EVT100ZX

DC TRANSISTORIZED MOTOR CONTROLLER
INSTALLATION AND OPERATION MANUAL

Note: *The information contained herein is intended to assist OEM's, Dealers and Users of electric forktrucks in the application, installation and service of GE solid-state controllers. This manual does not purport to cover all variations in OEM truck types. Nor does it provide for every possible contingency to be met involving forktruck installation, operation or maintenance. For additional information and/or problem resolution, please refer the matter to the OEM forktruck manufacturer through his normal field service channels. Do not contact GE directly for this assistance.*

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Section 1. INTRODUCTION

The EVT100ZX DC Transistor Motor Controller is a third generation product derived from the industry proven and very reliable EV100 SCR Control introduced in 1985. Since 1989, today's industry standard EV100LX SCR Controller with full featured programmable diagnostics brought electric forktruck features and functions to a new level. Now, GE's EVT100ZX brings a new level of power transistor (MOSFET & IGBT) control with new and expanded truck system diagnostic features and performance.... like ***GE SENTRY Software™*** RS-232-C communications protocol software for "real-time systems communication" with personal computers.

Section 2. FEATURES OF EVT100ZX TRANSISTOR MOTOR CONTROLLERS

Section 2.1 Performance

Section 2.1.1 Oscillator Card Features

The oscillator section of the card has two adjustable features and one fixed feature. The % ON time has a range of approximately 0 to 100 percent. Although the percent ON time and the percent OFF time varies, the frequency of the oscillator remains constant to reduce the amount of audible noise.

Section 2.1.1.a Creep Speed

With the accelerator at maximum ohms or volts, the creep speed can be adjusted by Function 2 of the Handset. At creep speed, the ON time can decrease to approximately 5%, with the OFF time approximately 95%. At full transistor operation, this condition will be reversed (short OFF time, long ON time). This variation of ON and OFF time of the oscillator varies the voltage applied to the motor thereby varying the speed of the motor for a given load.

Section 2.1.1.b Top Speed (Motor Volts) Limit

Top speed is fixed and is obtained with the accelerator at minimum ohms or volts. Speed limit (SL1) is active in all card types and must be disabled with the Handset (See Function 11 to disable) if speed limits are not used.

Section 2.1.1.c Control Acceleration and 1A Time

This feature allows for adjustment of the rate of time it takes for the control to accelerate to 100% applied battery voltage to the motor on hard acceleration. The 1A contactor will automatically close 0.2 seconds after the controlled acceleration stops and the accelerator input is less than 0.5 volts or less than 200 ohms. C/A is adjusted by function 3 from 0.1 to 22 seconds.

Section 2.1.2 Current Limit

This circuit monitors motor current by utilizing a sensor in series with the armature. The information detected across the sensor is fed back to the card so current may be limited to a pre-set value. If heavy load currents are detected, this circuit overrides the oscillator and limits the average current to a value set by Function 4 of the Handset. The C/L setting is based on the maximum thermal rating of the control. Because of the flyback current through 3REC, the motor current is usually greater than battery current, except at 100% ON time, or when the 1A contactor is closed. See current limit curves for available current and adjustment range.

Section 2.1.3 Braking

Section 2.1.3.a Plug Braking

Slow down is accomplished when reversing direction by providing a small amount of retarding torque for deceleration. If the vehicle

is moving and the directional lever is moved from one direction to the other, the motor field is reversed. The plug signal is initiated by the fact that the directional switch has moved from one direction to the other. The motor armature, driven by the inertia of the vehicle, acts as a generator. This generated current passes through 4REC and the sensor. The oscillator circuit regulates this plug current to the level set by the Handset by controlling the ON and OFF time of the transistors to bring the vehicle to a smooth stop and reversal. With the accelerator potentiometer at minimum resistance, Function 5 will enable adjustment of plugging current from maximum to minimum of the plug current limit range.

Section 2.1.3.b Regenerative Braking

If the vehicle is moving, and the directional lever is moved from one direction to the other, this initiates a plugging signal by reversing the motor field. During the standard running mode and plugging mode, the RB contactor remains picked up. In the plugging mode, the motor armature acts as a generator. Once the generated current reaches a particular current level, the plugging mode transitions to regenerative braking mode.

Transitioning to regenerative braking mode opens the RB contactor, disconnecting the motor armature from battery positive and inserting 7REC and Regen SENSOR-2 in the regen circuit. During the Q1 on time, the field and armature current is increased. During the power transistor Q1 off time, the energy stored in the field and armature generates the regenerative current, which passes through 7REC, #2 Sensor, battery, 3REC/4REC and back to the motor field and armature.

The control will remain in regenerative mode as long as the regen current can be maintained. When the regenerative current cannot be maintained and drops below the level set by the regenerative current limit trimpot (RB C/L), the regenerative braking mode transitions back to plugging mode. During the transition back to plugging mode, the RB contactor will reclose, enabling the control to function in plugging mode and regulating plugging currents to bring the vehicle to a smooth stop and reversal. The accelerator potentiometer input will modulate plugging as well as regenerative braking current. The major advantage of regen is longer motor life due to reduced motor heating.

This feature has two adjustable functions, regen current limit (Function 9) and regen start (Function 10). When using a logic card that contains the Auto-Regen feature, regenerative braking current may also be controlled by placing a potentiometer on the brake pedal. Using a potentiometer to regulate voltage at PA6, minimum regen current will be applied to the motor when PA6 is reduced to 3 volts, and maximum current is applied when the voltage is reduced to 1 volt. The brake potentiometer circuit is only available on logic cards that contain Auto-Regen.

Section 2.1.3.c Pedal Position Plug Braking

This feature allows control of the plugging distance based on pedal position when there has been a “directional switch” change. Pedal position will reduce the plugging current to the “value set by this function” as the accelerator is returned to the creep speed position. Maximum plug current is obtained with the accelerator in the top speed position. This feature is adjustable by using Function 16 on the Handset.

Section 2.1.3.d Auto Braking

This feature requires an “Auto Plug/Regen” logic card (see Section 4., Ordering Information) and can be setup with the Handset using Function 17. This feature is selected by initiating a “neutral position” with either the directional switch or the accelerator switch. Once activated, Auto Braking operates similar to Pedal Position Plug Braking and is adjusted by using Function 16 on the Handset.

Section 2.1.4 Auxiliary Speed Control

Section 2.1.4.a Field Weakening

If the vehicle is supplied with a field weakening circuit, the "FW PU" (Function 7) and "FW DO" (Functions 8) can be adjusted with the Handset. Field weakening is a method of attaining higher running speed for the vehicle in level running operation. Typical settings for this feature are: pickup FW contactor from l25 to l50 percent of normal full-load running current (1A), and dropout FW contactor from 275 to 300 percent current. FW contactor dropout puts the motor back in the lA range to climb ramps and inclines.

Section 2.1.4.b Speed Limits

This feature provides a means to control speed by limiting motor volts utilizing three "adjustable speed limits" initiated by individual limit switches. The NC switches are connected between input points on the control card and battery negative. ***The lower motor volt limit always takes priority when more than one switch input is open.*** This motor volt limit regulates top speed of the transistor controller, but actual truck speed will vary at any set point depending on the loading of the vehicle. Each speed limit can be adjustable with the Handset using Functions 11, 12, and 13, for speed limits SL1, SL2, and SL3 respectively. SL1 is active in all card types and must be disabled with the Handset if speed limits are not used.

Section 2.1.5 Ramp Start

This feature provides maximum control torque to restart a vehicle on an incline. The memory for this function is the directional switch. When stopping on an incline, the directional switch must be left in its original or neutral position to allow the control to initiate full power when restarted. The accelerator potentiometer input will modulate ramp start current.

Section 2.1.6 Steer Pump Contactor Time Delay

This feature provides two options for SP time delay. Option 1 provides a 0.5 to 63 second time delayed drop out of the steer pump contactor when the Forward or Reverse directional switch is opened. This Option 1 is overridden by a 1.5 second time delayed drop-out whenever the seat switch is opened. Option 2 provides a 0.5 to 63 second time delayed drop out of the SP contactor when the seat switch is opened.

Section 2.1.7 Constant Current Coil Drivers & Internal Coil Suppression

This feature allows the use of 24 volt Line, F, R, 1A, SP, RB, and FW contactor coils throughout the entire voltage range of the EVT100 (24 volts to 84 volts).

In addition, this feature allows the contactors to operate more efficiently with less wattage due to less current being applied to the coil after pick-up.

Section 2.2 System Protective Override

Section 2.2.1 Static Return to Off (SRO)

This inherent feature of the control is designed to require the driver to return the directional lever to the neutral position anytime he leaves the vehicle and returns. Additionally, if the seat switch or key switch is opened, the control shuts off and cannot be restarted until the directional lever is returned to neutral. A time delay of approximately 2 seconds is built into the seat switch input to allow momentary opening of the seat switch if a bump is encountered.

Section 2.2.2 Accelerator Volts Hold Off

This feature checks the voltage level at the accelerator input whenever the key switch or seat switch is activated. If the voltage is less than 2.5 volts, the control will not start. This feature

assures that the control is calling for low speed operation at start-up.

Section 2.2.3 Pulse Monitor Trip (PMT)

The PMT design contains three features which shut down or lock out control operation if a fault conditions occurs that would cause a disruption of normal vehicle operation:

- Look ahead
- Look again
- Automatic look again and reset

The PMT circuit will not allow the control to start under the following conditions:

1. If power transistor Q1 is shorted, or if 1A contactor is welded, the control will not allow the Fwd or Rev contactor to close.
2. If the Fwd and/or Rev internal coil drivers are shorted, or if the 3REC diode is shorted.

The PMT circuit will shut down operation of the control (opening of the F or R contactor) under the following conditions:

- If transistor Q1 fails to shut off , or if 1A power tips remain closed when they should be open. After opening the F or R contactor, the PMT circuit will check for a fault, and if none is found will reclose the directional contactor. If the fault still exists, the directional contactor will open and remain open.
- If 1A closes before a second failure, the look again counter will automatically reset. This eliminates the inconvenience of resetting the PMT with the key switch if the trip is due to random noise.

When the PMT circuit prevents the F or R contactors from closing, the PMT circuit must be reset by opening the key switch.

Section 2.2.4 1A Current Drop Out

This adjustable feature can be set to open the 1A contactor if the traction motor is subject to excessive currents. The dropout is adjustable with Function 6 using the Handset. Once the control has dropped out the 1A contactor due to excessive current, the directional or accelerator switch must be returned to neutral to reset the dropout circuit to allow the control to pick up the 1A contactor again. Using this feature may reduce the 1A contactor tip life, therefore, it should be used only where needed to protect the motor.

Section 2.2.5 1A Thermal Hold Off

This feature prevents the lA contactor from closing when the vehicle is in severe thermal cutback. When the control goes into severe cutback, the Must Pulse To Time feature will inhibit the lA timer.

Section 2.2.7 Must Pulse To Time

This feature prevents the lA timer from timing if the oscillation pulse rate has not reached a pre designed level of operation

Section 2.2.6 Thermal Protector (TP)

This temperature sensitive device is internal to the power transistor (Q1) module. If the transistor's temperature begins to exceed the design limits, the thermal protector will lower the maximum current limit, and maintain the transistors within their temperature limits. Even at a reduced current limit, the vehicle will normally be able to reach sufficient speed to initiate lA operation, thereby allowing the control to cool. As the control cools, the thermal protector will automatically reset, returning the control to full power.

.Section 2.2.8 Low Voltage

Batteries under load, particularly if undersized or more than 80 percent discharged, will produce low voltages at the control terminals. The EVTl00 control is designed for use down to 50 percent of a nominal battery voltage of 36-84 volts, and 75 percent of a nominal battery voltage

of 24 volts. Lower battery voltage may cause the control to operate improperly, however, the resulting PMT should open the F or R contactor in the event of a commutation failure.

Section 2.3 Diagnostics

Section 2.3.1 Systems Diagnostics

The logic card detects the system's present operating status and can be displayed to either the Dash Display or the Handset. There are currently over 75 status codes that are available with EVT100 systems using Traction and Pump controls and Truck Management Module (TMM). Along with the status code display from the TMM, the logic card is capable of reducing the current to the control, alerting the operator of a critical fault condition.

Section 2.3.1 Status Codes

Section 2.3.1a Standard Status Codes

The EVT100ZX has over 65 Status Codes that assist the service technician and operator in trouble shooting the forklift. If mis-operation of the vehicle occurs, a status code will be displayed on the Dash Display for vehicles so equipped, or by plugging the Handset into the logic card's "Y plug" location and then reading the status code.

With the status code number, follow the procedures outlined in Section 14. DIAGNOSTIC STATUS CODES to determine the problem and a solution.

Note: *The Status Code Instruction Sheets do not purport to cover all possible causes of a display of a "status code". They do provide instructions for checking the most direct inputs that can cause status codes to appear*

Section 2.3.1b Stored Status Codes

This feature records the last 16 "Stored Status Codes" that have caused a PMT controller shut down and/or disrupted normal vehicle operation. (PMT type faults are reset by cycling the key switch). These status codes, along with the corresponding BDI and hourmeter readings, can be accessed with the Handset, or by using the RS-232 communications port and dumping the information to a Personal Computer terminal.

Section 2.3.3 Hourmeter Readings

This feature will display the recorded hours of use of the traction and pump control to the Dash Display each time the key switch is turned off.

Section 2.3.3.a Maintenance Alert & Speed Limit

This feature is used to display Status Code -99 and/or activate a speed limit when the vehicle operating hours match the hours set into the maintenance alert register. This feature is set with the Handset using Functions 19, 20 and 21. The operator is alerted that maintenance on the vehicle is required.

Section 2.3.4 Battery Discharge Indication (BDI)

The latest in microprocessor technology is used to provide accurate battery state-of-charge information and to supply passive and active warning signals to the vehicle operator.
Features and functions:

- Displays 100 to 0 percent charge.
- Display blinks with 20% charge.
- Disables pump circuit with 10% charge.
- Auto ranging for 36/48 volt operation.
- Adjustable for use on 24 to 80 volts.

Section 2.3.4.a Internal Resistance Compensation

This feature is used when the Battery Discharge Indicator is present. Adjustment of this function will improve the accuracy of the BDI.

Section 2.3.5 Handset

This is a multi-functional tool used with the LX, ZX, and SX Series GE solid-state controls. The Handset consists of a Light Emitting Diode (LED) display and a keyboard for data entry.

Features and functions:

- Monitor existing system status codes for both traction and pump controls.
- Monitor intermittent random status codes.
- Monitor battery state-of-charge, if available.
- Monitor hourmeter reading on traction and pump controls.
- Monitor or adjust the control functions.

Section 2.3.6 RS-232 Communication Port

This serial communication port can be used with Interactive Custom Dash Displays to allow changes to vehicle operating parameters by the operator. Or, it can be used by service personnel to dump control operating information and settings into a personal computer program.

Section 2.3.6.a Interactive Dash Display Modes

The Interactive Custom Dash Display allows the operator to select the best vehicle performance for changing factory (task) conditions. There are four (4) "operator interaction modes" that can be selected by depressing a push-button on the dash display.

From the Dash Display, the operator may select any of four pre-set interactive modes consisting of (4) Controlled Acceleration levels, (4) Field Weakening Pick Up levels and (4) Speed Limit levels.

These interactive modes are "pre-set" using the Handset (Functions 48 - 62) or a personal computer (Functions 97 - 112). This feature allows the operator to select the best vehicle performance for changing factory (task) conditions.

The following table outlines the normal logic flow for pre-setting the four interactive modes:

Setting Logic Table

	Mode 1	Mode 2	Mode 3	Mode 4
C/A Time	=> Mode 2	=< Mode 1 => Mode 3	=< Mode 2 => Mode 4	=< Mode 3
FW Pickup	=< Mode 2	=> Mode 1 =< Mode 3	=> Mode 2 =< Mode 4	=> Mode 3
SL1	=> Mode 2	=< Mode 1 => Mode 3	=< Mode 2 => Mode 4	=< Mode 3

Section 2.3.7 Circuit Board Coil Driver Modules

Coil drivers are internal to the control card, and are the power devices that operate the Line, F, R, lA, D, FW, RB, and SP contactor coils. On command from the control card, these drivers initiate opening and closing the contactor coils. All driver modules are equipped with reverse battery protection, such that if the battery is connected incorrectly, the contactors can not be closed electrically.

Section 2.3.8 Truck Management Module (TMM)

The Truck Management Module is a multi-function accessory card (IC3645TMM7A), or an integral function of the EVT100 Pump control when used with the EVT100ZX Traction control. The Module provides the OEM the ability to initiate status codes or operator warning codes to be displayed on the Dash Display whenever a normally open switch or sensor wire provides a signal to the Module.

The TMM Module can be used to display a separate status code indicating over temperature of traction motors, hydraulic motors, or any other device or system that can activate a switch that closes.

It can also be used as a Brush Wear Indicator (BWI). The Brush Wear Indicator is designed to detect a "worn-out brush" and display a fault code on the Dash Display to warn maintenance personnel that the motor brushes need to be replaced before they wear to the point of causing destructive damage to the motor commutator surface.

Section 3. FEATURES OF EVT100P HYDRAULIC PUMP CONTROLLER

This hydraulic motor controller consists of the following features:

- Four speeds, adjustable from 0 to 100% motor volts.
- Fixed speeds actuated by switch closure to negative.
- P1A bypass contactor (if required)
- Variable resistor input (5K-0 ohms). Control starts when input is reduced to below 3.5 volts.
- PMT functions available when a pump contactor is used.
- Current limit and controlled acceleration adjustable.
- Battery Discharge Indicator interrupt compatible.

Operation of voltage regulator card:
This card provides the basic functions required for controlling the EVT100P pump control, optional contactors, and PMT functions. Battery positive is applied through a main control fuse to the key switch, energizing the control card power supply input to PB1.

When a pump contactor is used, PMT operation is the same as outlined for the EVT100 traction controllers.

The four speed (motor volts) reference points TB2, TB3, TB5 and TB6 are selected by connecting these points independently to battery negative.

The first speed is obtained by closing Speed Limit 1 (TB2) to control negative. SL1 is adjustable by Function 11 using the Handset to adjust motor voltage from 0 to 100%. The specified motor volts will be regulated, however, the magnitude of motor current will vary depending on the loading of the vehicle.
The second speed is obtained by closing SL2 (TB3) to control negative. SL2 is adjusted using the Handset and Function 12 similar to SL1.

The third speed is obtained by closing SL3 (TB5) to control negative. SL3 is adjusted using the Handset and Function 13 similar to SL1.

The fourth speed is obtained by closing SL 4 (TB6) to control negative. SL4 is adjusted using the Handset and Function 14 similar to SL1. P1A will close 0.2 seconds after controlled acceleration stops. Speed Limit 4 (Function 14) must be activated and set to >250 to enable the optional P1A contactor.

If more than one Speed Limit is activated, the selected speed with the highest motor volts will override the low motor volt speed.
The current limit circuit is adjustable and operates the same as the traction current limit.

The controlled acceleration circuit is adjustable and operates the same as the traction circuit. Adjustment range is from 0.1 to 5.5 seconds.

The variable resistor input will override the fixed motor volt limits set by the four (4) adjustable Speed Limits. It will vary motor volts above the set limits up to full motor volts, and closes P1A as resistance is decreased to less than 200 ohms.

The Battery Discharge Indicator (BDI) interrupt will disable the hydraulic controller if the connection at PB3 loses the 12 volt signal from the traction control. BDI interrupt can be disabled by Function 17 using the Handset. Select card type with or without BDI function.
The following are the input/output terminals for the pump control:

TB1	Accelerator pot input
TB2	SL1 input
TB3	SL2 input
PB1	Battery Positive
TB4	Key input
TB5	SL3 input
TB6	SL4 input and 1A enable
PB3	BDI enable signal
PB4	PMT driver
PB5	1A driver

Section 4. ORDERING INFORMATION FOR EVT100ZX CONTROLLERS

EXAMPLE.....	**IC3645EVT100**	**FL**	**1**	**T**	**LB**	**1**
ARGUMENT NO.	01	02	03	04	05	06

ARGUMENT NO. 01 BASIC CATALOG NUMBER

ARGUMENT NO. 02 POWER BASE MODULES

FH	TRACTION, FET, 600 AMP, 24/48 VDC
FL	TRACTION, FET, 450 AMP, 24/48 VDC
GH	TRACTION, IGBT, 600 AMP, 72/80 VDC
GL	TRACTION, IGBT, 450 AMP, 72/80 VDC
HP	PUMP, IGBT, 600 AMP, 72/80 VDC
LP	PUMP, IGBT, 450 AMP, 72/80 VDC
PH	PUMP, FET, 600 AMP, 24/48 VDC
PL	PUMP, FET, 450 AMP, 24/48 VDC

ARGUMENT NO. 03 VOLTAGE

1	24 TO 48 VDC (FET POWER BASE)
2	24 TO 80 VDC (IGBT POWER BASE)

ARGUMENT NO. 04 APPLICATION

P	PUMP CONTROL
T	TRACTION CONTROL (SINGLE MOTOR)

ARGUMENT NO. 05 CARD BOX TYPE

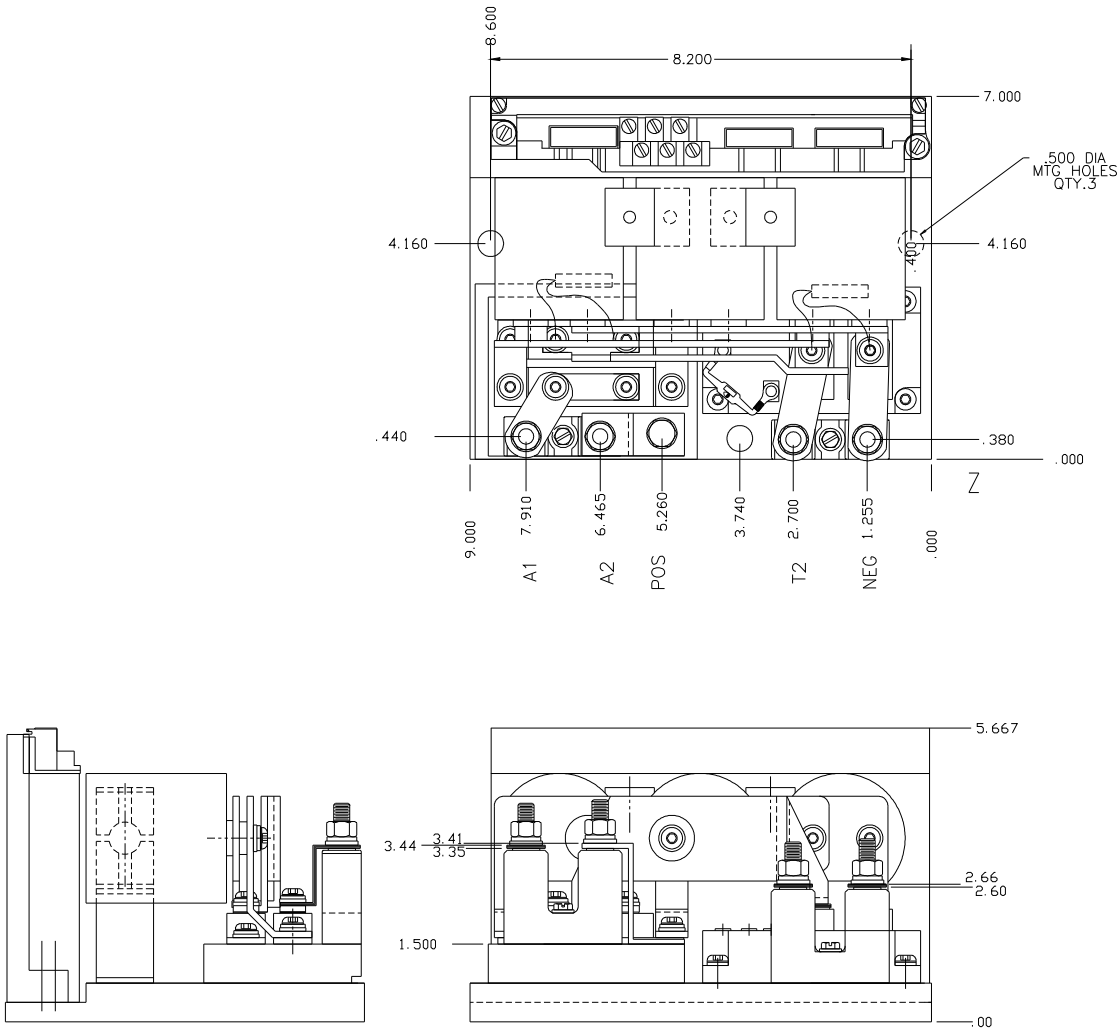
HB	TRACTION, 24 , 80 VDC, 600 AMP, WITH BDI (AUTO PLUG/REGEN)
HB	TRACTION, 24 , 80 VDC, 600 AMP, WITH BDI (NO AUTO PLUG/REGEN)
HN	TRACTION, 24 , 80 VDC, 600 AMP, WITHOUT BDI (AUTO PLUG/REGEN)
HN	TRACTION, 24 , 80 VDC, 600 AMP, WITHOUT BDI (NO AUTO PLUG/REGEN)
HP	PUMP, 24 , 80 VDC, 600 AMP
LA	TRACTION, 24 , 80 VDC, 450 AMP, WITH BDI (AUTO PLUG/REGEN)
LB	TRACTION, 24 , 80 VDC, 450 AMP, WITH BDI (NO AUTO PLUG/REGEN)
LF	TRACTION, 24 , 80 VDC, 450 AMP, WITHOUT BDI (NO AUTO PLUG/REGEN)
LN	TRACTION, 24 , 80 VDC, 450 AMP, WITHOUT BDI (AUTO PLUG/REGEN)
LP	PUMP, 24 , 80 VDC, 450 AMP
TZ	TRACTION, 24, 80 VDC, 600 AMP.

ARGUMENT NO. 06 REVISION LEVEL

1	CURRENT REVISION NUMBER

Section 5. OUTLINE DRAWINGS - EVT100ZX AND EVT100P

Dimensions in inches



Section 6.1 EVT100ZX & EVT100P High Power Component Identification

Component Identification Table on Page 16.

RECOMMENDED TORQUEING

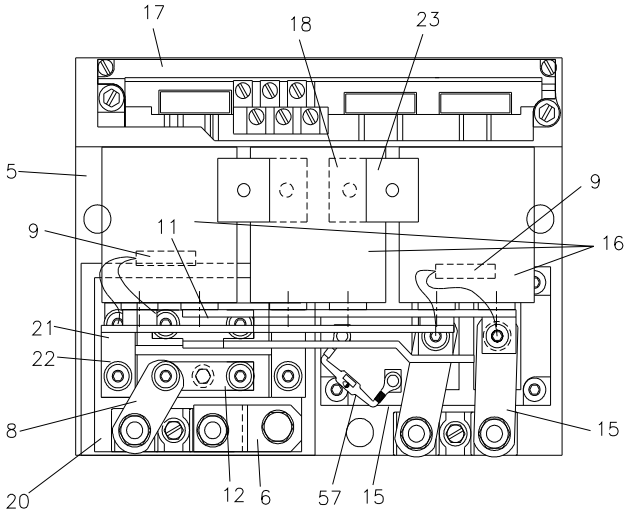
DEVICE OR PART TO PART	HARDWARE	HARDWARE TYPE	TORQUE LBS/IN
23 TO 18	M5 X 0.8	MACHINE	5
18 TO 5	M5 X 0.8	MACHINE	24
10 TO 5 & 7	M5 X 0.8	FORMING	24
17 TO 5	M5 X 0.8	FORMING	24
5 TO 7	M5 X 0.8	MACHINE	24
11 & 15 TO 19	M6 X 1.0	MACHINE	50
13 & 15 TO 19	M6 X 1.0	MACHINE	50
11 TO 21	1/4-20	MACHINE	50
12 TO 22	1/4-20	MACHINE	50
12 & 8 TO 22	1/4-20	MACHINE	50
21 & 22 70 7	M6 X 1.0	MACHINE	50
19 TO 5	M6 X 1.0	MACHINE	50
13 &14 TO 16	M6 X 1.0	MACHINE	50

RECOMMENDED TORQUEING

	DEVICE OR PART TO PART	HARDWARE	HARDWARE TYPE	TORQUE LBS/IN
*	6 TO 7 (POS)	M8 X 1.25	BOLT	75
*	30 TO 10 (A1)	M8 X 1.25	NUT	75
*	30 TO 10 (A2)	M8 X 1.25	NUT	75
*	30 TO 10 (T2)	M8 X 1.25	NUT	75
*	30 TO 10 (NEG)	M8 X 1.25	NUT	75

* CUSTOMER REFERENCE ONLY.

ASM. NOTE: USE SILICONE GREASE (DOC#342 OR GE#641) UNDER 1REC BETWEEN THERMAL INSULATION (PT.12) AND ALUMINUM BASE (PT.4).



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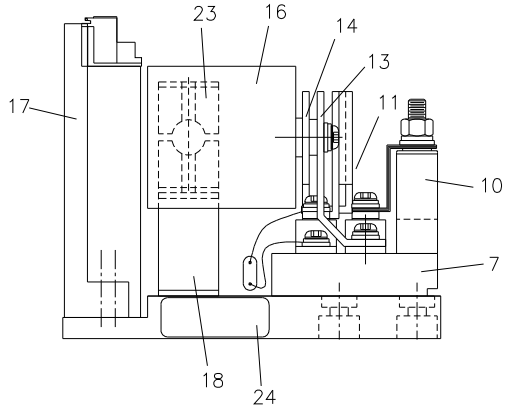

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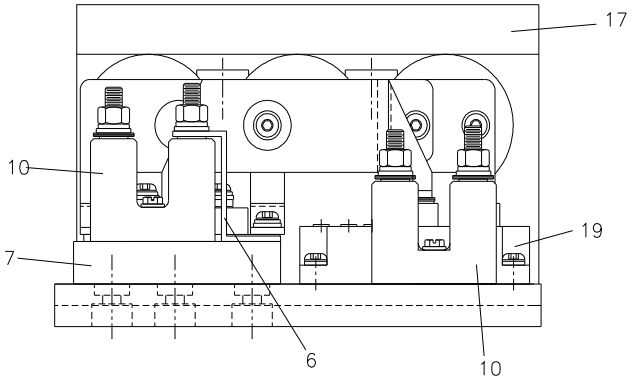

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Section 6.2 EVT100ZX & EVT100P Low Power Component Identification

Component Identification Table on Page 16.

RECOMMENDED TORQUEING

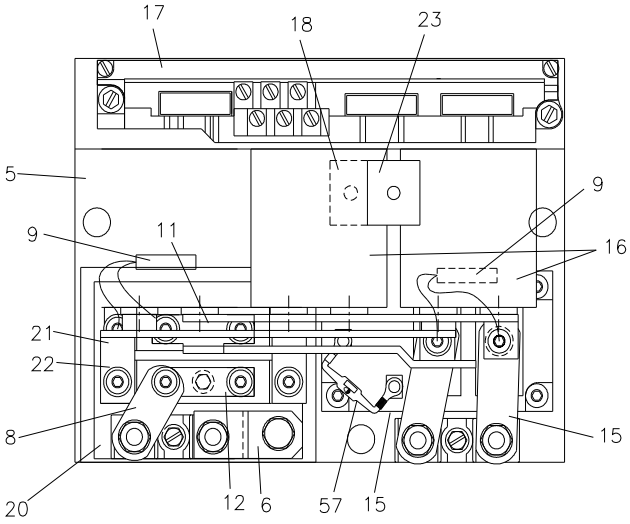
DEVICE OR PART TO PART	HARDWARE	HARDWARE TYPE	TORQUE LBS/IN
23 TO 18	M5 X 0.8	MACHINE	5
18 TO 5	M5 X 0.8	MACHINE	24
10 TO 5 & 7	M5 X 0.8	FORMING	24
17 TO 5	M5 X 0.8	FORMING	24
5 TO 7	M5 X 0.8	MACHINE	24
11 & 15 TO 19	M6 X 1.0	MACHINE	50
13 & 15 TO 19	M6 X 1.0	MACHINE	50
11 TO 21	1/4-20	MACHINE	50
12 TO 22	1/4-20	MACHINE	50
12 & 8 TO 22	1/4-20	MACHINE	50
21 & 22 70 7	M6 X 1.0	MACHINE	50
19 TO 5	M6 X 1.0	MACHINE	50
13 &14 TO 16	M6 X 1.0	MACHINE	50

RECOMMENDED TORQUEING

	DEVICE OR PART TO PART	HARDWARE	HARDWARE TYPE	TORQUE LBS/IN
*	6 TO 7 (POS)	M8 X 1.25	BOLT	75
*	30 TO 10 (A1)	M8 X 1.25	NUT	75
*	30 TO 10 (A2)	M8 X 1.25	NUT	75
*	30 TO 10 (T2)	M8 X 1.25	NUT	75
*	30 TO 10 (NEG)	M8 X 1.25	NUT	75

* CUSTOMER REFERENCE ONLY.

ASM. NOTE: USE SILICONE GREASE (DOC#342 OR GE#641) UNDER 1REC BETWEEN THERMAL INSULATION (PT.12) AND ALUMINUM BASE (PT.4).



