,
      ;so the driver is bad
      ;put your bad FET driver code HERE
      }
   }
```

Because in this example the Aux Contactor is on Output 2, the VCL code can check that the coil, once turned on, draws a reasonable current. If you look at Table 2 on page 7, you will see that the raw value of this current reading is put into ADC16_Output. The next example extends the fault checking to include this feature.

```
If (PWM2_Output = 32767)
   ;check if the Aux Contactor is closed (on)
   {
   If (ADC16_Output < 1000)
   ;the coil is drawing less than the minimum
   ;raw current reading
      {
      ;put your low current coil fault detect code HERE...
      }
   }
```

Note that all ADC#_Output values are raw 10 bit value. The VCL programmer must experientially determine the reasonable values for this reading. In the case of ADC15_Output and ADC16_output, a full scale reading (1024) is equal to about 3.33 amps.

The current feedback signal in Outputs 1 and 2 can also be used to create a current-controlled output. This type of output is useful for accurately positioning a flow proportional valve. In the basic wiring diagram, Output1 is shown wired to such a valve coil.

In order to create a constant current with a PWM output, a PID loop is added, using the current measurement as the feedback (see Section 14 of the Common Functions manual for more detail). The PID controller automatically regulates the PWM output so that the current reading matches the current command. To keep a valve from sticking in one position, a small amount of "jitter" is added to the command.

```
;setup code
Kp = 16767 ;Proportional gain
Ki = 2     ;Integral gain
Kd = 0     ;Derivative gain
Command equals User1
Command = 300 ;about 1 amp
Automate_PID(PID1,@Command,@ADC16_Output,@Kp,@Ki,@Kd,1,1)
Automate_PWM(PWM1,PID1_Output)
;Main Loop

Main:
If Command = 300
   {
   Command = 305  ;adding some jitter to the command
   }
Else
   {
   Command = 300
   }
   ;add some more code or force a delay HERE
Goto Main
```

Encoder Inputs

The encoder inputs can also be used as digital inputs. Pulling any of these pins down to ground will cause the input to turn Off. Leaving it open will cause it to be read On, as internally these 4 encoder inputs are pulled high to 5V. Care must be taken not connect these inputs to any voltage above 5.5V or the controller may be damaged.

```
If (SW_23 = ON)
    {
    ;put code here to run when encoder 1 channel A (J4-1) is On
    }

If (SW_24 = OFF)
    {
    ;put code here to run when encoder 1 channel B (J4-2) is Off
    }
```

These inputs also have the edge triggered variables SW_#_up and SW_#_ Down.

```
If (SW_23_Up = ON)
    {
    ;put code here to run when encoder 1 channel A goes
    ;from On to Off
    SW_23_Up = OFF
    ;clear the bit so VCL can read it next time around.
    }
```

The encoder channels can also be used to read a single pulse train. In the basic wiring configuration, Fig. 3, this can be seen on J4-3, encoder 2 channel A. When using the Setup_Encoder function, it is important to **turn off any fault checking.** The normal ENC#_Count and ENC#_Vel variables will be valid. Note that ENC#_Dir and ENC#_Error have no meaning in a single pulse train measurement.

```
Setup_Encoder(ENC2, ENC_COUNT, 0, 0)
;count mode with error checking turned off
```

Normally, the encoder will be powered by the +5 volt supply on J4-15 (ground is J4-16). The current leaving this pin is measured and placed in the variable ADC11_Output. Checking the actual values against a known nominal value will allow the VCL to catch a disconnected encoder/sensor (current is too low on ADC11) or a short/excessive current (current is too high on ADC11).

```
If (ADC11_Output < 10)
    {
    ;Error! encoder is disconnected, current draw is too low
    }
```

```
If (ADC11_Output > 1000)
   {
   ;Error! There is a short dragging down the supply
   ;or too much current draw.
   }
```

If the sensor or encoder needs +12V power, that is available at J3-4 and the output current is sensed at ADC-12.

Arrays

Strings are handled in a unique way in VCL. All the string definitions are taken in THE order they appear in VCL and concatenated together into one large string array that is attached to the end of the VCL program. The array of strings is then indirectly addressed through their index into the array. If we know the first message in the array, we can index off it to find the next. In this way, a one dimensional array of strings can be made and addressed. This can be useful in creating messages for the Spyglass.

The following example creates a 5-string array and outputs a new message to the Spyglass every 500 ms, depending on a user variable.

