

EV5 EV-T5

POWER MOSFET CONTROL

**SPECIFICATIONS
INSTRUCTIONS
TROUBLESHOOTING**

PARTS PRICING/ORDER INFORMATION: 800-333-1194



**FLIGHT SYSTEMS
INDUSTRIAL PRODUCTS**

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SPECIFICATIONS EV5 CONTROLS

APPLICATION

EV5 MOSFET Controls are designed utilizing the latest in power transistor technology for traction drives for use with series-wound dc motors. Prime uses include industrial walkie, rider/walkie and order picker lift trucks and light tractor electric vehicles. These controls have been successfully applied to meet Underwriter's Laboratory standards. Some of the tests the controls have passed include U/L dielectric, Department of Forestry shock and vibration, and radio interference.

DESCRIPTION

EV5 contains all the power and logic circuits that, when used with appropriate contactors, accelerator input, and switches, comprise a complete electric vehicle drive system. EV5 varies the voltage to the motor in a controlled manner to provide smooth acceleration of the vehicle.

FUNCTIONS

Controlled Acceleration and 1A Time - An adjustable function that allows smooth acceleration on vehicles of varying weights and speeds.

Current Limit - An adjustable function that renders self-protection to the control and the traction motor.

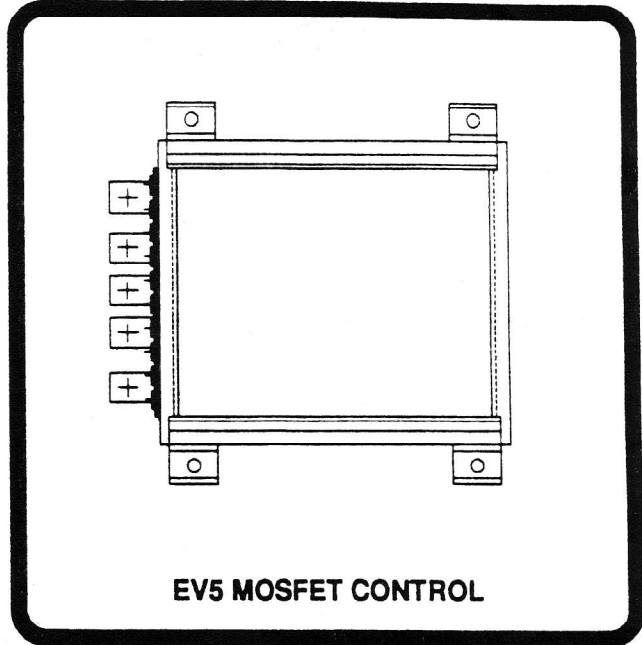
Fault Detection - Continuously monitors for a full-power fault both before and during operation, minimizing chances of runaway.

Thermal Protection - A protection circuit that gradually reduces current limit, if needed, to maintain rated component temperature.

Static Return to Off - requires the directional switch to be returned to neutral in order to start after the key switch has been opened.

Accelerator Position Plug - Plugging distance of the vehicle can be controlled by the operator depending on the position of the accelerator input during the plugging cycle.

Reduced 1A Arcing - Increased tip life can be expected due to arcless 1A operation when currents are below 250 amps.



EV5 MOSFET CONTROL

Low Accelerator Volts Lock Out - This circuit minimizes the chances of vehicle run away due to shorted or mis-adjusted accelerator input devices.

Emergency Reversal Circuit - This circuit allows for the use of an emergency reversal (belly-button) switch that immediately reverses the vehicle to the "forward" direction when activated.

Top Speed Limit - This circuit allows the setting of the top speed of the vehicle. When a normally open switch is used the circuit provides the rider speed for walkie/rider vehicles or when a normally closed switch is used provides a top speed limit function for order picker vehicles.

High Frequency Operation - This feature provides a bell shaped oscillation curve that ranges from 5 KHZ at creep speed to 15 KHZ at mid-speed to 5 KHZ at top speed. The high oscillation rate of EV5 allows for quieter operation, higher average motor current with lower peak motor currents, less ripple current at the motor, and less motor heating.

Reversed Battery Protection - This function disables the operation of the control if the battery connections are reversed.

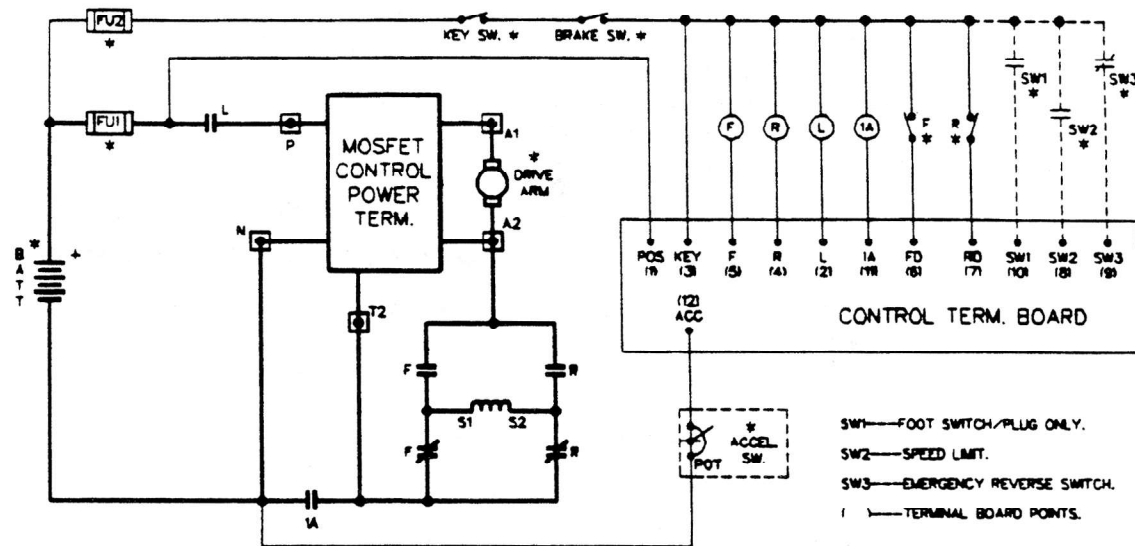
TECHNICAL DATA

Battery Voltage 24VDC
 Low Battery Operation Down to 62% of nominal
 Reverse Battery Yes
 Current Limit 250 Amps at 50% on time
 Full Load Running 100A with 1A contactor
 Full Load Running 75A without 1A contactor
 Max Plug Current 250 Amps
 Ambient Temperature -30 to +50 Degrees C
 Controlled Acceleration .. 1 to 4 seconds
 1A Pick-up Time Follows C/A time
 Creep Speed Fixed
 Fault Protection Look ahead and one count

WIRING DIAGRAM

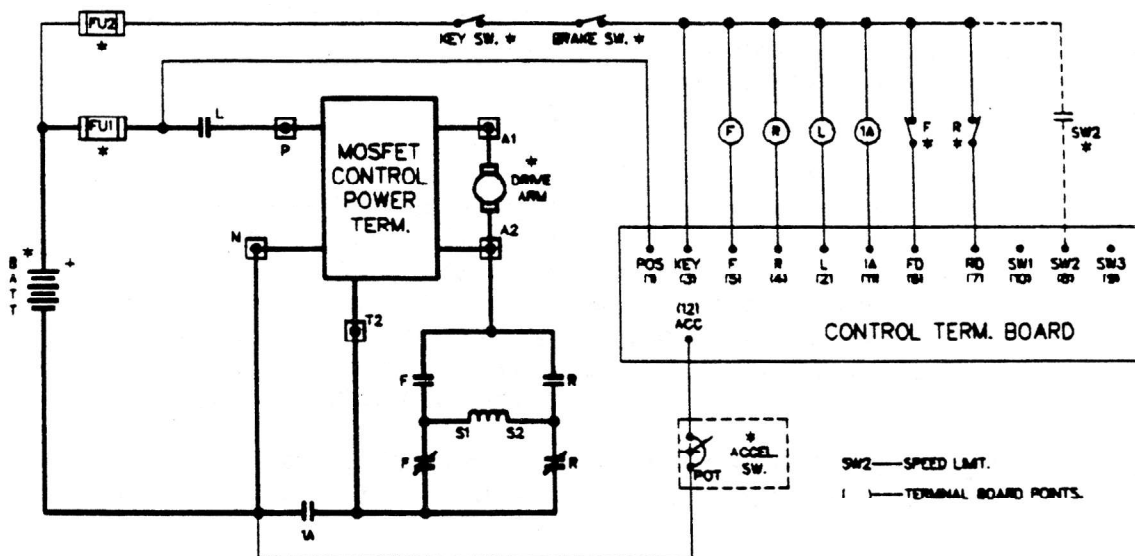
Speed Limit Adj - Zero to top speed
 On-board Drivers F/R, 1A and Inrush Ctr's
 Thermal Protection 85 Degree C cutback
 Accelerator Input 5K to 0 ohms
 3.5 to .5 VDC
 In-rush Protection Pre-charge line filter std
 Accelerator Position Plug Adj - 50 to 250 Amps
 Emergency Reversal Standard
 1A Arc Extinguishing Arcless below 250 Amps
 Shock and Vibration U.S. Forestry Specification
 Underwriter's U/L 583
 Approximate weight 7 pounds

ELEMENTARY DIAGRAM



- ⊗ MOSFET POWER CONNECTIONS.
- * SUPPLIED BY CUSTOMER.