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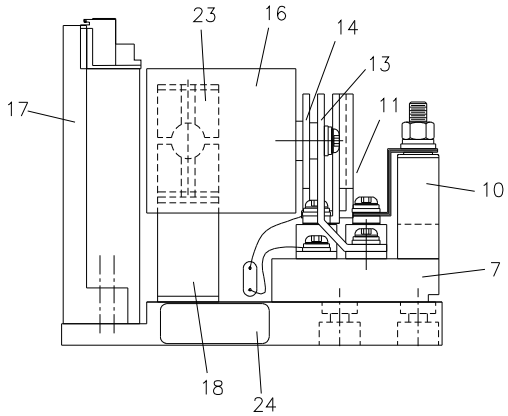

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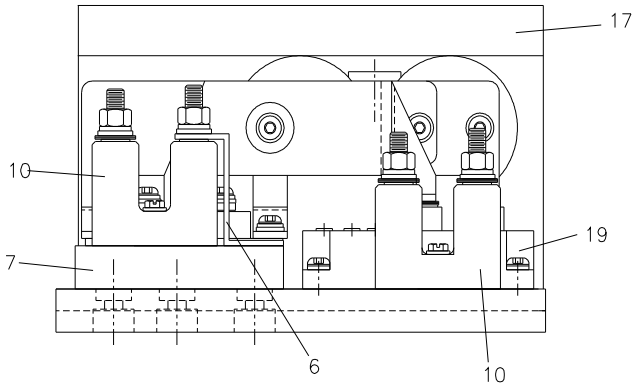

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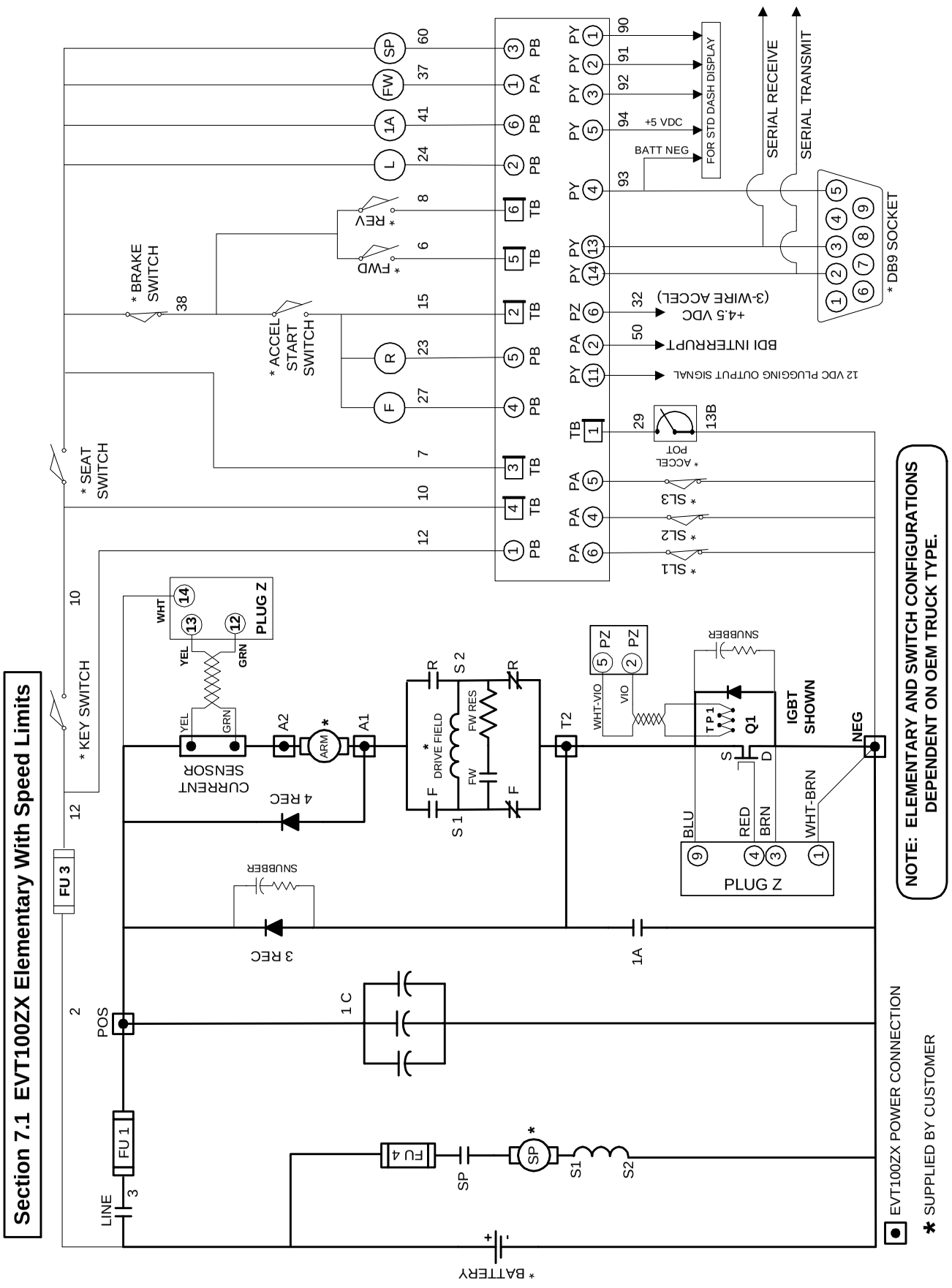
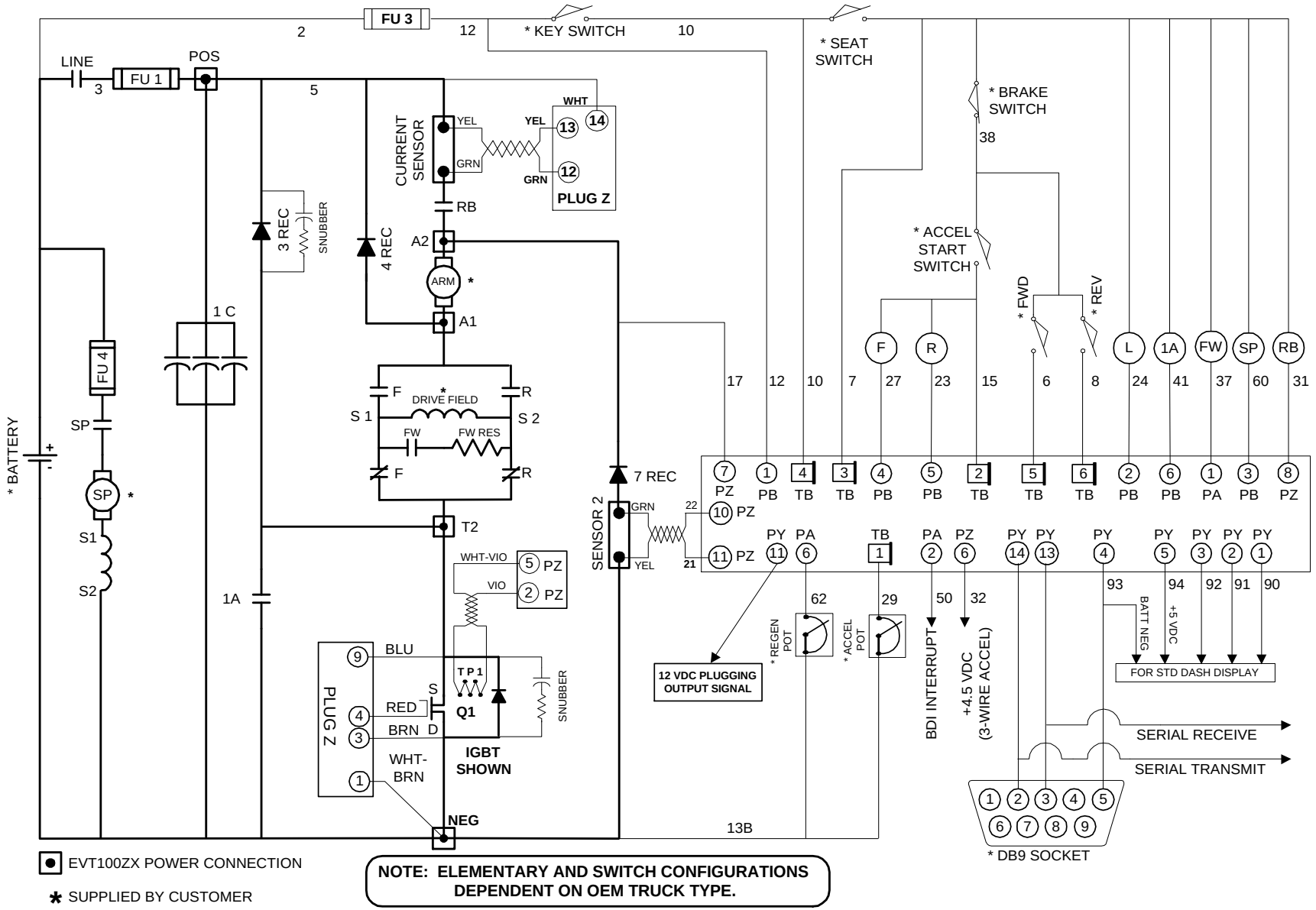
Section 6.3 Component Identification Table (for EVT100 AND EVT100P)

ITEM NO.	CATALOG NUMBER	DESCRIPTION	QTY.	U/M	REMARKS:
5	158C3100EGP1	EVT100 BASE	1	EA	
6	171B6578G1	CURRENT SHUNT	1	EA	
7	171B6577P1L	HEATSINK	1	EA	
8	232A9090RAP1	FLEX BUS	3	EA	
9	171B6581G1	SNUBBER ASSEMBLY	2	EA	
10	171B6569G1	DOUBLE TERMINAL POST	2	EA	
11	148B5615P1	BUS BAR	1	EA	
12	148B5614P2	BUS BAR	1	EA	
13	148B5615P4	BUS BAR (CAPACITOR POSITIVE)	1	EA	24-48V, (2) CAPS
13	148B5615P2	BUS BAR (CAPACITOR NEGATIVE)	1	EA	24-80V, (3) CAPS
14	148B5615P5	BUS BAR	1	EA	24-48V, (2) CAPS
14	148B5615P3	BUS BAR	1	EA	24-80V, (3) CAPS
15	232A9090RAP2	FLEX BUS	8	EA	
16	328A1532AGP1	CAPACITOR	2 or 3	EA	LO-VOLT
16	328A1532AJP1	CAPACITOR	3	EA	HI-VOLT
17	IC3645LXCD1****	EVT100 CARDBOX ASSEMBLY.	1	EA	**** See Argument No. 05, Section 4.**
18	171B6576P1	CAPACITOR SUPPORT	1	EA	
19	328A1516CHP1	IGBT POWER TRANSISTOR	1	EA	
20	328A1788P14	THERMAL INSULATION	1	EA	
21	328A1515AAP3	“DIODE MODULE, 3REC”	1	EA	LO-VOLT, LO POWER TRACTION / PUMP
21	328A1515AAP3	“DIODE MODULE, 3REC”	1	EA	LO-VOLT, HI POWER TRACTION / PUMP
21	328A1515AKP1	“DIODE MODULE, 3REC”	1	EA	HI-VOLT TRACTION / PUMP
22	328A1515AAP3	“DIODE MODULE, 4REC”	1	EA	LO-VOLT TRACTION
22	328A1515AKP1	“DIODE MODULE, 4REC”	1	EA	HI-VOLT TRACTION
23	328A1580BGP1	CAPACITOR SUPPORT	2	EA	
24	259A8133P2	NAMEPLATE	1	EA	
26	WH7152R69G1	WIRE HARNESS	1	EA	
36	205A5961P1	SCREW INSULATORS	3	EA	
57	44A718824-G05	SNUBBER ASSEMBLY	1	EA	FOR FET & IGBT
					Page 16 up-dated ECN 129 02/07/06 GB/SL


Section 7.1 EVT100ZX Elementary With Speed Limits
* BATTERY
LINE
FU 1
FU 3
FU 4
* KEY SWITCH
* SEAT SWITCH
* BRAKE SWITCH
* ACCEL START SWITCH
* REV
* FWD
* SL1
* SL2
* SL3
* ACCEL POT
SP
FW
1A
L
R
F
PLUG Z
WHT
YEL
GRN
CURRENT SENSOR
A1
A2
ARM
4 REC
3 REC
SNUBBER
DRIVE FIELD
FW RES
S 1
S 2
1 C
POS
T2
WHT-VIO
VIO
TP1
Q1
IGBT SHOWN
NEG
BLU
RED
BRN
WHT-BRN
1A
TB
PA
PB
PY
PZ
+5 VDC
BATT NEG
FOR STD DASH DISPLAY
SERIAL RECEIVE
SERIAL TRANSMIT
* DB9 SOCKET
(3-WIRE ACCEL)
+4.5 VDC
BDI INTERRUPT
12 VDC PLUGGING OUTPUT SIGNAL
NOTE: ELEMENTARY AND SWITCH CONFIGURATIONS DEPENDENT ON OEM TRUCK TYPE.
EVT100ZX POWER CONNECTION
* SUPPLIED BY CUSTOMER

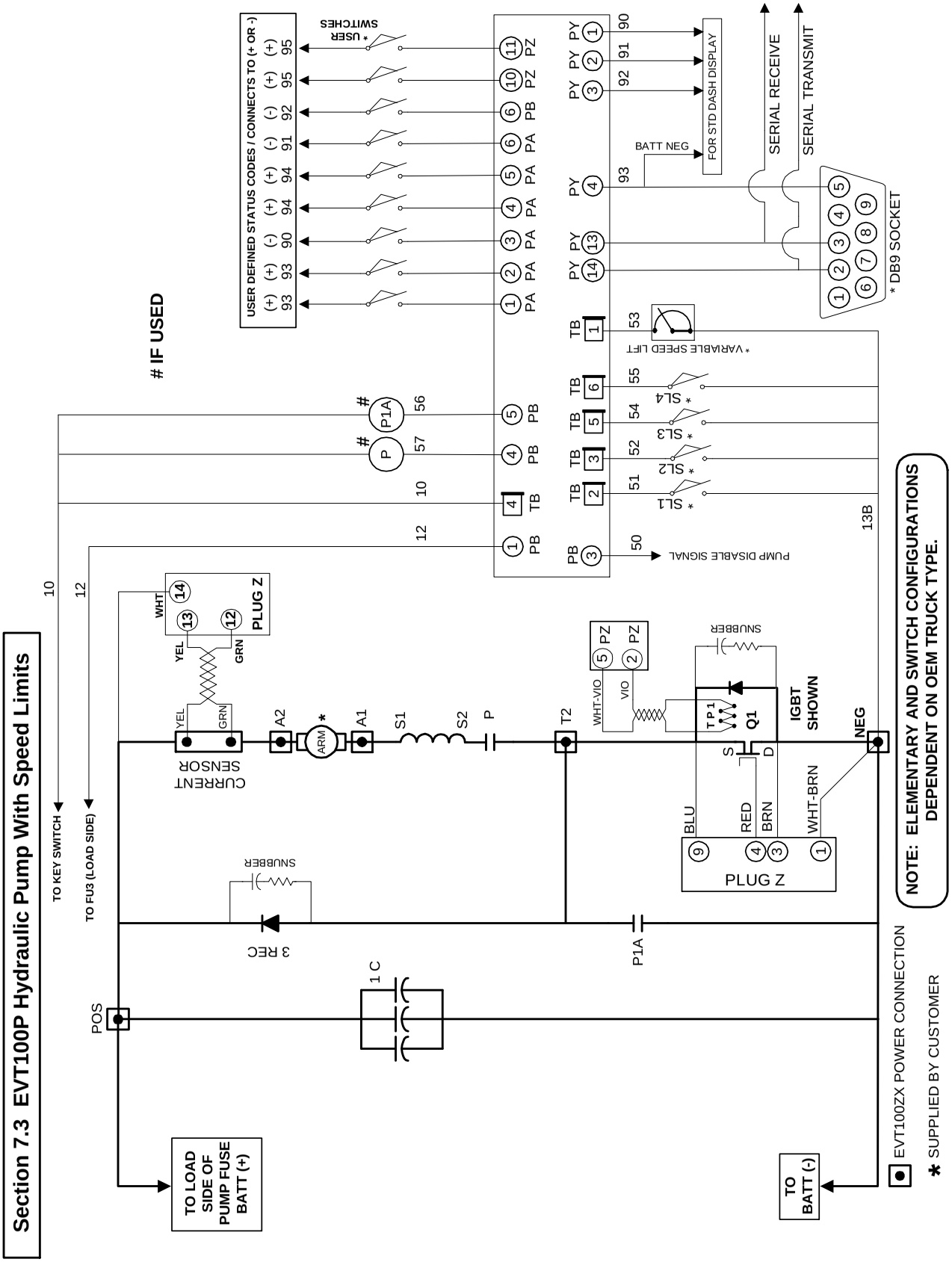
Section 7.2 EVT100ZX Elementary With Regenerative Braking



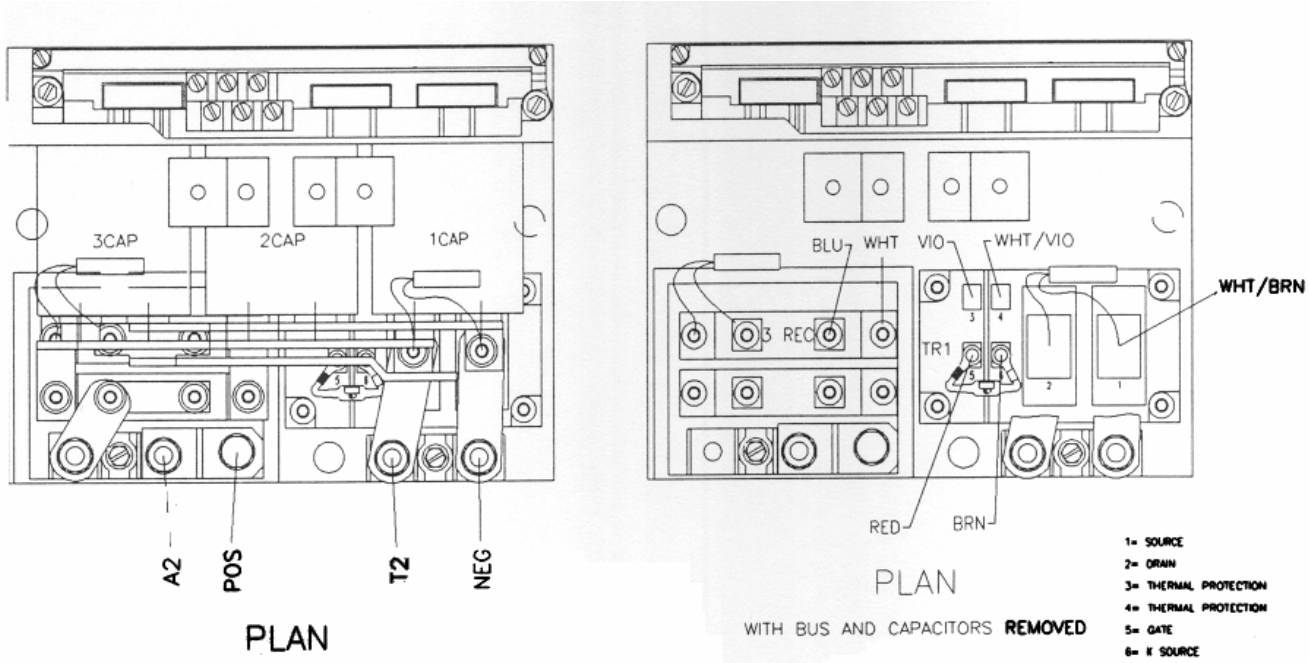
● EVT100ZX POWER CONNECTION

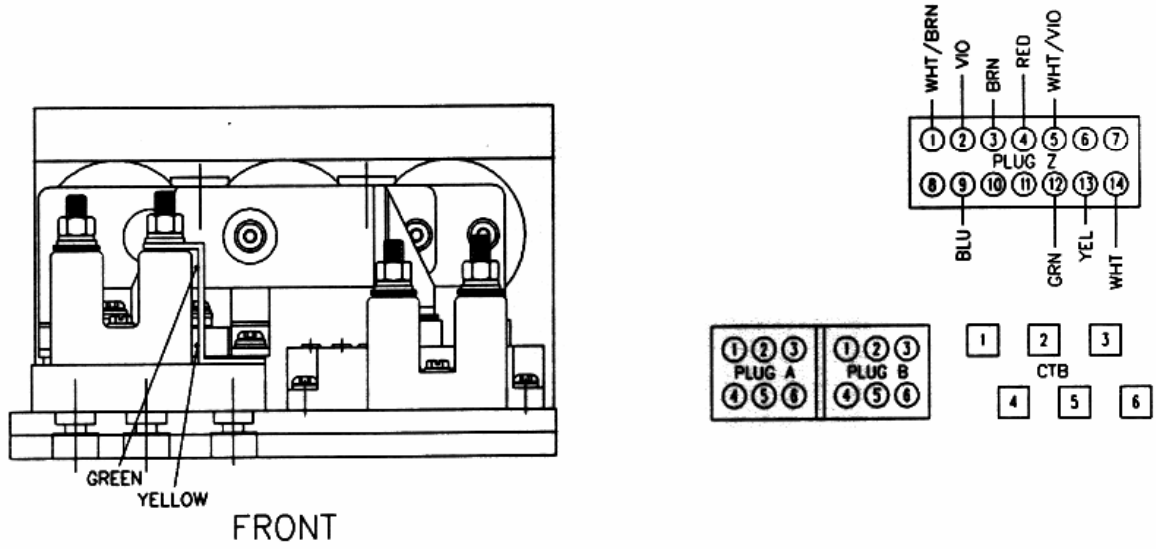
✱ SUPPLIED BY CUSTOMER

NOTE: ELEMENTARY AND SWITCH CONFIGURATIONS DEPENDENT ON OEM TRUCK TYPE.


Section 7.3 EVT100P Hydraulic Pump With Speed Limits
IF USED
USER DEFINED STATUS CODES / CONNECTS TO (+ OR -)
* USER SWITCHES
(+) 93
(+) 93
(-) 90
(+) 94
(+) 94
(-) 91
(-) 92
(+) 95
(+) 95
PZ 11
PZ 10
PB 6
PA 6
PA 5
PA 4
PA 3
PA 2
PA 1
PY 1
PY 2
PY 3
PY 4
PY 13
PY 14
90
91
92
93
FOR STD DASH DISPLAY
BATT NEG
SERIAL RECEIVE
SERIAL TRANSMIT
* DB9 SOCKET
TB 1
53
* VARIABLE SPEED LIFT
TB 6
55
* SL4
TB 5
54
* SL3
TB 3
52
* SL2
TB 2
51
* SL1
PB 3
50
PUMP DISABLE SIGNAL
13B
P1A
56
P
57
10
12
TB 4
PB 5
PB 4
PB 1
TO KEY SWITCH
TO FU3 (LOAD SIDE)
PLUG Z
WHT 14
YEL 13
GRN 12
CURRENT SENSOR
YEL
GRN
A2
ARM *
A1
S1
S2
P
T2
PZ 5
PZ 2
WHT-VIO
VIO
SNUBBER
T P 1
Q1
IGBT SHOWN
S
D
NEG
BLU
RED
BRN
WHT-BRN
PLUG Z
9
4
3
1
SNUBBER
3 REC
1 C
P1A
POS
TO LOAD SIDE OF PUMP FUSE BATT (+)
TO BATT (-)
NOTE: ELEMENTARY AND SWITCH CONFIGURATIONS DEPENDENT ON OEM TRUCK TYPE.
EVT100ZX POWER CONNECTION
* SUPPLIED BY CUSTOMER

SECTION 8.1 INTERNAL WIRING FOR MOSFET

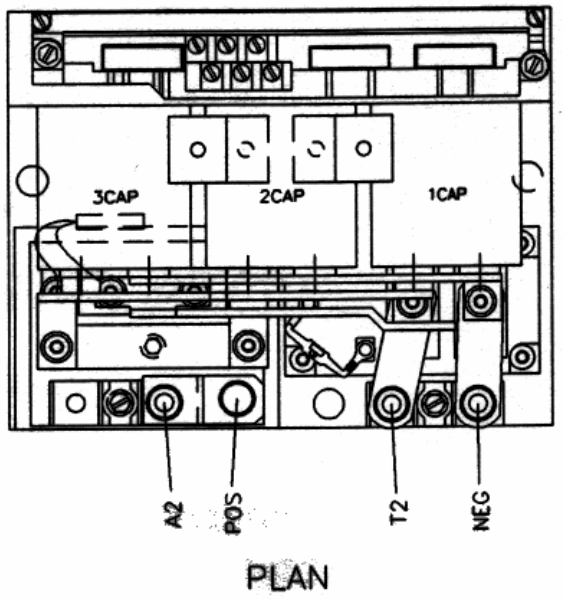




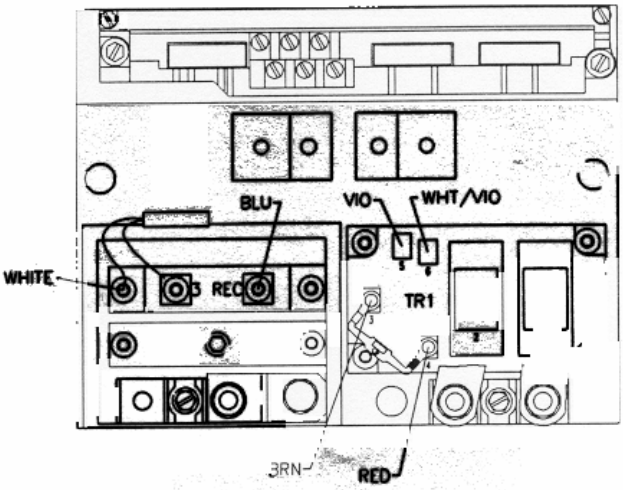
WIRE COLOR & SIZE	FROM	TO	WIRE DESCRIPTION
WHT #22	PZ-14	3 REC-G	259A9500P1
YEL #22	PZ-13	SHUNT	PART OF SHUNT ASSEMBLY — TWISTED PAIRS (7 TURNS)
GRN #22	PZ-12		
BRN #18	PZ-3	TR1-3	328A1550AAP18BN
RED #22	PZ-4	TR1-4	328A1550ALP3 — TWISTED GROUP (3 TURNS)
WHT/BRN #22	PZ-1	TR1-1	328A1550ALP16
WHT/VIO #22	PZ-5	TR1-6	328A1550ALP19 — TWISTED PAIRS (3 TURNS)
VIO #22	PZ-2	TR1-5	328A1550ALP10
BLU #22	PZ-9	3 REC-A	328A1550ALP6

NOTES:
ALL #22 WIRES MUST BE OF INSULATION GRIP TYPE.

SECTION 8.2 INTERNAL WIRING FOR IGBT



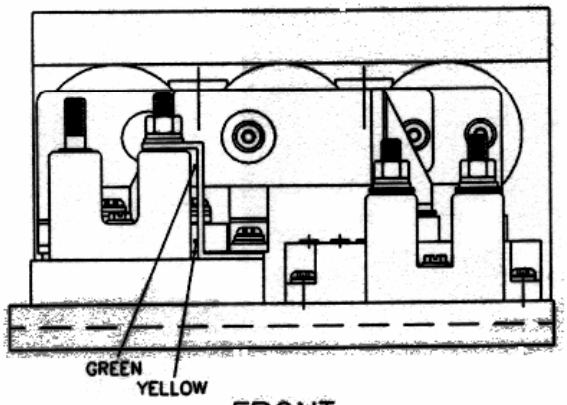
PLAN



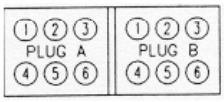
PLAN

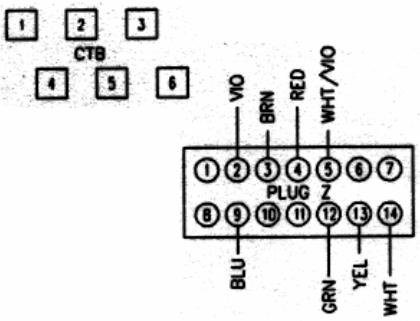
WITH BUS AND CAPACITORS REMOVED

1= EMITTER
2= COLLECTOR
3= EMITTER SENSOR
4= GATE
5= THERMAL PROTECTION
6= THERMAL PROTECTION



FRONT





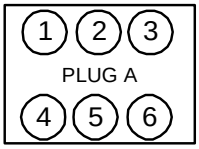
WIRE COLOR & SIZE	FROM	TO	WIRE DESCRIPTION
WHT #22	PZ-14	3 REC-G	259A9500P1
YEL #22	PZ-13	SHUNT	PART OF SHUNT ASSEMBLY — TWISTED PAIRS (7 TURNS)
GRN #22	PZ-12		
BRN #18	PZ-3	TR1-3	328A1550AAP18BN
RED #22	PZ-4	TR1-4	328A1550ALP3 — TWISTED PAIRS (3 TURNS)
WHT/VIO #22	PZ-5	TR1-6	328A1550ALP19
VIO #22	PZ-2	TR1-5	328A1550ALP10 — TWISTED PAIRS (3 TURNS)
BLU #22	PZ-9	3 REC-A	328A1550ALP6

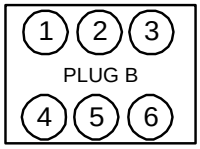
NOTES:
ALL #22 WIRES MUST BE OF INSULATION GRIP TYPE.

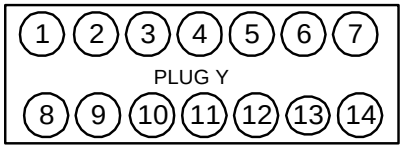
Section 9. TERMINAL & PLUG CONNECTIONS FOR EVT100ZX LOGIC CARD

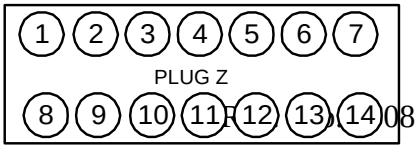
INPUT	TRACTION STANDARD	TRACTION SL/FW	TRACTION REGEN/FW	PUMP
TB1	Accel Pot Input	Accel Pot Input	Accel Pot Input	Accel Pot Input
TB2	Start Switch Input	Start Switch Input	Start Switch Input	SL1
TB3	Seat Switch Input	Seat Switch Input	Seat Switch Input	SL2
TB4	Key Switch Input	Key Switch Input	Key Switch Input	Key Switch Input
TB5	Forward Switch Input	Forward Switch Input	Forward Switch Input	SL3
TB6	Reverse Switch Input	Reverse Switch Input	Reverse Switch Input	SL4
PA1	FW Coil Driver	FW Coil Driver	FW Coil Driver	Status Code 93 Input
PA2	BDI Interrupt	BDI Interrupt	BDI Interrupt	Status Code 93 Input
PA3	Hourmeter Input	Hourmeter Input	Hourmeter Input	Status Code 90 Input
PA4	Not Used	SL2	Not Used	Status Code 94 Input
PA5	Not Used	SL3	Not Used	Status Code 94 Input
PA6	Not Used	SL1	Brake Potentiometer Input	Status Code 91 Input
PB1	Battery Positive	Battery Positive	Battery Positive	Battery Positive
PB2	Line Coil Driver	Line Coil Driver	Line Coil Driver	Line Coil Driver
PB3	SP Coil Driver	SP Coil Driver	SP Coil Driver	BDI Enable Signal Input
PB4	F Coil Driver	F Coil Driver	F Coil Driver	Pump (PMT) Coil Driver
PB5	R Coil Driver	R Coil Driver	R Coil Driver	1A Coil Driver
PB6	1A Coil Driver	1A Coil Driver	1A Coil Driver	Status Code 92 Input
PY1	Dash Display 4 Input	Dash Display 4 Input	Dash Display 4 Input	Dash Display 4 Input
PY2	Dash Display 3 Input	Dash Display 3 Input	Dash Display 3 Input	Dash Display 3 Input
PY3	Dash Display 1 Input	Dash Display 1 Input	Dash Display 1 Input	Dash Display 1 Input
PY4	Dash Display 2 Input	Dash Display 2 Input	Dash Display 2 Input	Dash Display 2 Input
PY5	Dash Display 5 Input	Dash Display 5 Input	Dash Display 5 Input	Not Used
PY6	Handset Store	Handset Store	Handset Store	Handset Store
PY7	Motor Current	Motor Current	Motor Current	Motor Current
PY8	TMMA-9 / Pump-PY12	TMMA-9 / Pump-PY12	TMMA-9 / Pump-PY12	Not Used
PY9	TMMA-7 / Pump-PY11	TMMA-7 / Pump-PY11	TMMA-7 / Pump-PY11	Not Used
PY10	TMMA-13 / Pump-PY10	TMMA-13 / Pump-PY10	TMMA-13 / Pump-PY10	Traction PY10
PY11	12 VDC Plugging Signal	12 VDC Plugging Signal	12 VDC Plugging Signal	Traction PY9
PY12	Not Used	Not Used	Not Used	Traction PY8
PY13	Serial Receive	Serial Receive	Serial Receive	Serial Receive
PY14	Serial Transmit	Serial Transmit	Serial Transmit	Serial Transmit
PZ	1,2,3,4,5,9,12,13 & 14	For GE Use Only		
PZ6	4.5 VDC 3-Wire Accel	4.5 VDC 3-Wire Accel	4.5 VDC 3-Wire Accel	Not Used
PZ7	Not Used	Not Used	Motor A2 Input	Not Used
PZ8	Regen Coil Driver	Regen Coil Driver	Regen Coil Driver	Not Used
PZ10	Not Used	Not Used	Sensor 2 Green Wire	Status Code 95 Input
PZ11	Not Used	Not Used	Sensor 2 Yellow Wire	Status Code 95 Input

PLUGS SHOWN FROM "WIRE END"









Section 9.1 Control Plug Terminal/Wire Installation Instructions

GENERAL: The plug system used in the GE EVT100 utilizes AMP Ampmodu 1 pins and receptacles (wire terminals). The plugs are sealed to provide protection in the electric vehicle environment.

Note: Should the need arise to assemble or disassemble the terminals from plugs, correct tools and procedures must be followed to prevent damage to the plug body, wire terminals or the card terminal plug.

PROCEDURES:

1. To Unplug Harness Plugs from Control Cards

- Depress latch on plug.
- Grasp plug body and pull plug from terminal board.
- If the plug has a shoulder near the terminal board, insert a medium size flat blade screwdriver in this gap and gently pry out the plug, on alternating sides.

2. To remove a terminal from the plug body

- Referring to Figure 1, insert the terminal removal tool into the plug body (which depresses the terminal locking lance). With a gentle "push-pull motion" on the wire, remove the wire.
- Use GE terminal removal tool - 44A727068-001, or AMP removal tool - 91065-2

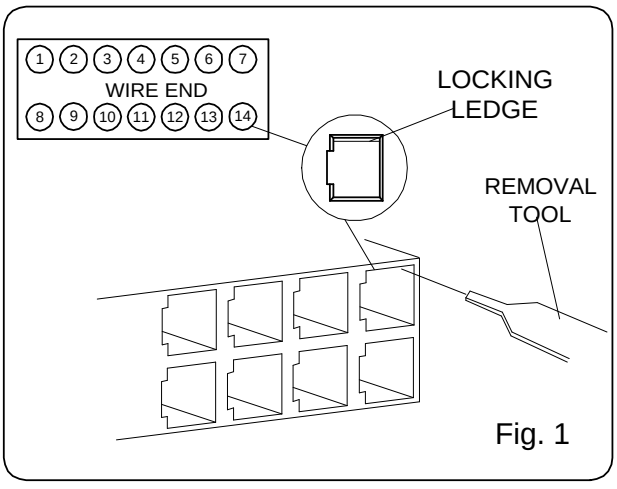


Fig. 1

3. To insert a terminal into the plug body.

- Referring to Figure 2, orient the plug body as shown with the latch up, **and terminal locking lance up.**
- Check that the locking lance protrudes up .030 to .060 inches (.8 to 1.5 mm). If not, adjust the lance. Insert the terminal into the plug body until it latches. A **"CLICK"** sound will be heard when the terminal latches.
- Check for correct latching by moving the wire gently with a push-pull motion in direction shown.

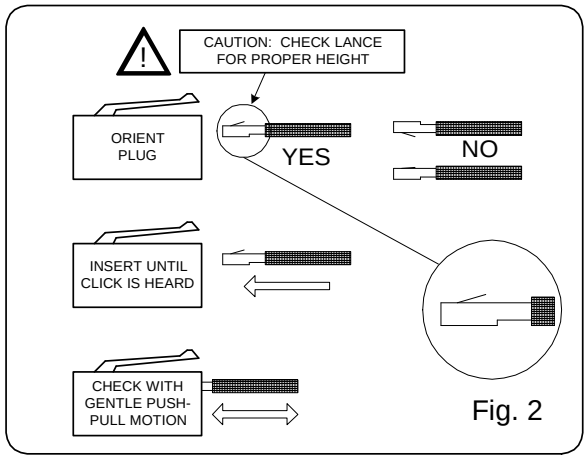


Fig. 2

TERMINAL LUBRICATION:

For long term reliable operation, the plug and control card pins must be lubricated with the recommended lubricant which provides environmental and fretting protection. New and re-manufactured controls are lubricated prior to shipment, however, in applications where severe vibration or high temperature cycling and excessive humidity (such as freezers) are present, it is recommended that the terminals of the plug and the pins in the card terminal plug be lubricated every year with the lubricant supplied in lube kit 328A1692G1. In normal applications, the lubricant should be applied every two years, or sooner should intermittent problems arise with the plug.

DO NOT USE ANY OTHER LUBRICANT OR CLEANER THAN THE ONE SPECIFIED.

REFERENCE:

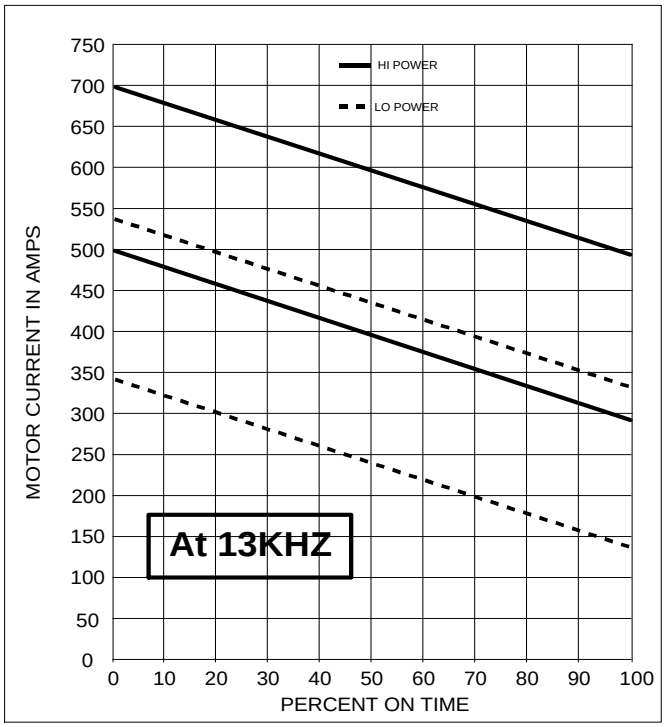
"A" Plug	328A1544ADP4
"B" Plug	328A1544ADP5
"Y" Plug	328A1544ADP1
"Z" Plug	328A1544ADP2
"A,B" Plug Seal	328A1580AWP1
"Y,Z" Plug Seal	328A1580AXP1
Receptacle	AMP # 102103-3 (Loose)
	AMP # 102099-5 (Reel, side-feed)
Crimp Tool	AMP # 90274-2 (wire size, 18-22)
Removal Tool	44A727068-001 or AMP 91065-1
Term Lube Kit	328A1692G1

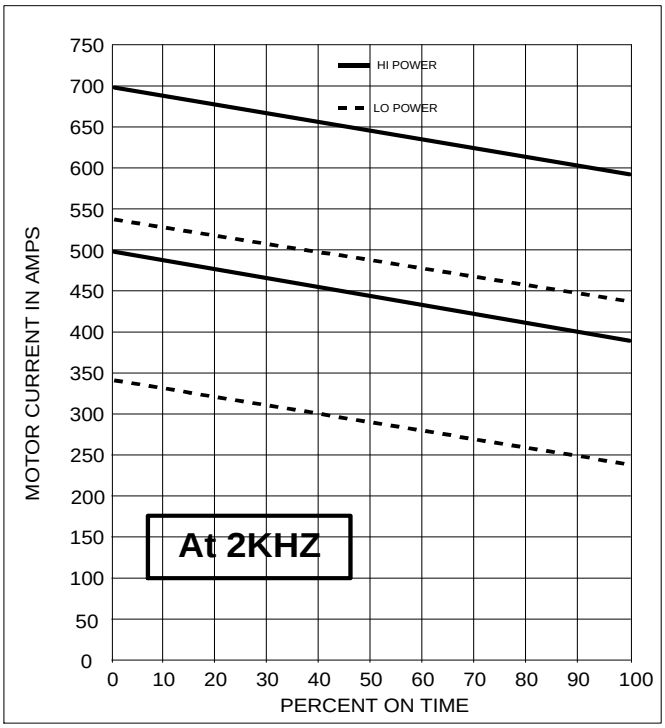
Section 10. EVT100ZX LOGIC CARD SPECIFICATIONS

CONTROL CARD FEATURES	TRACTION	PUMP
On-Board Diagnostics	Standard, Displayed to Handset or Dash Display	Standard, Displayed to Handset or Dash Display
Hourmeter	1-Displayed to Dash 1-Secure (Handset Read)	1-Displayed to Dash 1-Secure (Handset Read)
Stored Status Codes	16 Codes with BDI and Hourmeter Reference	16 Codes with BDI and Hourmeter Reference
Card Type Selection	Standard Enable/Disable Features	Standard Enable/Disable Features
Creep Speed	Adjustable 2% to 15% On Time	Not Applicable
Current Limit	Adjustable See C/L Curves That Follow Standard/High Performance	Adjustable See C/L Curves That Follow Standard/High Performance
Plugging	Adjustable 200 to 800 Amps	Not Applicable
Pedal Position Plug	Adjustable 100 to 800 Amps Can be Disabled	Not Applicable
Ramp Start	Standard	Not Applicable
Full Power Transition	Standard with 1A Contactor	Standard with P1A Contactor
Controlled Acceleration	Adjustable 0.1 to 22 seconds	Adjustable 0.1 to 5.5 seconds
1A Timed Pick-Up	Follows CA by 0.2 seconds when Accel Volts are < 0.5V or Accel Ohms are < 200	Follows CA by 0.2 seconds when Accel Volts are < 0.5V or Accel Ohms are < 200
1A Thermal Hold-Off	Standard at 90^{o}C Cutback at 20% Time On	Standard at 90^{o}C Cutback at 20% Time On
1A Plugging Hold-Off	Standard	Not Applicable
PMT (Fault Shut Down)	Standard Look Ahead and Reset Two Count	Standard Look Ahead and Reset Two Count
Thermal Protection	Standard 90^{o} C Cutback	Standard 90^{o} C Cutback
Static Return to Off	Standard 2 Second Delay	Not Applicable
Voltage Range	24-80 VDC	24-80 VDC
Accelerator Input (Potentiometer) Accelerator Input (Voltage)	5000-0 Ohms, 3.5-0 VDC (Non-Linear) 3.5 - 0 VDC (Linear)	5000-0 Ohms, 3.5-0 VDC
Low Battery Operation	Standard, 50% at 36-80 VDC 75% at 24 VDC	Standard, 50% at 36-80 VDC 75% at 24 VDC
Reverse Battery Protection	Standard	Standard
Ambient Temperature	-30 to +50^{o} C	-30 to +50^{o} C

CONTROL CARD FEATURES	TRACTION	PUMP
Approximate Weight	5.5 Kg	5.5 Kg
Coil Drivers - F/R - Line - 1A - FW - Regen - SP	 On-Board On-Board On-Board On-Board On-Board On-Board	 On-Board On-Board On-Board Not Applicable Not Applicable Not Applicable
Shorted Driver Protection	Standard	Standard
Shorted 3 REC Protection	Standard	Standard
Switch Loading for F/R and Speed Input	Logic Current	Logic Current
1A Current dropout	Adjustable, 450 to 1260 Amps	Not Applicable
Regenerative Braking	Adjustable Regen C/L = 75A to 630A Regen Start = 15% to 96%	Not Applicable
Field Weakening	Adjustable Pick-up = 52A to 466A Drop-out = 65A to 895A	Not Applicable
Speed Limit, Ranges from Creep to Full Speed	Standard (3 Ranges) Adjustable Input by Limit Switch	Standard (4 Ranges) Adjustable Input by Limit Switch
Steer Pump Time Delay	Seat = 0.5 to 63 Seconds Neutral = 0.5 to 63 Seconds	Not Applicable
Accelerator Volts Hold-Off	Standard, Accel volts > 2.5 VDC	Standard, Accel volts > 2.5 VDC
Battery Volts Check	Standard	Standard
Function Mode Registers: Selectable by Inputs From Interactive Dash Display	4 - C/A Modes 4 - FW Pickup Modes 4- SL1 Modes	4 - C/A Modes 4- SL2 Modes 4- SL4 Modes
RS-232 Communication Port	Standard	Standard
Battery Discharge Indication	Optional	Optional
Full Load Level Running Motor Current at 50% 1A duty	150 Amps Plus	150 Amps Plus
Continuous Duty Motor Current with 0.3^{o} C/Watt Heatsink at 40^{o} C Ambient	103 Amps Plus	103 Amps Plus

CONTROL CARD FEATURES	TRACTION	PUMP
Plug Current Limit - Min-Max at 1 Second - Min-Max at 3 Second	 330/800 Amps 330/650 Amps	Not Applicable
Average Motor C/L with Typical Motor Inductance at 13 KHZ & 2 KHZ Constant Frequency.	SEE FOLLOWING CHARTS	SEE FOLLOWING CHARTS





Section 11. FUNDAMENTALS OF CIRCUIT OPERATION

The control is energized by plugging in the battery. A capacitor charging circuit charges capacitors (1C) to battery volts in approximately 2 seconds. When the key and seat switches are closed, the control then makes the following start-up checks before the control is allowed to operate:

1. Insures that the voltage at T2 is between 12 percent and 88 percent of battery volts. This checks for shorted forward, reverse, and 1A contactor drivers, shorted 3 REC and power transistors, welded forward, reverse, and 1A contactors.
2. Checks for open F and R switch inputs, Voltage at TB5 and TB6 should be 0 volts.
3. Checks for accelerator volts at TB1 to be greater than 2.5 volts.