```
Display_Offset  equals  User1
MSG_01          string  "HELLO"
MSG_02          string  "ARRAYS"
MSG_03          string  "WITHIN"
MSG_04          string  "VCL"
MSG_05          string  "STRINGS"
Display_Offset = 0

Main:
Put_Spy_Text(MSG_01 + Display_Offset)
setup_delay(DLY2, 500)
while (DLY2_Output <> 0) {} ; 500 msec
Display_Offset = Display_Offset + 1
If (Display_Offset = 5)
   {
   Display_Offset = 0
   ;reset the offset if it is past the last message
   }
goto Main
```

6 DIAGNOSTICS AND TROUBLESHOOTING

The following errors will be returned if VCL encounters a runtime error while running one of its internal library functions. The error code consists of the ID of the module where the error occurred and a Returned Error Value. The Module ID can be found in the variable *Last_VCL_Error_Module*. The Error Value is held in the variable *Last_VCL_Error*.

When an error occurs, its code is automatically sent out over the serial port in Spyglass format. The format is EV *VCL Module Value – Returned Error Value*; e.g., EV55-01 means Error VCL DAC Module Bad ID.

The VCL Module Values and Returned Error Values are listed in Tables 6 and 7.

Table 6 VCL Module IDs

VCL MODULE	VALUE	DESCRIPTION
MOD_CAN	01	Routines for CAN Bus
MOD_MAP	02	Routines for Mapping
MOD_VCL	03	Run-Time Interpreter
MOD_RMP	04	Routines for Ramping
MOD_SEL	05	Routines for Input Selectors
MOD_DLY	06	Routines for Delays
MOD_LIM	07	Routines for Limits
MOD_SCL	08	Routines for Scaling
MOD_CPY	09	Routines for Copying Objects
MOD_NVM	10	Routines for Non_Volatile Memory Access
MOD_PID	12	Routines for PID Control
MOD_TMR	13	Routines for Timers
MOD_ABS	14	Routines for Absolute Value Functions
MOD_ASP	15	Routines for Asynchronous Serial I/O
MOD_SYS	16	Routines for System Level Functions
MOD_FLT	17	Routines for Filtering
MOD_PAR	18	Routines for Non_Volatile Parameter Access
MOD_SPY	19	Routines for Spyglass
MOD_MTD	21	Routines for Multiply then Divide fucntion
MOD_ESP	23	Routines for Extended Serial Protocol Processing
MOD_ADC	50	Routines for Analog Inputs
MOD_POT	51	Routines for Pot Inputs
MOD_ENC	52	Routines to Read Encoder Inputs
MOD_PWM	53	Routines for PWM Outputs
MOD_SWI	54	Routines for Binary Switch Inputs
MOD_DAC	55	Routines for Analog Outputs
MOD_RTC	56	Routines for Real Time Clock

Table 7 Returned Errors

RETURNED ERROR	VALUE	DESCRIPTION
BAD_ID	01	Bad Index (device ID)
PT_RANGE	02	Variable Table Access out of range
AUTO_RUN	03	Attempt to access element running automatically
UNIT_UNDEF	04	Element accessed before being set up
PARAM_RANGE	05	Parameter is out of range
UNIT_BUSY	06	Unit is already busy
NO_FLASH_BLOCK	07	Could not find the specified flash block
FLASH_CHECKSUM	08	Flash block checksum is bad
TASK_OVR_RUN	09	Task queue overrun
NO_INIT	10	Tried to execute before initialization
CMD_END	11	Found end of table command
BAD_ENDIF	12	Bad End If location
CALL_OVF	13	Too many call statements
CALL_UNF	14	Too many return statements
OP_BAD	15	Undefined op-code
OP_UNKN	16	Unknown op-code
FUNC_IND	17	Function index is out of range
VAR_IND	18	Variable index is out of range
EVAL_OVF	19	Evaluation stack overflow
EVAL_UNF	20	Evaluation stack underflow
RESULT_OVF	21	Result stack overflow
RESULT_UNF	22	Result stack underflow
LOW_IPMS	23	Not enough instructions per millisecond
BAD_BAUD	30	Bad CAN Baud Rate
BAD_MO_ID	31	Bad Mailbox ID
BAD_MO_LEN	32	Bad Mailbox Length parameter
MO_INACTIVE	33	Attempt to access an inactive mailbox
MO_SENDING	34	Resending a message before old one sent
MO15_XMIT	35	Attempt to set mailbox to transmit
TYPE_UNDEF	40	Accessed a limit block with an undefined type
TYPE_SETUP	41	Accessed a limit block with a bad type specifier
TYPE_RUN	42	Bad type specifier in limit block while running
BAD_EEADD	43	EEPROM address is out of range
BAD_DEFAULTS	44	Parameter block default values are not up to date