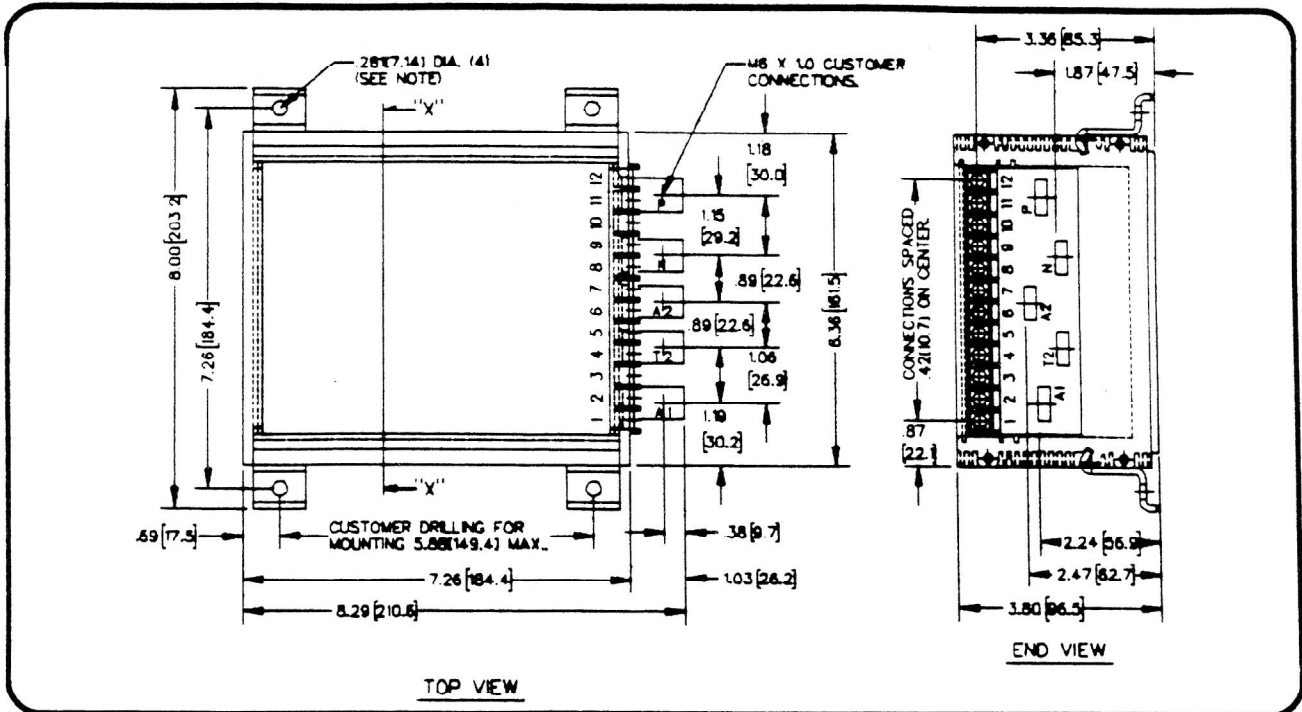
WALKIE/RIDER



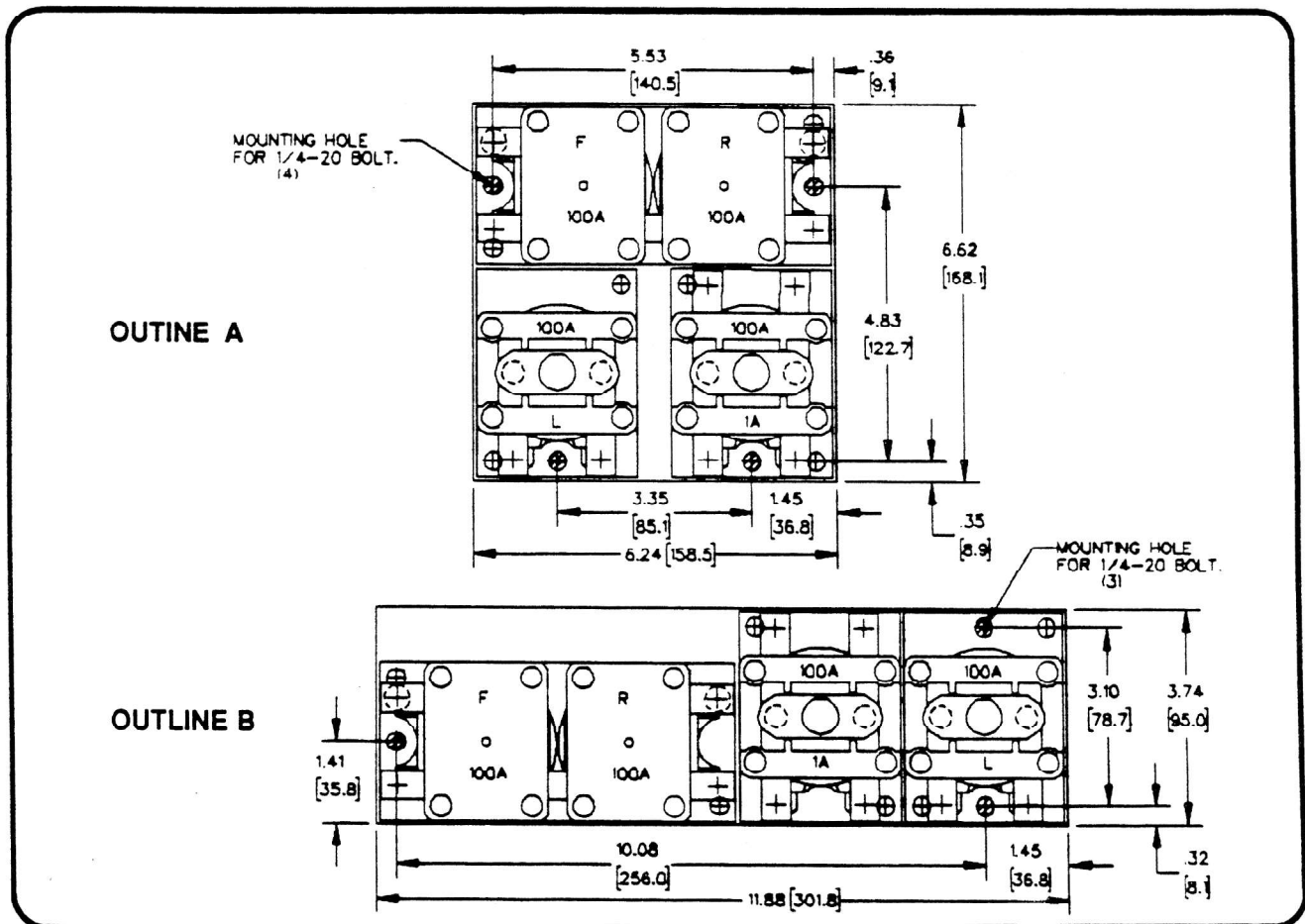
- ⊗ MOSFET POWER CONNECTIONS.
- * SUPPLIED BY CUSTOMER.