If all the above start-up checks are satisfied and if the capacitor 1C is fully charged, the line contactor will close, and normal vehicle operation can begin.

Selecting either forward or reverse direction will close the proper direction contactor, completing the power circuit to the drive motor. The card then supplies gate voltage to the power transistors, turning them on. Current flows from the battery through the motor armature, motor field, and power transistors back to battery negative. When gate voltage at the transistors is removed, they turn off. During the off time, the energy stored in the motor, by virtue of the motor's inductance, will cause current to circulate through the motor around the loop formed by 3REC, providing what is called flyback current. The battery current continues to flow from battery positive through 1C to negative during the entire off time, due to the high frequency of oscillation. The control converts battery current at battery voltage into a higher motor current at lower motor volts. This is why measured motor current will be greater than battery current except when control is operating at 100% on time.
The time for the next ON and OFF cycle to start is determined by the time the control card takes to oscillate. Slow speed is obtained by having maximum ohms or volts from the speed input signal . As the resistance or voltage decreases, the speed of the motor increases. The transistor circuit is capable of delivering approximately 100% battery volts. For maximum torque operation, the 1A contactor is closed to apply full battery voltage across the motor.

Figure 1 and 2 show battery and motor current paths during the on and off times for a typical running condition of 100 amps motor current at 50% on time (half speed).

Fig. 1 ON TIME

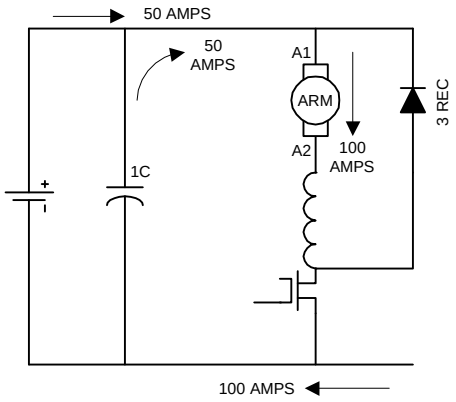
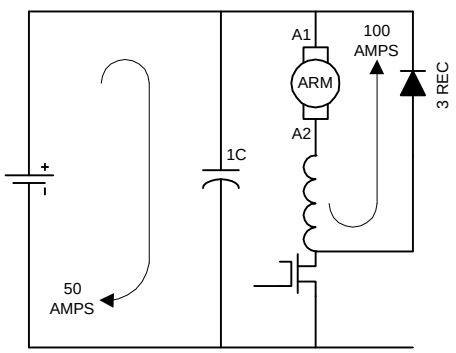


Fig. 2 OFF TIME



Section 12. GENERAL MAINTENANCE INSTRUCTIONS

The transistor control, like all electrical apparatus, does have some thermal losses. The semiconductor junctions have finite ***temperature*** limits, above which these devices may be damaged. For these reasons, normal maintenance should guard against any action which will expose the components to excessive heat, such as steam cleaning, and/or which will reduce the heat dissipating ability of the control, such as restricting air flow.

The following DO's and DONT's should be observed:

Any controls that will be applied in ambient temperatures over 100^{o} F (40^{o} C) should be brought to the attention of the vehicle manufacturer.

All external components having inductive coils must be filtered. Refer to vehicle manufacturer for specifications.

The control should not be steam cleaned.
In dusty areas, blow low-pressure air over the control to remove dust. In oily or greasy areas, a mild solution of detergent or denatured alcohol can be used to wash off the control, and then low-pressure air should be used to completely dry the control.

For the control to be most effective, it must be mounted against the frame of the vehicle. The vehicle frame, acting as an additional heat sink, will give improved vehicle performance by keeping the control package cooler. ***Apply a thin layer of heat-transfer grease (such as Dow Corning 340) between the control heatsink and the vehicle frame.***

Control wire plugs and other exposed transistor control parts should be kept free of dirt and paint that might change the effective resistance between points.

CAUTION: The vehicle should not be plugged when the vehicle is jacked up and the drive wheels are in a free wheeling position. The higher motor speeds can create excessive voltages that can be harmful to the control.

Do not hipot (or megger) the control. Refer to control manufacturer before hipotting.

Use a lead-acid battery with the voltage and ampere hour rating specified for the vehicle. Follow normal battery maintenance procedures, recharging before 80 percent discharged and with periodic equalizing charges.

Section 13. TROUBLE SHOOTING INSTRUCTIONS

Section 13.1 General Instructions

Trouble-shooting the EVT100 control should be quick and easy by following the instructions outlined in the following status code instruction sheets.

If mis-operation of the vehicle occurs, a status code will be displayed on the Dash Display for vehicles equipped with a Dash Display or by plugging a Handset into the logic card's plug "Y" location and then reading the status code.

With the status code number, follow the procedures outlined in the status code instruction sheets to determine the problem.

Checking and replacement of components are also outlined in sections of this instruction book. Please refer to those sections as needed.

Important Note: Due to the interaction of the logic card with all vehicle functions, almost any status code or control fault could be caused by the logic card. After all other status code procedures have been followed and no problem is found, the logic card should then be replaced as the last option to correct the problem.

The same device designations have been maintained on different controls but the wire numbers may vary. Refer to the elementary and wiring diagrams for your specific control. The wire numbers shown on the elementary diagram will have identical numbers on the corresponding wiring diagrams for a specific truck, but these numbers may be different from the numbers referenced in this publication.

WARNING: Before trouble-shooting, jack up the drive wheels, disconnect the battery, and discharge capacitor 1C as explained in Section 15.3. Reconnect the battery as needed for the specific check. Capacitors should be discharged by connecting a 200 ohm 2 watt resistor between the positive and negative terminal on the control panel.

Check resistance on R x 1000 scale from frame to power and control terminals. A resistance of less than 20,000 ohms can cause misleading symptoms. Resistance less than 1000 ohms should be corrected first.

Before proceeding, visually check for loose wiring, mis-aligned linkage to the accelerator switch, signs of overheating of components, etc.

Tools and test equipment required are: clip leads, volt-ohm meter (20,000 ohms per volt) and basic hand tools.

Section 13.2 Removal of the Capacitor Bank

Caution! **Discharge The Capacitors Before Removing (See Section 15.3)!**

Electrolytic capacitors can store a significant amount of charge (energy) and must be shorted (discharged) by touching a 200 ohm 2-watt resistor between positive (+) and negative (-) for three seconds or greater.

(1C) Assembly (For 3 Cap, High Power)

To remove the Capacitor Bank Assembly, use the following procedure and Section 13.2.1 Exploded View for Removal of the Capacitor Bank. It is necessary to remove the Capacitor Bank Assembly prior to replacing the power transistor (Q1) or the 3REC or 4REC.

1. Remove the three (3) Cap Bus connections to Q1 (NEG), and two (2) connections to the

POS heatsink [4.0 MM hex driver is required].

- On a traction control, two connections will be to the cathode connections on the 4REC.
- On a pump control, two connections will be to a bus bar "spacer" (No 4REC).

2. Remove the two (2) capacitor mounting support screws between the caps. [Blade screwdriver is required].

   - First remove the two (2) top rubber supports.
   - Slide the wiring harness back towards (to) the cardbox.
   - Lift the capacitor assembly out.

Section 13.3 Disassembly for Component Replacement. (For 3 Cap, High Power)

Note! Q1, 3REC and 4REC can be checked for faults without disassembly from the controller power base, however, 4REC "A1" connection must be disconnected to check. See Section 15. COMPONENT TESTING for instruction on checking components.

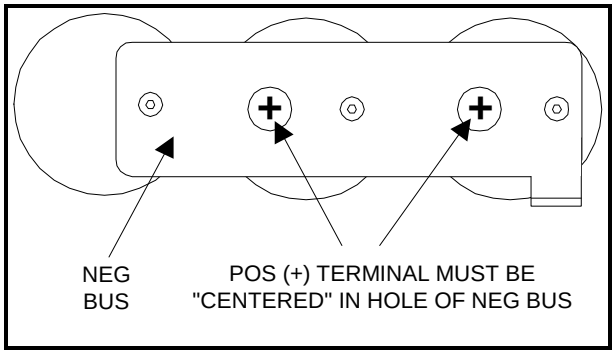
If a defective component is found, the Capacitor assembly must be removed and then follow instructions in Section 13.3.1 Exploded View For Disassembly.

1. Remove T2 Bus bar which mounts to the 3REC and Q1 [requires a 7/16" driver and 4 MM driver]. At this point, the snubber assembly on Q1 will now be loose. Lay aside for replacement later on.
2. Q1 and/or 3REC can now be rechecked and replaced if necessary.
   - Remove wiring harness from component.
   - Remove component and replace with correct catalog number.

Section 13.4 Disassembly of the Capacitor Bank Assembly. (For 3 Cap, High Power)

To check capacitors, disassemble per diagram shown in Section 13.4.1 Exploded View for Disassembly and Replacement of Capacitors and the following instructions:

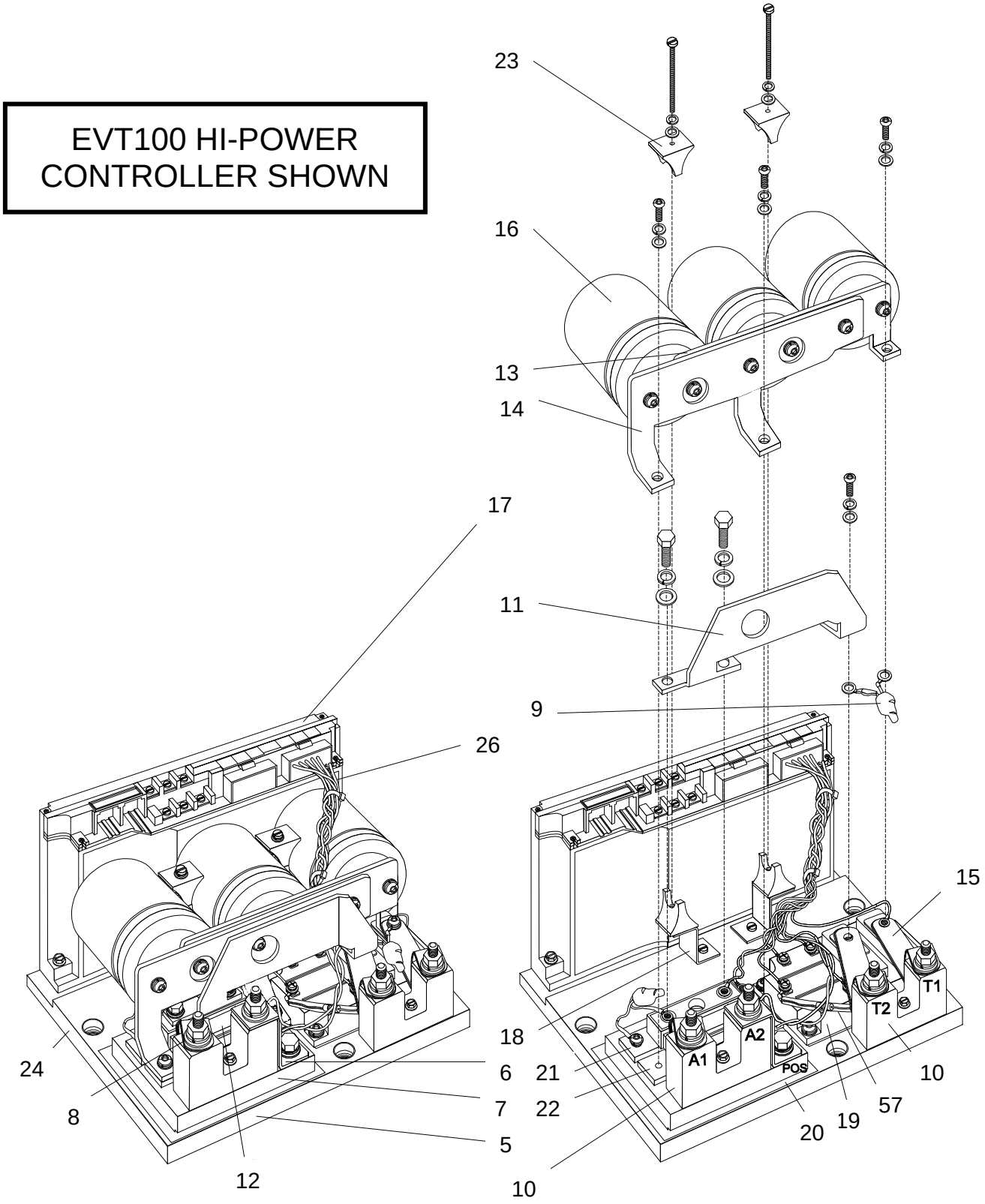
1. With a felt tip pen, mark the outside cap bus POS (+) and the inner cap bus NEG (-).
2. Remove the three (3) screws from the outside (+) cap bus.
3. Remove the three (3) screws from the inside (-) cap bus.
4. Check capacitors per instructions in Section 15. COMPONENT TESTING. Replace cap(s) if necessary making sure that the correct cap voltage is selected. The best procedure to check and replace caps is "one-at-a-time".
5. If all caps are removed, reassemble caps and bus bars as follows:
   a. Caps must be positioned "terminals up" on a table.
   b. Orient POS (+) terminal to left and NEG (-) to right.
   c. **It is very important that the POS terminals be oriented through the NEG**



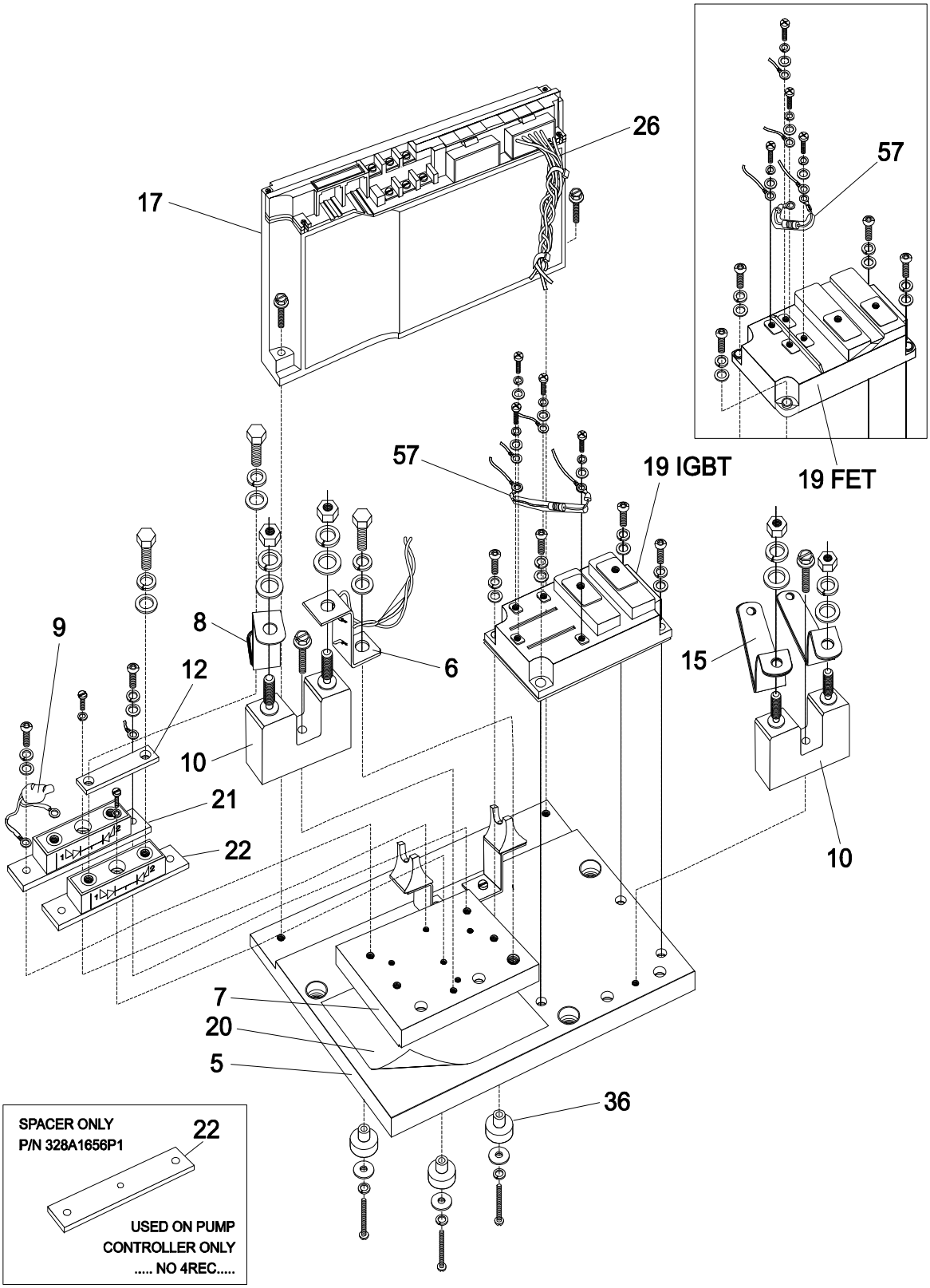
Bus as shown in following drawing.

   d. Install NEG Bus first.
   e. Install POS Bus last.
6. Remount Capacitor assembly to controller power base.

Section 13.2.1 Exploded View for Removal of the Capacitor Bank

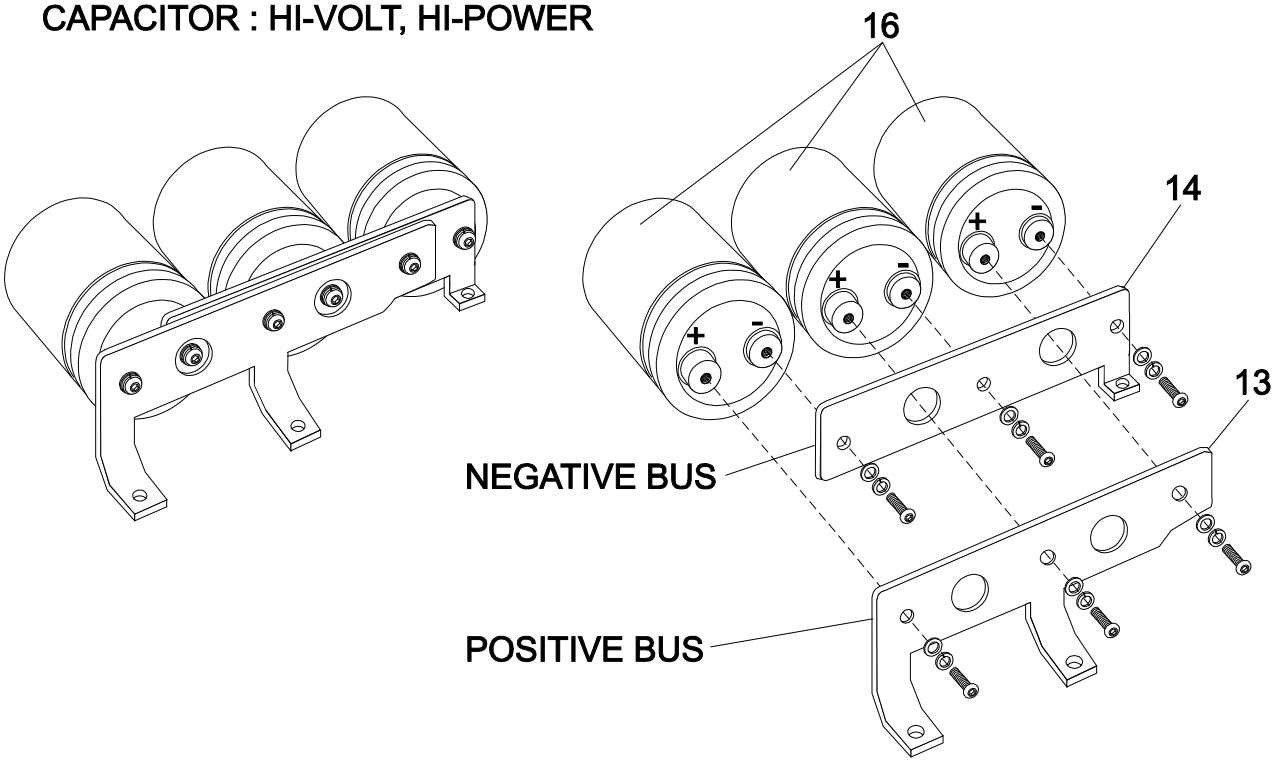


Section 13.2.1 Exploded View for Component Replacement

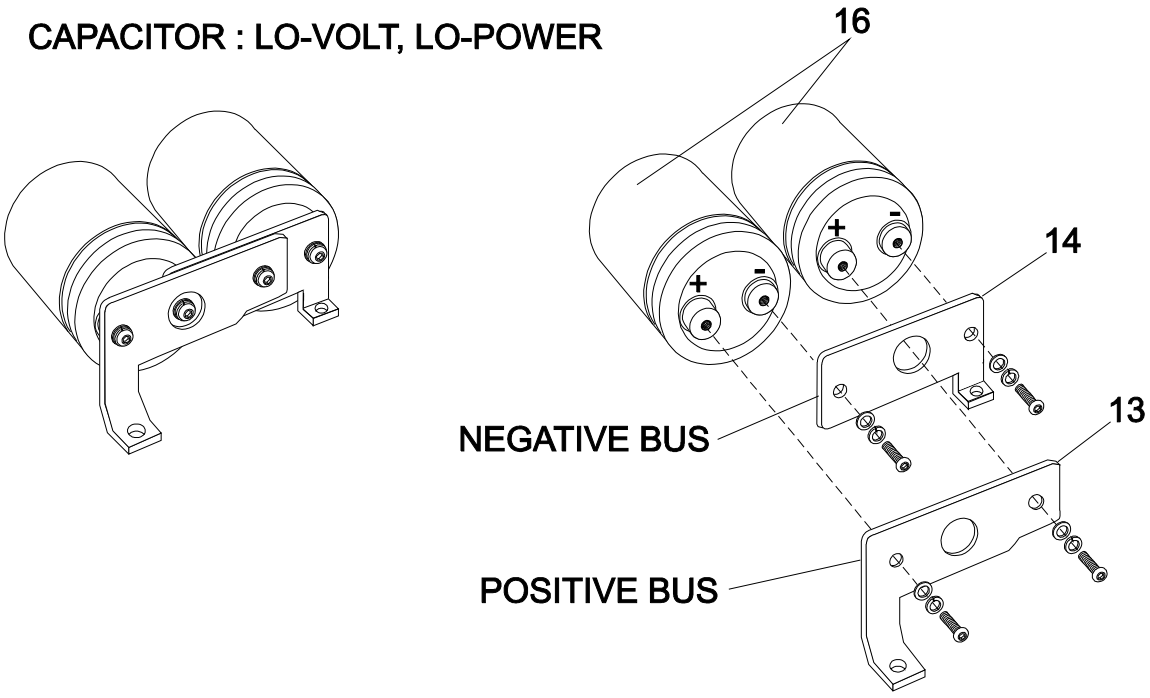


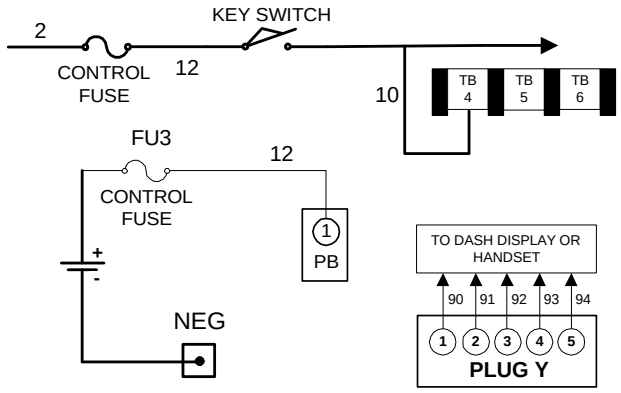
Section 13.4.1 Exploded View for Disassembly and Replacement of Capacitors

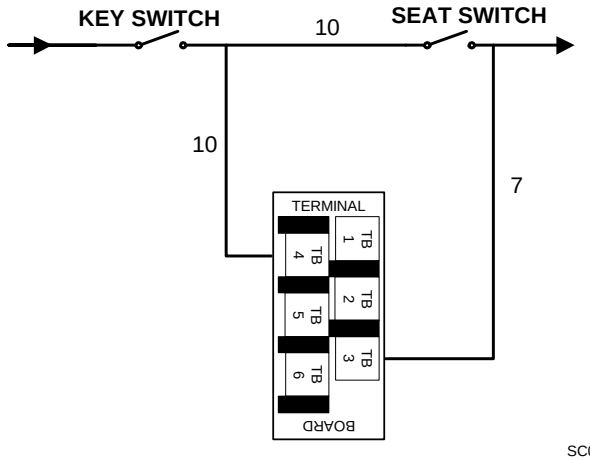
CAPACITOR : HI-VOLT, HI-POWER

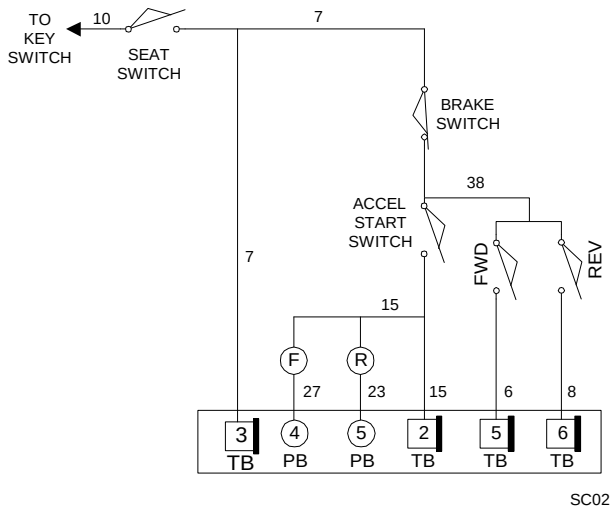


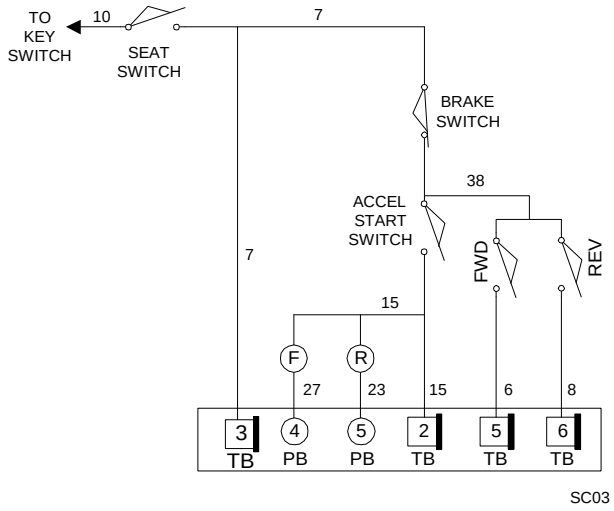
CAPACITOR : LO-VOLT, LO-POWER

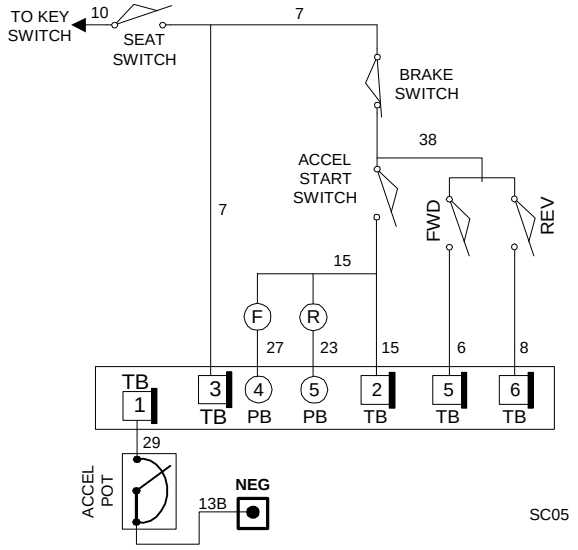


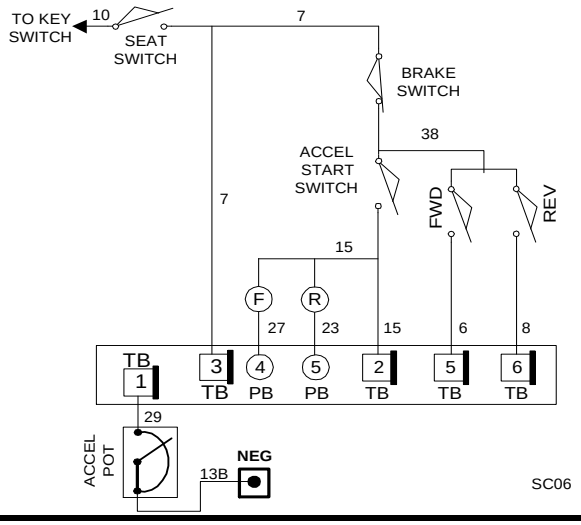
TRACTION STATUS CODE	DESCRIPTION OF STATUS	CAUSE OF STATUS INDICATION
NONE	Segments do not illuminate on the Dash Display and/or the Handset.	No input voltage to the control card or the display unit.
MEMORY RECALL **NO**	**CORRECTIVE ACTIONS**	**TROUBLE-SHOOTING DIAGRAM**
Circuits valid for Traction Controller & Pump Controller	**SYMPTOM** Display screen on Dash Display and/or Handset is blank. **POSSIBLE CAUSE** **Positive or negative control voltage is not present.** • Insure that the key switch is closed and voltage is present between PB1 & battery negative (Power Terminal "N"). Also check for voltage between TB4 and control negative. **Open circuit between control card Plug Y & the Dash Display or Handset.** • Check for an open circuit or loose connection going from the "Y" plug and the Dash Display or Handset. **Defective Dash Display or Handset.** • Replace Dash Display or Handset.	 SC00

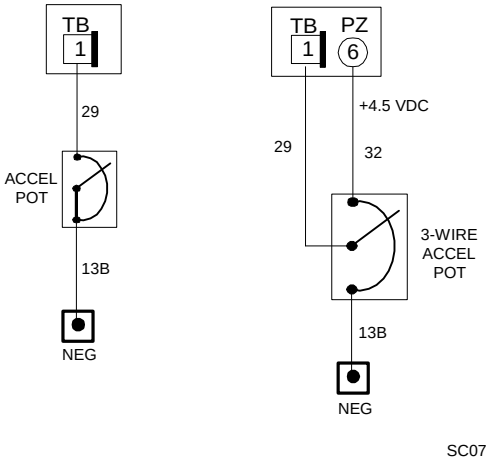
TRACTION STATUS CODE	DESCRIPTION OF STATUS	CAUSE OF STATUS INDICATION
-01	No seat switch or deadman switch input. (No voltage to TB3)	This status code will be displayed when TB3 is less than 50% battery volts.
MEMORY RECALL **NO**	**CORRECTIVE ACTIONS**	**TROUBLE-SHOOTING DIAGRAM**
Circuits valid for Traction Controller	**SYMPTOM** Forward or Reverse contactor will not close. **POSSIBLE CAUSE** **Mis-adjusted or defective seat or deadman switch.** • Check to see that the seat switch closes properly. **Open circuit between battery positive and TB3.** • Check for loose connections or broken wires: - Between the seat switch and TB3. - Between the key switch and the battery positive side of the seat switch. - Between the seat switch and TB4. • **On vehicles without a seat/deadman switch, check for a loose connection or broken wire from TB4 and/or TB3**	 SC01

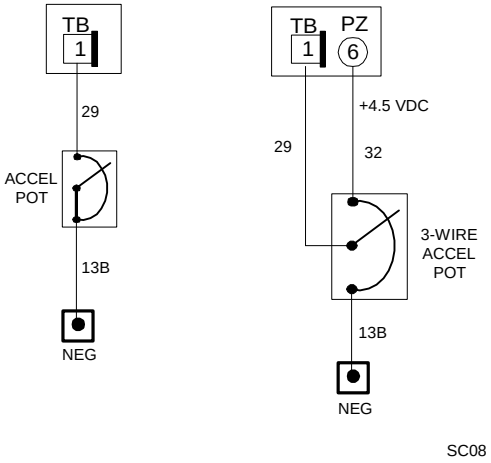
TRACTION STATUS CODE	DESCRIPTION OF STATUS	CAUSE OF STATUS INDICATION
-02	Forward directional switch is closed on initial power up.	This status code will be displayed when TB5 is greater than 60% of battery voltage at initial key switch on.
MEMORY RECALL **NO**	**CORRECTIVE ACTIONS**	**TROUBLE-SHOOTING DIAGRAM**
Circuits valid for Traction Controller	**SYMPTOM** Forward contactor will not close because of Static Return to Off (SRO) lock out. **POSSIBLE CAUSE** **Forward directional switch is closed on initial start up (i.e. closure of battery, key switch or seat/deadman switch).** • Return directional switch lever to neutral and then return lever to forward position. **Forward directional switch is welded closed or mis-adjusted to be held closed.** • Replace or adjust directional switch to insure that it opens when the directional switch is returned to neutral. **Short circuit between TB2 and TB5.** • Disconnect the wire from TB5 and check for a short circuit between TB2 and the wire that was connected to TB5. **Defective logic card.** • Replace the logic card.	 SC02

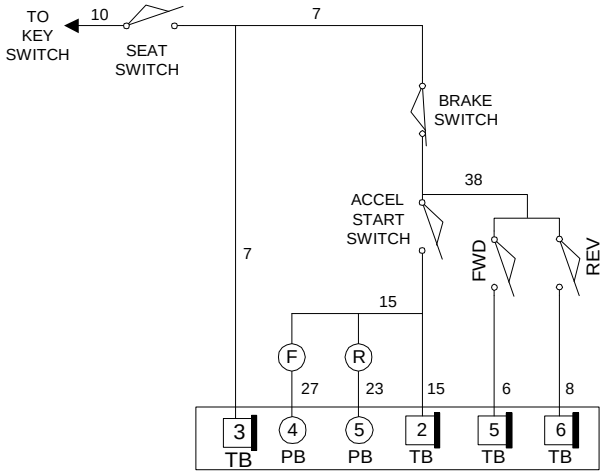
TRACTION STATUS CODE	DESCRIPTION OF STATUS	CAUSE OF STATUS INDICATION
-03	Reverse directional switch is closed on initial power up.	This status code will be displayed when TB6 is greater than 60% of battery voltage at initial key switch on.
MEMORY RECALL **NO**	**CORRECTIVE ACTIONS**	**TROUBLE-SHOOTING DIAGRAM**
Circuits valid for Traction Controller	**SYMPTOM** Reverse contactor will not close because of Static Return to Off (SRO) lock out. **POSSIBLE CAUSE** **Reverse directional switch is closed on initial start up (i.e. closure of battery, key switch or seat/deadman switch).** • Return directional switch lever to neutral and then return lever to reverse position. **Reverse directional switch is welded closed or mis-adjusted to be held closed.** • Replace or adjust directional switch to insure that it opens when the directional switch is returned to neutral. **Short circuit between TB2 and TB6.** • Disconnect the wire from TB6 and check for a short circuit between TB2 and the wire that was connected to TB6. **Defective logic card.** • Replace the logic card.	 SC03

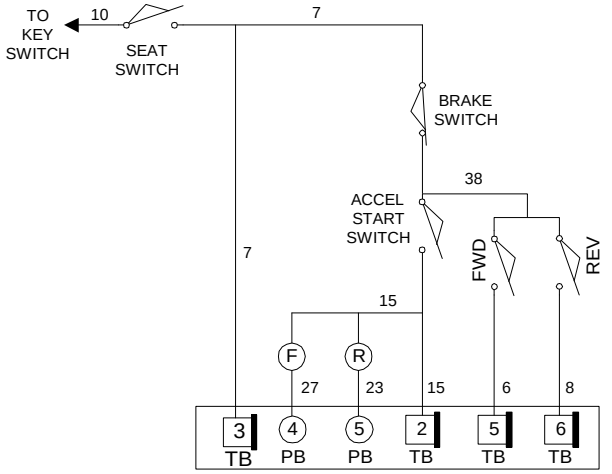
TRACTION STATUS CODE	DESCRIPTION OF STATUS	CAUSE OF STATUS INDICATION
-05	Start switch or brake switch fails to close.	This status code will be displayed when TB1 is less than 2.5 volts and TB2 is less than 60% of battery volts.
MEMORY RECALL **NO**	**CORRECTIVE ACTIONS**	**TROUBLE-SHOOTING DIAGRAM**
Circuits valid for Traction Controller	**SYMPTOM** Forward or reverse contactor will not pick up. **POSSIBLE CAUSE** **Defective brake switch circuit.** • Check brake switch to insure closure with brake pedal released. • Check for open circuit or loose connections in wiring from brake switch to seat switch and TB3, and from brake switch to start switch. **Defective start switch circuit.** • Check start switch to insure closure when accelerator is depressed. • Check for open circuit or loose connections in wiring from brake switch to start switch and from TB2 to start switch. **Defective accelerator switch.** • Check accelerator switch potentiometer for proper operation and ohmic value.	