PARAM_RO	45	Tried to write to a Read-Only parameter
BAD_P_TYPE	50	Pot Type out of range
ENC_PHASE	51	Encoder phase error

Note: All the VCL faults share LED fault code 68. The controller's two LEDs will display this repeating pattern:

RED	YELLOW	RED	YELLOW
*	* * * * * *	* *	* * * * * * * *
(first digit)	(6)	(second digit)	(8)

7 MAINTENANCE

The Real-Time Clock battery is the only user serviceable part in Curtis 1310 controller. This battery is accessed from the rear panel (with the label and Status LEDs.) **No attempt should be made to open the front panel, remove the PCB, or otherwise modify the controller.** Doing so may damage the controller and will void the warranty. Carefully follow the procedure below to replace the RTC battery.

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. Discharge the capacitors in the controller by connecting a load (such as a contactor coil) across the controller's **B+** and **B-** power tabs.
3. 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.
4. Make sure the connections are tight and plugs are seated and latched.

FAULT HISTORY

The 1311 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.

REPLACING THE RTC BATTERY

It is not likely that you will need to replace the RTC battery as it is designed to last 10+ years. But if the RTC has stopped functioning, the battery may be dead.

1. Remove the six Phillips head screws on the rear panel (the panel with the Status LEDs).
2. Carefully slide out the battery, noting the polarity.
3. Replace with an identical lithium battery, taking care of the proper polarity.
4. Replace rear panel, noting the Status LEDs are on the lower right.
5. Replace the six Phillips screws. You may need to press lightly on the bottom center cover to align the lower screw holes.

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 control products.

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). PWM drivers can contribute to RF emissions. Pulse width modulated square waves with fast rise and fall times are rich in harmonics. (Note: PWM drivers at 100% do not contribute to emissions.) The impact of these switching waveforms can be minimized by making the wires from the controller to the load as short as possible and by placing the load drive and return wires near each other.

For applications requiring very low emissions, the solution may involve enclosing the system, interconnect wires and loads together in one shielded box. Emissions can also couple to battery supply leads and 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.

The Curtis 1310 includes bypass capacitors on the printed circuit board's sensitive input signals 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. A full metal enclosure can also improve immunity by shielding the 1310 from outside RF energy.

ELECTROSTATIC DISCHARGE (ESD)

Curtis products, like most modern electronic devices, contain ESD-sensitive components, and it is therefore necessary to protect them from ESD (electrostatic discharge) damage. Most of the product's signal connections 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

PROGRAMMERS

Curtis programmers provide programming, diagnostic, and test capabilities for 1310 controllers. The power for operating the programmer is supplied by the host controller via a 4-pin connector. Two programmers are available: the PC Programming Station (1314) and the handheld programmer (1311). The Programming Station has features not available on the handheld unit; on the other hand, the handheld programmer has the advantage of being more portable. Typically the Programming Station is used to set up the parameters initially and the handheld programmer is used to made adjustments in the field.