UTILITY

EV5 OUTLINE DRAWING



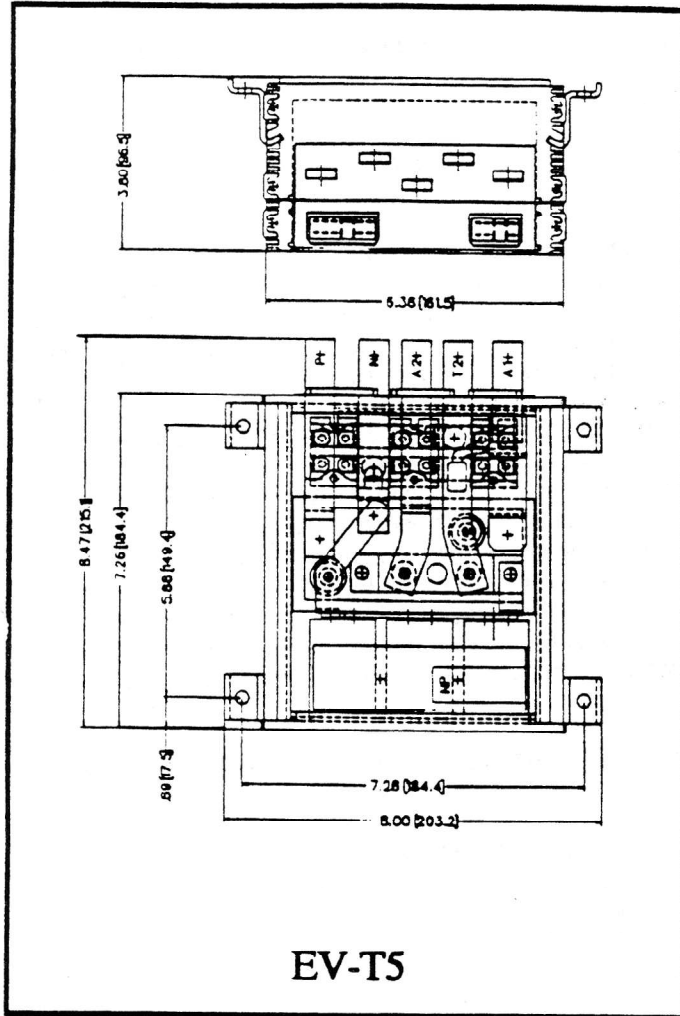
STANDARD REVERSER OUTLINE DRAWINGS





GE Electric Vehicle
Systems

SPECIFICATIONS
EV-T5 TRANSISTOR CONTROL



EV-T5

FEATURES

EV-T5

Frequency	5KHZ to 15KHZ
Modulation	PWM and FM
Creep Speed Adj	0-25%
Current Limit Adj	100-Max
Controlled Acceleration adj	.5-3 SEC
Plugging Adj	100A-Max Plug
Pedal Plug Adj	FIXED
1A Time Adj	C/A + .2 SEC
Adj Method	TRIMPOTS
Bypass Operation	OPTIONAL
Arcless Bypass	UP TO Max C/L
On-Board Coil Suppressors	YES
PMT	YES
SRO	YES
Speed Limit (Adjustable)	ONE
Ramp Start	YES
Reversed Battery Protection	LINE CTR

Control Features Descriptions:

Plugging - slows the vehicle to a stop when reversing, by providing a small amount of retarding torque for deceleration. The oscillator circuit regulates braking at an adjustable plug current limit level to bring the truck to a smooth stop and reversal.

Pedal Position Plug - regulates plugging distance based on pedal position. Maximum plug current is obtained with the accelerator in the top speed position.

Ramp Start - provides full 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 assure full power when restarted.

Full Power Transition - provides smooth transition from control to 1A bypass. This is accomplished by the control continuing to pulse until the 1A contactor power tips close.

Control Acceleration and 1A Time - allows for 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 .2 seconds after the controlled acceleration stops and the accelerator input is less than .5 volts or less than 50 ohms.

Accelerator Volts Hold-Off - 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 operate. This is to insure low speed operation at start up.

FEATURES

EV-T5

Voltage Range (VDC)	24 or 36 VDC
Mtr Current Limit (Option)	350A
Mtr Current Limit (Option)	275A
Mtr Current Limit (Option)	200A
1 Hour Rating (Amps)	170A
Max. Plug Current (Option)	450A
Max. Plug Current (Option)	350A
Max. Plug Current (Option)	250A
Ambient Temperature	-40C +50C
Thermal Protection	LINEAR 90C
Accelerator Input	5k-0.3.5v-0
Dimensions (HxLxW)	96x184x161
Repair	FIELD/RET
Power Device	MOSFET
Logic Card	GAL/ANALOG

Static Return to Off (SRO) - If the seat switch or key switch is opened, the control will shut off and cannot be restarted until directional lever is returned to neutral. A time delay of approximately 1.5 seconds is built into the seat switch input to allow momentary opening of the seat switch if a bump is encountered.

Pulse Monitor Trip (PMT) - The PMT circuit will not allow the control to start if main transistors are shorted or, if the 1A contactor is welded, (uncontrolled top speed conditions), the control will not allow the F or R contactor to close.

The PMT circuit will shut down operation of the control (opening of the F or R contactor), if the main transistors fail to shut off , or if 1A power tips remain closed when they should be open. When the PMT circuit prevents F or R contactors from closing, the PMT circuit can be reset only by opening the key switch.

Thermal Protector (TP) - These are temperature sensitive devices that are mounted on the MOSFETs heat sink and filter capacitors. If the MOSFETs or capacitors temperature begins to exceed the design limits, the thermal protector will lower the maximum current limit and not allow the devices to exceed its temperature limits. Even at a reduced current limit, the vehicle will normally be able to reach sufficient speed for full 1A operation, thereby allowing the panel to cool. As the panel cools, the thermal protector will automatically return the control to full power.

Reverse Battery Protection - An external line contactor protects the control if the battery connections are reversed. Proper operation will begin when the connections are corrected.

Shorted 3REC Protection - prevents the control from operating if the flyback diode (3REC) is in a shorted condition .

Shorted Capacitor Protection - prevents the line contactor from closing if the capacitors are shorted.

Controlled Capacitor Pre-Charge - An external line contactor prevents high in-rush current which could cause battery plug damage.

Low Current Control Switches - can be used for the directional input switches, the only coil current carrying switches are the key, brake, seat and start switches.

Coil Driver Modules and Coil Suppression - the drivers are internal to the logic card and are current limited for short circuit protection. These drivers open or close these coils on command from the logic card.

1A Thermal Hold Off - prevents the 1A contactor from closing when the truck is in severe thermal cutback to avoid torque jumps. When the control goes into severe cutback, this feature will inhibit the 1A timer.

Low Voltage - Batteries under load, particularly if undersized or more than 80 percent discharged, will produce low voltages at the MOSFET control terminals. The EV-T5 control is designed for use down to 16V. Lower battery volts may cause the control to not operate correctly; however the PMT will open the F and R contactor when battery volts drop below 16 volts.

High Frequency Operation - This feature provides a bell shaped oscillation curve that ranges from 1KHZ at creep speed to 5KHZ at mid-speed to 1KHZ at top speed. The high oscillation rate of the control allows quieter operation, higher average motor current with lower peak motor currents, less ripple current at the motor, and less motor heating.

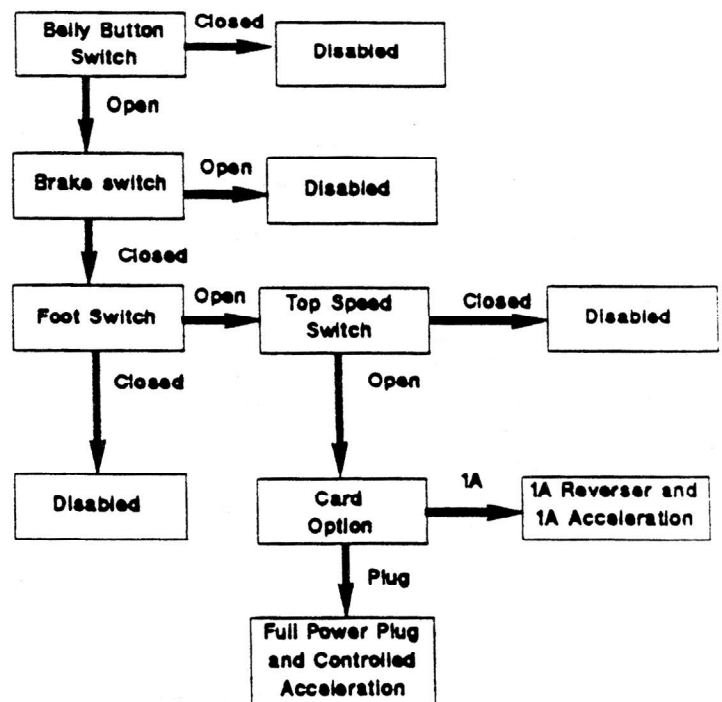
Tip Bounce Timer and Arcless 1A - Tip Bounce Timer synchronizes the contactors and the power base so that under normal operating conditions, the forward and reverse contactors do not make or break current.

Under normal operating conditions, the 1A contactor makes current but does not have break current. Arcless interruption greatly increases 1A tip life.

Top Speed (Motor Volts) Limit - provides a means to limit motor volts to an adjustable limit by limit switch opening between the input point on the control card and negative. This motor volt limit affects top speed of the control, but actual truck speed will vary at any set point depending on the loading of the vehicle.

Emergency Reversal Circuit - If the Emergency Reversal button is opened the control automatically drops out the forward contactor, picks up the reverse and option 1); picks up the 1A contactor and reverses the vehicle at full battery power until the emergency reversal switch releases, or option 2); plugs to a stop and re-accelerates in the reverse direction until the reversal switch is released. At this time, the control is inoperable. If the emergency reversal switch is again opened, the control will allow a reversal again but normal control operation will not be restored until the brake switch is recycled.