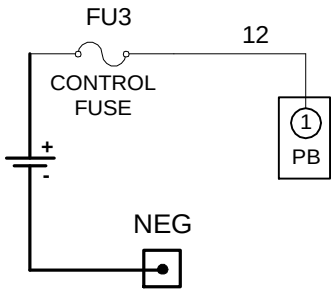
TRACTION STATUS CODE	DESCRIPTION OF STATUS	CAUSE OF STATUS INDICATION
-06	Accelerator depressed with no direction selected.	This status code will be displayed when TB5 & TB6 are less than 60% of battery volts, and TB1 is less than 2.5 volts.
MEMORY RECALL **NO**	**CORRECTIVE ACTIONS**	**TROUBLE-SHOOTING DIAGRAM**
Circuits valid for Traction Controller	**SYMPTOM** Forward or reverse contactor will not pick up. **POSSIBLE CAUSE** **Accelerator pedal is depressed before closing forward or reverse directional switch.** • Status code will disappear when directional switch is closed or when accelerator pedal is released. **Defective directional switch** • Check forward or reverse switch to insure closure when direction is selected. **Open circuit between directional switch(es) and battery positive or between directional switch(es) and TB5 or TB6.** • Check all control wires and connections shown in Trouble Shooting Diagram.	

TRACTION STATUS CODE	DESCRIPTION OF STATUS	CAUSE OF STATUS INDICATION
-07	Accelerator input voltage too high during run mode.	This status code will be displayed when the accelerator input voltage at TB1 is higher than 3.7 volts, and a directional contactor is picked up.
MEMORY RECALL **NO**	**CORRECTIVE ACTIONS**	**TROUBLE-SHOOTING DIAGRAM**
Circuits valid for Traction Controller	**SYMPTOM** Forward or reverse contactor picks up but control will not operate when accelerator pedal is depressed or status code -07 is displayed then disappears when the vehicle starts to accelerate. **POSSIBLE CAUSE** **Accelerator input mis-adjusted or defective.** • Input voltage at TB1 should be less than 3.7 volts. Adjust or replace accelerator unit to insure that the voltage at TB1 will vary from 3.5 volts to less than .5 volts when the pedal is depressed. **Open circuit between battery negative and TB1 in accelerator input circuit.** • Check for broken wires or loose connections or open potentiometer / voltage supply in the circuit shown in Figure 1. **Short circuit from battery positive to wiring in accelerator input circuit.** • Disconnect wire from TB1 and measure voltage at wire to negative. Should be zero volts for potentiometer type and less than 3.7 volts for solid state type accelerator input.	 SC07

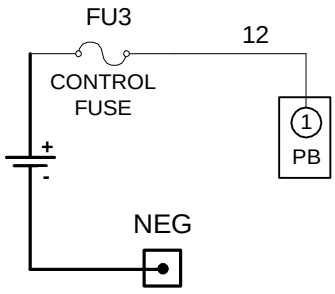
TRACTION STATUS CODE	DESCRIPTION OF STATUS	CAUSE OF STATUS INDICATION
-08	Accelerator input voltage too low on power up after initial key switch closure.	This status code will be displayed when the accelerator input voltage at TB1 is less than 3.0 volts, and any of the following connections are opened & closed: battery plug, seat switch or key switch.
MEMORY RECALL **NO**	**CORRECTIVE ACTIONS**	**TROUBLE-SHOOTING DIAGRAM**
Circuits valid for Traction Controller	**SYMPTOM** Forward or reverse contactor does not pick up. **POSSIBLE CAUSE** **Accelerator input mis-adjusted or defective.** • Input voltage at TB1 should be more than 3.0 volts. Adjust or replace accelerator unit to insure that the voltage at TB1 is more than 3.0 volts before depressing pedal. **Short circuit between battery negative and TB1 in accelerator input circuit.** • Disconnect wire from TB1. Check for short circuit from wire to battery negative. Resistance should be greater than 4.7K ohms. **Defective Card** • Disconnect wire from TB1. Measure voltage from TB1 to negative. Voltage should be greater than 4.5 volts, if not, replace card.	 SC08

TRACTION STATUS CODE	DESCRIPTION OF STATUS	CAUSE OF STATUS INDICATION
-09	Both the forward and reverse directional switches are closed at the same time.	This status code will be displayed when TB5 & TB6 are greater than 60% of battery volts at the same time.
MEMORY RECALL **NO**	**CORRECTIVE ACTIONS**	**TROUBLE-SHOOTING DIAGRAM**
Circuits valid for Traction Controller	**SYMPTOM** Forward or reverse contactor will not pick up. **POSSIBLE CAUSE** **Forward or reverse directional switch welded closed or mis-adjusted to be held closed.** • Replace or adjust directional switches to insure that they open when directional switch is returned to neutral. **Short circuit between battery positive and TB5 and/or TB6.** • Disconnect wires from TB5 and TB6 and check wire for short circuit to positive side of directional switch. **Defective card** • Disconnect wires and measure voltage at TB5 and TB6. Voltage should be less than 60% of battery volts.	 SC09

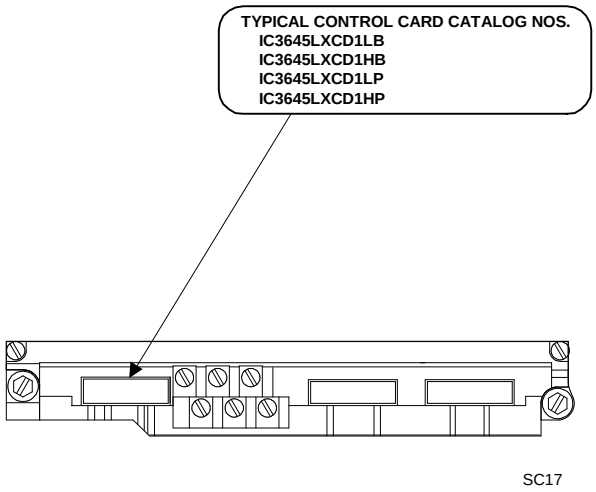
TRACTION STATUS CODE	DESCRIPTION OF STATUS	CAUSE OF STATUS INDICATION
-11	Start switch closed on power up after initial key switch closure.	This status code will be displayed when TB2 is greater than 60% of battery voltage when the key switch is closed.
MEMORY RECALL **NO**	**CORRECTIVE ACTIONS**	**TROUBLE-SHOOTING DIAGRAM**
Circuits valid for Traction Controller	**SYMPTOM** Forward or reverse contactor does not pick up. **POSSIBLE CAUSE** **Start switch input mis-adjusted or defective.** • Input voltage at TB2 should be less than 60% battery volts at key switch closing. Adjust or replace accelerator unit to insure that the voltage at TB2 is less than 60% battery volts before closing the start switch pedal. **Short circuit between battery positive and TB2 in start switch input circuit.** • Disconnect wire from TB2. Check for short circuit from wire to battery positive. Resistance should be greater than 4.7K ohms. **Defective Card** • Disconnect wire from TB2. Measure voltage from TB2 to negative. Voltage should be zero, if not, replace card.	 SC11

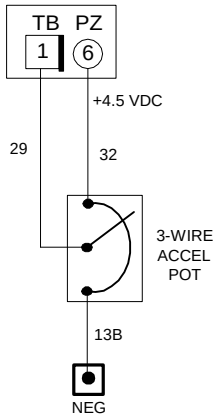
TRACTION STATUS CODE	DESCRIPTION OF STATUS	CAUSE OF STATUS INDICATION
-15	Battery voltage is too low or control card is mis-adjusted.	This status code will be displayed when the battery volts are less than 1.95 volts per cell at initial key switch on. See table below.
MEMORY RECALL **NO**	**CORRECTIVE ACTIONS**	**TROUBLE-SHOOTING DIAGRAM**
Circuits valid for Traction Controller	**SYMPTOM** Forward or reverse contactor will not pick up. **POSSIBLE CAUSE** **Discharged battery** • Check battery for proper open circuit voltage as shown in SC 15 figure and charge battery, if required. **Defective battery** • Check each battery cell for proper voltage (greater than 1.95 volts at cell). Replace or repair battery. **Incorrect control card adjustment.** • Check Function 15 for proper adjustment for battery being used. See Handset instruction sheet for details. Adjust to proper settings. **Check "minimum" battery volts at PB1 & NEG.**	 SC15

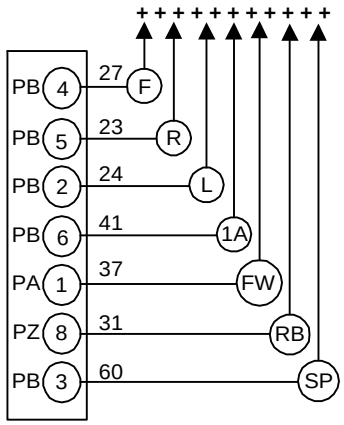
NOMINAL BATTERY VOLTS	MINIMUM LIMIT VOLTS AT 1.95 VDC PER CELL
24	23.4
36	35.1
48	46.8
72	70.2
80	78

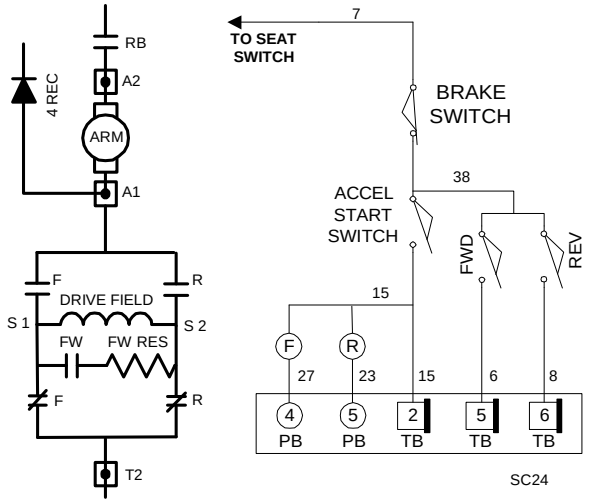
TRACTION STATUS CODE	DESCRIPTION OF STATUS	CAUSE OF STATUS INDICATION
-16	Battery voltage is too high or control card is mis-adjusted.	This status code will be displayed when the battery volts are greater than 2.4 volts per cell at initial key switch on. See table below.
MEMORY RECALL **NO**	**CORRECTIVE ACTIONS**	**TROUBLE-SHOOTING DIAGRAM**
Circuits valid for Traction Controller	**SYMPTOM** Forward and reverse contactor will not pick up. **POSSIBLE CAUSE** **Incorrect control card adjustment** • Check Function 15 for proper adjustment for battery being used. See Handset instructions for details. Adjust to proper setting. **Battery over charged or incorrect battery used.** • Check battery for proper open circuit voltage as shown in SC 16 figure. If voltage is excessive, check battery charger for proper output voltage. **Check "maximum" battery volts at PB1 & NEG.**	 SC16

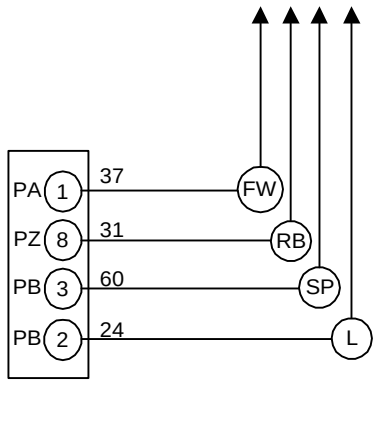
NOMINAL BATTERY VOLTS	MAXIMUM LIMIT VOLTS AT 2.40 VDC PER CELL
24	28.8
36	43.2
48	57.6
72	86.4
80	96.0

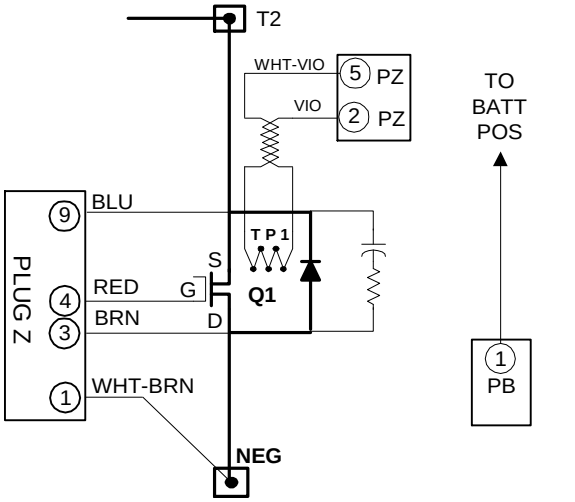
TRACTION STATUS CODE	DESCRIPTION OF STATUS	CAUSE OF STATUS INDICATION
-17	"Card Type" selection is invalid.	This status code will be displayed when the card type selection value is set to an invalid number.
MEMORY RECALL **NO**	**CORRECTIVE ACTIONS**	**TROUBLE-SHOOTING DIAGRAM**
Circuits valid for Traction Controller	**SYMPTOM** Forward or reverse contactors will not close. **POSSIBLE CAUSE** **Invalid card type selection.** • Review function 17 in the Handset Instruction sheets. Adjust and set card type value as instructed by OEM service manual. **Verify that the correct logic card catalog number is installed in the controller.**	

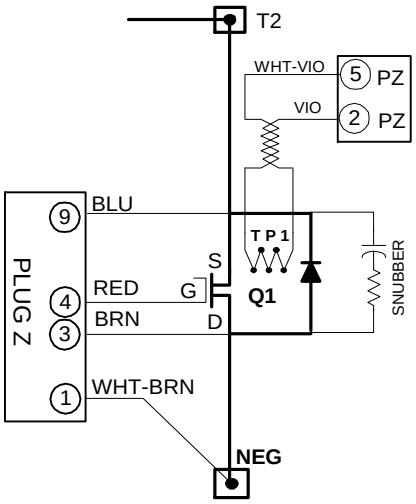
TRACTION STATUS CODE	DESCRIPTION OF STATUS	CAUSE OF STATUS INDICATION
-21	3-wire Accelerator input is less than 0.25 volts.	This status code will be displayed when TB1 voltage is less than 0.25 volts.
MEMORY RECALL **NO**	**CORRECTIVE ACTIONS**	**TROUBLE-SHOOTING DIAGRAM**
Circuits valid for Traction Controller	**SYMPTOM** Controller will not operate. **POSSIBLE CAUSE** **Accelerator potentiometer needs adjustment or is damaged.** • Input voltage at TB1 must be greater than 0.25 volts when the accelerator pedal is fully released. **Short-circuit between battery negative and TB1 in accelerator input circuit.** • Disconnect wire from TB1 and check for short-circuit from end of wire to battery NEG. Resistance must be greater than 4.7 K ohms. **Open-circuit between accelerator potentiometer and PZ6.** • Make sure +4.5 volts is present from PZ6 to accelerator.	

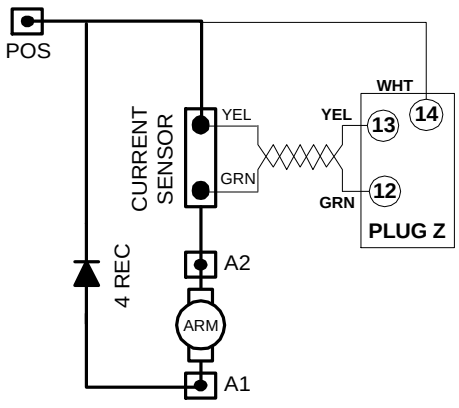
TRACTION STATUS CODE	DESCRIPTION OF STATUS	CAUSE OF STATUS INDICATION
-23	Forward and reverse contactor coil current is low.	This status code will be displayed when the current draw in the forward or reverse contactor coil circuit is less than 100 milliamps & T2 volts is <88% of Bat volts.
MEMORY RECALL **NO**	**CORRECTIVE ACTIONS**	**TROUBLE-SHOOTING DIAGRAM**
Circuits valid for Traction Controller	**SYMPTOM** Forward or reverse contactor will not pick up. Status code may alternate between code 23 and code 24. Complete check for code 23, if the problem is not found, perform check for code 24. **POSSIBLE CAUSE** **Defective F and R contactor coil circuit.** • Check for open circuit or loose connection between PB4 and positive side of F contactor coil and between PB5 and positive side of R contactor coil. • Remove plug B. Check ohmic value from PB4 to positive side of F coil. Value should be 10 to 14 ohms. Make same check for R coil. **Defective 1A, FW, RB, L1, or SP contactor coil.** • Remove plug B. Check ohmic value from positive side of each coil to its respective plug connection. Value should be 10 to 14 ohms.	 SC23

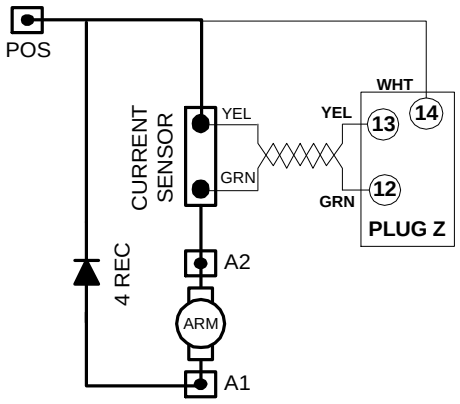
TRACTION STATUS CODE	DESCRIPTION OF STATUS	CAUSE OF STATUS INDICATION
-24	T2 voltage is low. (Less than 88% battery voltage.)	This status code will be displayed when T2 volts is less than 88% of battery volts and the “F” & “R” driver is energized.
MEMORY RECALL **NO**	**CORRECTIVE ACTIONS**	**TROUBLE-SHOOTING DIAGRAM**
Circuits valid for Traction Controller	**SYMPTOM** Control does not operate. Status code may alternate between code 23 and code 24. Complete checks for 24, if the problem is not found, perform code 23 check. **POSSIBLE CAUSE** **Defective F or R contactor.** • F or R power tips fail to close because: 1) Welded normally closed power tips. 2) Binding contactor tip assembly. 3) Defective F or R contactor coil. (See status code 23) **“RB” contactor (if applicable) failed to close.** **Open motor circuit** • Check for open circuit or loose connection in motor circuit from the A1 connection to the A2 connection on the control panel.	 SC24

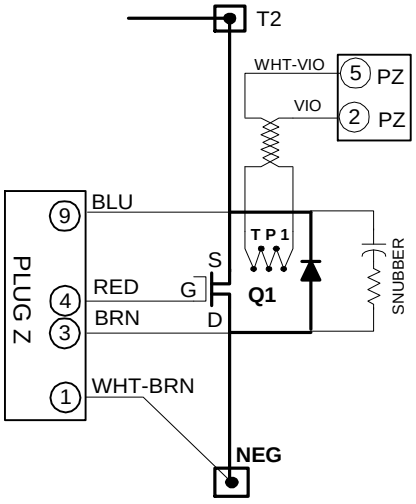
TRACTION STATUS CODE	DESCRIPTION OF STATUS	CAUSE OF STATUS INDICATION
-26	Shorted coil driver for SP, RB, L, or FW contactors.	This status code will be displayed when there is a shorted SP, RB, L, or FW coil driver.
MEMORY RECALL **NO**	**CORRECTIVE ACTIONS**	**TROUBLE-SHOOTING DIAGRAM**
Circuits valid for Traction Controller	**SYMPTOM** SP, RB, L, or FW contactor picks up immediately when key switch is closed. **POSSIBLE CAUSE** **Defective coil driver internal to logic card.** • Replace logic card.	

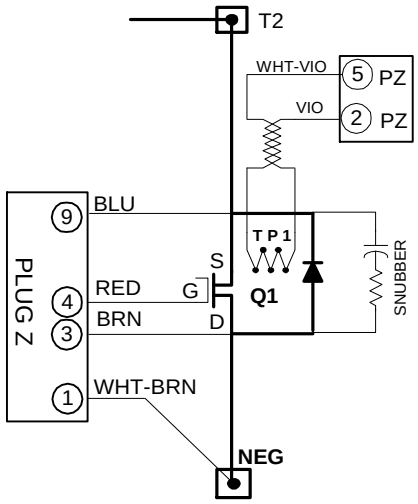
TRACTION STATUS CODE	DESCRIPTION OF STATUS	CAUSE OF STATUS INDICATION
-27	Logic card power supply is less than 10 Volts DC.	This status code will be displayed when the logic card power supply is less than 10 volts.
MEMORY RECALL **YES**	**CORRECTIVE ACTIONS**	**TROUBLE-SHOOTING DIAGRAM**
Circuits valid for Traction Controller	**SYMPTOM** Forward or reverse contactors close and open, then can only be closed by opening and closing the key switch. **POSSIBLE CAUSE** **Discharged Battery** • Check battery to insure proper state of charge. Voltage may be dropping below 10 Volts DC under load. **Loose connection at PB1.** • Insure that the wire connection at PB1 is tight. **Defective logic card** • Replace logic card. **Defective Q1 Power Transistor.** • Measure for low resistance (<200 ohms) at PZ4 to NEG.	

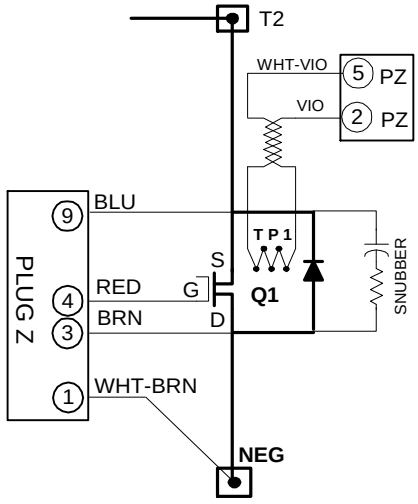
TRACTION STATUS CODE	DESCRIPTION OF STATUS	CAUSE OF STATUS INDICATION
-41	Open thermal protector (TP) or transistor over temperature.	This status code will be displayed when the voltage between PZ2 and PZ5 is greater than 0.8 volts.
MEMORY RECALL **NO**	**CORRECTIVE ACTIONS**	**TROUBLE-SHOOTING DIAGRAM**
Circuits valid for Traction Controller	**SYMPTOM** Reduced or no power to traction motor in control range. **POSSIBLE CAUSE** **Control is in thermal cut-back.** • Allow control to cool, status code should disappear. **Open thermal protector circuit.** • Check for loose connection or broken wire between: - WHT/VIO wire-Thermal protector and PZ5 - VIO wire-Thermal protector and PZ2. **Defective thermal protector.** • Disconnect wires from PZ2 and PZ5. At room temperature (25° C or 75° F) measure resistance between WHT/VIO and VIO wire. Replace Q1 if ohmic value is greater than 1200 ohms.	 SC41

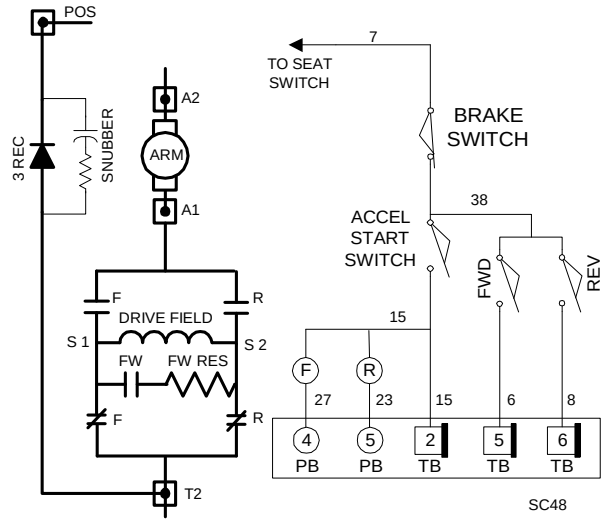
TRACTION STATUS CODE	DESCRIPTION OF STATUS	CAUSE OF STATUS INDICATION
-42	Controller “motor current sensor” input is missing (PZ12 - Green).	This status code will be displayed when the voltage between PZ12 & PZ13 is greater than 0.1 volts with no current flowing in the motor circuit.
MEMORY RECALL **NO**	**CORRECTIVE ACTIONS**	**TROUBLE-SHOOTING DIAGRAM**
Circuits valid for Traction Controller	**SYMPTOM** No power to traction motor in control range. **POSSIBLE CAUSE** **Open sensor wire circuit to PZ12 .** • Check for loose connection or broken wire (green wire) from current sensor to PZ12 on the logic card.	 SC42

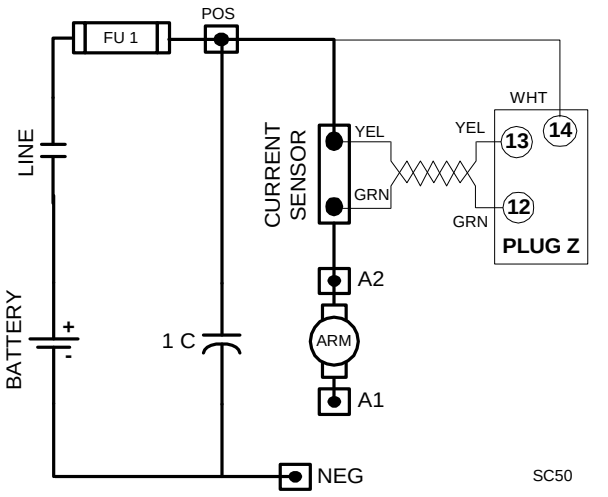
TRACTION STATUS CODE	DESCRIPTION OF STATUS	CAUSE OF STATUS INDICATION
-43	Controller "motor current sensor" input is missing (PZ13 - Yellow).	This status code will be displayed when the voltage between PZ12 & PZ13 is greater than 0.1 volts with no current flowing in the motor circuit.
MEMORY RECALL **NO**	**CORRECTIVE ACTIONS**	**TROUBLE-SHOOTING DIAGRAM**
Circuits valid for Traction Controller	**SYMPTOM** No power to traction motor in control range. **POSSIBLE CAUSE** **Open sensor wire circuit to PZ13 .** • Check for loose connection or broken wire (yellow wire) from current sensor to PZ13 on the logic card.	 SC43

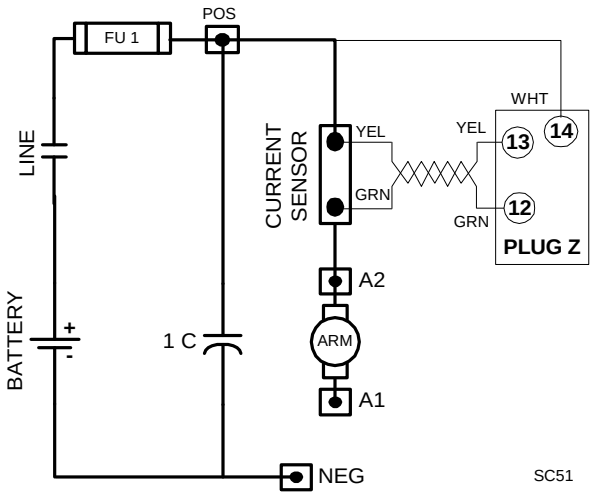
TRACTION STATUS CODE	DESCRIPTION OF STATUS	CAUSE OF STATUS INDICATION
-44	Power Transistor (Q1) did not turn off properly.	This status code will be displayed when, during control operation, the transistor fails to turn off. This will result in a PMT condition.
MEMORY RECALL **YES**	**CORRECTIVE ACTIONS**	**TROUBLE-SHOOTING DIAGRAM**
Circuits valid for Traction Controller	**SYMPTOM** Forward or reverse contactors close and open, then can only be closed by opening and closing the key switch. **POSSIBLE CAUSE** **Defective Q1 power transistor.** • Turn off time for transistor is out of specification. No field test is possible. Replace transistor. • Check for open circuit or loose connections between the transistor and PZ4 (red wire).	 SC44

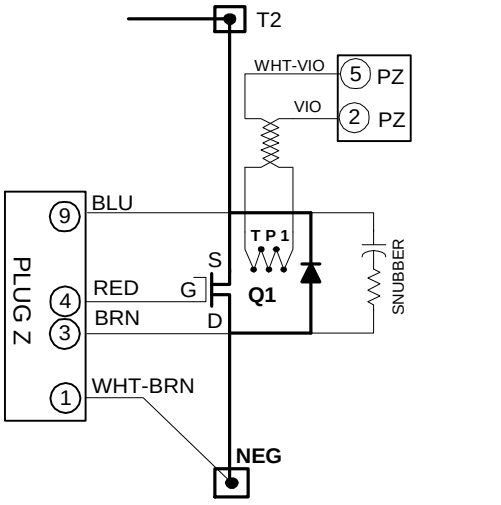
TRACTION STATUS CODE	DESCRIPTION OF STATUS	CAUSE OF STATUS INDICATION
-45	Power Transistor (Q1) did not turn on properly.	This status code will be displayed when the Power Transistor fails to gate "on".
MEMORY RECALL **YES**	**CORRECTIVE ACTIONS**	**TROUBLE-SHOOTING DIAGRAM**
Circuits valid for Traction Controller	**SYMPTOM** Forward or reverse contactor will close and open, and then can only be closed by opening and closing the key switch. **POSSIBLE CAUSE** **Defective transistor circuit.** • Check for open circuit or loose connections between the transistor and PZ4 (red wire). • Check for open circuit or loose connection between T2 and PZ9 (blue wire). **Defective Q1 power transistor.** • Intermittent or open transistor gate. Field test may or may not show defect. Replace transistor after above checks show no problem found.	 SC45

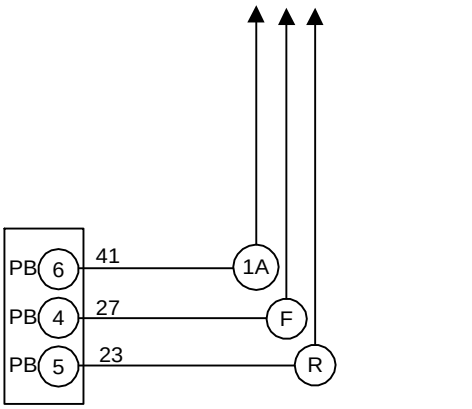
TRACTION STATUS CODE	DESCRIPTION OF STATUS	CAUSE OF STATUS INDICATION
-46	"Look Ahead" test for T2 volts less than 12% of battery volts.	This status code will be displayed when the voltage at T2 is less than 12% of battery volts.
MEMORY RECALL **NO**	**CORRECTIVE ACTIONS**	**TROUBLE-SHOOTING DIAGRAM**
Circuits valid for Traction Controller	**SYMPTOM** Forward or reverse contactor will not pick up. **POSSIBLE CAUSE** **Defective Q1 power transistor.** • Check for shorted transistor. **Defective 1A contactor.** • Check for welded 1A contactor power tips. **Defective snubber.** • Check for shorted snubber.	 SC46

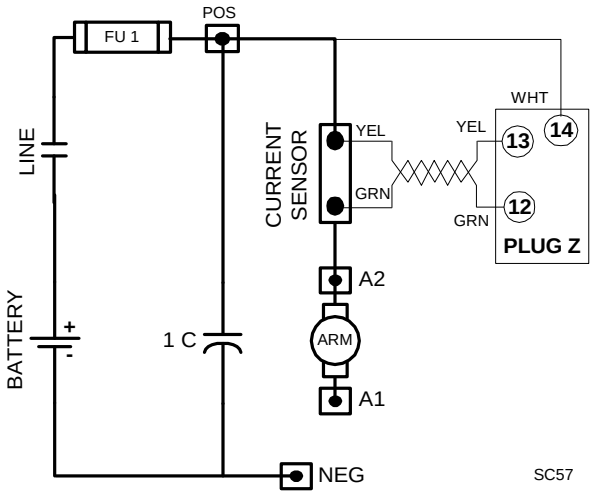
TRACTION STATUS CODE	DESCRIPTION OF STATUS	CAUSE OF STATUS INDICATION
-48	"Look Ahead" test for T2 volts greater than 88% of battery volts.	This status code will be displayed when the voltage at T2 is greater than 88% of battery volts.
MEMORY RECALL **NO**	**CORRECTIVE ACTIONS**	**TROUBLE-SHOOTING DIAGRAM**
Circuits valid for Traction Controller	**SYMPTOM** Forward or reverse contactor will not pick up. **POSSIBLE CAUSE** **Defective forward or reverse contactor.** • Check for welded forward or reverse contactor power tips. • Check for sluggish operation of forward or reverse contactor. **Defective 3 REC circuit.** • Check for shorted 3 REC.	

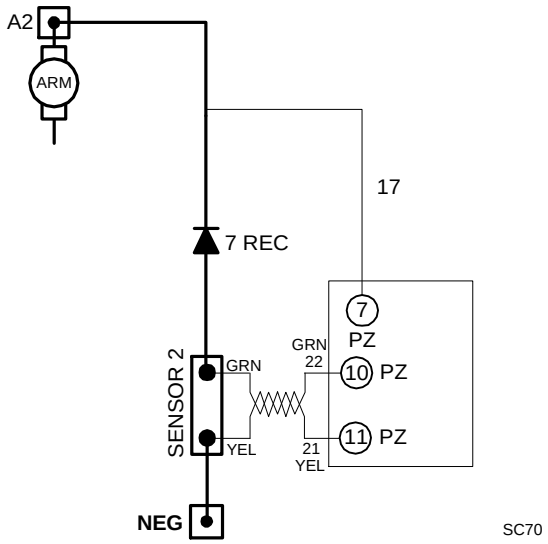
TRACTION STATUS CODE	DESCRIPTION OF STATUS	CAUSE OF STATUS INDICATION
-50	Capacitor volts low after line contactor closes.	This status code will be displayed when the capacitor volts is less than 85% of battery volts during the run mode.
MEMORY RECALL **NO**	**CORRECTIVE ACTIONS**	**TROUBLE-SHOOTING DIAGRAM**
Circuits valid for Traction Controller	**SYMPTOM** Forward or reverse contactor picks up. Control does not operate. **POSSIBLE CAUSE** **Defective Line contactor.** • Check for open line contactor power tips. • Check for loose or open connections in cables from battery positive to control positive circuit. **Defective Power fuse.** • Check power fuse for open circuit. **No battery voltage at PZ14.** • Check for battery voltage at POS and PZ14. • Check for loose connection at PZ14 (white wire).	

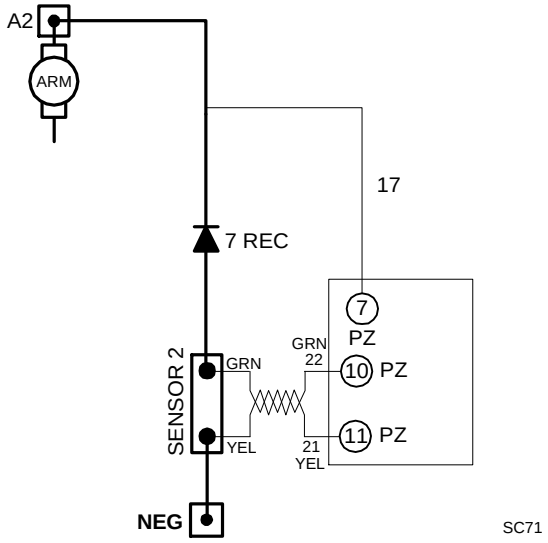
TRACTION STATUS CODE	DESCRIPTION OF STATUS	CAUSE OF STATUS INDICATION
-51	Capacitor volts are low before the line contactor closes (internal card function during precharge).	This status code will be displayed during "key on" when the capacitor volts is less than 85% of battery volts at initial key switch on.
MEMORY RECALL **NO**	**CORRECTIVE ACTIONS**	**TROUBLE-SHOOTING DIAGRAM**
Circuits valid for Traction Controller	**SYMPTOM** Line contactor does not close when Capacitor does not precharge. **POSSIBLE CAUSE** **Defective capacitor.** • Check capacitor bank per component checking section. • Check for loose or open connections in capacitor circuit. **Defective control fuse for PB1 input.** • Check control fuse for open circuit. **Defective logic card** • Replace logic card. **Defective Q1 power transistor.** • Check transistor Q1 for shorted condition and replace if necessary. **Note:** Repeated "charging/discharging" the capacitors during trouble shooting will cause status code -51. Also, "do not" connect **any** loads to the load side of the Line Contactor.	