Multiple versions of the programmers are available, each of which can adjust the parameters at its own access level and below. A Dealer programmer, for example, can adjust all the Dealer, Service and User-access parameters, but not the OEM-access parameters.

HANDHELD PROGRAMMER (1311)

The 1311 programmer is easy to use, with self-explanatory functions. After plugging in the programmer, wait a few seconds for it to boot up and gather

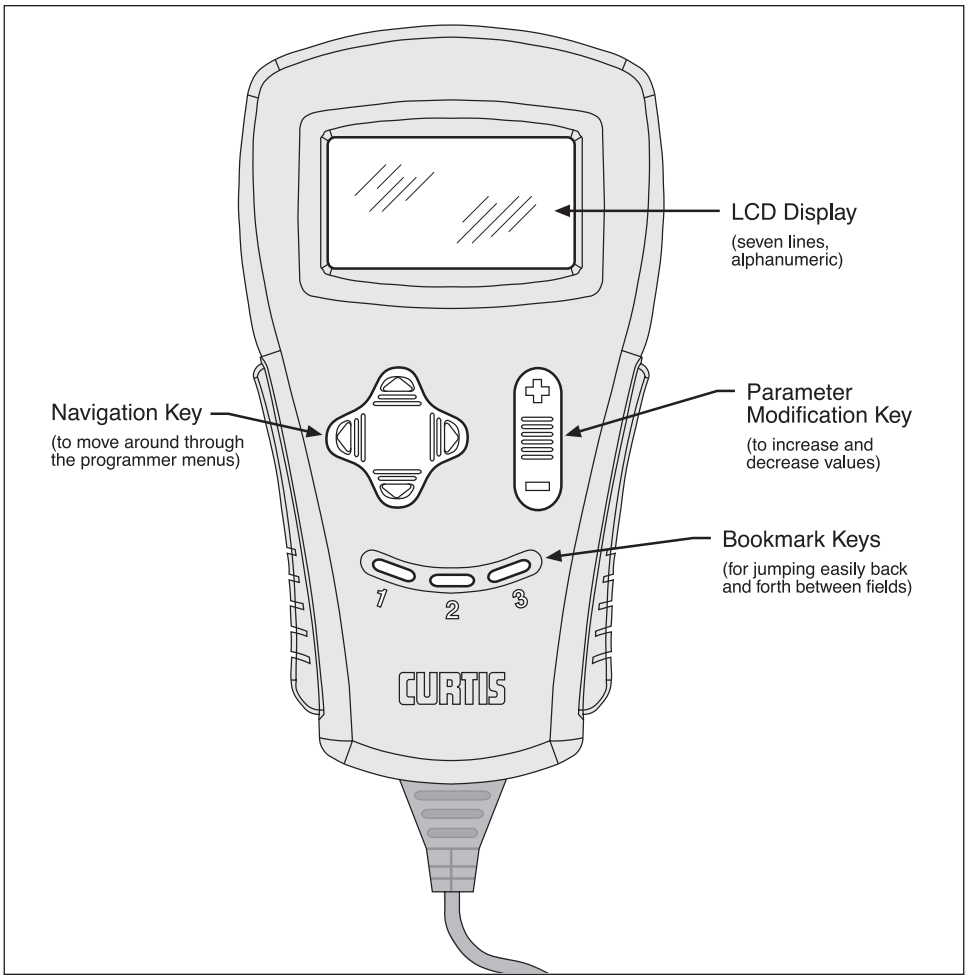


Fig. B-1 *Curtis 1311 handheld programmer.*

information from the controller. For experimenting with settings, the programmer can be left plugged in while the vehicle is driven.

The bookmark keys can make parameter adjustment more convenient. To set a bookmark, press one of the three bookmark keys for more than two seconds. To jump to a bookmarked location, press the appropriate bookmark key quickly (for less than two seconds). For example, in setting the drive forward throttle parameters, you might set a bookmark at the first of these parameters [Program » Throttle » Forward Offset] and another at the raw throttle readout [Monitor » Inputs » Throttle Pot]; this way you can easily toggle between the readout and the parameters.

The bookmark keys also have another function that makes programming easier. When setting the value of a parameter, you can use these keys to adjust the increments by which the value changes—with Bookmark Key 1, the value changes in 10-digit steps up or down; with Bookmark Key 2 pressed, the value changes in 100-digit steps; and with Bookmark Key 3, in 1000-digit steps—which, for most parameters, takes you from the maximum to the minimum, or vice versa.

PC PROGRAMMING STATION (1314)

The Programming Station is an MS-Windows 32-bit application that runs on a standard Windows PC. It can do everything the handheld programmer can do, and more. Its additional capabilities include saving/restoring sets of parameters to/from disk and updating software. Instructions for using the Programming Station are included with the software.

PROGRAMMER MENUS

The programmers have six menus, which in turn lead to nested submenus.

Program — provides access to the programmable parameters (see Section 3).

Monitor — presents real-time values during vehicle operation; these include all inputs and outputs, as well as the mapped throttle values and conditioned throttle requests (see Section 4a).

Faults — presents diagnostic information, and also a means to clear the fault history file (see Section 6).

Functions — provides access to the controller-cloning commands and to the "reset" command.

Information — displays data about the host controller: model and serial numbers, date of manufacture, hardware and software revisions, and itemization of other devices that may be associated with the controller's operation.

Programmer Setup — displays data about the programmer: model and serial numbers, and date of manufacture.

APPENDIX C

SPECIFICATIONS

Table C-1 SPECIFICATIONS: 1310 CONTROLLER

Nominal input voltage	24–48V
Electrical isolation to case	500 V ac (minimum)
Storage ambient temperature range	-50°C to 90°C
Operating ambient temperature range	-40°C to 85°C
Enclosure protection rating	IP42
Weight	0.82 kg
Dimensions (L×W×H)	198 × 138 × 46 mm
EMC Immunity	Designed to meet EN 50082-2: 1995
EMI Emissions	Designed to meet EN 50081-1: 1992
Safety	Designed to meet EN 1175-1: 1998
Enclosure Flammability Rating	Class UL 94-V0.

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

MODEL NUMBER	NOMINAL BATTERY VOLTAGE	OUTPUTS / INPUTS	OPTIONS
1310-5210	24–48 V	8 outputs / 18 inputs [a, b]	Real-Time Clock
1310-5310	24–48 V	16 outputs / 22 inputs [a]	Real-Time Clock, PV Drivers [c]

Notes: a Encoder inputs can be used for an additional 4 inputs.

b Outputs 9–16 are available; Inputs 14, 15, and 17 are not available.

c PV (Proportional Valve) drivers are on Outputs 1 and 2, and have current feedback.