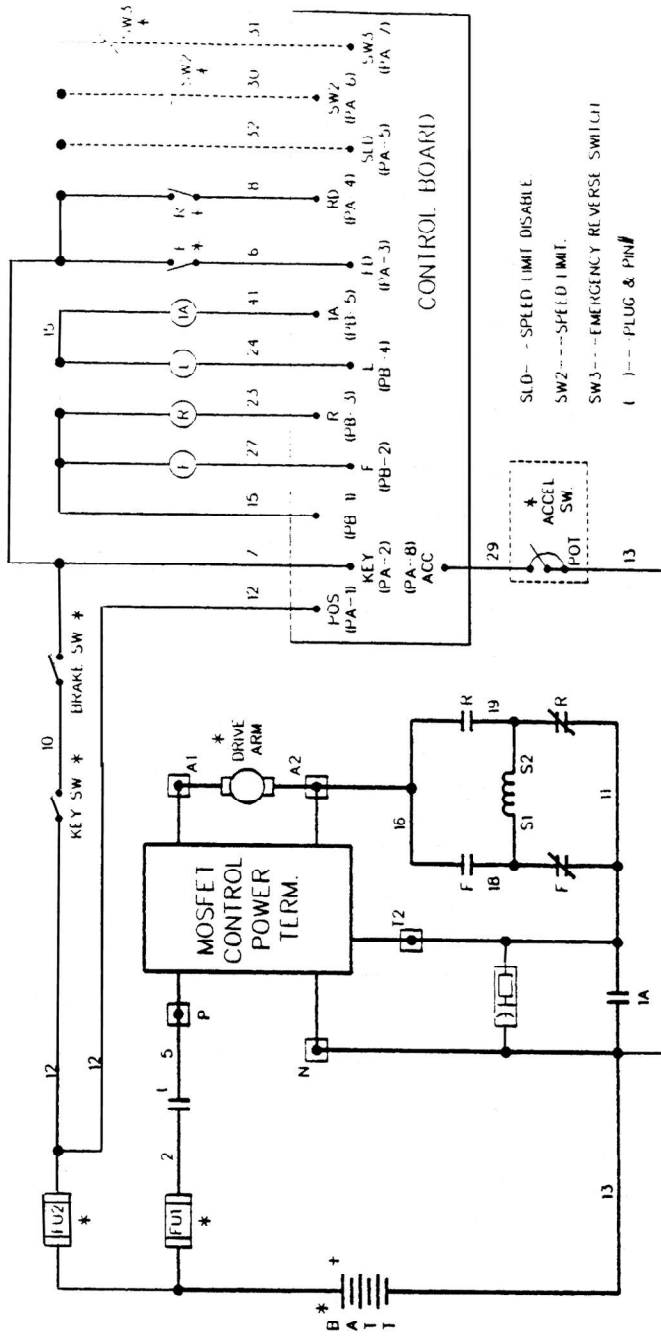
The Emergency Reversal Circuit operation logic is as follows:



116C6930

REVISIONS

REV	DATE	BY	DESCRIPTION
1	4/15/89	W CAMPBELL	WALKIE
2	11/20/89	E CAMPBELL	WALKIE
3	9/21/90	W CAMPBELL	WALKIE
4	11/26/90	W CAMPBELL	WALKIE



□ MOSFET POWER CONNECTIONS.

* SUPPLIED BY CUSTOMER.

WALKIE/RIDER

UNLESS OTHERWISE SPECIFIED	SIGNATURES
DESIGNED BY: W. CAMPBELL	DATE: 02/06/89
DESIGNED BY: W. CAMPBELL	DATE: 02/06/89
DESIGNED BY: W. CAMPBELL	DATE: 02/06/89
DESIGNED BY: W. CAMPBELL	DATE: 02/06/89
DESIGNED BY: W. CAMPBELL	DATE: 02/06/89

CLIPPER ELECTRIC
WALKIE/RIDER, WALKIE R. C. DA
ELEMENTARY

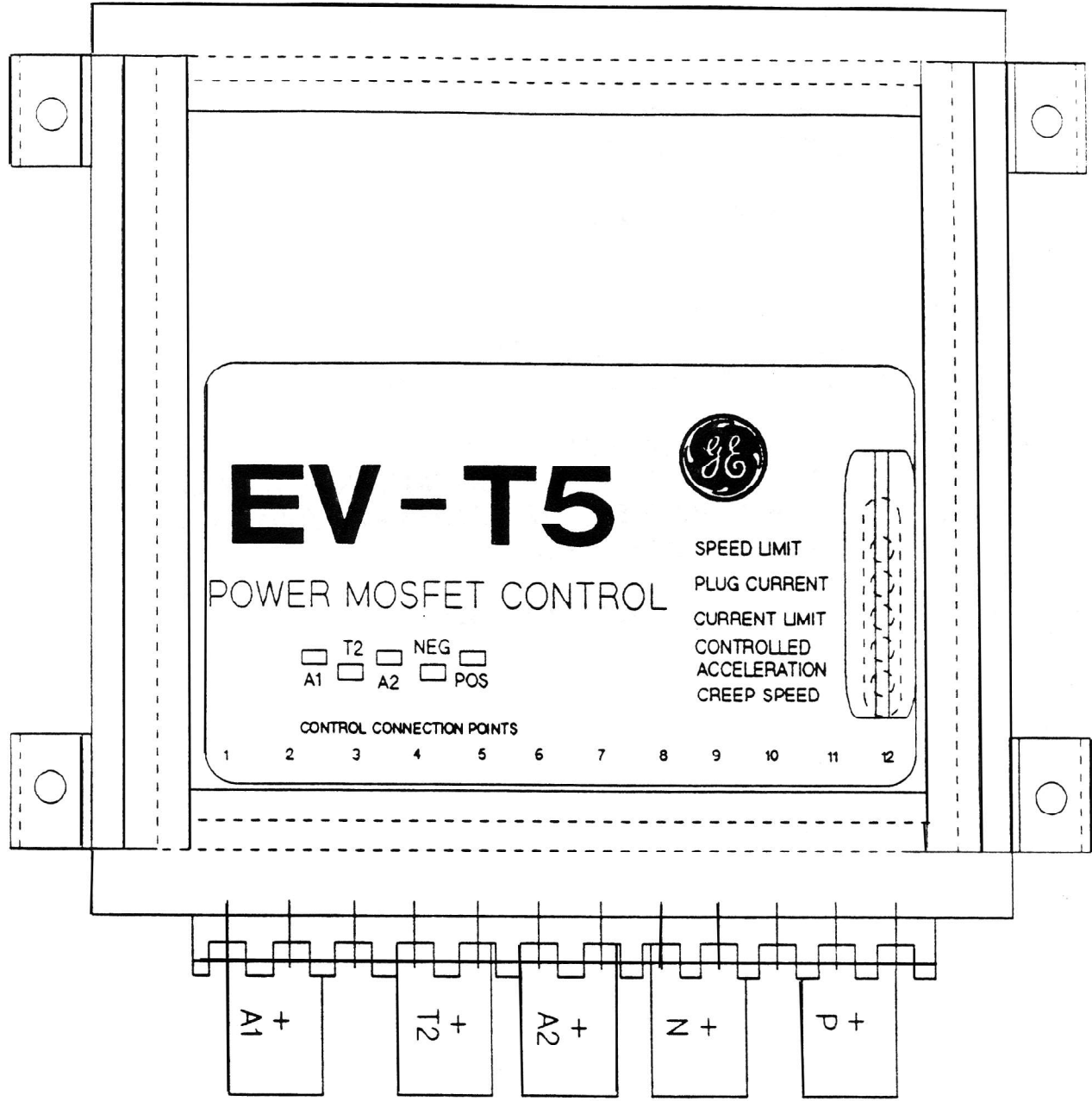
116C6995

116C6930



GE Electric Vehicle
Systems

**INSTRUCTIONS
EV-T5 MOSFET
CONTROL**



The information contained herein is intended to assist truck users and dealers in the servicing of Mosfet controls furnished by the General Electric Company. It does not purport to cover all variations in equipment nor to provide for every possible contingency to be met with installation, operation or maintenance.

Should further information be desired or should particular problems arise which are not covered sufficiently for the purchaser's purpose, the matter should be referred to the truck manufacturer through his normal service channels, not directly to the General Electric Company.