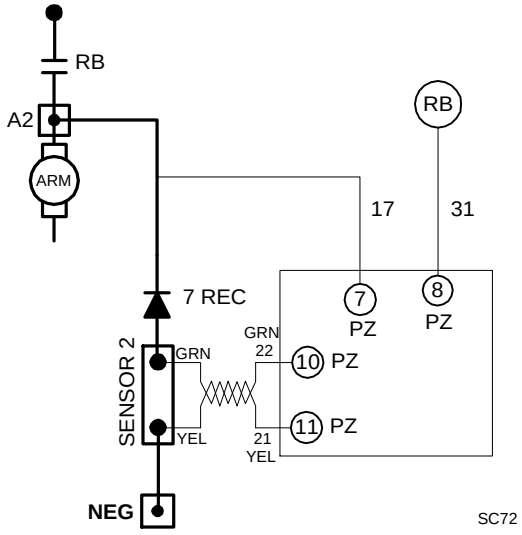
TRACTION STATUS CODE	DESCRIPTION OF STATUS	CAUSE OF STATUS INDICATION
-53	Power Transistor fails to turn off during plugging operation.	This status code will be displayed when the transistor fails to turn off while plugging. This will result in a PMT condition.
MEMORY RECALL **YES**	**CORRECTIVE ACTIONS**	**TROUBLE-SHOOTING DIAGRAM**
Circuits valid for Traction Controller	**SYMPTOM** Forward or reverse contactors close and open, then can only be closed by opening and closing the key switch. **POSSIBLE CAUSE** **Defective Q1 power transistor.** • Turn off time for transistor is out of specification. No field test is possible. Replace transistor. • Check for open circuit or loose connections between the transistor and PZ4 (red wire)	

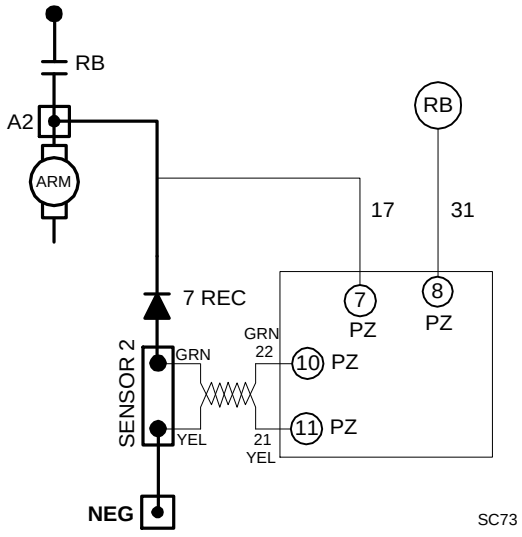
TRACTION STATUS CODE	DESCRIPTION OF STATUS	CAUSE OF STATUS INDICATION
-54	Shorted F, R, or 1A contactor coil driver on the logic card.	This status code will be displayed when any of the Forward, Reverse or 1A contactor coil driver(s) is shorted internal to the logic card.
MEMORY RECALL **NO**	**CORRECTIVE ACTIONS**	**TROUBLE-SHOOTING DIAGRAM**
Circuits valid for Traction Controller	**SYMPTOM** Control will not operate. **POSSIBLE CAUSE** **Defective logic card.** • Replace logic card.	 SC54

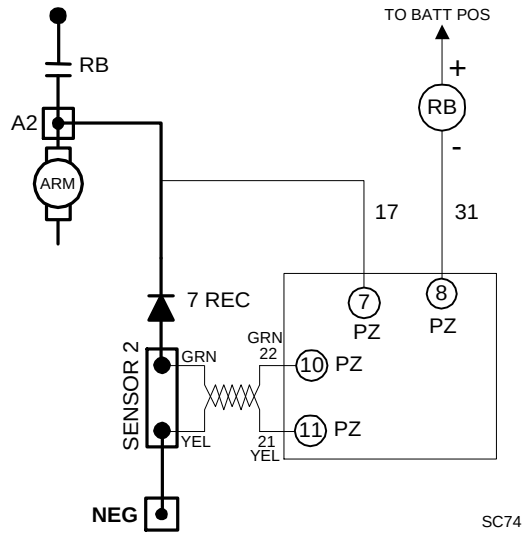
TRACTION STATUS CODE	DESCRIPTION OF STATUS	CAUSE OF STATUS INDICATION
-57	Controller “motor current sensor” input voltage polarity check.	This status code will be displayed when the voltage input to PZ13 and PZ12 is the wrong polarity.
MEMORY RECALL **YES**	**CORRECTIVE ACTIONS**	**TROUBLE-SHOOTING DIAGRAM**
Circuits valid for Traction Controller	**SYMPTOM** Forward or reverse contactors close and open, then can only be closed by opening and closing the key switch. **POSSIBLE CAUSE** **Reversed yellow and green current sensor wires.** • Insure that the green wire connects to PZ12 with no open circuits and that the yellow wire connects to PZ13 with no open circuits or loose connections. **Reversed power cable connection.** • Insure that the battery positive cable connects to control POS and the motor A2 cable connects to control A2. **Line contactor tips open during run mode.** • Check contactor operation and contactor tips.	 SC57

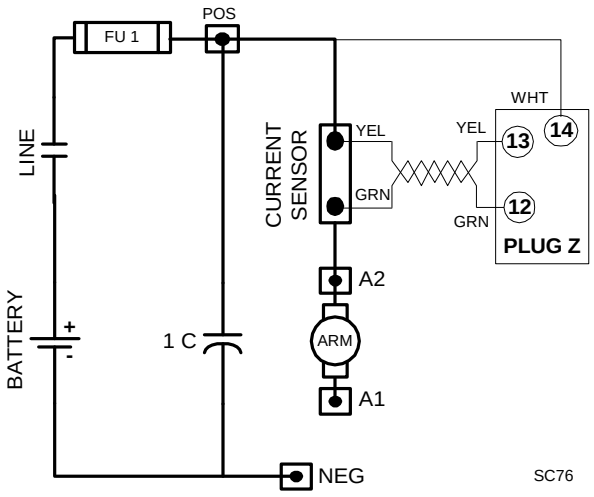
TRACTION STATUS CODE	DESCRIPTION OF STATUS	CAUSE OF STATUS INDICATION
-70	Regen current sensor input missing (green wire).	This status code will be displayed when the input signal at PZ10 is missing.
MEMORY RECALL **YES**	**CORRECTIVE ACTIONS**	**TROUBLE-SHOOTING DIAGRAM**
Circuits valid for Traction Controller	**SYMPTOM** Control does not operate. **POSSIBLE CAUSE** **Defective regen sensor input circuit.** • Check green sensor wire for open circuit or loose connection between sensor (welded connection) and PZ10.	

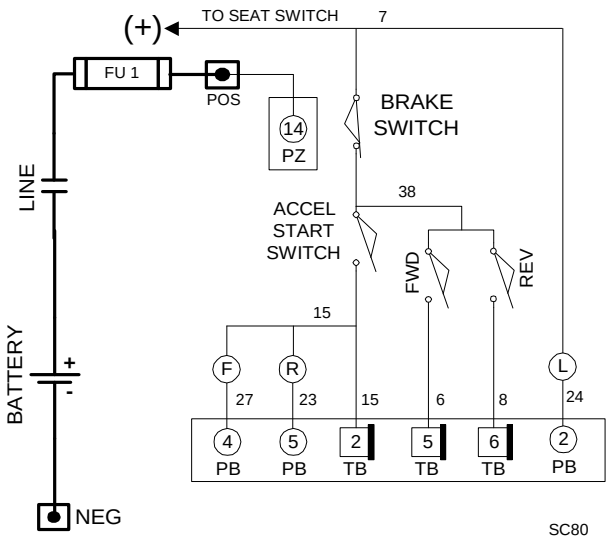
TRACTION STATUS CODE	DESCRIPTION OF STATUS	CAUSE OF STATUS INDICATION
-71	Regen current sensor input missing (yellow wire).	This status code will be displayed when the input signal at PZ11 is missing.
MEMORY RECALL **YES**	**CORRECTIVE ACTIONS**	**TROUBLE-SHOOTING DIAGRAM**
Circuits valid for Traction Controller	**SYMPTOM** Control does not operate. **POSSIBLE CAUSE** **Defective regen sensor input circuit.** • Check yellow sensor wire for open circuit or loose connection between sensor (welded connection) and PZ11.	

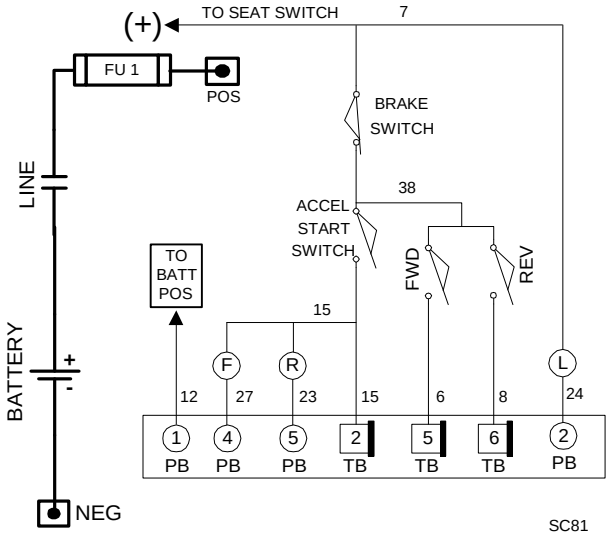
TRACTION STATUS CODE	DESCRIPTION OF STATUS	CAUSE OF STATUS INDICATION
-72	Regen contactor (RB) does not pick up.	This status code will be displayed when the logic card is in the run mode and less than 50% battery volts at PZ7.
MEMORY RECALL **YES**	**CORRECTIVE ACTIONS**	**TROUBLE-SHOOTING DIAGRAM**
Circuits valid for Traction Controller	**SYMPTOM** Regen contactor does not operate. **POSSIBLE CAUSE** **Open connection in the PZ7 circuit.** • Check for open circuit or loose connection between PZ7 and the A2 connection of the controller. • Check for open circuit or loose connection between 7 REC and the A2 connection of the controller.	

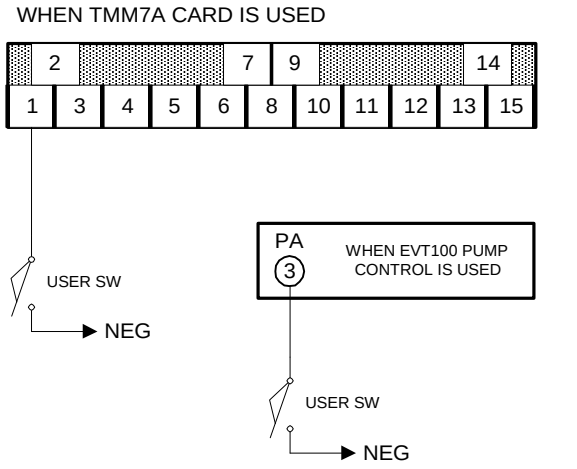
TRACTION STATUS CODE	DESCRIPTION OF STATUS	CAUSE OF STATUS INDICATION
-73	Regen contactor (RB) does not drop out or drops out slowly.	This status code will be displayed when the RB contactor power tips fail to open after 100 milliseconds after power is removed from the RB contactor coil.
MEMORY RECALL **YES**	**CORRECTIVE ACTIONS**	**TROUBLE-SHOOTING DIAGRAM**
Circuits valid for Traction Controller	**SYMPTOM** Forward or reverse contactor close and open, then opens and can only close by opening and closing the key switch. **POSSIBLE CAUSE** **Defective RB contactor.** • Check RB contactor for smoothness of operation and excessive wear on moving parts. **Short circuit to positive at PZ7 input.** • Check for short circuit between PZ7 and battery positive.	

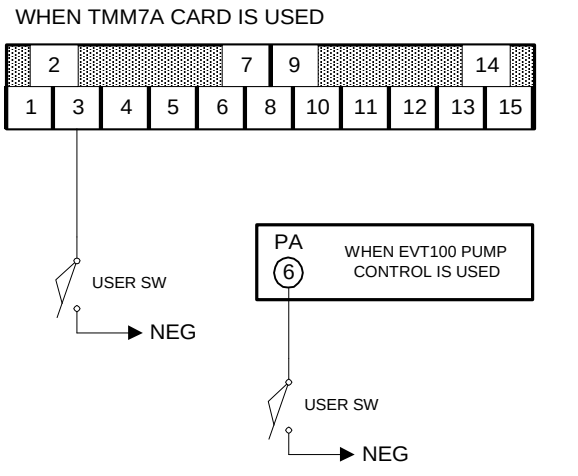
TRACTION STATUS CODE	DESCRIPTION OF STATUS	CAUSE OF STATUS INDICATION
-74	Regen contactor (RB) picks up too slowly.	This status code will be displayed when the RB contactor power tips do not close within 100 milliseconds after power is applied to the RB contactor coil.
MEMORY RECALL **YES**	**CORRECTIVE ACTIONS**	**TROUBLE-SHOOTING DIAGRAM**
Circuits valid for Traction Controller	**SYMPTOM** Forward or reverse contactor close and open, then opens and can only close by opening and closing the key switch. **POSSIBLE CAUSE** **Defective RB contactor.** • Check RB contactor for smoothness of operation and excessive wear on moving parts. **Intermittent PZ7 input.** • Check for loose connections in PZ7 circuit from PZ7 to RB contactor A2 connection. **Defective RB contactor coil circuit.** • Check RB contactor coil for proper ohmic value. It should be 10-14 ohms. • Check coil connection from PZ8 to RB coil (-) for loose connection. • Check coil connection from battery positive to RB coil (+) for loose connection.	

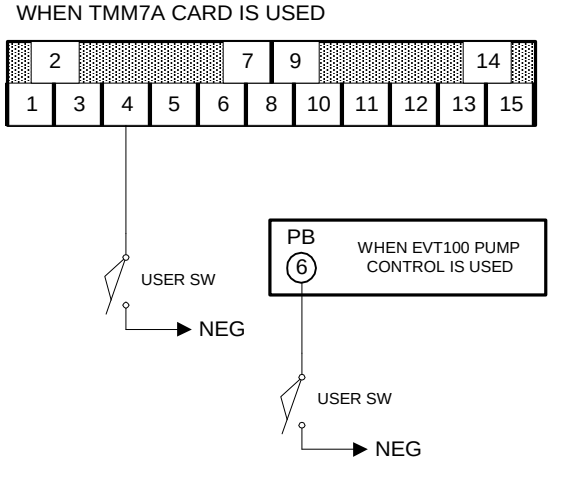
TRACTION STATUS CODE	DESCRIPTION OF STATUS	CAUSE OF STATUS INDICATION
-76	Capacitor (1C) voltage too high.	This status code will be displayed when the voltage on the capacitor goes above 96 volts during the regenerative braking cycle.
MEMORY RECALL **YES**	**CORRECTIVE ACTIONS**	**TROUBLE-SHOOTING DIAGRAM**
Circuits valid for Traction Controller	**SYMPTOM** Forward or reverse contactor close and open, then opens and can only close by opening and closing the key switch. **POSSIBLE CAUSE** • Unplugging the battery connector during regenerative braking. • Line contactor bouncing open during regen. • Main power fuse opening during regen. • Intermittent battery plug connection.	

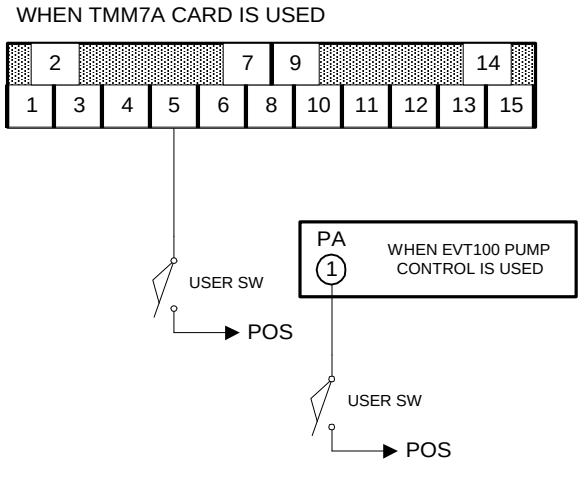
TRACTION STATUS CODE	DESCRIPTION OF STATUS	CAUSE OF STATUS INDICATION
-80	Voltage at capacitor (1C) is less than 14 volts.	This status code will be displayed when the voltage at PZ14 is less than 14 volts. This occurs typically in the run mode of operation.
MEMORY RECALL **YES**	**CORRECTIVE ACTIONS**	**TROUBLE-SHOOTING DIAGRAM**
Circuits valid for Traction Controller	**SYMPTOM** Forward or reverse contactor will not pick up. **POSSIBLE CAUSE** **Line Contactor opened up during run.** • Check connection from PB2 to L coil (-) for loose connection. • Check connection from battery (+) to L coil (+) for loose connection. • Check power connection from battery (+) to contactor L. • Check FU1 and FU3 for blown element.	

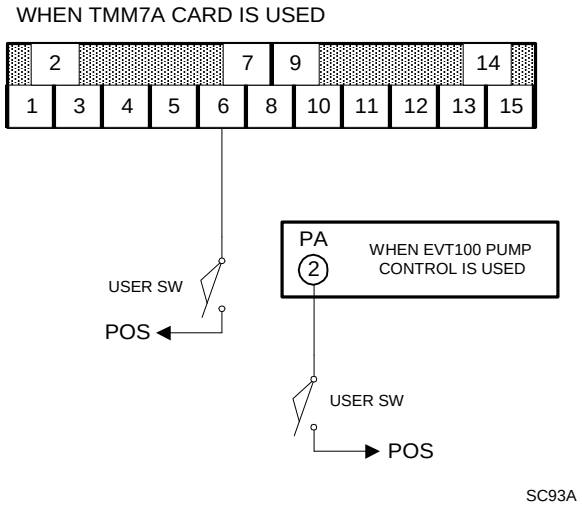
TRACTION STATUS CODE	DESCRIPTION OF STATUS	CAUSE OF STATUS INDICATION
-81	Battery voltage is less than 14 volts.	This status code will be displayed when the battery voltage measured at PB1 is less than 14 volts.
MEMORY RECALL **YES**	**CORRECTIVE ACTIONS**	**TROUBLE-SHOOTING DIAGRAM**
Circuits valid for Traction Controller	**SYMPTOM** Forward or reverse contactor will not pick up. **POSSIBLE CAUSE** **Line Contactor opened up during run.** • Check connection from PB2 to L coil (-) for loose connection. • Check connection from battery (+) to L coil (+) for loose connection. • Check power connection from battery (+) to contactor L. • Check FU1 and FU3 for blown element.	

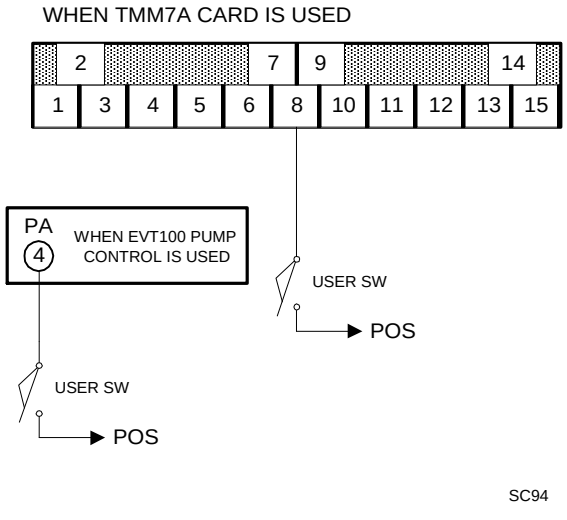
TRACTION STATUS CODE	DESCRIPTION OF STATUS	CAUSE OF STATUS INDICATION
-90	**USER DEFINED STATUS CODE** See Instructions for Truck Management Module for details.	This status code will be displayed when the voltage at the respective terminal of the TMM or Pump Logic Card is at zero volts.
MEMORY RECALL **NO**	**CORRECTIVE ACTIONS**	**TROUBLE-SHOOTING DIAGRAM**
Circuits valid for Traction Controller & Pump Controller	**SYMPTOM** Status Code flashes "on and off". **POSSIBLE CAUSE** **User defined status code is displayed by switch closure or motor brush sensor closure to Negative.** • See GEH-TMM7A Truck Management Module Instructions for OEM Defined Status Codes for complete corrective action required. **Other causes for status code:** • Terminal 1 (TMM7A) is shorted to Negative. • Plug PA3 (Pump) is shorted to Negative. • Defective input switch (shorted). • Defective TMM card. • Defective Pump card.	

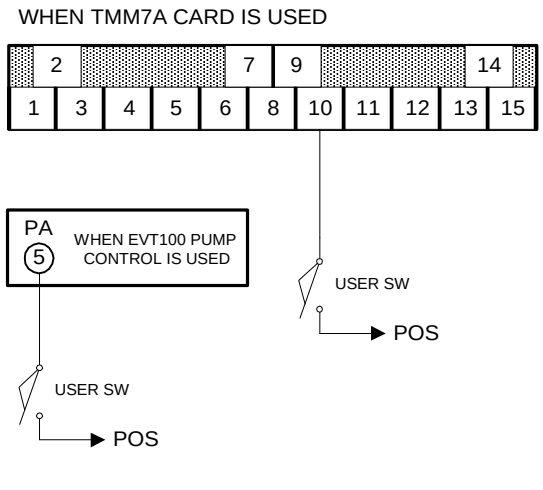
TRACTION STATUS CODE	DESCRIPTION OF STATUS	CAUSE OF STATUS INDICATION
-91	**USER DEFINED STATUS CODE** See Instructions for Truck Management Module for details.	This status code will be displayed when the voltage at the respective terminal of the TMM or Pump Logic Card is at zero volts.
MEMORY RECALL **NO**	**CORRECTIVE ACTIONS**	**TROUBLE-SHOOTING DIAGRAM**
Circuits valid for Traction Controller & Pump Controller	**SYMPTOM** Status Code flashes "on and off". **POSSIBLE CAUSE** **User defined status code is displayed by switch closure or motor brush sensor closure to Negative.** • See GEH-TMM7A Truck Management Module Instructions for OEM Defined Status Codes for complete corrective action required. **Other causes for status code:** • Terminal 3 (TMM7A) is shorted to Negative. • Plug PA6 (Pump) is shorted to Negative. • Defective input switch (shorted). • Defective TMM card. • Defective Pump card.	

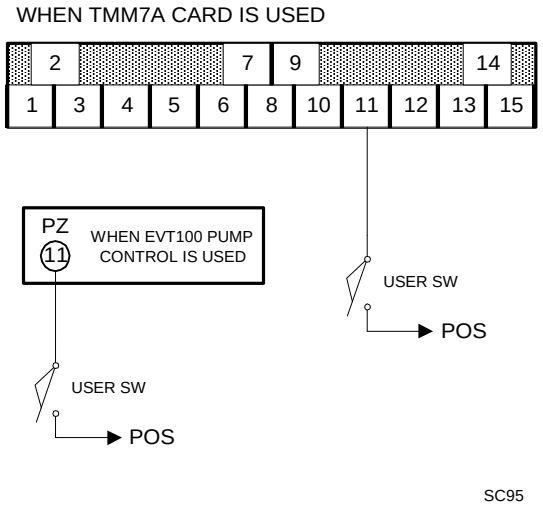
TRACTION STATUS CODE	DESCRIPTION OF STATUS	CAUSE OF STATUS INDICATION
-92	**USER DEFINED STATUS CODE** See Instructions for Truck Management Module for details.	This status code will be displayed when the voltage at the respective terminal of the TMM or Pump Logic Card is at zero volts.
MEMORY RECALL **NO**	**CORRECTIVE ACTIONS**	**TROUBLE-SHOOTING DIAGRAM**
Circuits valid for Traction Controller & Pump Controller	**SYMPTOM** Status Code flashes "on and off". **POSSIBLE CAUSE** **User defined status code is displayed by switch closure or motor brush sensor closure to Negative.** • See GEH-TMM7A Truck Management Module Instructions for OEM Defined Status Codes for complete corrective action required. **Other causes for status code:** • Terminal 4 (TMM7A) is shorted to Negative. • Plug PB6 (Pump) is shorted to Negative. • Defective input switch (shorted). • Defective TMM card. • Defective Pump card.	 SC92

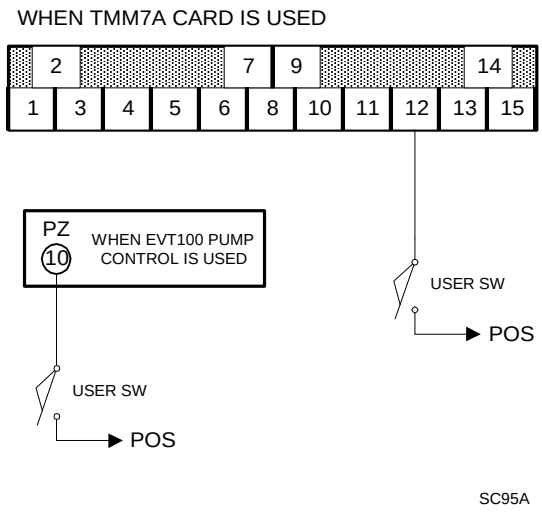
TRACTION STATUS CODE	DESCRIPTION OF STATUS	CAUSE OF STATUS INDICATION
-93	**USER DEFINED STATUS CODE** See Instructions for Truck Management Module for details.	This status code will be displayed when the voltage at the respective terminal of the TMM or Pump Logic Card is at battery volts.
MEMORY RECALL **NO**	**CORRECTIVE ACTIONS**	**TROUBLE-SHOOTING DIAGRAM**
Circuits valid for Traction Controller & Pump Controller	**SYMPTOM** Status Code flashes "on and off". **POSSIBLE CAUSE** **User defined status code is displayed by switch closure or motor brush sensor closure to Positive.** • See GEH-TMM7A Truck Management Module Instructions for OEM Defined Status Codes for complete corrective action required. **Other causes for status code:** • Terminal 5 (TMM7A) is shorted to Positive. • Plug PA1 (Pump) is shorted to Positive. • Defective input switch (shorted). • Defective TMM card. • Defective Pump card.	 SC93

TRACTION STATUS CODE	DESCRIPTION OF STATUS	CAUSE OF STATUS INDICATION
-93	**USER DEFINED STATUS CODE** See Instructions for Truck Management Module for details.	This status code will be displayed when the voltage at the respective terminal of the TMM or Pump Logic Card is at battery volts.
MEMORY RECALL **NO**	**CORRECTIVE ACTIONS**	**TROUBLE-SHOOTING DIAGRAM**
Circuits valid for Traction Controller & Pump Controller	**SYMPTOM** Status Code flashes "on and off". **POSSIBLE CAUSE** **User defined status code is displayed by switch closure or motor brush sensor closure to Positive.** • See GEH-TMM7A Truck Management Module Instructions for OEM Defined Status Codes for complete corrective action required. **Other causes for status code:** • Terminal 6 (TMM7A) is shorted to Positive. • Plug PA2 (Pump) is shorted to Positive. • Defective input switch (shorted). • Defective TMM card. • Defective Pump card.	

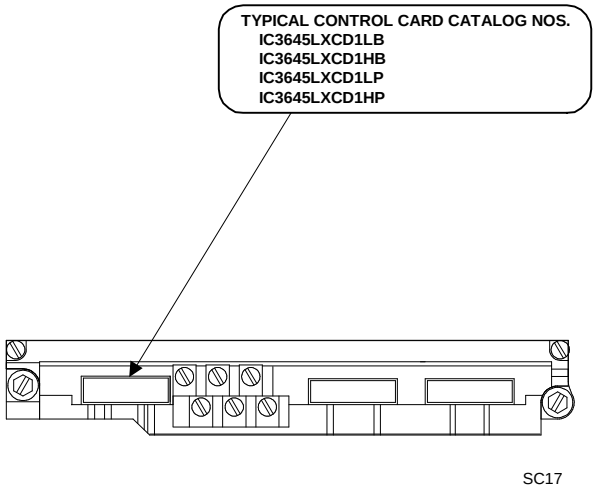
TRACTION STATUS CODE	DESCRIPTION OF STATUS	CAUSE OF STATUS INDICATION
-94	**USER DEFINED STATUS CODE** See Instructions for Truck Management Module for details.	This status code will be displayed when the voltage at the respective terminal of the TMM or Pump Logic Card is at battery volts.
MEMORY RECALL **NO**	**CORRECTIVE ACTIONS**	**TROUBLE-SHOOTING DIAGRAM**
Circuits valid for Traction Controller & Pump Controller	**SYMPTOM** Status Code flashes "on and off". **POSSIBLE CAUSE** **User defined status code is displayed by switch closure or motor brush sensor closure to Positive.** • See GEH-TMM7A Truck Management Module Instructions for OEM Defined Status Codes for complete corrective action required. **Other causes for status code:** • Terminal 8 (TMM7A) is shorted to Positive. • Plug PA4 (Pump) is shorted to Positive. • Defective input switch (shorted). • Defective TMM card. • Defective Pump card.	

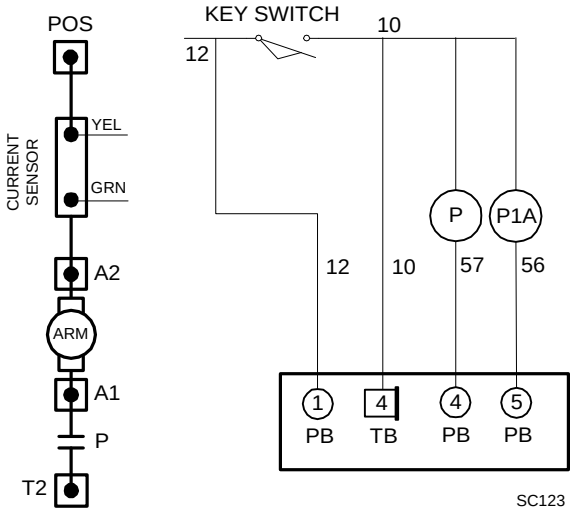
TRACTION STATUS CODE	DESCRIPTION OF STATUS	CAUSE OF STATUS INDICATION
-94	**USER DEFINED STATUS CODE** See Instructions for Truck Management Module for details.	This status code will be displayed when the voltage at the respective terminal of the TMM or Pump Logic Card is at battery volts.
MEMORY RECALL **NO**	**CORRECTIVE ACTIONS**	**TROUBLE-SHOOTING DIAGRAM**
Circuits valid for Traction Controller & Pump Controller	**SYMPTOM** Status Code flashes "on and off". **POSSIBLE CAUSE** **User defined status code is displayed by switch closure or motor brush sensor closure to Positive.** • See GEH-TMM7A Truck Management Module Instructions for OEM Defined Status Codes for complete corrective action required. **Other causes for status code:** • Terminal 10 (TMM7A) is shorted to Positive. • Plug PA5 (Pump) is shorted to Positive. • Defective input switch (shorted). • Defective TMM card. • Defective Pump card.	

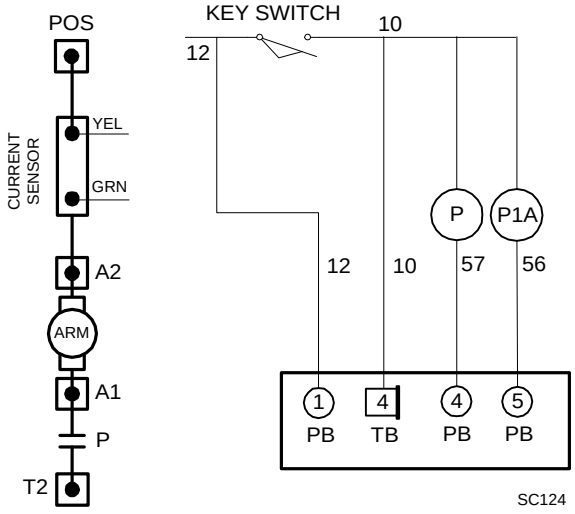
TRACTION STATUS CODE	DESCRIPTION OF STATUS	CAUSE OF STATUS INDICATION
-95	**USER DEFINED STATUS CODE** See Instructions for Truck Management Module for details.	This status code will be displayed when the voltage at the respective terminal of the TMM or Pump Logic Card is at battery volts.
MEMORY RECALL **NO**	**CORRECTIVE ACTIONS**	**TROUBLE-SHOOTING DIAGRAM**
Circuits valid for Traction Controller & Pump Controller	**SYMPTOM** Status Code flashes "on and off". **POSSIBLE CAUSE** **User defined status code is displayed by switch closure or motor brush sensor closure to Positive.** • See GEH-TMM7A Truck Management Module Instructions for OEM Defined Status Codes for complete corrective action required. **Other causes for status code:** • Terminal 11 (TMM7A) is shorted to Positive. • Plug PZ11 (Pump) is shorted to Positive. • Defective input switch (shorted). • Defective TMM card. • Defective Pump card.	

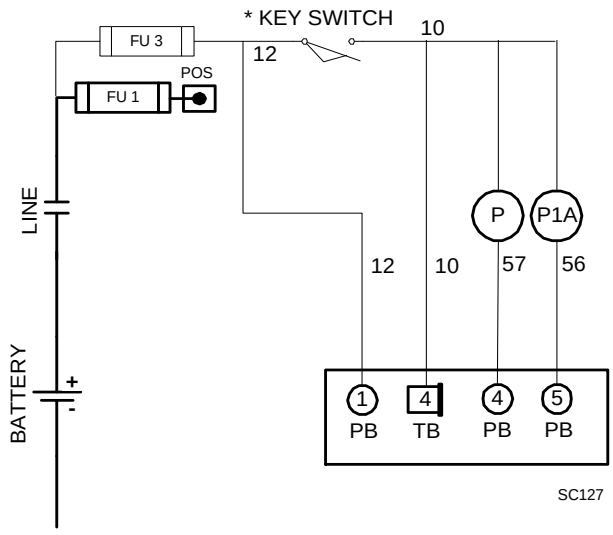
TRACTION STATUS CODE	DESCRIPTION OF STATUS	CAUSE OF STATUS INDICATION
-95	**USER DEFINED STATUS CODE** See Instructions for Truck Management Module for details.	This status code will be displayed when the voltage at the respective terminal of the TMM or Pump Logic Card is at battery volts.
MEMORY RECALL **NO**	**CORRECTIVE ACTIONS**	**TROUBLE-SHOOTING DIAGRAM**
Circuits valid for Traction Controller & Pump Controller	**SYMPTOM** Status Code flashes "on and off". **POSSIBLE CAUSE** **User defined status code is displayed by switch closure or motor brush sensor closure to Positive.** • See GEH-TMM7A Truck Management Module Instructions for OEM Defined Status Codes for complete corrective action required. **Other causes for status code:** • Terminal 12 (TMM7A) is shorted to Positive. • Plug PZ10 (Pump) is shorted to Positive. • Defective input switch (shorted). • Defective TMM card. • Defective Pump card.	

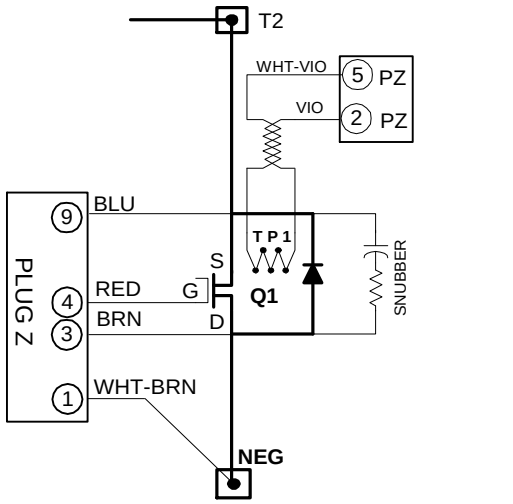
TRACTION STATUS CODE	DESCRIPTION OF STATUS	CAUSE OF STATUS INDICATION
-99	**USER DEFINED STATUS CODE** Maintenance Alert & Speed Limit.	This status code will be displayed when the "normal" hourmeter reading exceeds the "maintenance alert hours" setting for the truck.
MEMORY RECALL **NO**	**CORRECTIVE ACTIONS**	**TROUBLE-SHOOTING DIAGRAM**
Circuits valid for Traction Controller	**SYMPTOM** Status Code is displayed for 4-seconds when the key switch is first turned on, and/or the truck may run at a reduced speed. **CUSTOMER SELECTED SETTING WITH THE HANDSET:** **User defined status code is displayed when the normal hourmeter reading exceeds the programmed "maintenance alert hours" setting selected by the user.** • Maintenance Code Hourmeter, Function 19 & 20 are programmed with the Handset and command the display of status code -99. • If desired, Maintenance Code Speed Limit, Function 21 can be programmed with the Handset. User should perform desired maintenance function.	NO DIAGRAM USER SHOULD PERFORM THE DESIRED MAINTENANCE FUNCTION

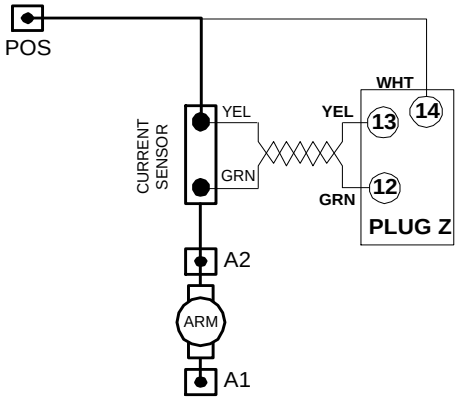
PUMP STATUS CODE	DESCRIPTION OF STATUS	CAUSE OF STATUS INDICATION
-117	"Card Type" selection is invalid.	This status code will be displayed when the card type selection value is set to an invalid number.
MEMORY RECALL **NO**	**CORRECTIVE ACTIONS**	**TROUBLE-SHOOTING DIAGRAM**
Circuits valid for Pump Controller	**SYMPTOM** Pump control will not operate. **POSSIBLE CAUSE** **Invalid card type selection.** • Review function 17 in the Handset Instruction sheets. Adjust and set card type value as instructed by OEM service manual. **Verify that the correct logic card catalog number is installed in the controller.**	

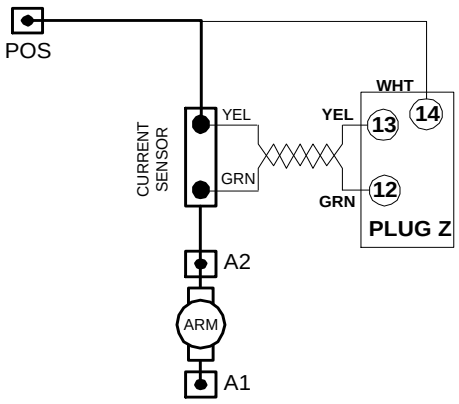
PUMP STATUS CODE	DESCRIPTION OF STATUS	CAUSE OF STATUS INDICATION
-123	Pump contactor coil current is low.	This status code will be displayed when the current draw in the pump contactor coil circuit is less than 100 milliamps and T2 is less than 88% of battery volts.
MEMORY RECALL **NO**	**CORRECTIVE ACTIONS**	**TROUBLE-SHOOTING DIAGRAM**
Circuits valid for Pump Controller	**SYMPTOM** Pump contactor will not pick up. Status code may alternate between code 123 and code 124. Complete check for code 123, if the problem is not found, perform check for code 124. **POSSIBLE CAUSE** **Defective Pump contactor coil circuit.** • Check for open circuit or loose connection between PB4 and positive side of P contactor coil. • Remove plug B. Check ohmic value from PB4 to positive side of P coil. Value should be between 10 and 14 ohms. **Defective P1A contactor coil.** • Remove plug B. Check ohmic value from positive side of coil to its plug connection. Value should be between 10 and 14 ohms.	

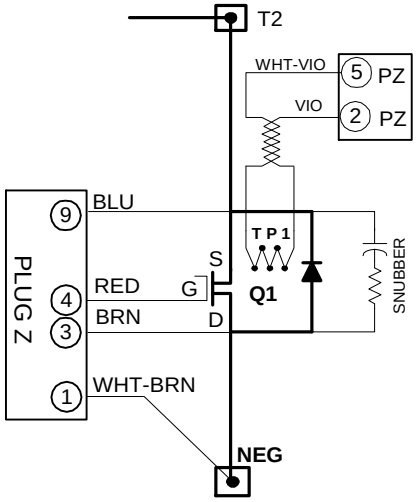
PUMP STATUS CODE	DESCRIPTION OF STATUS	CAUSE OF STATUS INDICATION
-124	T2 voltage is low. (Less than 88% of battery voltage.)	This status code is displayed when T2 voltage is less than 88% of battery volts and the Pump driver is energized.
MEMORY RECALL **NO**	**CORRECTIVE ACTIONS**	**TROUBLE-SHOOTING DIAGRAM**
Circuits valid for Pump Controller	**SYMPTOM** Control does not operate. Status code may alternate between code 123 and code 124. Complete checks for 124, if the problem is not found, perform code 123 check. **POSSIBLE CAUSE** **Defective Pump contactor.** Pump power tips fail to close because: 1) Binding contactor tip assembly. 2) Defective Pump contactor coil. (See status code 123) **Open motor circuit** • Check for open circuit or loose connection in pump motor circuit from the A1 connection to the A2 connection on the control panel. **Defective P1A contactor.** • Perform checks as outlined in status 123.	