ORDERING INFORMATION FOR EV-T5 MOSFET

EV-T5 MOSFET CONTROL

EXAMPLE----- IC3645EVT5 24 C 1T A
ARGUMENT NO. 01 02 03 04 05

ARGUMENT NO. 01
BASIC CATALOG NUMBER

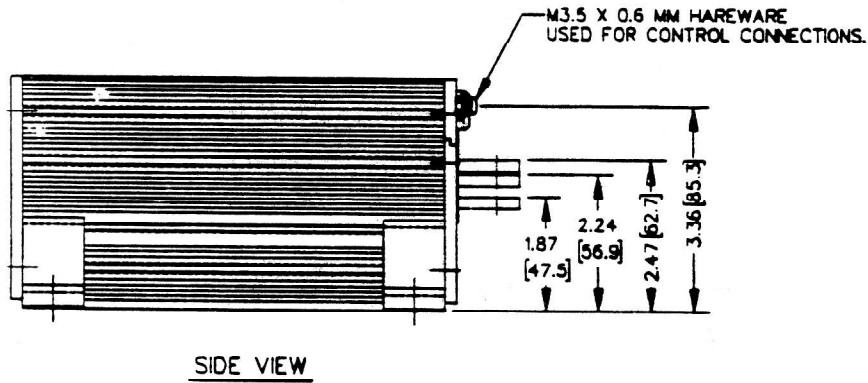
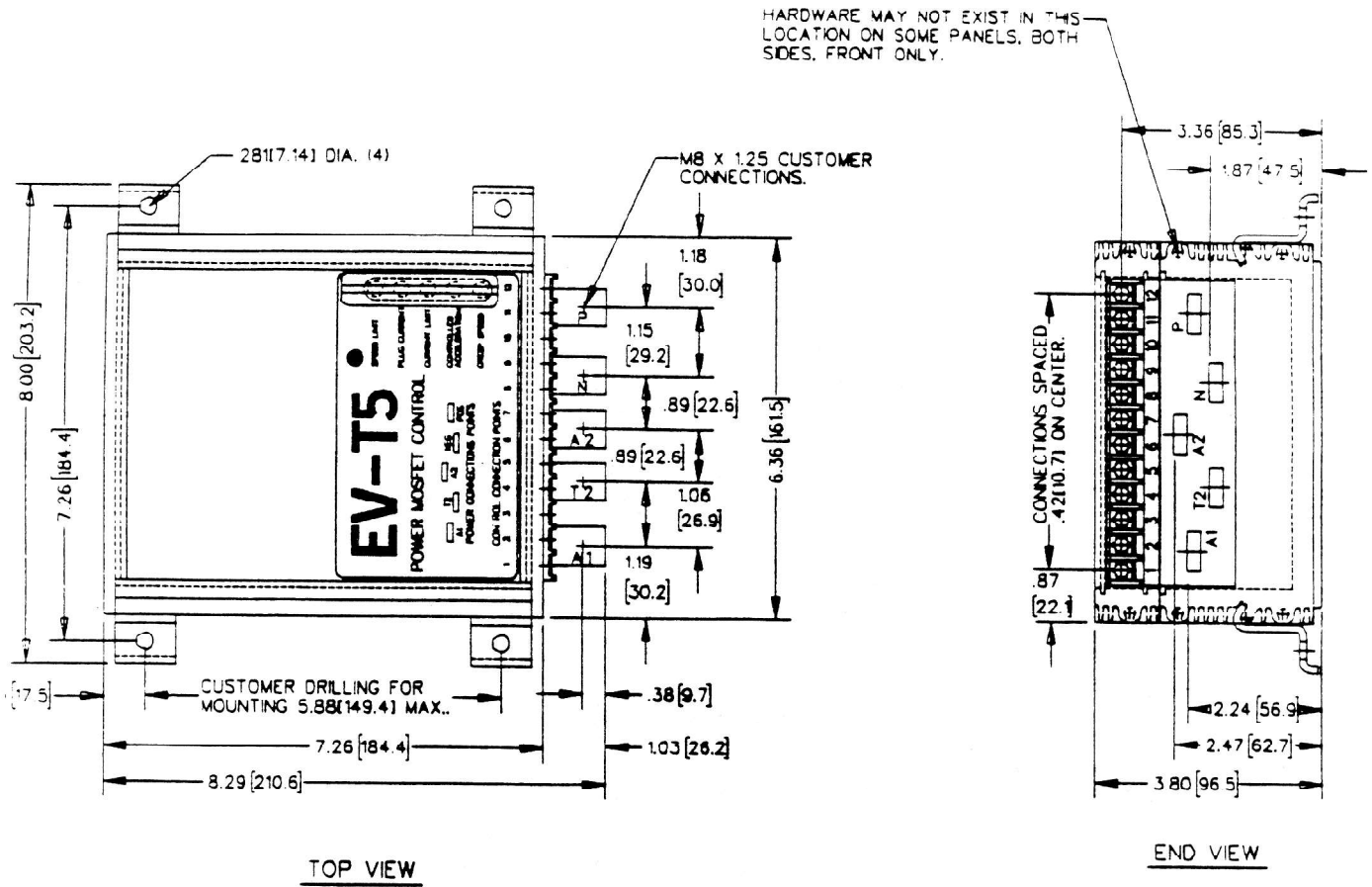
ARGUMENT NO. 02 CONTROL OPERATING VOLTAGE
24 -24 VOLT

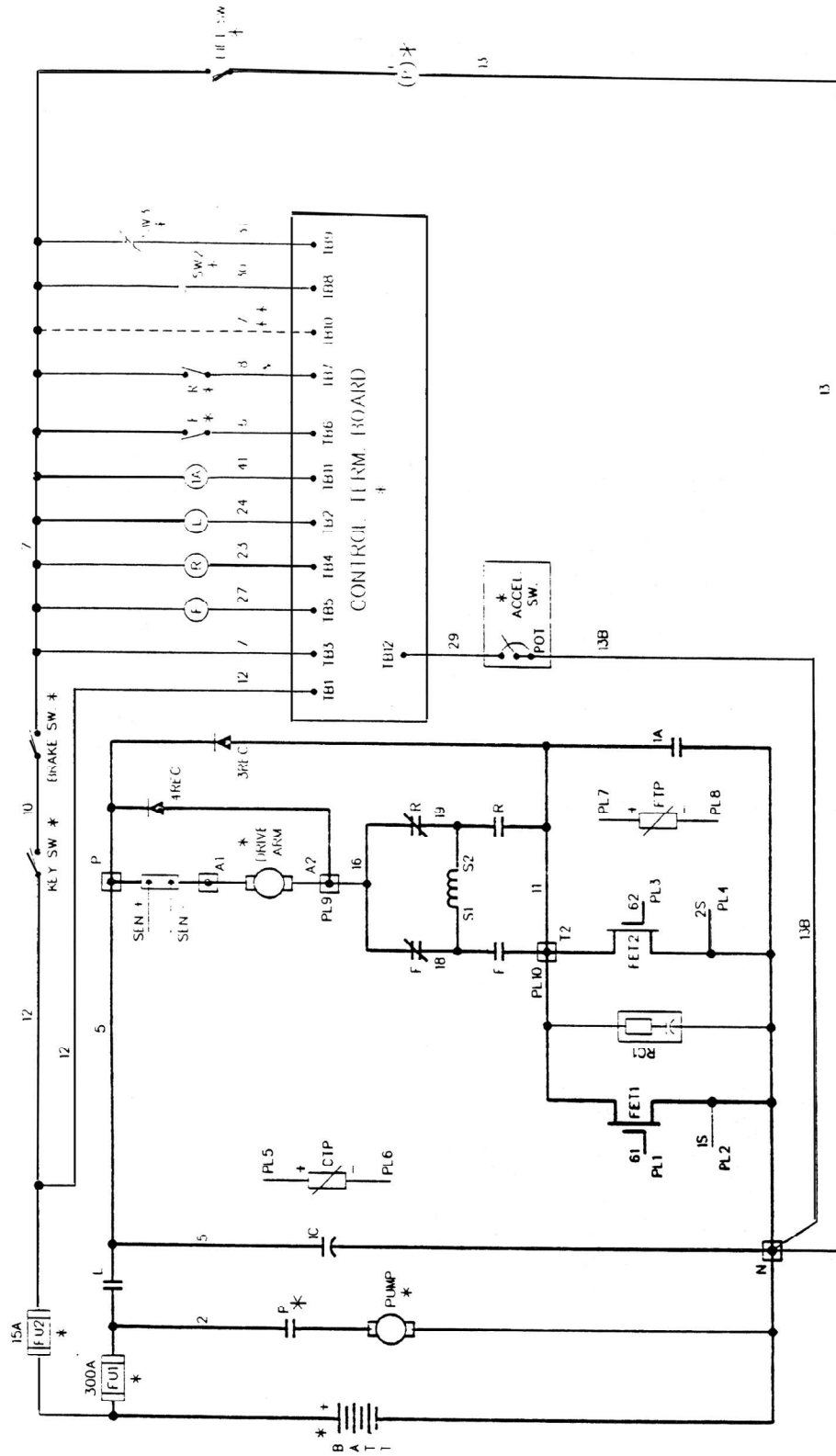
ARGUMENT NO. 03 POWER BASE
C - STANDARD 250 AMP C/L, 250 AMP PLUG LIMIT.
D - STANDARD 250 AMP C/L, 350 AMP PLUG LIMIT.

ARGUMENT NO. 04 OSCILLATOR CARD
1T - STANDARD TRACTION CARD (USE WITH "C" POWER BASE).
2T - HIGH POWER PLUG, STD. TRACTION CARD (250A C/L, 350A PLUG)
(USE WITH "D" POWER BASE).

ARGUMENT NO. 05 CURRENT REVISION CODE

EV-T5 OUTLINE





□ MOSFET POWER CONNECTIONS.

* SUPPLIED BY CUSTOMER.

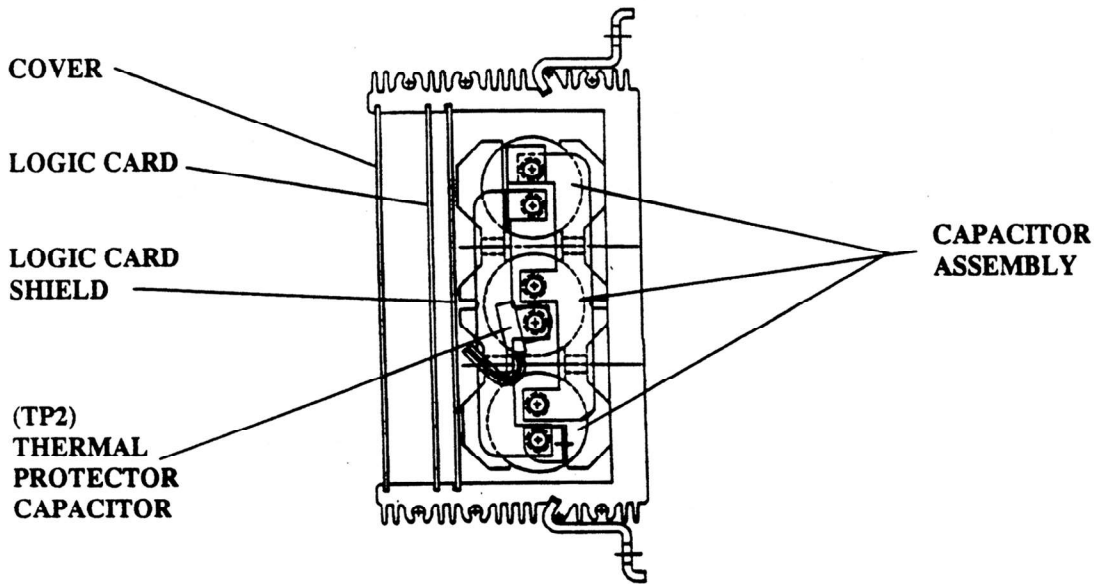
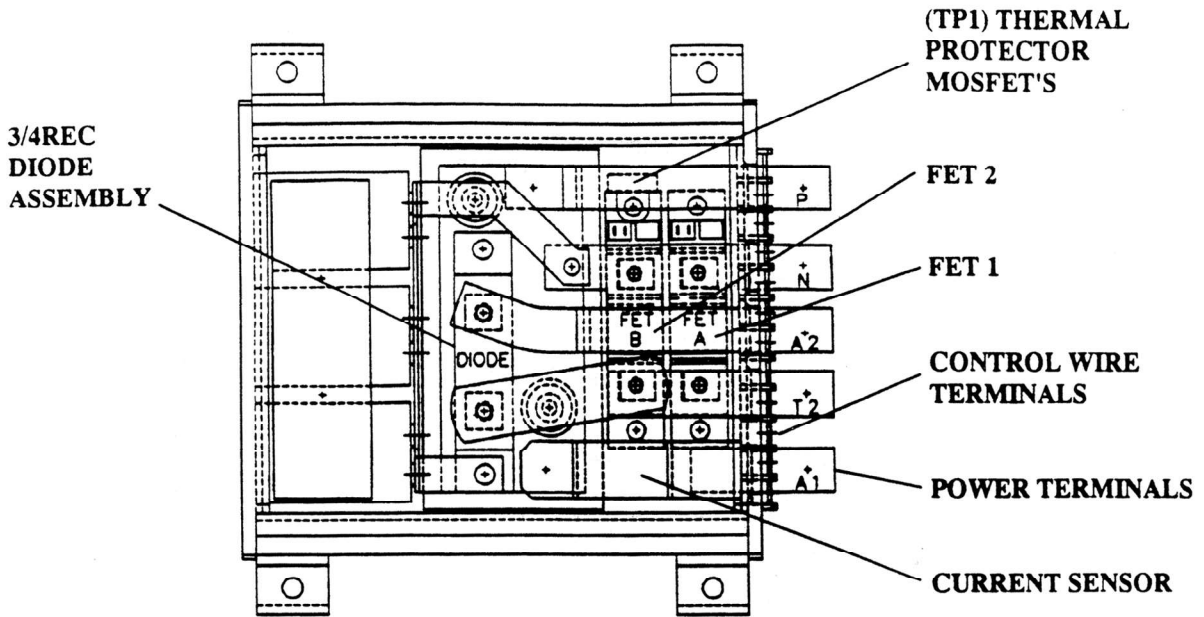
** JUMPER TO DEFEAT SPEED LIMIT.

SW2SPEED LIMIT.

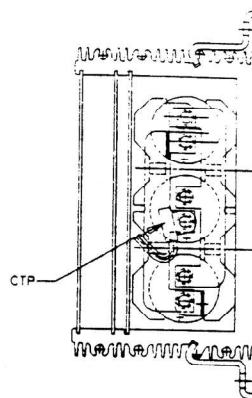
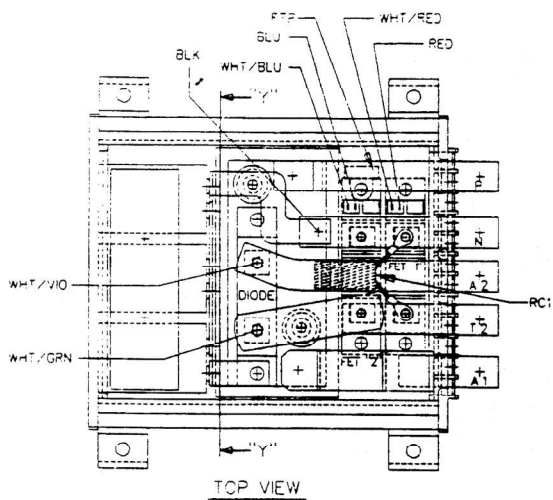
SW3.....EMERGENCY REVERSE SWITCH.

WALKIE RIDER

EV-T5 COMPONENT IDENTIFICATION

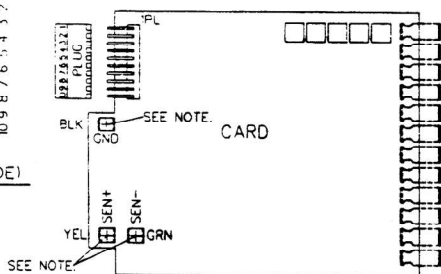
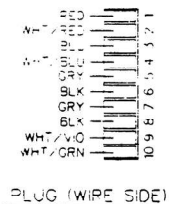


EV-T5 INTERNAL WIRING



SECTION "Y-Y"

COVER, CARD AND SHIELD HAVE BEEN REMOVED TO SHOW CONNECTIONS BELOW.



NOTE:
USE SCREW N57P900486 (PT. 93, SEE ML) TO FASTEN YEL, GRN AND BLK WIRES TO CARD.