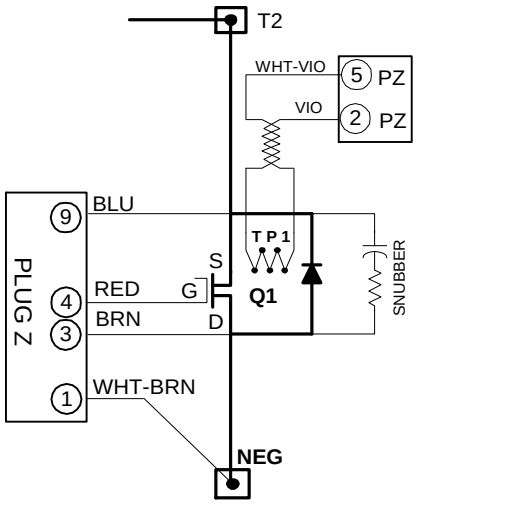
PUMP STATUS CODE	DESCRIPTION OF STATUS	CAUSE OF STATUS INDICATION
-127	Logic card power supply is less than 10 VDC.	This status code is displayed when the logic card power supply is less than 10 volts.
MEMORY RECALL **YES**	**CORRECTIVE ACTIONS**	**TROUBLE-SHOOTING DIAGRAM**
Circuits valid for Pump Controller	**SYMPTOM** Pump control does not operate. **POSSIBLE CAUSE** **Discharged Battery** • Check battery to insure proper state of charge. **Loose connection at PB1.** • Insure that the wire connection at PB1 is tight and control fuse is not blown. **Defective logic card.** • Replace logic card.	

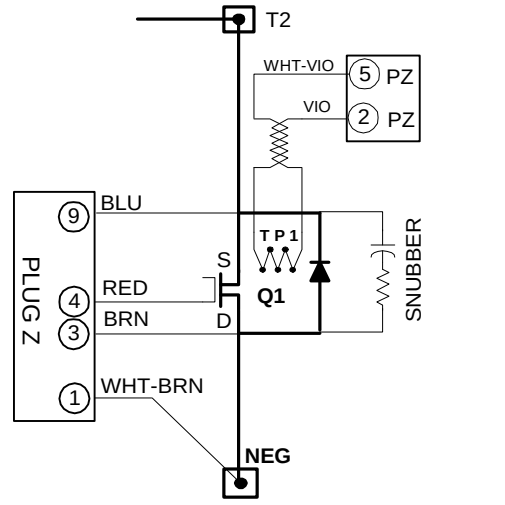
PUMP STATUS CODE	DESCRIPTION OF STATUS	CAUSE OF STATUS INDICATION
-141	Open thermal protector (TP1) or transistor is over temperature.	This status code is displayed when the voltage between PZ2 and PZ5 is greater than 0.8 volts.
MEMORY RECALL **NO**	**CORRECTIVE ACTIONS**	**TROUBLE-SHOOTING DIAGRAM**
Circuits valid for Pump Controller	**SYMPTOM** Reduced or no power to pump motor in control range. **POSSIBLE CAUSE** **Control is in thermal cut-back.** • Allow control to cool, status code should disappear. **Open thermal protector circuit.** • Check for loose connection or broken wire between: W/VIO wire-Thermal protector and PZ5 VIO wire-Thermal protector and PZ2. **Defective thermal protector.** • Disconnect wires from PZ2 and PZ5. At room temperature (25° C or 75° F) measure resistance between WHT/VIO and VIO wire. Replace Q1 if ohmic value is greater than 1200 ohms.	 SC141

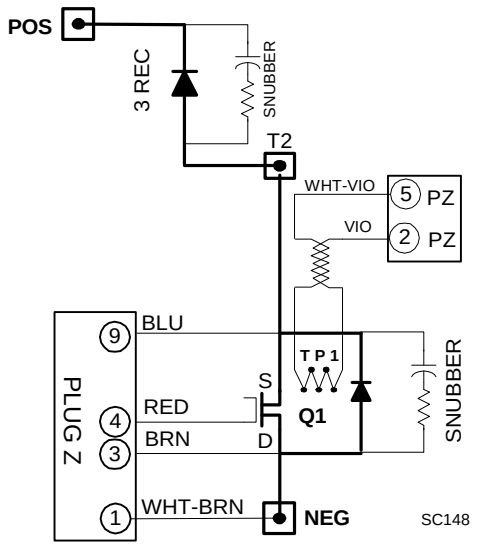
PUMP STATUS CODE	DESCRIPTION OF STATUS	CAUSE OF STATUS INDICATION
-142	Pump Controller “motor current sensor” input is missing (PZ12 - GRN).	This status code is displayed when the voltage between PZ12 and PZ13 is greater than 0.1 volts with no current flowing in the motor circuit.
MEMORY RECALL **NO**	**CORRECTIVE ACTIONS**	**TROUBLE-SHOOTING DIAGRAM**
Circuits valid for Pump Controller	**SYMPTOM** No power to pump motor in control range. **POSSIBLE CAUSE** **Open sensor wire circuit to PZ12 .** • Check for loose connection or broken wire (green wire) from current sensor to PZ12 on the logic card.	 SC142

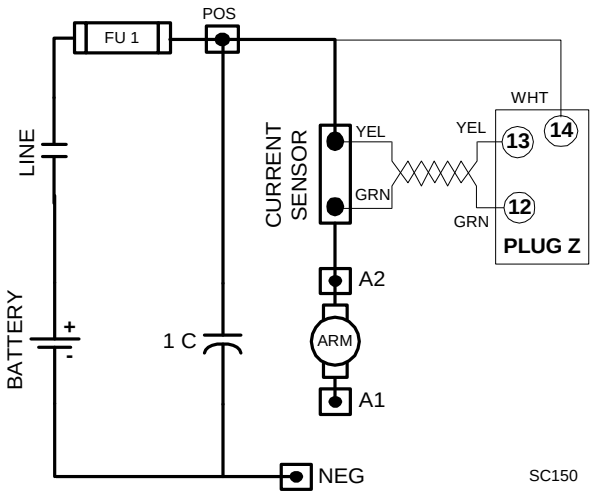
PUMP STATUS CODE	DESCRIPTION OF STATUS	CAUSE OF STATUS INDICATION
-143	Pump Controller "motor current sensor" input is missing (PZ13 - YEL).	This status code is displayed when the voltage between PZ12 and PZ13 is greater than 0.1 volts with no current flowing in the motor circuit.
MEMORY RECALL **NO**	**CORRECTIVE ACTIONS**	**TROUBLE-SHOOTING DIAGRAM**
Circuits valid for Pump Controller	**SYMPTOM** No power to pump motor in control range. **POSSIBLE CAUSE** **Open sensor wire circuit to PZ13 .** • Check for loose connection or broken wire (yellow wire) from current sensor to PZ13 on the logic card.	 SC143

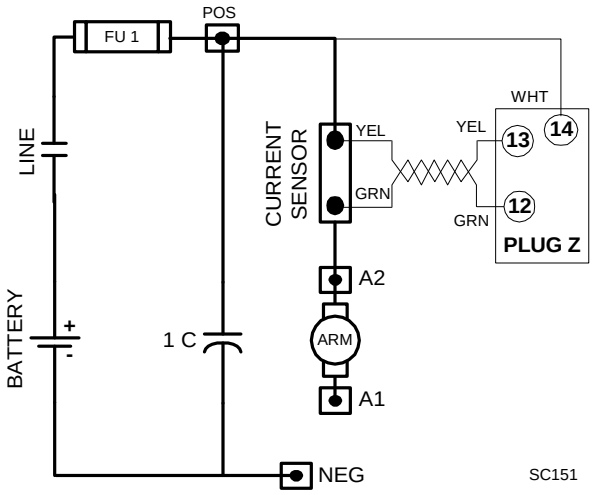
PUMP STATUS CODE	DESCRIPTION OF STATUS	CAUSE OF STATUS INDICATION
-144	Power Transistor (Q1) did not turn off properly.	This status code is displayed when the transistor fails to turn off. This will result in a PMT condition.
MEMORY RECALL **YES**	**CORRECTIVE ACTIONS**	**TROUBLE-SHOOTING DIAGRAM**
Circuits valid for Pump Controller	**SYMPTOM** If equipped with a P Contactor, control will not operate. With no P Contactor, control may run continuously. **POSSIBLE CAUSE** **Defective Q1 power transistor.** • Turn off time for transistor is out of specification. No field test is possible. Replace transistor. • Check for open circuit or loose connections between the transistor and PZ4 (red wire).	 SC144

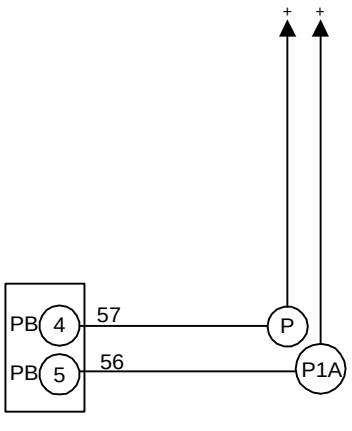
PUMP STATUS CODE	DESCRIPTION OF STATUS	CAUSE OF STATUS INDICATION
-145	Power Transistor (Q1) did not turn on properly.	This status code is displayed when the transistor fails to turn on.
MEMORY RECALL **YES**	**CORRECTIVE ACTIONS**	**TROUBLE-SHOOTING DIAGRAM**
Circuits valid for Pump Controller	**SYMPTOM** Pump control does not operate. **POSSIBLE CAUSE** **Defective transistor circuit.** • Check for open circuit or loose connections between the transistor and PZ4 (red wire). • Check for open circuit or loose connection between T2 and PZ9 (blue wire) **Defective Q1 power transistor.** • Intermittent or open transistor gate. Field test may or may not show defect. Replace transistor if checks above show no problem found.	 SC145

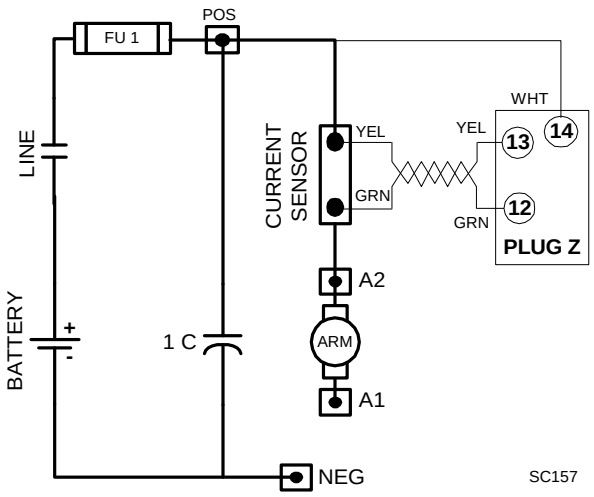
PUMP STATUS CODE	DESCRIPTION OF STATUS	CAUSE OF STATUS INDICATION
-146	"Look Ahead" test for T2 volts less than 12% of battery volts.	This status code will be displayed when the voltage at T2 is less than 12% of battery volts.
MEMORY RECALL **YES**	**CORRECTIVE ACTIONS**	**TROUBLE-SHOOTING DIAGRAM**
Circuits valid for Pump Controller	**SYMPTOM** If equipped with a P Contactor, control will not operate. With no P Contactor, control may run continuously. **POSSIBLE CAUSE** **Defective Q1 power transistor.** • Check for shorted transistor. **Defective P1A contactor.** • Check for welded P1A contactor power tips. **Defective Snubber.** • Check for shorted snubber.	 SC146

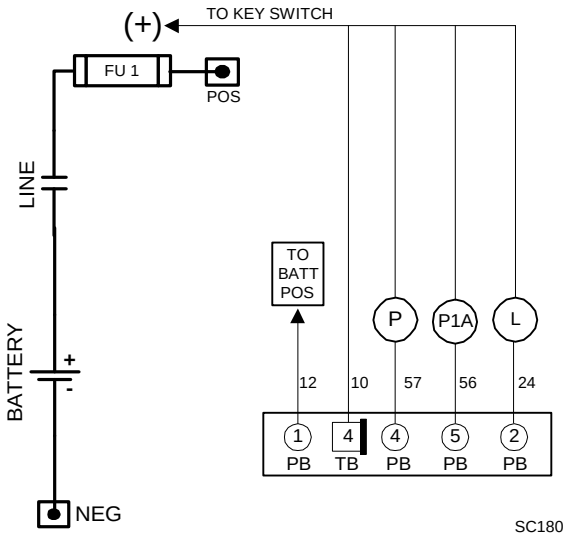
PUMP STATUS CODE	DESCRIPTION OF STATUS	CAUSE OF STATUS INDICATION
-148	"Look Ahead" test for T2 volts greater than 88% of battery volts.	This status code will be displayed when the voltage at T2 is greater than 88% of battery volts.
MEMORY RECALL **NO**	**CORRECTIVE ACTIONS**	**TROUBLE-SHOOTING DIAGRAM**
Circuits valid for Pump Controller	**SYMPTOM** Pump contactor will not pick up. **POSSIBLE CAUSE** **Defective pump contactor.** • Check for welded pump contactor power tips. • Check for sluggish operation of pump contactor. **Defective 3 REC circuit.** • Check for shorted 3 REC. • Check for shorted snubber.	

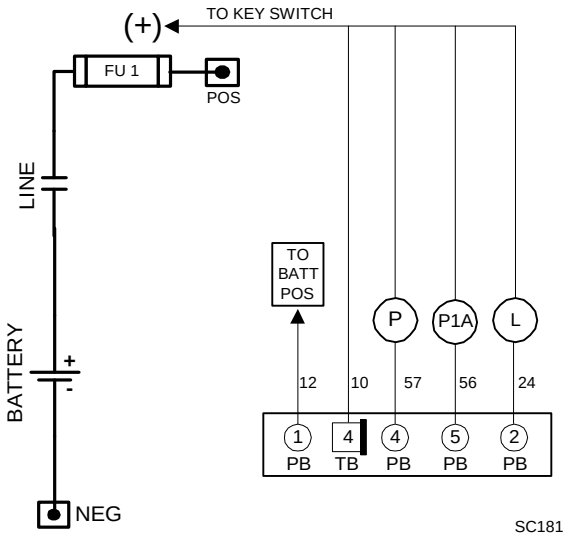
PUMP STATUS CODE	DESCRIPTION OF STATUS	CAUSE OF STATUS INDICATION
-150	Capacitor volts low after line contactor closes.	This status code will be displayed when the capacitor volts is less than 85% of battery volts in the run mode.
MEMORY RECALL **NO**	**CORRECTIVE ACTIONS**	**TROUBLE-SHOOTING DIAGRAM**
Circuits valid for Pump Controller	**SYMPTOM** Pump control does not operate. **POSSIBLE CAUSE** **Defective Line contactor.** • Check for open line contactor power tips. • Check for loose or open connections in cables from battery positive to control positive circuit. **Defective Power fuse.** • Check power fuse for open circuit. **No battery voltage at PZ14.** • Check for battery voltage at POS and PZ14. • Check for loose connection at PZ14.	

PUMP STATUS CODE	DESCRIPTION OF STATUS	CAUSE OF STATUS INDICATION
-151	Capacitor volts are low before the line contactor closes. (Internal card function during precharge)	This status code will be displayed during "key on" when the capacitor volts is less than 85% of battery volts at initial key switch on.
MEMORY RECALL **NO**	**CORRECTIVE ACTIONS**	**TROUBLE-SHOOTING DIAGRAM**
Circuits valid for Pump Controller	**SYMPTOM** Line contactor does not close due to no Capacitor Precharge. **POSSIBLE CAUSE** **Defective capacitor.** • Check capacitor bank per component checking section. • Check for loose or open connections in capacitor circuit. **Defective control fuse for PB1 input.** • Check control fuse for open circuit. **Defective logic card.** • Replace logic card. **Defective Q1 power transistor.** • Check transistor Q1 for shorted condition and replace if necessary. **Note:** Repeated "charging/discharging" the capacitors during trouble shooting will cause status code -151. Also, "do not" connect **any** loads to the load side of the Line Contactor.	

PUMP STATUS CODE	DESCRIPTION OF STATUS	CAUSE OF STATUS INDICATION
-154	Shorted P or P1A contactor coil driver on the logic card.	This status code will be displayed when either the Pump (P) or Pump 1A (P1A) contactor coil driver is shorted internal to the logic card.
MEMORY RECALL **NO**	**CORRECTIVE ACTIONS**	**TROUBLE-SHOOTING DIAGRAM**
Circuits valid for Pump Controller	**SYMPTOM** Pump Control will not operate. **POSSIBLE CAUSE** **Defective logic card.** • Replace logic card.	

PUMP STATUS CODE	DESCRIPTION OF STATUS	CAUSE OF STATUS INDICATION
-157	Controller "motor current sensor" input voltage polarity check.	This status code will be displayed when the voltage input to PZ13 and PZ12 is of the wrong polarity.
MEMORY RECALL **NO**	**CORRECTIVE ACTIONS**	**TROUBLE-SHOOTING DIAGRAM**
Circuits valid for Pump Controller	**SYMPTOM** If equipped with a P Contactor, control will not operate. With no P Contactor, control may run continuously. **POSSIBLE CAUSE** **Reversed yellow and green current sensor wires.** • Insure that the green wire connects to PZ12 with no open circuits and that the yellow wire connects to PZ13 with no open circuits or loose connections. **Reversed power cable connection.** • Insure that the battery positive cable connects to control POS and the motor A2 cable connects to control A2.	

PUMP STATUS CODE	DESCRIPTION OF STATUS	CAUSE OF STATUS INDICATION
-180	Voltage at capacitor (1C) is less than 14 volts.	This status code will be displayed when the voltage at PZ14 is less than 14 volts. This occurs typically in the run mode of operation.
MEMORY RECALL **NO**	**CORRECTIVE ACTIONS**	**TROUBLE-SHOOTING DIAGRAM**
Circuits valid for Pump Controller	**SYMPTOM** Pump (P) or Pump 1A (P1A) contactor will not pick up, or pump motor will not run. **POSSIBLE CAUSE** **Line Contactor opened up during run.** • Check connection from PB2 to L coil (-) for loose connection. • Check connection from battery (+) to L coil (+) for loose connection. • Check power connection from battery (+) to contactor L. • Check for loose connections on P and P1A contactor coils. • Check FU1 and FU3 for blown element.	

PUMP STATUS CODE	DESCRIPTION OF STATUS	CAUSE OF STATUS INDICATION
-181	Battery voltage is less than 14 volts.	This status code will be displayed when the battery voltage measured at PB1 is less than 14 volts.
MEMORY RECALL **NO**	**CORRECTIVE ACTIONS**	**TROUBLE-SHOOTING DIAGRAM**
Circuits valid for Pump Controller	**SYMPTOM** Pump (P) or Pump 1A (P1A) contactor will not pick up, or pump motor will not run. **POSSIBLE CAUSE** **Line Contactor opened up during run.** • Check connection from PB2 to L coil (-) for loose connection. • Check connection from battery (+) to L coil (+) for loose connections. • Check power connection from battery (+) to contactor L. • Check for loose connections on P and P1A contactor coils. • Check FU1 and FU3 for blown element.	

Section 15. COMPONENT TESTING

Note: For disassembly of the capacitor bank and/or component replacement, follow instructions in **Section 13.2 Removal of the Capacitor Bank (1C) Assembly** and **Section 13.3 Disassembly for Component Replacement.**

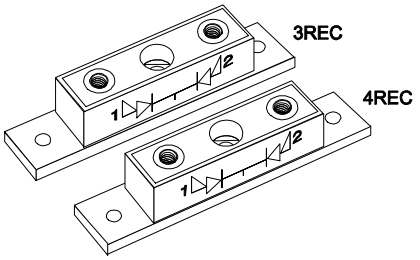
Note:* *The following component tests can be performed with a meter similar to a Simpson #260, a SEC #CT-500, or a digital meter similar to a Wavetek #110DVM or a TEK #DMM254. The settings for these instruments are shown in the tables below.

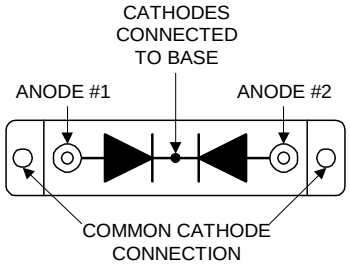
Section 15.1 Diode Modules (3REC AND 4REC)

3REC and 4REC diodes measure about 5 to 15 ohms in the conducting direction (anode to cathode) on the R X 100 scale and 10,000 ohms or higher, in the non-conducting direction (cathode to anode) on the R X 10000 scale.

	DIODE MODULE (3 & 4 REC) COMP TERM ID NUMBER			Analog Scale	Simpson 260	SEC CT-500	DMM Scale	Wavetek 110 DVM	TEK DMM 254
TEST	**1**	**2**	**BASE**						
1	**+**		**-**	R x 1	5 ohms	5-6 ohms	Diode	0.181v	0.155v
2		**+**	**-**	R x 1	5 ohms	5-6 ohms	Diode	0.182v	0.153v
3	**-**		**+**	R x 1	Inf.	Inf.	Diode	O/L	F/S
4		**-**	**+**	R x 1	Inf.	Inf.	Diode	O/L	F/S

Note: (+) and (-) refer to Positive & Negative lead of meter. Note: O/L, F/S, & Inf. indicates beyond meter scale.





Section 15.2 Power Transistor Test (Q1)

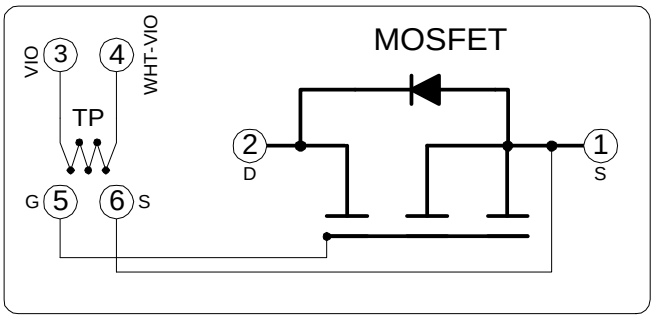
Note: The only Thermal Protector on the EVT100 is internal to the Power Transistor (Q1). To test the thermal protector, read the resistance between the PZ2 (VIO) and PZ5 (WHT/VIO) wires at the card plug. The reading should be approximately 750 ohms nominal at 25° C.

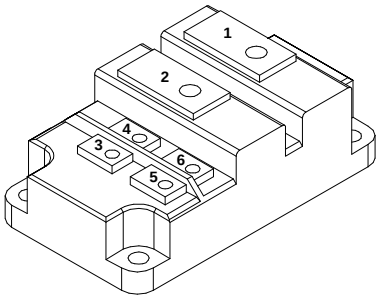
Section 15.2.1 MOSFET Test

	MOSFET MODULE COMPONENT TERMINAL IDENTIFICATION NUMBER						Analog Scale	Simpson 260	SEC CT-500	DMM Scale	Wavetek 110 DVM	TEK DMM 254
TEST	**1**	**2**	**3**	**4**	**5**	**6**						
1	**+**	**-**			**	**	R x 100	440 ohms	1K ohms	Diode	0.445v	0.414v
2	**-**	**+**			**	**	R x 100	Inf.	Inf.	20K	O/L	38K ohms*
3			**+**	**-**			R x 100	730 ohms	900 ohms	20K	740 ohms	780 ohms*
4					**+**	**-**	R x 100	Inf.	Inf.	20K	O/L	O/L*
5					**-**	**+**	R x 100	950 ohms	1.6K ohms	20K	O/L	O/L*

Note: (+) and (-) refer to Positive & Negative lead of meter.
**** Jumper 5 & 6**

Note: O/L, F/S, & Inf. indicates beyond meter scale. *40K scale





MOSFET

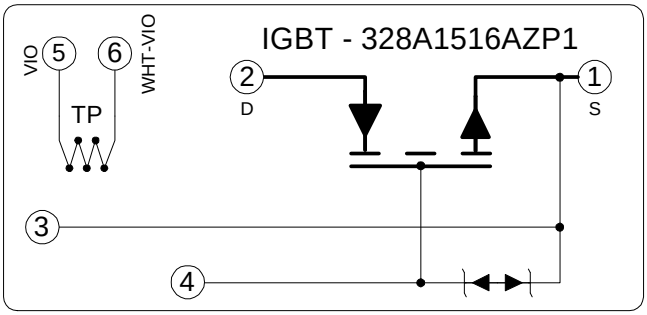
Section 15.2.2 IGBT Tests

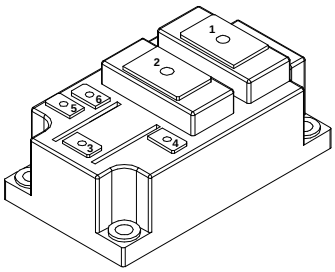
	IGBT MODULE – 328A1516AZP1 COMPONENT TERMINAL IDENTIFICATION NUMBER						Analog Scale	**Simpson 260**	DMM Scale	**Wavetek 110 DVM**
TEST	**1**	**2**	**3**	**4**	**5**	**6**				
1	+	-	**	**			R x 100	3.6K ohms	200K	41.5K ohms
2	-	+	**	**			R x 10K	55K ohms	200K	41.5K ohms
3					+	-	R x 100	720 ohms	2K	778 ohms
4			+	-			R x 100	Inf.	200K	O/L
5			-	+			R x 100	Inf.	200K	O/L

Note: (+) and (-) refer to Positive & Negative lead of meter.

**** Jumper 3 & 4**

Note: O/L, F/S, & Inf. indicates beyond meter scale.





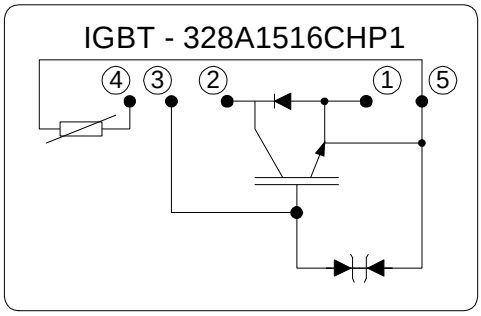
IGBT - 328A1516AZP1

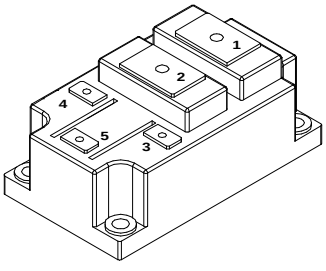
	IGBT MODULE – 328A1516CHP1 COMPONENT TERMINAL IDENTIFICATION NUMBER					Analog Scale	**Simpson 260**	DMM Scale	**Wavetek 110 DVM**
TEST	**1**	**2**	**3**	**4**	**5**				
1	+	-	**	**		R x 100	3.6K ohms	200K	41.5K ohms
2	-	+	**	**		R x 10K	55K ohms	200K	41.5K ohms
3				-	+	R x 100	720 ohms	2K	778 ohms
4			+	-		R x 100	Inf.	200K	O/L
5			-	+		R x 100	Inf.	200K	O/L

Note: (+) and (-) refer to Positive & Negative lead of meter.

**** Jumper 3 & 4**

Note: O/L, F/S, & Inf. indicates beyond meter scale.

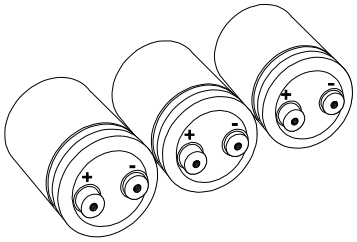


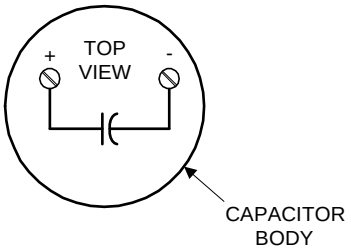


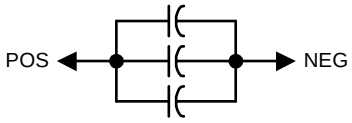
IGBT - 328A1516CHP1

Section 15.3 Capacitor (C1) Test

Note: Electrolytic capacitors can store a significant amount of charge (energy) and must be shorted (discharged) by placing a 200 ohm 2 watt resistor between positive (+) and negative (-) for three seconds or greater.







Single Capacitor Test

Measure ohms through the capacitor using the Rx100 scale. Meter should swing toward zero, and then reverse and swing slowly to above 200 ohms. Meter polarity is not critical.

Capacitor Bank Test

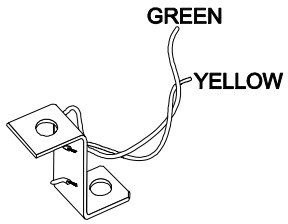
Measure ohms through the capacitor using the R x 100 scale. Meter should swing toward zero then reverse and swing slowly to above 2000 ohms. Meter polarity is not critical.

Caution:

- One shorted capacitor in bank, bank fails test.
- One open capacitor in bank, bank passes test. Each Capacitor must be checked individually for open circuit test.

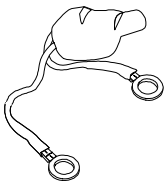
Section 15.4 Current Sensor Test

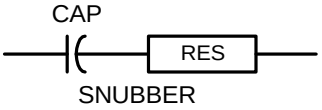
The Current Sensor should read zero ohms (in either direction) from the green to yellow wires on the R x 1 scale.

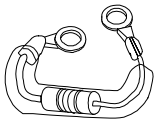


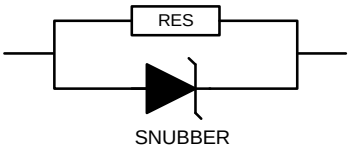
Section 15.5 Snubber Test

The snubber is a resistor and capacitor/zener filter assembly. Using a R x 100 scale across the two terminals (in either direction), the meter will briefly swing toward zero and then quickly back to infinity.









Section 16.1 RS-232 MEMORY MAP TABLES

For Single Motor Traction Logic Card

E^2 No.	Func No.	HS No.	Traction Control Function	Access By:	Restrictions
0	1	1	Fault Code	HS or PC	Erases when battery is unplugged
1	2	2	Creep	HS or PC	None
2	3	3	Controlled Acceleration	HS or PC	None
3	4	4	Current Limit	HS or PC	None
4	5	5	Plug Current Limit	HS or PC	None
5	6	6	1A Dropout	HS or PC	None
6	7	7	FW Pickup	HS or PC	None
7	8	8	FW Dropout	HS or PC	None
8	9	9	Regen Current Limit	HS or PC	None
9	10	10	Regen Start	HS or PC	None
10	11	11	Speed Limit 1	HS or PC	None
11	12	12	Speed Limit 2	HS or PC	None
12	13	13	Speed Limit 3	HS or PC	None
13	14	14	IR Compensation	HS or PC	None
14	15	15	Battery Volts Select	HS or PC	None
15	16	16	Pedal Position Plug	HS or PC	None
16	17	17	Card Type Select	HS or PC	None
17	18	18	Steer Pump Time Delay	HS or PC	None
18	19	19	Maint Alert (Tens/Ones)	HS or PC	None
19	20	20	Maint Alert (Thou/Hun)	HS or PC	None
20	21	21	Maint Speed Limit	HS or PC	None
21	22	22	Mode Reference	HS or PC	For Dash Display on battery power up
22	23	23	Hourmeter (Min)	HS or PC	None
23	24	24	Hourmeter (Sec)	HS or PC	None
24	25	25	Fault Reg Data	HS or PC	GE Temporary Storage
25	26	26	Battery Charge Data	HS or PC	GE Temporary Storage
26	27	27	Battery Volts Data	HS or PC	GE Temporary Storage
27	28	28	Fault Count Pointer	HS or PC	None (Location of last fault recorded)
28	29	29	HM (Tens/Units)	HS or PC	None
29	30	30	HM (Thou/Hun)	HS or PC	None
30	31		Aux HM (Tens/Ones)	PC Only	None
31	32		Aux HM (Thou/Hun)	PC Only	None
32	33	***(18)***	*Stored Status Code #1*	PC Only	Reset to Zero Only
33	34		BDI 1	PC Only	Reset to Zero Only
34	35		Hours (Tens/Ones) 1	PC Only	Reset to Zero Only
35	36		Hours (Thou/Hun) 1	PC Only	Reset to Zero Only
36	37	***(20)***	*Stored Status Code #2*	PC Only	Reset to Zero Only
37	38		BDI 2	PC Only	Reset to Zero Only
38	39		Hours (Tens/Ones) 2	PC Only	Reset to Zero Only
39	40		Hours (Thou/Hun) 2	PC Only	Reset to Zero Only
40	41	***(22)***	*Stored Status Code #3*	PC Only	Reset to Zero Only
41	42		BDI 3	PC Only	Reset to Zero Only
42	43		Hours (Tens/Ones) 3	PC Only	Reset to Zero Only
43	44		Hours (Thou/Hun) 3	PC Only	Reset to Zero Only

Numbers in ***(bold italics)*** are Stored Status Code pointers.

Section 16.1 RS-232 MEMORY MAP TABLES

For Single Motor Traction Logic Card

E2 No.	Func No.	HS No.	Traction Control Function	Access By:	Restrictions
44	45	***(24)***	*Stored Status Code #4*	PC Only	Reset to Zero Only
45	46		BDI 4	PC Only	Reset to Zero Only
46	47		Hours (Tens/Ones) 4	PC Only	Reset to Zero Only
47	48		Hours (Thou/Hun) 4	PC Only	Reset to Zero Only
48	49	***(26)***	*Stored Status Code #5*	PC Only	Reset to Zero Only
49	50		BDI 5	PC Only	Reset to Zero Only
50	51		Hours (Tens/Ones) 5	PC Only	Reset to Zero Only
51	52		Hours (Thou/Hun) 5	PC Only	Reset to Zero Only
52	53	***(28)***	*Stored Status Code #6*	PC Only	Reset to Zero Only
53	54		BDI 6	PC Only	Reset to Zero Only
54	55		Hours (Tens/Ones) 6	PC Only	Reset to Zero Only
55	56		Hours (Thou/Hun) 6	PC Only	Reset to Zero Only
56	57	***(30)***	*Stored Status Code #7*	PC Only	Reset to Zero Only
57	58		BDI 7	PC Only	Reset to Zero Only
58	59		Hours (Tens/Ones) 7	PC Only	Reset to Zero Only
59	60		Hours (Thou/Hun) 7	PC Only	Reset to Zero Only
60	61	***(32)***	*Stored Status Code #8*	PC Only	Reset to Zero Only
61	62		BDI 8	PC Only	Reset to Zero Only
62	63		Hours (Tens/Ones) 8	PC Only	Reset to Zero Only
63	64		Hours (Thou/Hun) 8	PC Only	Reset to Zero Only
64	65	***(34)***	*Stored Status Code #9*	PC Only	Reset to Zero Only
65	66		BDI 9	PC Only	Reset to Zero Only
66	67		Hours (Tens/Ones) 9	PC Only	Reset to Zero Only
67	68		Hours (Thou/Hun) 9	PC Only	Reset to Zero Only
68	69	***(36)***	*Stored Status Code #10*	PC Only	Reset to Zero Only
69	70		BDI 10	PC Only	Reset to Zero Only
70	71		Hours (Tens/Ones) 10	PC Only	Reset to Zero Only
71	72		Hours (Thou/Hun) 10	PC Only	Reset to Zero Only
72	73	***(38)***	*Stored Status Code #11*	PC Only	Reset to Zero Only
73	74		BDI 11	PC Only	Reset to Zero Only
74	75		Hours (Tens/Ones) 11	PC Only	Reset to Zero Only
75	76		Hours (Thou/Hun) 11	PC Only	Reset to Zero Only
76	77	***(40)***	*Stored Status Code #12*	PC Only	Reset to Zero Only
77	78		BDI 12	PC Only	Reset to Zero Only
78	79		Hours (Tens/Ones) 12	PC Only	Reset to Zero Only
79	80		Hours (Thou/Hun) 12	PC Only	Reset to Zero Only
80	81	***(42)***	*Stored Status Code #13*	PC Only	Reset to Zero Only
81	82		BDI 13	PC Only	Reset to Zero Only
82	83		Hours (Tens/Ones) 13	PC Only	Reset to Zero Only
83	84		Hours (Thou/Hun) 13	PC Only	Reset to Zero Only
84	85	***(44)***	*Stored Status Code #14*	PC Only	Reset to Zero Only
85	86		BDI 14	PC Only	Reset to Zero Only
86	87		Hours (Tens/Ones) 14	PC Only	Reset to Zero Only
87	88		Hours (Thou/Hun) 14	PC Only	Reset to Zero Only

Numbers in ***(bold italics)*** are Stored Status Code pointers.

Section 16.1 RS-232 MEMORY MAP TABLES
For Single Motor Traction Logic Card

E^2 No.	Func No.	HS No.	Traction Control Function	Access By:	Restrictions
88	89	***(46)***	*Stored Status Code #15*	PC Only	Reset to Zero Only
89	90		BDI 15	PC Only	Reset to Zero Only
90	91		Hours (Tens/Ones) 15	PC Only	Reset to Zero Only
91	92		Hours (Thou/Hun) 15	PC Only	Reset to Zero Only
92	93	***(48)***	*Stored Status Code #16*	PC Only	Reset to Zero Only
93	94		BDI 16	PC Only	Reset to Zero Only
94	95		Hours (Tens/Ones) 16	PC Only	Reset to Zero Only
95	96		Hours (Thou/Hun) 16	PC Only	Reset to Zero Only
96	97	48	Dash Display CA-1	HS or PC	None
97	98	49	Dash Display FWPU-1	HS or PC	None
98	99	50	Dash Display SL1-1	HS or PC	None
99	100	51	Spare-1	HS or PC	None
100	101	52	Dash Display CA-2	HS or PC	None
101	102	53	Dash Display FWPU-2	HS or PC	None
102	103	54	Dash Display SL1-2	HS or PC	None
103	104	55	Spare-2	HS or PC	None
104	105	56	Dash Display CA-3	HS or PC	None
105	106	57	Dash Display FWPU-3	HS or PC	None
106	107	58	Dash Display SL1-3	HS or PC	None
107	108	59	Spare-3	HS or PC	None
108	109	60	Dash Display CA-4	HS or PC	None
109	110	61	Dash Display FWPU-4	HS or PC	None
110	111	62	Dash Display SL1-4	HS or PC	None
111	112		Spare-4	PC Only	None
112	113		Secure HM (Tens/Ones)	PC Only	OEM Read Only
113	114		Secure HM (Thou/Hun)	PC Only	OEM Read Only
114	115		Sec Aux HM (Tens/Ones)	PC Only	OEM Read Only
115	116		Sec Aux HM (Thou/Hun)	PC Only	OEM Read Only
116	117		Reserved	PC Only	GE Future Use Only
117	118		Reserved	PC Only	GE Future Use Only
118	119		Reserved	PC Only	GE Future Use Only
119	120		Reserved	PC Only	GE Future Use Only
120	121		OEM Use	PC Only	None
121	122		OEM Use	PC Only	None
122	123		OEM Use	PC Only	None
123	124		OEM Use	PC Only	None
124	125		OEM Use	PC Only	None
125	126		OEM Use	PC Only	None
126	127		OEM Use	PC Only	None
127	128		OEM Use	PC Only	None

Numbers in ***(bold italics)*** are Stored Status Code pointers.