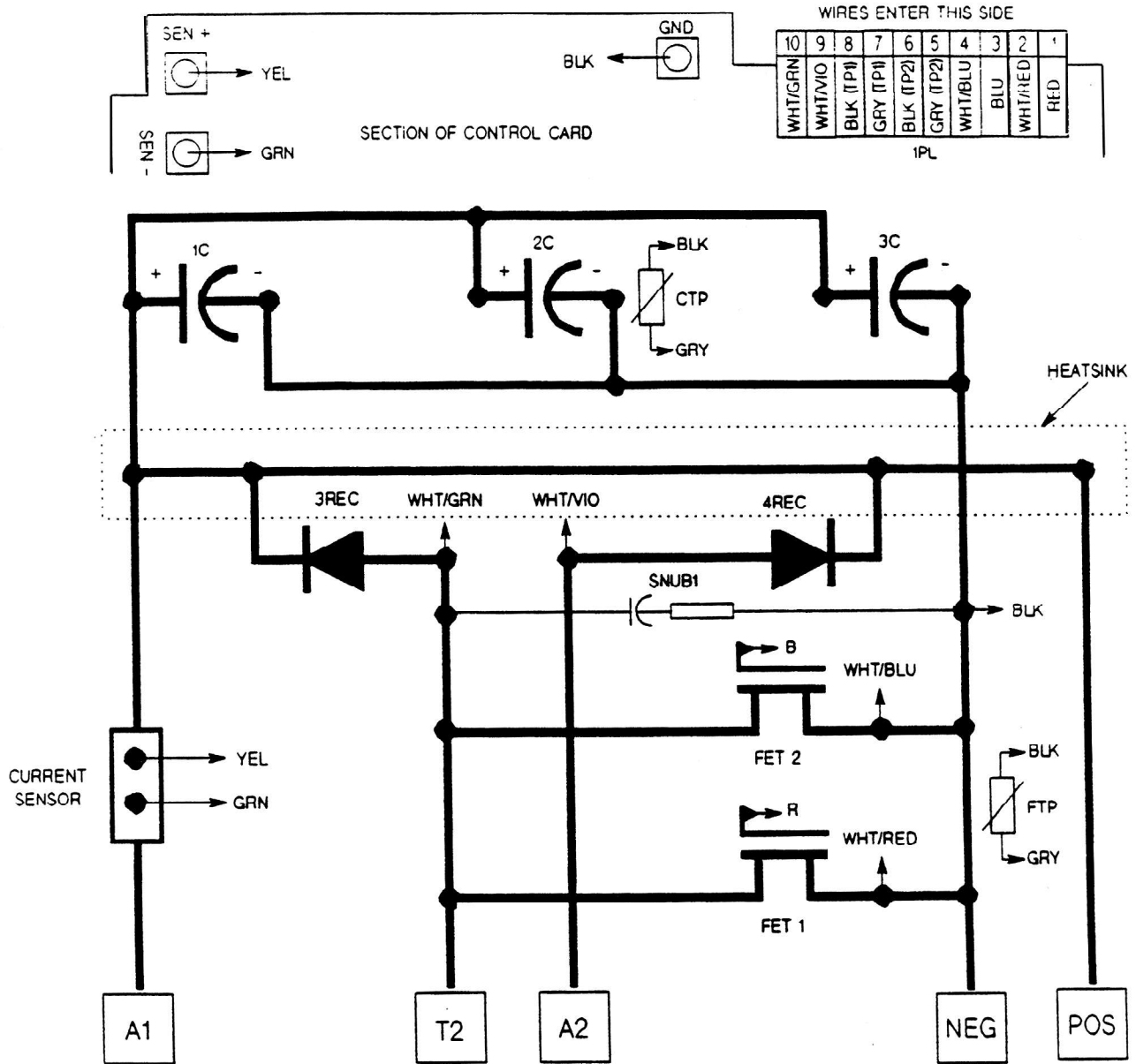
WIRE	CONNECTION SEQ. #22 259A9500P2 (BLK)
BLK	CARD GND, FET BUS
WIRE	CONNECTION SEQ. #22 259A9500P9 (WHT/VIO)
WHT/VIO	DIODE, PLUG 9
WIRE	CONNECTION SEQ. #22 259A9500P13 (WHT/GRN)
WHT/GRN	DIODE, PLUG 10
WIRE	CONNECTION SEQ. #22 259A9500P3 (RED)
RED	FET-1 GATE, PLUG 1
WIRE	CONNECTION SEQ. #22 259A9500P12 (WHT/RED)
WHT/RED	FET-1 SOURCE, PLUG 2
WIRE	CONNECTION SEQ. #22 259A9500P6 (BLU)
BLU	FET-2 GATE, PLUG 3
WIRE	CONNECTION SEQ. #22 259A9500P15 (WHT/BLU)
WHT/BLU	FET-2 SOURCE, PLUG 4

TWISTED PAIR

TWISTED PAIR

WIRE	CONNECTION SEQ.
YEL	CARD SEN+ SENSOR
GRN	CARD SEN- SENSOR
GRY	CTP, PLUG 6
BLK	
GRY	FTP, PLUG 4
BLK	

EV-T5 INTERNAL ELEMENTARY



EV-T5 INPUT/OUTPUT CONNECTIONS

- TB1 - Battery positive
- TB2 - Line contactor coil negative
- TB3 - Key switch/Brake switch input
- TB4 - Reverse contactor coil negative
- TB5 - Forward contactor coil negative
- TB6 - Forward directional switch input
- TB7 - Reverse directional switch input
- TB8 - Speed limit (open switch enable)
- TB9 - Emergency reversal switch input
- TB10 - Speed limit disable for walkies
- TB11 - 1A contactor coil negative
- TB12 - Accelerator pot input

EV-T5 SPECIFICATIONS

CONTROL FEATURES	CURRENT	CONTROL FEATURES	
CREEP SPEED	ADJUSTABLE 5% TO 15% ON TIME	STATIC RETURN TO OFF	STANDARD 1.5 SECOND DELAY
CURRENT LIMIT	ADJUSTABLE SEE CURRENT LIMIT CURVE	VOLTAGE RANGE	24VDC
PLUGGING	ADJUSTABLE 350 TO 250 AMPS(HIGH) 250 TO 100 AMPS(LOW)	ACCELERATOR INPUT REQUIREMENTS	5000-200 OHMS 3.5-0 V
PEDAL POSITION PLUG	ADJUSTABLE 100 TO 350 AMPS	LOW BATTERY OPERATION	STANDARD 75%-16V
RAMP START	STANDARD 200A OR 350A	REVERSE BATTERY PROTECTION	STANDARD WITH LINE CTR
FULL POWER TRANSITION	STANDARD APPLICABLE WITH 1A ONLY	AMBIENT TEMPERA- TURE	-30 TO +50 DEG C
CONTROLLED ACCELERATION	ADJUSTABLE .5 TO 2.5 SECONDS	APPROXIMATE WEIGHT	9 POUNDS
1A TIMED PICK UP	FIXED, FOLLOWS C/A BY .2 SECONDS ACCEL VOLTS<.9V ACCEL<350 OHMS	COIL DRIVERS F/R 1A LINE	ON-BOARD 2 AMPS ON-BOARD 2 AMPS ON-BOARD 2 AMPS
1A THERMAL HOLD-OFF	STANDARD AT 90C CUTBACK 20% ON TIME	SHORTED ON-BOARD DRIVER PROTECTION	STANDARD
1A PLUGGING HOLD-OFF	STANDARD	SHORTED 3REC PROTECTION	STANDARD
DELAY TO FIRST PULSE	STANDARD	F/R AND SPEED INPUT SWITCH LOADING	LOGIC CURRENT
PMT	STANDARD LOOK-AHEAD AND RESET	ACCELERATOR START- UP LOCK-OUT (ACC V>2.5V)	STANDARD
THERMAL CUTBACK START @ 90C	STANDARD	SPEED LIMIT SPEED RANGE CREEP-TOP SPEED	STANDARD ADJUSTABLE INPUT BY LIMIT SW

**CONTROL
FEATURES**

CURRENT

ARCLESS 1A

WHEN LESS THAN
CURRENT LIMIT

EMERGENCY REVER-
SAL

1A OR PLUG

FULL LOAD, FULL
FIELD
RUNNING MOTOR
CURRENT
@50% DUTY IN 1A

100 AMPS PLUS

PLUG CURRENT
LIMIT(LOW)
MIN-MAX @ 3 SEC

50/150 AMPS

PLUG CURRENT
LIMIT(HIGH)
MIN-MAX @ 3 SEC

100/350 AMPS

AVERAGE MOTOR C/L
@ TYPICAL MOTOR
IND

MIN-MAX @30% ON-
TIME

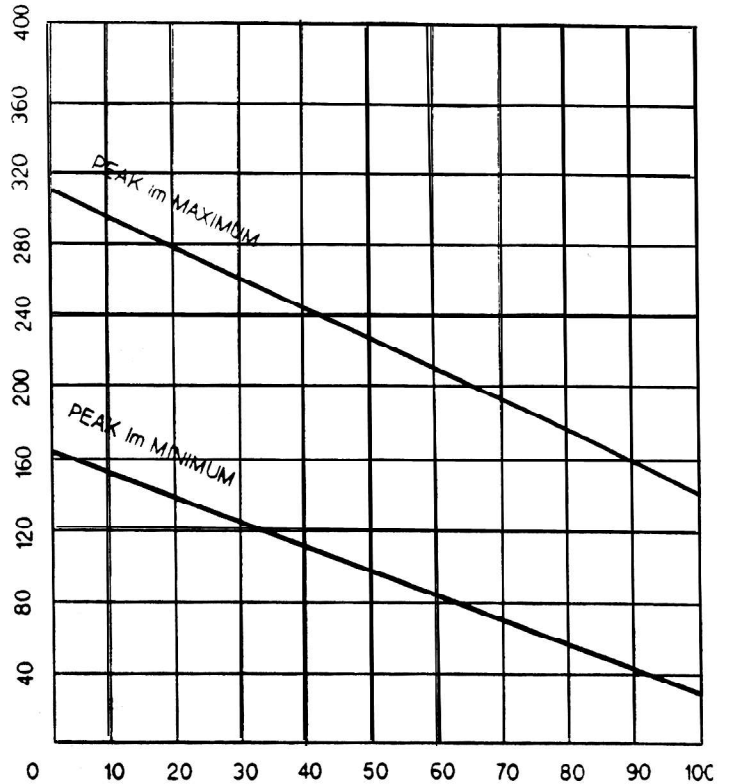
150/275 AMPS (STD)