Section 16.2 RS-232 MEMORY MAP TABLES
For Hydraulic Pump Motor Logic Card

E^2 No.	Func No.	HS No.	Pump Control Function	Access By:	Restrictions
0	1	1	Fault Code	HS or PC	Erases when battery is unplugged
1	2	2	IR Start	HS or PC	None
2	3	3	C/A	HS or PC	None
3	4	4	C/L	HS or PC	None
4	5	5	Spare		
5	6	6	Spare		
6	7	7	IR Comp Rate	HS or PC	None
7	8	8	Spare		
8	9	9	Spare		
9	10	10	Spare		
10	11	11	Speed Limit (SL1)	HS or PC	None
11	12	12	Speed Limit (SL2)	HS or PC	None
12	13	13	Speed Limit (SL3)	HS or PC	None
13	14	14	Speed Limit (SL4)	HS or PC	None
14	15	15	Spare		
15	16	16	Speed/Torque Compensation	HS or PC	None
16	17	17	Card Type Select	HS or PC	None
17	18	18	Spare		
18	19	19	Spare		
19	20	20	Spare		
20	21	21	Spare		
21	22	22	Mode Reference	HS or PC	For Dash Display on battery power up
22	23	23	Hourmeter (Min)	HS or PC	None
23	24	24	Hourmeter (Sec)	HS or PC	None
24	25	25	Fault Reg Data	HS or PC	GE Temporary Storage
25	26	26	Spare		
26	27	27	Spare		
27	28	28	Fault Count Pointer	HS or PC	None (Location of last fault recorded)
28	29	29	HM (Tens/Ones)	HS or PC	None
29	30	30	HM (Thou/Hun)	HS or PC	None
30	31		Aux HM (Tens/Ones)	PC Only	None
31	32		Aux HM (Thou/Hun)	PC Only	None
32	33	***(18)***	*Stored Status Code #1*	PC Only	Reset to Zero Only
33	34		Spare		
34	35		Hours (Tens/Ones) 1	PC Only	Reset to Zero Only
35	36		Hours (Thou/Hun) 1	PC Only	Reset to Zero Only
36	37	***(20)***	*Stored Status Code #2*	PC Only	Reset to Zero Only
37	38		Spare		
38	39		Hours (Tens/Ones) 2	PC Only	Reset to Zero Only
39	40		Hours (Thou/Hun) 2	PC Only	Reset to Zero Only
40	41	***(22)***	*Stored Status Code #3*	PC Only	Reset to Zero Only
41	42		Spare		
42	43		Hours (Tens/Ones) 3	PC Only	Reset to Zero Only
43	44		Hours (Thou/Hun) 3	PC Only	Reset to Zero Only

Numbers in ***(bold italics)*** are Stored Status Code pointers.

Section 16.2 RS-232 MEMORY MAP TABLES
For Hydraulic Pump Motor Logic Card

E^2 No.	Func No.	HS No.	Pump Control Function	Access By:	Restrictions
44	45	***(24)***	*Stored Status Code #4*	PC Only	Reset to Zero Only
45	46		Spare		
46	47		Hours (Tens/Ones) 4	PC Only	Reset to Zero Only
47	48		Hours (Thou/Hun) 4	PC Only	Reset to Zero Only
48	49	***(26)***	*Stored Status Code #5*	PC Only	Reset to Zero Only
49	50		Spare		
50	51		Hours (Tens/Ones) 5	PC Only	Reset to Zero Only
51	52		Hours (Thou/Hun) 5	PC Only	Reset to Zero Only
52	53	***(28)***	*Stored Status Code #6*	PC Only	Reset to Zero Only
53	54		Spare		
54	55		Hours (Tens/Ones) 6	PC Only	Reset to Zero Only
55	56		Hours (Thou/Hun) 6	PC Only	Reset to Zero Only
56	57	***(30)***	*Stored Status Code #7*	PC Only	Reset to Zero Only
57	58		Spare		
58	59		Hours (Tens/Ones) 7	PC Only	Reset to Zero Only
59	60		Hours (Thou/Hun) 7	PC Only	Reset to Zero Only
60	61	***(32)***	*Stored Status Code #8*	PC Only	Reset to Zero Only
61	62		Spare		
62	63		Hours (Tens/Ones) 8	PC Only	Reset to Zero Only
63	64		Hours (Thou/Hun) 8	PC Only	Reset to Zero Only
64	65	***(34)***	*Stored Status Code #9*	PC Only	Reset to Zero Only
65	66		Spare		
66	67		Hours (Tens/Ones) 9	PC Only	Reset to Zero Only
67	68		Hours (Thou/Hun) 9	PC Only	Reset to Zero Only
68	69	***(36)***	*Stored Status Code #10*	PC Only	Reset to Zero Only
69	70		Spare		
70	71		Hours (Tens/Ones) 10	PC Only	Reset to Zero Only
71	72		Hours (Thou/Hun) 10	PC Only	Reset to Zero Only
72	73	***(38)***	*Stored Status Code #11*	PC Only	Reset to Zero Only
73	74		Spare		
74	75		Hours (Tens/Ones) 11	PC Only	Reset to Zero Only
75	76		Hours (Thou/Hun) 11	PC Only	Reset to Zero Only
76	77	***(40)***	*Stored Status Code #12*	PC Only	Reset to Zero Only
77	78		Spare		
78	79		Hours (Tens/Ones) 12	PC Only	Reset to Zero Only
79	80		Hours (Thou/Hun) 12	PC Only	Reset to Zero Only
80	81	***(42)***	*Stored Status Code #13*	PC Only	Reset to Zero Only
81	82		Spare		
82	83		Hours (Tens/Ones) 13	PC Only	Reset to Zero Only
83	84		Hours (Thou/Hun) 13	PC Only	Reset to Zero Only
84	85	***(44)***	*Stored Status Code #14*	PC Only	Reset to Zero Only
85	86		Spare		
86	87		Hours (Tens/Ones) 14	PC Only	Reset to Zero Only
87	88		Hours (Thou/Hun) 14	PC Only	Reset to Zero Only

Numbers in ***(bold italics)*** are Stored Status Code pointers.

Section 16.2 RS-232 MEMORY MAP TABLES
For Hydraulic Pump Motor Logic Card

E^2 No.	Func No.	HS No.	Pump Control Function	Access By:	Restrictions
88	89	***(46)***	*Stored Status Code #15*	PC Only	Reset to Zero Only
89	90		Spare		
90	91		Hours (Tens/Ones) 15	PC Only	Reset to Zero Only
91	92		Hours (Thou/Hun) 15	PC Only	Reset to Zero Only
92	93	***(48)***	*Stored Status Code #16*	PC Only	Reset to Zero Only
93	94		Spare		
94	95		Hours (Tens/Ones) 16	PC Only	Reset to Zero Only
95	96		Hours (Thou/Hun) 16	PC Only	Reset to Zero Only
96	97	48	Dash Display CA-1	HS or PC	None
97	98	49	Dash Display SL2-1	HS or PC	None
98	99	50	Dash Display SL4-1	HS or PC	None
99	100	51	Spare-1	HS or PC	None
100	101	52	Dash Display CA-2	HS or PC	None
101	102	53	Dash Display SL2-2	HS or PC	None
102	103	54	Dash Display SL4-2	HS or PC	None
103	104	55	Spare-2	HS or PC	None
104	105	56	Dash Display CA-3	HS or PC	None
105	106	57	Dash Display SL2-3	HS or PC	None
106	107	58	Dash Display SL4-3	HS or PC	None
107	108	59	Spare-3	HS or PC	None
108	109	60	Dash Display CA-4	HS or PC	None
109	110	61	Dash Display SL2-4	HS or PC	None
110	111	62	Dash Display SL4-4	HS or PC	None
111	112		Spare-4	PC Only	None
112	113		Secure HM (Tens/Ones)	PC Only	OEM Read Only
113	114		Secure HM (Thou/Hun)	PC Only	OEM Read Only
114	115		Sec Aux HM (Tens/Ones)	PC Only	OEM Read Only
115	116		Sec Aux HM (Thou/Hun)	PC Only	OEM Read Only
116	117		Reserved	PC Only	GE Future Use Only
117	118		Reserved	PC Only	GE Future Use Only
118	119		Reserved	PC Only	GE Future Use Only
119	120		Reserved	PC Only	GE Future Use Only
120	121		OEM Use	PC Only	None
121	122		OEM Use	PC Only	None
122	123		OEM Use	PC Only	None
123	124		OEM Use	PC Only	None
124	125		OEM Use	PC Only	None
125	126		OEM Use	PC Only	None
126	127		OEM Use	PC Only	None
127	128		OEM Use	PC Only	None

Numbers in ***(bold italics)*** are Stored Status Code pointers.

Section 17. TRUCK MANAGEMENT MODULE (TMM)

Section 17.1 General Features

The Truck Management Module is a multi-function accessory card (IC3645TMM7A), or an integral function of the EVT100 Pump control when used with the EVT100ZX Traction control. The Module provides the OEM the ability to initiate status codes or operator warning codes to be displayed on the Dash Display whenever a normally open switch or sensor wire provides a signal to the Module.

The TMM Module can be used to display a separate status code indicating over temperature of traction motors, hydraulic motors, or any other device or system that can activate a switch that closes.

It can also be used as a Brush Wear Indicator (BWI). The Brush Wear Indicator is designed to detect a "worn-out brush" and display a fault code on the Dash Display to warn maintenance personnel that the motor brushes need to be replaced before they wear to the point of causing destructive damage to the motor commutator surface. The BWI function is compatible with any sensor that short circuits to the motor armature to signal limits of brush wear.

Note: Motor armature must be in the positive side of the battery circuit.

Section 17.2 Operation

The Module utilizes 9 OEM input points and 3 output points that connect to the "Y" plug on the EVT100ZX traction logic card. **Due to the low level signal value of this output, shielded wire should always be used to insure proper operation.** The input to the Module is either a switch or sensor wire closure to battery negative or positive. The table following outlines the status code displayed for each input, when that point is closed to battery negative or positive as indicated.

TMM7A Card Terminal	Pump Control Terminal	Status Code	Connect To
TB1	PA3	90 *	Neg
TB3	PA6	91	Neg
TB4	PB6	92	Neg
TB5	PA1	93 *	Pos
TB6	PA2	93 *	Pos
TB8	PA4	94	Pos
TB10	PA5	94	Pos
TB11	PZ11	95	Pos
TB12	PZ10	95	Pos

* Status codes 90 and 93 can also be programmed with the Handset to reduce the speed of the truck from 100 to 0 percent-on-time. The instructions for adjustment of the speed limit function of status codes 90 and 93 are described in detail in Section 18. EVT100 GE HANDSET INSTRUCTIONS (Function 13: SPEED LIMIT).

IMPORTANT NOTE: Status Codes 93, 94 and 95 are only checked when a neutral signal is present (i.e., open start switch or open F/R switch). The status code is displayed and the speed limit enabled when the control is returned to the run mode. Do not use status code 93 speed limit for applications requiring immediate speed limit on switch closure.

Typical wiring diagrams and outline drawings for the TMM7A accessory card and EVT100 Pump TMM functions are shown in Sections 17.4 and 17.5.

Section 17.3 Installation

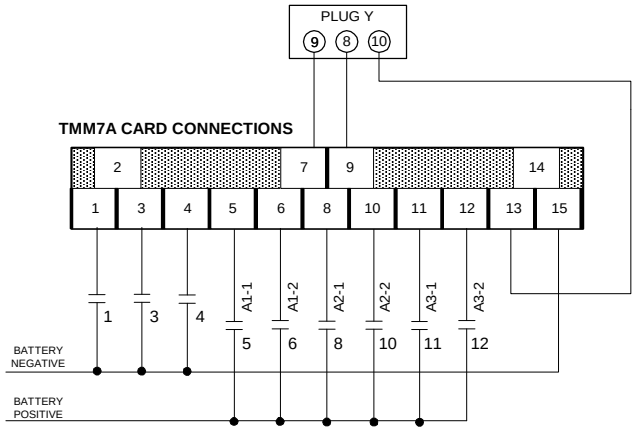
WARNING: Before any adjustments, servicing or act requiring physical contact with working components, jack drive wheels off the floor, disconnect the battery and discharge the capacitors in the traction and pump controls, as explained in Section 15.3.

The TMM7A accessory card should be mounted to a flat surface (in any plane) in an area

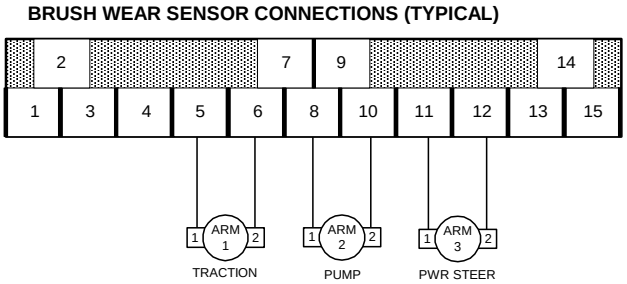
protected from water, oil and battery acid. Mounting dimensions are shown in Section 17.5. Two (0.187 inch, 4.75mm) mounting holes are provided.

Section 17.4 Connection Diagrams

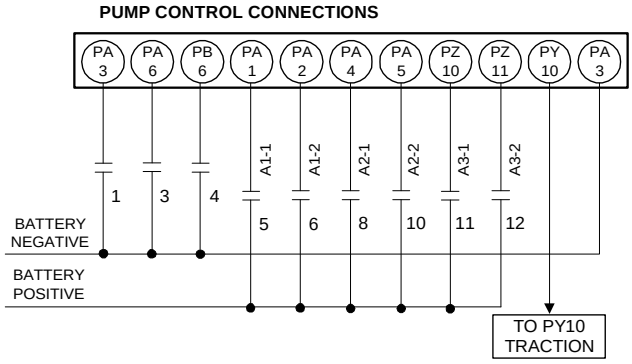
Section 17.4.1 TMM7A Card Connections



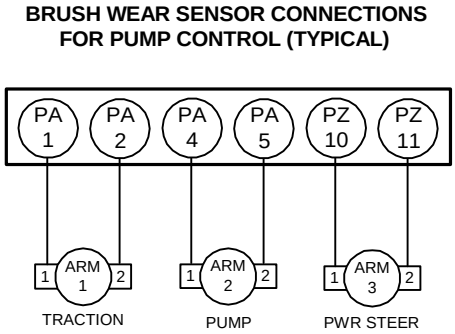
Section 17.4.2 Typical Brush Wear Sensor Connections



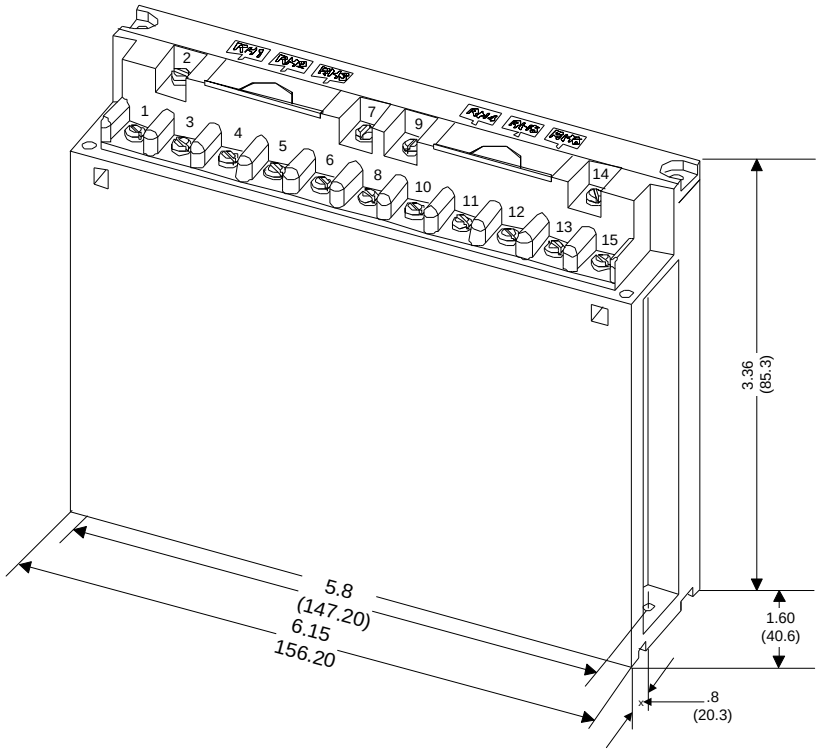
Section 17.4.3 TMM Pump Control Connections



Section 17.4.4 Typical Brush Wear Sensor Connections For Pump Control



Section 17.5 TMM7A Outline Drawings



Section 18. EVT100 GE HANDSET INSTRUCTIONS

Section 18.1 General Features

The GE Handset is a multi-functional tool to be used with the LX, ZX, and SX Series GE solid-state controls. The Handset consists of a Light Emitting Diode (LED) display and a keyboard for data entry.

Section 18.2 Purpose / Setup Functions

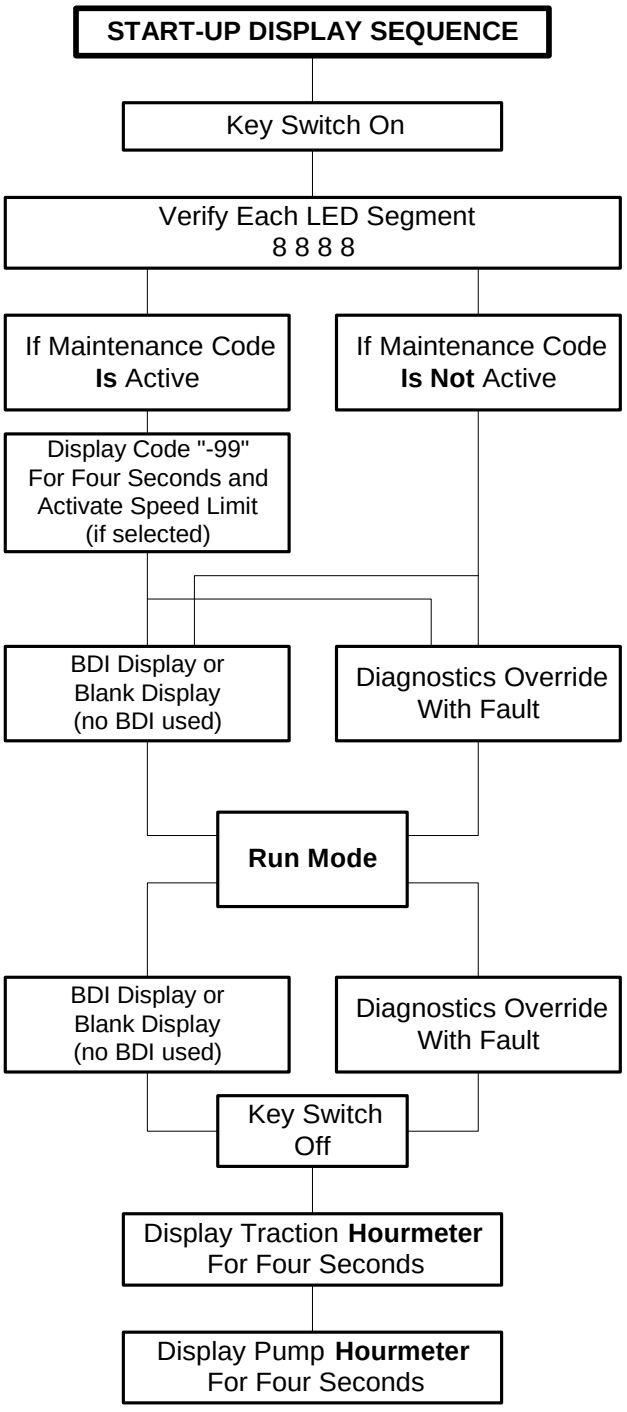
The purpose of the Handset is to allow authorized personnel to perform the following functions of the EVT100ZX Control:

- Monitor existing system fault codes
- Monitor intermittent random fault codes
- Monitor battery state of charge on systems with BDI
- Monitor hourmeter reading
- Monitor or adjust the following control functions:
- Creep speed
- Controlled Acceleration and 1A time
- Regenerative Braking Current Limit and Disable
- Current Limit
- Plugging Distance (Current)
- Pedal Position Plug Range or Disable
- 1A Drop Out Current or Disable
- Speed Limit Points
- Truck Management Fault Speed Limit
- Internal Resistance Compensation for Battery State of Charge Indication
- Battery Voltage (36/48 volts is auto ranging)
- Selection of Card Operation Type.

Warning : Before connecting or disconnecting the Handset tool, turn off the key switch, unplug the battery and jack up the drive wheels of the vehicle.

At the transistor control traction card, unplug the "Y plug" if the dash display is in use, and plug in the Handset to the plug location "Y" on the control card. After installing the Handset tool, plug the battery in and turn the key switch on.

The following is the start-up display sequence that will occur:



NOTE: The vehicle can be operated with the Handset connected, however, the adjustment knob must be set fully clockwise to insure the control operates at top speed.

Section 18.3 Setup Function Procedures

***Warning**: Before making any adjustments to the control, you must consult the operating and maintenance instructions supplied by the vehicle manufacturer. Failure to follow proper set up instructions could result in mis-operation or damage to the control system.*

With the Handset connected, hold down the **CONT** key and turn on the key switch. This will place you in the set up mode, ready to monitor or adjust control function settings.

NOTE: The term "Push" means to depress key for approximately one second.

Section 18.3.1 Setup Mode

SET-UP MODE

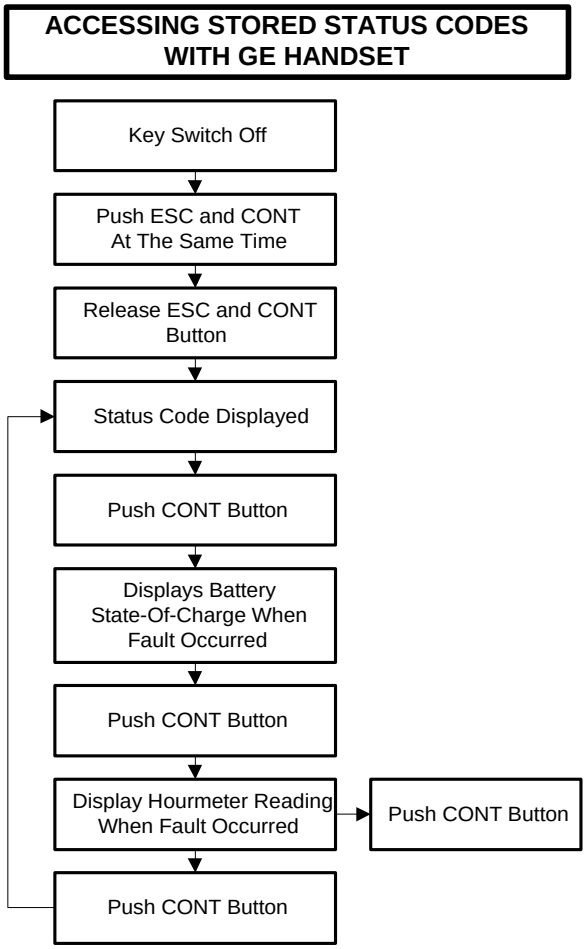
ACTION	DISPLAY SHOWS	REMARKS
Hold Down CONT And Turn On Key	8 8 8 8	Segment Check Displayed
Push Function Number	U 0 0 5	Selected Function No. Is Displayed
After One Second Time Delay	0 8 5	Stored Value For The Function Is Displayed
Push CONT	0 8 5	Display Value Will Blink
Change Value With Adjustment Know	125	Value Changes While Blinking
Push STORE	125	New Value Stored And Blinking Stops
Push ESC	8 8 8 8	Segment Check Displayed

At this point, another function can be monitored/changed by pushing another function number, or the vehicle can be placed in the run mode by holding the **ESC** key down for one second or longer. The display will return to either the diagnostics mode, the BDI display, or a blank display (if BDI is not used and there are no fault codes). The vehicle can now be operated with the Handset connected or the Handset can be disconnected before operation.

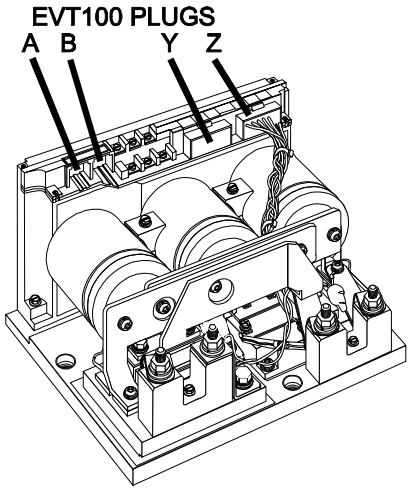
NOTE: You can return to the segment check mode at any time, by holding down the ESC key until 8888 appears in the display.

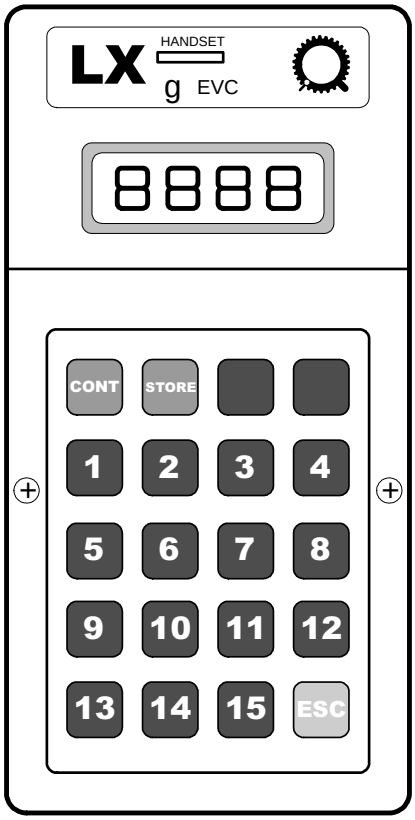
Section 18.3.2 Status Code Scrolling

The EV-T100ZX controller furnishes a function register that contains the last 16 "stored status codes" that shut down vehicle operation (a PMT type fault that is reset by cycling the key switch) and the battery state of charge reading at the time the fault occurred. The first of the 16 status codes will be overwritten each time a new status code occurs. This stored status code register can be cleared from memory by using the Handset.



Section 18.3.3 EVT100ZX Handset, Plug Connections and Outline Drawing





Section 18.4 Description of Setup Function Numbers

Section 18.4.1 Setup Functions for Single Motor Traction Logic Cards

FUNCTION 1: [Push 1]
STORED FAULT CODE

This function register contains the last fault that shut down vehicle operation (PMT type fault that is reset by cycling the key switch). This fault code will be over written each time a new fault occurs and can be cleared from memory by adjusting the value to zero. This register will be cleared when the battery is unplugged.

FUNCTION 2: [Push 2]
CREEP SPEED

This function allows for the adjustment of the creep speed of the vehicle. A constant creep speed frequency will be maintained when an accelerator input voltage between 3.7 and 3.5 volts or an accelerator ohmic input between 6K and 4.7K ohms is provided.

Range	2% to 15% on time
Setting	0 to 255
Resolution	0.03% per set unit

Example: Setting of 20 = 2.6% on time

FUNCTION 3: [Push 3]
CONTROLLED ACCELERATION AND 1A TIME

This function allows for the adjustment of the rate of time it takes for the control to accelerate to 96% applied battery voltage to the motor on hard acceleration. The 1A contactor will automatically close 0.2 seconds after the controlled acceleration stops and the accelerator input is less than 0.5 volts or less than 200 ohms.

Range	0.1 to 22.0 seconds
Setting	0 to 255
Resolution	0.084 seconds per set unit

Example: Setting of 20 = 1.8 seconds C/A and 2.0 1A time.

FUNCTION 4: [Push 4]
CURRENT LIMIT

This function allows for the adjustment of the current limit of the control. The rating of the control will determine the range of adjustment for this function. Please refer to the operating instructions for the control used in your vehicle.

Range	See control C/L curves
Setting	0 to 255

Example: 0 = min. current, 255 = max. current

FUNCTION 5: [Push 5]
PLUGGING DISTANCE (CURRENT)

This function allows for the adjustment of the plugging distance of the vehicle. The larger the current setting, the shorter the stopping distance.

Range	200 to 800 amps
Setting	0 to 255
Resolution	2.35 amps per set unit

Example: Setting of 20 = 247 amps

***Warning:* Plug settings must be in accordance with control operating instructions. An excessively high setting could cause damage to control system or traction motor.**

FUNCTION 6: [Push 6]
1A DROP OUT CURRENT

This function allows for the adjustment of the 1A contactor drop out current. The 1A contactor will be dropped out and the vehicle motor torque will be limited to TRANSISTOR current limit when the set drop out current is reached.

Range	450 to 1260 amps
Setting	0 to 250
Resolution	3.24 amps per set unit

Settings above 250 set units will disable 1A drop out function (1A will not drop out).

Example: Setting of 20 = 515 amps

FUNCTION 7: [Push 7]
FIELD WEAKENING PICK UP

This function allows the adjustment of field weakening contactor pick up current. This setting allows the FW contactor to pick up when the vehicle has returned to about 150% of its full load level running current after acceleration.

Range	52 to 466 amps
Setting	0 to 255
Resolution	1.6 amps per set unit

Example: Setting of 20 = 84 amps

Note: The FW contactor will not pick up with a setting of less than 5.

FUNCTION 8: [Push 8]
FIELD WEAKENING DROP OUT

This function allows for the adjustment of the field weakening contactor drop out current. This setting allows the FW contactor to drop out when the vehicle requires greater than 300% of the full load level running current for greater torque.

Range	65 to 895 amps
Setting	0 to 255
Resolution	3.25 amps per set unit

Example: Setting of 20 = 130 amps

FUNCTION 9: [Push 9]
REGEN BRAKING C/L

This function allows for the adjustment of the Regen braking current limit. The higher the current, the shorter the stopping distance.

Range	75 to 630 amps
Setting	0 to 255
Resolution	2.2 amps per set unit

Example: Setting of 20 = 119 amps

FUNCTION 10: [Push 10]
REGEN START

This function allows for the adjustment of the percent on time at which the control will start to regen. Adjustment of this function allows the OEM to set the regen start speed of the vehicle to eliminate regen attempts when motor regen current is low.

Range	0 to 95% on time
Setting	0 to 255
Resolution	.37% per set unit

Example: Setting of 20 = 7.4% on time

FUNCTION 11: [Push 11]
SPEED LIMIT 1 (SL1)

This function allows for the adjustment of the speed limit (maximum battery volts to the motor) when the SL1 limit switch input signal is received by the control card. SL1 limit switch is a normally closed switch connected to battery negative, the switch opening enables speed limit.

Range	96% to 0% battery volts
Setting	0 to 180

Note: Setting of 0 set units will disable speed limit function and allow top speed with no limit switch connected.

FUNCTION 12: [Push 12]
SPEED LIMIT 2 (SL2)

Same as Function 11 except using SL2 limit switch for input.

FUNCTION 13: [Push 13]
SPEED LIMIT 3 (SL3)

Same as Function 11 except using SL3 limit switch for input.

Note: The SL3 set speed limit is also activated by the Truck Management Module fault codes 90 and 93. See instructions for IC3645TMM7A Truck Management Module for details.

FUNCTION 14: [Push 14]
INTERNAL RESISTANCE COMPENSATION

This function is used when the Battery Discharge Indicator is present. Adjustment of this function will improve the accuracy of the BDI. In order to make this setting the voltage drop ***of a fully charged battery*** under load must first be determined by following the steps listed below:

1. Load the traction motor to 100 amps in 1A and record the voltage (V_O) at the control panel positive and negative power terminal.
2. Load the traction motor to 200 amps in 1A and record the voltage (V_L) at the control panel positive and negative power terminal.
3. Calculate voltage drop (V_D) as follows:
   $V_D = V_O - V_L$
4. Use the table below to determine the setting using the calculated V_D as a reference.

SETTING	EVT100 V_D	SETTING	EVT100 V_D
2	11.44	17	1.34
3	7.60	18	1.27
4	5.72	19	1.20
5	4.57	20	1.14
6	3.81	21	1.09
7	3.27	22	1.04
8	2.86	23	0.99
9	2.54	24	0.95
10	2.28	25	0.91
11	2.08	26	0.88
12	1.90	27	0.85
13	1.76	28	0.82
14	1.63	29	0.79
15	1.52	30	0.76
16	1.43	31	0.74

FUNCTION 15: [Push 15]
BATTERY VOLTS

This function allows for the adjustment of voltage range for controls equipped with the Battery Discharge Indication function. In order for the BDI to operate properly, the setting as shown in the table must be entered .

Battery volts	**Set units**
24 volts	Between 0 and 31
36 volts	Between 32 and 44
48 volts	Between 45 and 69
72 volts	Between 70 and 80
80 volts	Between 81 and 183
36/48 volts	Between 184 and 250
No BDI	Between 251 and 255

Note: The following functions have function numbers larger than the numbers on the Handset keyboard. To access these functions, push the CONT key and the number shown in the following instructions at the same time.

The Seat Switch must be open.

FUNCTION 16: [Push CONT and 1]
PEDAL POSITION PLUG

This function will allow the adjustment of the pedal position plug range. Pedal position will reduce the plugging current to the current value set by this function as the accelerator is returned to the creep speed position. Maximum plug current is obtained with the accelerator in the top speed position.

Range	100 to 800 amps
Setting	0 to 255
Resolution	2.75 amps per set unit

Example: Setting of 20 = 155 amps

To disable the pedal position plug function, adjust the current value to the same current value as the plug distance current.

Example: If plug distance current (Function 5) is set at 500 amps, then set pedal plug current at 500 amps. With this setting, pedal position will have no effect on plugging distance.

FUNCTION 17: [Push CONT and 2]
CARD TYPE SELECTION

This function allows for the selection of the card type used for your vehicle's application. The table below shows the setting to select card application type, depending on which control card is used.

Note: Non-Auto Plug/Regen Logic cards must be used for settings below.

EVT100 FUNCTIONS	STANDARD WITH FW	SPEED LIMIT	REGEN & FW
Std C/L	0 to 4	20 to 24	40 to 44
High C/L	5 to 9	25 to 29	45 to 49

Note: Auto Plug/Regen Logic cards must be used for settings below.

STD C/L Auto Plug	10 to 14	30 to 34	50 to 54
HIGH C/L Auto Plug	15 to 19	35 to 39	55 to 59

Settings for these functions should be made in between the values shown.

Warning: These settings must be changed by authorized personnel only, following instructions supplied by the manufacturer. Card type selection must be made within the capabilities of the TRANSISTOR control panel used and the supporting electro-mechanical devices. Failure to comply with proper application standards could result in mis-operation or damage to the control and/or motors.

FUNCTION 18: [Push CONT and 3]
STEER PUMP TIME DELAY

This function allows for the selection of steer pump contactor pick up input, either seat switch or directional switch closing, and adjustment of the time delay for the contactor drop out.

- **Pick up on seat switch closure and time delay drop out on seat switch opening:**

Range	1.5 to 65 seconds
Setting	Between 0 and 128
Resolution	0.5 seconds per set unit

Example: Setting of 20 = 10.5 seconds

- **Pick up on directional switch closure and drop out time delay on directional switch opening:**

Range	0.5 to 63 seconds
Setting	129 to 255
Resolution	0.5 seconds per set unit

Example: Setting of 149 = 10.5 seconds

Note: Drop out will be 1.5 seconds after the seat switch opens.

Note: To set the Maintenance hours (user selectable) to 1,234 hours, follow the instructions in Function 19 & 20.

FUNCTION 19: [Push CONT and 4] MAINTENANCE CODE TENS AND ONES HOURS SET

This function allows for the adjustment of the tens and ones hours of the maintenance code activation time.

Range	0 to 99
Setting	0 to 99

Example: 34 Hours

FUNCTION 20: [Push CONT and 5] MAINTENANCE CODE THOUSANDS AND HUNDREDS HOURS SET

This function allows for the adjustment of the thousands and hundreds hours of the maintenance code activation time.

Range	0 to 99
Setting	0 to 99

Example: 12 Hours

Note: The maintenance hours have now been set to 1,234.

FUNCTION 21: [Push CONT and 6] MAINTENANCE CODE SPEED LIMIT

This function allows for the adjustment of the speed limit (maximum battery volts to the motor) when the maintenance code is activated by the control card.

Range	100% to 0% battery volts
Setting	0 to 180
Resolution	-0.56 % per set unit

Example: Setting of 20 = 88.8 % battery volts

FUNCTION 28: [Push CONT and 13] STORED STATUS CODE COUNT POINTER

This register contains the location of the last stored status code recorded of the 16 stored status codes. These stored status codes have caused a PMT controller shutdown and/or disruption of normal vehicle operation.

To determine which stored status code was the last one recorded, read the number stored in Function 28. Using the **Memory Map** (See Section 16.1) for your logic card, match the **"stored status code pointer number"** [the number shown in ***(bold italics)*** in the HS (Handset) number column] on the memory map, with the number obtained from Function 28. This will be the last stored status code recorded.

Note: When scrolling the stored status code register, the register always starts at status code 1 and scrolls to status code 16. Instructions for scrolling the register are in Section 18.3.2 of this instruction booklet.

DASH DISPLAY INTERACTIVE MODES

Note: The following functions (Functions 48 - 62) are mode settings that are activated from the Interactive Dash Display. Each function must be set using the logic table shown below. If you try to set the function outside these guidelines, an error code will be displayed to prompt you to enter the correct setting.

If: 80 is displayed, the setting is too low
If: 81 is displayed, the setting is too high

Setting Logic Table

	Mode 1	Mode 2	Mode 3	Mode 4
C/A Time	=> Mode 2	=< Mode 1 => Mode 3	=< Mode 2 => Mode 4	=< Mode 3
FW Pickup	=< Mode 2	=> Mode 1 =< Mode 3	=> Mode 2 =< Mode 4	=> Mode 3
SL1	=> Mode 2	=< Mode 1 => Mode 3	=< Mode 2 => Mode 4	=< Mode 3

Note: The following functions have function numbers larger than the numbers on the Handset keyboard. To access these functions, push the CONT key and the number shown in the following instructions at the same time.
The Seat Switch must be closed.

FUNCTION 48: [Push CONT and 1]
MODE 1 - CONTROLLED ACCELERATION AND 1A TIME

This function allows for the adjustment of the rate of time it takes for the control to accelerate to 96% applied battery voltage to the motor on hard acceleration. The 1A contactor will automatically close 0.2 seconds after the controlled acceleration stops and the accelerator input is less than 0.5 volts or less than 50 ohms. This CA and 1A time takes effect when the Mode 1 settings are called for by the interactive Dash Display.

Range 0.1 to 22.0 seconds
Setting 0 to 255
Resolution 0.084 seconds per set unit

Example: Setting of 20 = 1.8 seconds C/A and 2.0 1A time.

FUNCTION 53: [Push CONT and 6]
MODE 2 - FIELD WEAKENING PICK UP

This function allows the adjustment of field weakening contactor pick up current. This setting allows the FW contactor to pick up when the vehicle has returned to about 150% of its full load level running current after acceleration. This FW pick-up value takes effect when the Mode 1 settings are called for by the interactive Dash Display.

Range 52 to 466 amps
Setting 0 to 255
Resolution 1.6 amps per set unit

Example: Setting of 20 = 84 amps

FUNCTION 50: [Push CONT and 3]
MODE 1 - SPEED LIMIT 1 (SL1)

This function allows for the adjustment of the speed limit (maximum battery volts to the motor) that is activated whenever mode 1 is selected by the operator. **No speed limit switch is required for this function. Therefore, to disable the function, this register must be set to zero.**

Range 96% to 0% battery volts
Setting 0 to 180

Note: Setting of 0 set units will disable speed limit function and allow top speed with no limit switch connected. This Speed Limit (SL1) value takes effect when the Mode 1 settings are called for by the Interactive Dash Display.

FUNCTION 52: [Push CONT and 5]
MODE 2 - CONTROLLED ACCELERATION AND 1A TIME

Same as function 48.

This CA and 1A time takes effect when the Mode 2 settings are called for by the interactive Dash Display.

FUNCTION 49: [Push CONT and 2]
MODE 1 - FIELD WEAKENING PICK UP

Same as Function 49.

This FW pick-up value takes effect when the Mode 2 settings are called for by the Interactive Dash Display.

FUNCTION 54: [Push CONT and 7]
MODE 2 - SPEED LIMIT 1 (SL1)

Same as Function 50.

This Speed Limit (SL1) value takes effect when the Mode 2 settings are called for by the Interactive Dash Display.

FUNCTION 56: [Push CONT and 9]
MODE 3 - CONTROLLED ACCELERATION AND 1A TIME

Same as function 48.

This CA and 1A time takes effect when the Mode 3 settings are called for by the Interactive Dash Display.

FUNCTION 57: [Push CONT and 10]
MODE 3 - FIELD WEAKENING PICK UP

Same as Function 49.

This FW pick-up value takes effect when the Mode 3 settings are called for by the Interactive Dash Display.

FUNCTION 58: [Push CONT and 11]
MODE 3 - SPEED LIMIT 1 (SL1)

Same as Function 50.

This Speed Limit (SL1) value takes effect when the Mode 3 settings are called for by the Interactive Dash Display.

FUNCTION 60: [Push CONT and 13]
MODE 4 - CONTROLLED ACCELERATION AND 1A TIME

Same as function 48.

This CA and 1A time takes effect when the Mode 4 settings are called for by the Interactive Dash Display.

FUNCTION 61: [Push CONT and 14]
MODE 4 - FIELD WEAKENING PICK UP

Same as Function 49.

This FW pick-up value takes effect when the Mode 4 settings are called for by the Interactive Dash Display.

FUNCTION 62: [Push CONT and 15]
MODE 4 - SPEED LIMIT 1 (SL1)

Same as Function 50.

This Speed Limit (SL1) value takes effect when the Mode 4 settings are called for by the Interactive Dash Display.

Section 18.4.2 Setup Functions for Hydraulic Pump Motor Logic

FUNCTION 1: [Push 1]
STORED FAULT CODE

This function register contains the last status code that shut down vehicle operation (PMT type fault that is reset by cycling the key switch). This status code will be over written each time a new fault occurs and can be cleared from memory by adjusting the value to zero. This register will be cleared when the battery is unplugged.

FUNCTION 2: [Push 2]
INTERNAL RESISTANCE COMPENSATION START

This function allows for the adjustment of the current level at which the internal resistance compensation feature (Function 16) will take effect.

Range	0 to 1325 amps
Setting	0 to 255
Resolution	6.5 amps per set unit

Example: Setting of 72 = 130 amps

FUNCTION 3: [Push 3]
CONTROLLED ACCELERATION AND P1A TIME

This function allows for the adjustment of the rate of time it takes for the control to accelerate to 96% applied battery voltage to the motor on hard acceleration. The P1A contactor will automatically close 0.2 seconds after the controlled acceleration stops and the accelerator input is less than 0.5 volts or less than 200 ohms.

Range	0.1 to 5.5 seconds
Setting	0 to 255
Resolution	0.021 seconds per set unit

Example: Setting of 20 = 0.52 seconds C/A and 0.72 seconds 1A time.

FUNCTION 4: [Push 4]
CURRENT LIMIT

This function allows for the adjustment of the current limit of the control. The rating of the control will determine the range of adjustment for this function. Please refer to the operating instructions for the control used in your vehicle.

Range	See control C/L curves
Setting	0 to 255

Example: 0 = min. current, 255 = max. current

FUNCTION 7: [Push 7]
INTERNAL RESISTANCE COMPENSATION RATE

This function allows for the adjustment of the rate of time it takes for the control to add the internal resistance compensation voltage that is applied to the motor. This function will add 0.375 volts to the motor at the rate of time adjusted until the total IR compensation voltage has been added.

Range	0.0015 to 0.383 seconds
Setting	0 to 255
Resolution	0.0015 seconds per set unit

Example: Setting of 20 = 0.032 seconds
For example, if you had selected 2.08 volts from Function 16 to be added to the motor, it would take 0.18 seconds to add a total of 2.08 volts. (2.08/0.375)=0.032

FUNCTION 11: [Push 11]
SPEED LIMIT 1 (SL1)

This function allows for the adjustment of the speed limit (maximum battery volts to the motor) when the SL1 limit switch input signal is received by the control card. SL1 limit switch is a normally open switch connected to battery negative, the switch closing enables speed limit.

Range	0% to 100% battery volts
Setting	0 to 255
Resolution	0.375 volts per set unit

Example: Setting of 50=18.75 volts

FUNCTION 12: [Push 12]
SPEED LIMIT 2 (SL2)

Same as Function 11 except using SL2 limit switch for input.

FUNCTION 13: [Push 13]
SPEED LIMIT 3 (SL3)

Same as Function 11 except using SL3 limit switch for input.

FUNCTION 14: [Push 14]
SPEED LIMIT 4 (SL4)

Same as Function 11 except using SL4 limit switch for input.

Note: For P1A operation with SL4 switch closure, setting should be at 255.

Note: The following functions have function numbers larger than the numbers on the Handset keyboard. To access these functions, push the CONT key and the number shown in the following instructions at the same time.

The Key Switch must be open.

FUNCTION 16: [Push CONT and 1] SPEED / TORQUE COMPENSATION

This function is used to stabilize pump speed at heavy loads. The voltage selected will be added to the motor at each 100 amp increment starting at the value set in Function 2. The voltage compensation selected will be added in increments of 0.375 volts until the entire voltage is added. Foe example, a setting of 2 will be added in 30 steps of 0.375 volts each whereas, a setting of 4 will be added in 15 steps of 0.375 volts each.

SPEED / TORQUE COMPENSATION TABLE

SETTING	VOLTAGE DROP	SETTING	VOLTAGE DROP
2	11.44	17	1.34
3	7.60	18	1.27
4	5.72	19	1.20
5	4.57	20	1.14
6	3.81	21	1.09
7	3.27	22	1.04
8	2.86	23	0.99
9	2.54	24	0.95
10	2.28	25	0.91
11	2.08	26	0.88
12	1.90	27	0.85
13	1.76	28	0.82
14	1.63	29	0.79
15	1.52	30	0.76
16	1.43	31	0.74

FUNCTION 17: [Push CONT and 2] CARD TYPE SELECTION

This function allows for the selection of the card type used for your vehicle's application. The table below shows the setting to select card application type depending on which control card is used:

Function	With Pump Ctr/PMT	Without Pump Ctr/PMT
Std C/L	0 to 8	36 to 44
High C/L	9 to 17	45 to 53
Std C/L BDI (Lockout)	18 to 26	54 to 62
High C/L BDI (Lockout)	27 to 35	63 to 71

BDI Lockout means that the BDI signal from the traction control must be present in order for the pump control to operate. This control will stop operation when the battery state of charge reaches 10%.

Settings for these functions should be made in between the values shown.

***Warning**: These setting must be changed by authorized personnel only, following instructions supplied by the manufacturer. Card type selection must be made within the capabilities of the TRANSISTOR control panel used and the supporting electro-mechanical devices. Failure to comply with proper application standards could result in mis-operation or damage to the control and/or motors.*

FUNCTION 28: [Push CONT and 13] FAULT COUNT POINTER

This register contains the location of the last stored status code recorded of the 16 stored status codes. These stored status codes have caused a PMT controller shutdown and/or disruption of normal vehicle operation.

To determine which stored status code was the last one recorded, read the number stored in

Function 28. Using the **Memory Map** (See Section 16.2) for your logic card, match the **"stored status code pointer number"** [the number shown in ***(bold italics)*** in the HS (Handset) number column] on the memory map, with the number obtained from Function 28. This will be the last stored status code recorded.

Note: When scrolling the stored status code register, the register always starts at status code 1 and scrolls to status code 16. Instructions for scrolling the register are in Section 18.3.2 of this instruction booklet.

DASH DISPLAY INTERACTIVE MODE

Note: The following functions (Functions 48 - 62) are mode settings that are activated from the Interactive Dash Display. Each function must be set using the logic table shown below. If the you try to set the function outside these guidelines, an error code will be displayed to prompt you to enter the correct setting.

If: 80 is displayed, the setting is too low
If: 81 is displayed, the setting is too high

Setting Logic Table

	Mode 1	Mode 2	Mode 3	Mode 4
C/A Time	=> Mode 2	=< Mode 1 => Mode 3	=< Mode 2 => Mode 4	=< Mode 3
FW Pickup	=< Mode 2	=> Mode 1 =< Mode 3	=> Mode 2 =< Mode 4	=> Mode 3
SL1	=> Mode 2	=< Mode 1 => Mode 3	=< Mode 2 => Mode 4	=< Mode 3

Note: The following functions have function numbers larger than the numbers on the Handset keyboard. To access these functions, push the CONT key and the number shown in the following instructions at the same time.

The Key Switch must be closed.

FUNCTION 48: [Push CONT and 1] MODE 1 - CONTROLLED ACCELERATION AND P1A TIME

This function allows for the adjustment of the rate of time it takes for the control to accelerate to 96% applied battery voltage to the motor on hard acceleration. The P1A contactor will automatically close 0.2 seconds after the controlled acceleration stops and the accelerator input is less than 0.5 volts or less than 200 ohms. This CA and P1A time takes effect when the Mode 1 settings are called for by the Interactive Dash Display.

Range	0.1 to 22.0 seconds
Setting	0 to 255
Resolution	0.084 seconds per set unit

Example: Setting of 20 = 1.8 seconds C/A and 2.0 1A time.

FUNCTION 49: [Push CONT and 2] MODE 1 - SPEED LIMIT 2 (SL2)

This function allows for the adjustment of the speed limit (maximum battery volts to the motor) when the SL2 limit switch input signal is received by the control card. SL2 limit switch is a normally open switch connected to battery negative, the switch closing enables speed limit. This Speed Limit 2 (SL2) takes effect when the Mode 1 settings are called for by the Interactive Dash Display.

Range	0% to 100% battery volts
Setting	0 to 255
Resolution	0.375 volts per set unit

Example: Setting of 50=18.75 volts

FUNCTION 50: [Push CONT and 3] MODE 1 - SPEED LIMIT 4 (SL4)

This function allows for the adjustment of the speed limit (maximum battery volts to the motor) when the SL4 limit switch input signal is received by the control card. SL4 limit switch is a normally open switch connected to battery negative, the switch closing enables speed limit.

This Speed Limit 4 (SL4) takes effect when the Mode 1 settings are called for by the Interactive Dash Display.

Range	0% to 100% battery volts
Setting	0 to 255
Resolution	0.375 volts per set unit

Example: Setting of 50=18.75 volts

FUNCTION 52: [Push CONT and 5] MODE 2 - CONTROLLED ACCELERATION AND P1A TIME

Same as function 48.

This CA and P1A time takes effect when the Mode 2 settings are called for by the Interactive Dash Display.

FUNCTION 53: [Push CONT and 6] MODE 2 - SPEED LIMIT 2 (SL2)

Same as Function 49.

This Speed Limit (SL2) value takes effect when the Mode 2 settings are called for by the Interactive Dash Display.

FUNCTION 54: [Push CONT and 7] MODE 2 - SPEED LIMIT 4 (SL4)

Same as Function 50.

This Speed Limit (SL4) value takes effect when the Mode 2 settings are called for by the Interactive Dash Display.

FUNCTION 56: [Push CONT and 9] MODE 3 - CONTROLLED ACCELERATION AND P1A TIME

Same as function 48.

This CA and P1A time takes effect when the Mode 3 settings are called for by the Interactive Dash Display.

FUNCTION 57: [Push CONT and 10] MODE 3 - SPEED LIMIT 2 (SL2)

Same as Function 49.

This Speed Limit (SL2) value takes effect when the Mode 3 settings are called for by the Interactive Dash Display.

FUNCTION 58: [Push CONT and 11] MODE 3 - SPEED LIMIT 4 (SL4)

Same as Function 50.

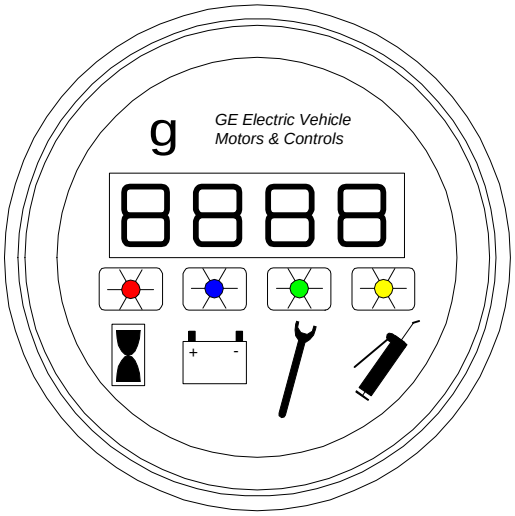
This Speed Limit (SL4) value takes effect when the Mode 3 settings are called for by the Interactive Dash Display.

Section 19. DASH DISPLAYS

Section 19.1 Application

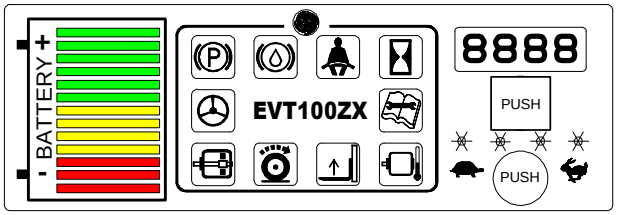
The EVT100ZX Standard and Interactive Dash Displays allow the operator and maintenance personnel easy access to truck operation information and real-time systems diagnostics of the controller, motor and various accessories. Hourmeter readings, battery discharge information, maintenance information and system status codes are clearly displayed during startup and running modes. Shielded cable connections are made to the Dash Display by means of five (5) 22-gage wires to the "Y" Plug of the traction and hydraulic pump controls.

Section 19.2 Standard Dash Displays



The GE Standard Dash Display is a four segment Light Emitting Diode (LED) instrument that displays the GE LX, ZX, and SX Status Codes, Hourmeter Readings, Battery Discharge Indication, and Maintenance Required Code. The four LED's above the symbols indicate the active readout mode.

Section 19.3 Interactive Custom Dash



Displays

The Interactive Custom Dash Display allows the operator to select the best vehicle performance for changing factory (task) conditions. There are four (4) "operator interaction modes" that can be selected by depressing a pushbutton on the dash display.

From the Dash Display, the operator may select any of four pre-set interactive modes consisting of (4) Controlled Acceleration levels, (4) Field Weakening Pick Up levels and (4) Speed Limit levels.

These interactive modes are "pre-set" using the Handset (Functions 48 - 62) or a personal computer (Functions 97 - 112). This feature allows the operator to select the best vehicle performance for changing factory (task) conditions.

The table below outlines the normal logic flow for pre-setting the four interactive modes:

Setting Logic Table

	Mode 1	Mode 2	Mode 3	Mode 4
C/A Time	=> Mode 2	=< Mode 1 => Mode 3	=< Mode 2 => Mode 4	=< Mode 3
FW Pickup	=< Mode 2	=> Mode 1 =< Mode 3	=> Mode 2 =< Mode 4	=> Mode 3
SL1	=> Mode 2	=< Mode 1 => Mode 3	=< Mode 2 => Mode 4	=< Mode 3

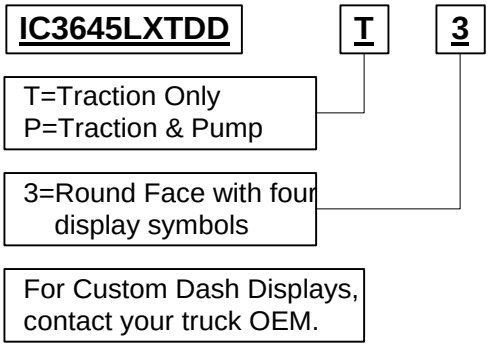
The Custom Dash Display incorporates all the features and functions of the Standard Dash Display in addition to the following customer options:

- LED graphics to display Battery Discharge Indication status.
- Various LED indicators for Maintenance Required Status Codes. These can include options for traction, pump and power steer motors, hourmeter, over temperature, seat belt, brake and other safety sensors.
- A pushbutton associated with the four segment LED that displays Status Codes can be used to scroll the last 16 “Stored Status Codes” that shut down vehicle operation with a PMT fault.

CONNECTIONS

Connections are made to the Dash Display with five (22-gage) wires to Plug "Y" of each control. Shielded cable is required to eliminate signal interference.

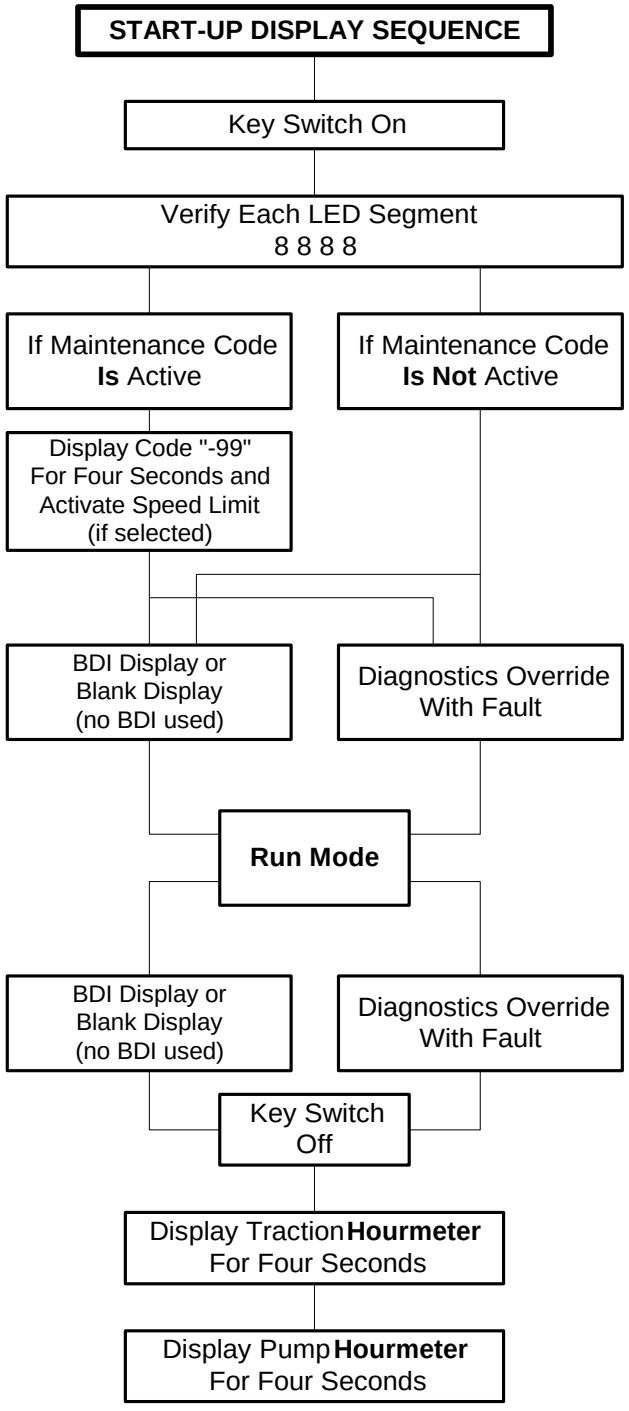
PART NUMBER



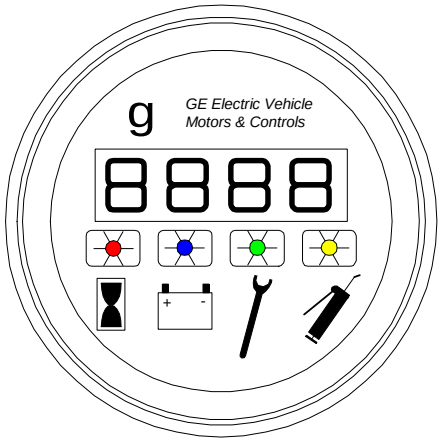
REFERENCE

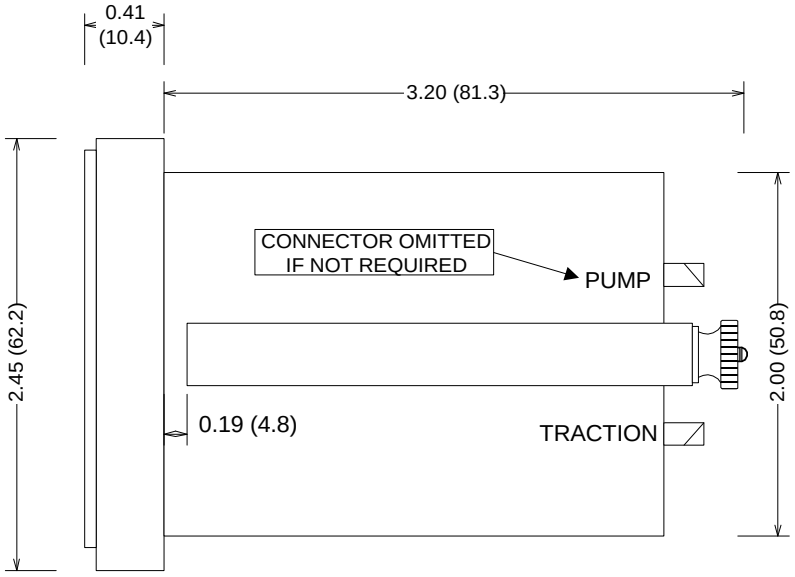
AMP#102241-3	Dash Display mating plug
AMP#1-87195-8	Dash Display mating pin
44A723596-G09	Dash Display Plug Kit
328A1544ADP1	"Y" Plug
AMP#102103-3	"Y" Plug receptacle

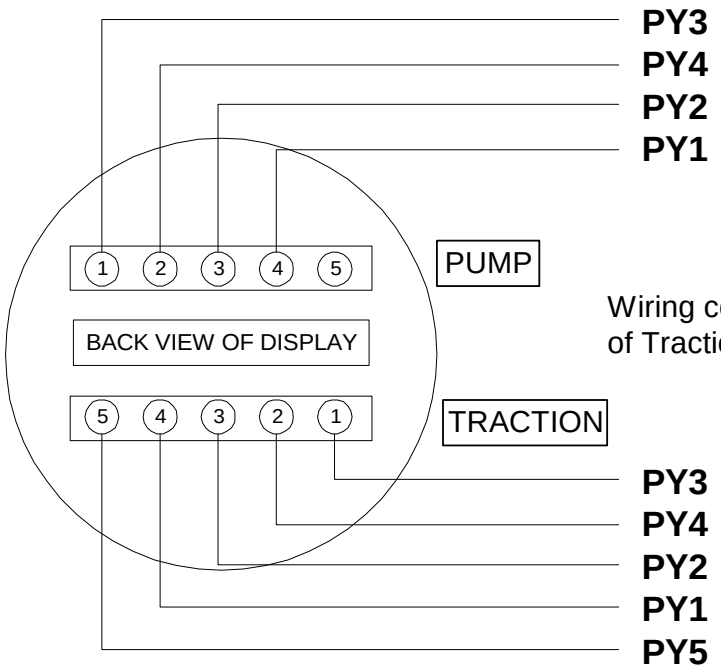
Section 19.4 Start-Up Display Sequence



Section 19.5 Outline Drawings







Wiring connections to "Y" plugs of Traction & Pump control.

Section 20. SOFTWARE DRIVERS FOR EVT100ZX CONTROLLERS.

Section 20.1 Driver Application Guidelines

20.1.1 Summary of Driver Functions.

The GE Electric Vehicle Systems Communication Software driver library is designed to complement Microsoft QuickBasicTM 4.5 (or greater), and BASIC Professional Development System 7.0TM .

The GE driver software contains routines that perform a variety of chores that would be tedious or difficult for the end user to write himself.

There are two separate drivers included in the GE driver package. One driver that supports the GE "EVLX" communication protocol, which requires additional hardware for the IBM personal Computer and an interface module. The other driver fully supports the GE "EVZX" RS-232-C communications protocol.

The third function that is contained in the GE library is a revision notification for the end user. This function may be called at any time during the operation of the user's main module code. When called, this function will display the current driver software revision level and revision date for four seconds before terminating. It is highly desirable for the end user to include this call at the initialization of the main module code.

Section 20.1.2 Driver Descriptions for EVT100LX Systems

The LX communication driver is a stand alone driver that operates like a standard QuickBasic TM Sub, or function program. The driver handles all of the communication protocol requirements of the GE LX family of control systems. The Driver name is simply "LXDRIVER", and can be invoked by the user created module level code by using the Basic "Call" statement.

The driver must be declared at the beginning of the user module level code in the following format:

DECLARE SUB LXDRIVER (FunctionKey%, Value%, ADDRESS)

Where:

FunctionKey%
Is an integer value representing the number of the function register that you wish to program. Valid range of values for this parameter is 0 to 30.

Value%
Is an integer value representing the value the user wishes to store in the selected function. Valid range of values for this parameter is 0 to 255.

ADDRESS
Is the hexadecimal base address of the MetrabyteTM DDA-06 installed in the IBMTM Personal Computer. A typical address is hexadecimal #300 (&300H). Consult the MetraByte users manual for further information.

The **GE LXDRIVER** will support more than one DDA-06 MetraByteTM card in a single IBMTM PC by simply changing the address. Therefore, it is possible to program multiple GE LX products from the same programmer station.

The **GE LXDRIVER** does not do any error checking on the parameters passed to it by the user created module level code. It is imperative for the proper programming of the LX product that the user assume full responsibility to insure that the values passed to the driver are valid values as described previously.

The following is a sample segment of code that uses the LXDRIVER to program an EVLX control system.

```
DEFINT A-Z
DECLARE SUB LXDRIVER
        (FunctionKey%,Value%,ADDRESS)

DECLARE SUB REVISION()

CALL REVISION
ADDRESS = &H300

FOR X = 1 TO 10
        FunctionKey% = X
        Value% = (X*2)
Call LXDRIVER
        (FunctionKey%,Value%,ADDRESS)

NEXT X
END
```

In the above example the GE LX product functions 1 through 10 are programmed to a value that is equal to twice the function.

It is essential that the user have the LX product in the programming mode as described in the particular LX product programming instruction sheet prior to the execution of the programming module code.

Section 20.1.3 Driver Description for EVT100ZX Systems

The ZX communication driver is a stand alone driver that operates like a standard QuickBasicTMTM Sub, or function program. The drive handles all of the communication protocol including the RS-232-C serial communications handshaking requirements of the GE ZX family of control systems. The Driver name is simply "ZXDRIVER", and can be invoked by the user created module level code by using the Basic "Call" statement.

The driver must be declared at the beginning of the user module level code in the following format:

DECLARE SUB ZXDRIVER
(Opcode%, FunKey%, Value%, Comm%, Password$, Status$)

Where:
Opcode% is an integer value between 1 and 100 that is the Operation Code for the ZX Device.

The Opcodes are defined as follows:

10 - READ the current value from a specified register. The ZX driver will return the current stored value in the Value% variable.

20 - WRITE the value of the Value% variable to the specified function register. The ZX driver will echo the function and value to the main module code at the completion of the write command.

30 - READ Software Identification byte 1.
The software Identification is a two byte wide word which contains alpha numeric data.
(The ID and Software Revision bytes must be converted to ASCII characters by the user main module level code. The ZX driver will return the binary value of the character.)

31 - READ Software Identification byte 2.
This command returns the second byte of the Software Identification word from the ZX device. The ID bytes are returned in the Value% variable. This byte must be converted to an ASCII Character.

40 - READ Software Revision byte 1.
The Software Revision like the Identification is a 2 byte wide word which contains alpha numeric data.
As in Opcode 30 this command returns the software revision level byte one from the ZX control which must be converted to ASCII.

41 - Read Software Revision byte 2.

This command returns the second byte of the software revision from the ZX control.

50 - Log on. This is the first command that has to be sent to the ZX control to establish communication with the device.

Once communication has been successfully established the ZX driver will echo the command back to the main module level code.

Once the opcode 50 has been sent and communication is successful, normal operation of the vehicle is inhibited until opcode 60 is transmitted, or the control system is powered down and re-initialized.

60 - Log Off. The last command sent to the ZX device should be the Opcode 60 command to "log off" from the ZX control and allow it to resume normal operation.

100 - Request to re-transmit. This command is returned to the ZX device by the ZXDRIVER requesting the ZX device to transmit the current command / response again. The ZXDRIVER will automatically handle the request from the ZX device up to ten consecutive transmits of the same command. After ten tries the driver will terminate and return an opcode of "100" to the Main module level code"

FunctionKey% is an integer value between the value of 1 and 128. This value corresponds to the function register to which the user wishes to read or write a program value.

Value% The value variable is an integer value between the values of 0 and 255. This variable contains the actual program value that is either read or written to the ZX control function specified.

Comm% The Comm% variable is an integer value of either 1 or 2 which indicates which IBM PC serial port that the GE "ZX" device is connected to. The ZXDRIVER fully supports COM 1 and COM 2.

Due to interrupt difficulties that can occur in the various configurations of Personal Computers, Com ports greater than two are not supported at this time.

Password$ The Password$ is a string variable that contains the user's password which is required by the ZXDRIVER for proper operation.
A null or space is considered to be a valid password entry by the ZXDRIVER.

Status$ The status$ is a string variable in which the ZXDRIVER returns status conditions incurred by the ZXDRIVER program.

The ZX driver does have extensive error checking for parameters that are out of range, unauthorized operations on restricted functions, and communication problems between the IBM PC and the GE ZX control.

The status codes returned by the ZXDRIVER are defined as follows:

OPR000 - Operation complete with no errors incurred during communication.

ERR001 - Invalid Opcode. During the Call function the value of the Opcode% variable was not within the valid range. No transmission to the ZX device occurred.

ERR002 - Invalid Function. During the Call function the value of the FunctionKey% was not within the valid range. No transmission to the ZX device occurred.

ERR003 - Invalid Value. During the Call function the value of the Value% variable was not within the valid range. No transmission to the ZX device occurred.

ERR004 - Invalid Comm port identified. During the Call function the value of the

Comm% variable was not within the valid range. No transmission to the ZX device occurred.

ERR005 - Time out on Receive. Communication Failure between the ZX control and the IBM PC. The ZXDRIVER transmitted data to the ZX control but after ten seconds no data had been received from the GE ZX control.

ERR006 - Unable to receive valid data. After several successive tries to communicate with the ZX device the ZXDRIVER was unable to receive valid data (checksum).

ERR007 - Read Only Register. A restricted access register was attempted to be written to without the proper password.

ERR008 - Com port Device Not Ready. The ZXDRIVER attempted to establish contact with the ZX device, however, the ZX control was not connected to the PC or not set to the proper "SRO" conditions to establish a data link between the computer and the ZX control.

ERR009 - Transmit Failure. After ten tries the ZXDRIVER was unable to transmit valid data to the ZX control.

ERR010 - Fault register write error. A value greater than zero was attempted to be written to one of the fault code registers. These registers (33 through 96) may be read or cleared by the user.

Programming them to a value of zero will clear the register.

The following segment of module level code demonstrates the use of the ZXDRIVER to Log on, program and read back the first 10 function registers of the ZX control, and log off.

```
DEFINT A-Z

DECLARE SUB ZXDRIVER (Opcode%,
FunKey%, Value%, Comm%, Password$,
Status$)

DECLARE SUB REVISION ()

CALL REVISION

Comm% = 1
Password$ = "bigbubba"
Status$ = ""

REM LOG ON  to the ZX Control
Opcode% = 50
FunKey% = 1
CALL ZXDRIVER
(Opcode%,FunKey%,Value%,Comm%,Passwor
d$,Status$)

REM Write the first 10 Registers with the value
of 255
Opcode% = 20
Value% = 255

FOR X = 1 to 10
FunKey% = X - 1
REM the ZX EEPROM starts at Register 0
REM Therefore, always -1 on transmit &
REM +1 on receive

CALL ZXDRIVER
(Opcode%,FunKey%,Value%,Comm%,Passwor
d$,Status$)
IF Status$ << "OPR000" then goto error
NEXT X

REM READ back the first 10 registers
Opcode% = 10
FOR X = 1 TO 10
FunKey% = X - 1
CALL ZXDRIVER
(Opcode%,FunKey%,Value%,Comm%,Passwo
d$,Status$)
FunKey% = FunKey% +1
Print  Opcode%,FunKey%,Value%,Status$
NEXT X

REM LOG OFF of ZX control

OPCODE% = 60
FunKey% = 1
```

```
CALL ZXDRIVER
(Opcode%,FunKey%,Value%,Comm%,Passwor
d$,Status$)
GOTO QUIT

ERROR:    REM print the detected error and
          end
          PRINT " ERROR DETECTED ,
          STATUS CODE = ";Status$

QUIT:     END
```

In the previous example the program logs onto the ZX control, writes the first ten registers then reads back the same registers and prints the data to the CRT. Notice that there is an error trapping routine incorporated to detect error codes returned by the EVDRIVER.

Note: Notice that when reading and writing the function register to the ZX Driver or when writing to the ZX device the function number is decremented by one and when reading the function number back it is incremented by one. This is because the publications indicate that the first register location is one, however, in the device that first addressable register is really zero. Thus, for readability of the human interface the function register is offset by one.

1.3 System Requirements

The following requirements must be met to implement the GE EVS driver package.

1. IBMTM Personal Computer XT or greater. with 640K RAM, minimum of 20 meg hard drive.
2. One open RS-232-C Com Port, either COM 1 or COM2.
3. GE EVS programmer interface module and cables, or equal means to provide the proper battery inputs to the EVLX or EVZX device (Vbat, Key, etc).
4. Nine pin DB-9 Serial cable, Male to Female for ZX type controls.
5. GE RS-232-C adapter module for ZX type controls.
6. Microsoft QuickBasicTM 4.5 or greater installed.

1.4 GE Driver Installation

To install the General Electric EVS Driver library simply copy the "EVDRIVER.LIB" file from the supplied disk on to the IBM PC hard drive in the same directory as the QuickBasicTM existing libraries are installed.

1.5 Using the GE Driver Library

The GE EVDRIVER is considered by QuickBasicTM to be an "external library". Therefore, to use the GE driver package the programmer must compile and link the source code outside of the QuickBasicTM editor environment as a stand alone Executable file.

When you compile a BASIC program, the MicrosoftTM BC compiler converts your code into equivalent machine language instructions and places the result in an object file with the extension of ".OBJ". Programs written in other MicrosoftTM languages such as assembler, C, or Pascal are also compiled and converted to the same object file format. Subroutines written in these languages can be added to your compiled BASIC object files when the final program is created with the LINK.EXE command.

To Create an executable file from your source code and the GE driver library follow the following steps:

1. Save the source code "Sample.BAS" and exit from the BASIC editor environment.

2. From the dos command line while in the directory in which QuickBasic™ resides, compile the source code using the "BC" command.
example BC
Sample.BAS,Sample.OBJ,NUL.LST

3. Next you must link the newly created Sample.OBJ file to the appropriate libraries in order to create the stand alone executable file. This is accomplished by using the "LINK" command from the DOS command line example LINK Sample.OBJ,Sample.EXE,NUL.MAP,EVDRIVER.LIB

4. The program is now compiled and linked into a stand alone executable file. In the above example the file Sample.EXE has been created and can run from the dos prompt like any other .EXE file without any run time libraries or other supporting files.
Refer to the MicrosoftTM QuickBasicTM Programmer's manual for additional information on how to use add on libraries with the MicrosoftTM QuickBasicTM package.

ZX Command Summary

OPCODES	Command Description
10	READ from a Register
20	WRITE to a Register
30	READ 1st Character of Software ID
31	READ 2nd Character of Software ID
40	READ 1st Character of Software Revision
41	READ 2nd Character of Software Revision
50	LOG-ON
60	LOG-OFF
100	Request to RE-transmit

ZX STATUS CODE SUMMARY

STATUS CODE	Error Description
OPR000	Operation Complete, no errors
ERR001	Invalid Opcode sent.
ERR002	Invalid Function Register specified.
ERR003	Invalid Value sent.
ERR004	Com Port identified is not supported.
ERR005	Time out on receive.
ERR006	Unable to receive valid data.
ERR007	Read only register.
ERR008	Com port device not ready.
ERR009	Transmit failure.
ERR010	Fault register write error.

Appendix A - RS-232-C Connection Diagram