MIN-MAX @50% ON-
TIME

125/250 AMPS (STD)

MIN-MAX @70% ON-
TIME

100/225 AMPS (STD)



**EV-T5 TRACTION STANDARD
PERFORMANCE**

BASICS OF CIRCUIT OPERATION

The control is energized by plugging in the battery. A capacitor charging circuit charges 1C to battery volts in approximately 2 seconds. The control checks for 0 volts at TB3 (with key and brake switches open). When the key and brake switches are closed, the control then makes several safety checks:

- 1) T2 voltage is between 6 and 20 volts. This checks for shorted forward, reverse, and 1A contactor drivers, shorted 3 REC and power FETs, welded forward, reverse, and 1A contactors.
- 2) Checks for open Speed Limit switch. Should be 0 volts at TB8.
- 3) Checks for closed emergency reversal switch. If TB9 is at 0 volts when brake switch is closed, the vehicle will not reverse.
- 4) Checks for open F and R switch inputs, TB6 and TB7 at 0 volts.
- 5) Checks for accelerator volts to be greater than 2.5 volts.

If all the above safety 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 FETs turning them on. Current flows from the battery through the motor armature, motor field, power FETs back to battery negative. When gate voltage at the FETs is removed, they turn off. During the off time, the energy stored in the motor, by virtue of the motors 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.

The time for the next ON and OFF cycle to start is determined by the time the control card takes to oscillate. This frequency of oscillation is controlled by the potentiometer in the accelerator and automatic circuitry in the card. Slow speed is obtained by having maximum ohms in the potentiometer. As the resistance in the potentiometer decreases, the speed of the motor increases. The MOSFET circuit is capable of delivering approximately 95% speed. For full speed 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 at 50% on time (half speed).

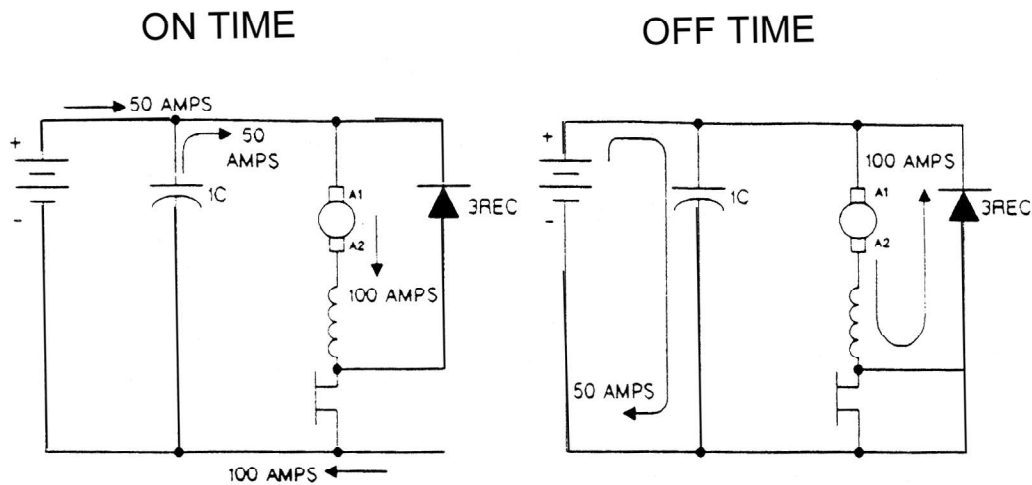


FIG 1

FIG 2

CONTROL FEATURES

OSCILLATOR - The oscillator section of the card has two adjustable features and one fixed feature. With the accelerator potentiometer at maximum ohms, the creep speed can be adjusted by the creep trimpot. Top speed is fixed by card and is obtained with the accelerator potentiometer at minimum ohms. The % ON time has a range of approximately 5 to 95 percent. The center operating condition of the oscillator is at 50 percent ON time with a nominal 33 microseconds ON time and 33 microsecond OFF time. This corresponds to a maximum operating frequency of about 15KHZ. At creep the ON time will decrease to approximately 20 microseconds while OFF time will become in the order of 300 microseconds. At full MOSFET operation, this condition will be reversed (short OFF time, long ON time). This variation of ON and OFF time of the oscillator produces the optimum frequencies through the MOSFET range. The frequency curve of the oscillator is shown in Figure 3.

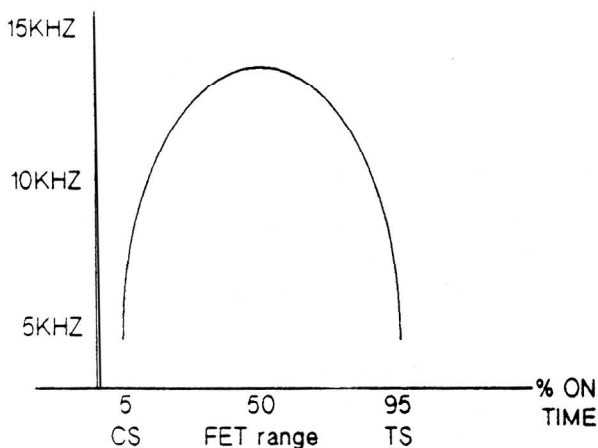


Figure 3

The rate at which the oscillator may increase its percent ON time is limited by "Controlled Acceleration". The minimum time required to go from creep speed to 95% on time point may be varied by the controlled acceleration trimpot. Adjustable from approximately 0.5 seconds to 2.5 seconds.

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 current limit trimpot. The C/L setting is based on the maximum thermal rating of the MOSFET's and the filter capacitors. Because of the flyback current through 3REC, the motor current usually runs 2 to 3 times battery current. See current limit curves for available current and adjustment range.

PLUGGING - Slow down is accomplished when reversing 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 generator. This generated current passes through 4 REC and the sensor. The oscillator circuit regulates at a plug current limit level as set by the plug current trimpot. This controls the pulse rate of the FETs to regulate the generated motor current and bring the truck to a smooth stop and reversal.

ACCELERATOR POSITION PLUG - This feature will allow for plugging distance based on accelerator position. Accelerator position will reduce the plugging current as the accelerator is returned to the creep speed position. Maximum plug current is obtained with the accelerator is returned in the top speed position.

RAMP START - This feature provides full MOSFET torque to restart a vehicle on an incline. The maximum current available for ramp start is the maximum rating of 4 REC. 350 A for the high current and 250 A for the low current.

FULL POWER TRANSITION - This built-in feature provides smooth transition from MOSFET to 1A bypass. This is accomplished by the MOSFET continuing to pulse until the 1A contactor power tips close.

CONTROL ACCELERATION AND 1A TIME - This feature allows for adjustment of the time it takes for the control to accelerate to 95% on time of applied battery voltage to the motor on hard acceleration. The 1A contactor will automatically close .2 seconds after the controlled acceleration stops and the accelerator input is less than .9 volts or less than 350 ohms. C/A is adjusted by the C/A trimpot from .5 to 2.5 seconds.

ACCELERATOR VOLTS HOLD-OFF - This feature checks the voltage level at the accelerator input when ever the key switch or brake switch is activated. If the voltage is less than 2.5 volts the control will not start. This is to assure that the control is calling for low speed operation at start-up.

COIL DRIVERS - These drivers are internal to the logic card. They are the power devices that operate F, R, 1A, and line contactor coils. These drivers open or close these coils on command from the logic card.

1A THERMAL HOLD OFF - This feature prevents the 1A contactor from closing when the truck is in severe thermal cutback to avoid torque jumps. When the control goes into severe cutback, the must pulse to time will inhabit the 1A timer. If % on time is less than 20%.

MUST PULSE TO TIME - This feature prevents the 1A timer from timing if the oscillation pulse rate has not reached a particular level of operation.

PULSE MONITOR TRIP (PMT) - This feature shuts down or locks out control operation if fault conditions exist that would allow uncontrolled (run away) speed of the vehicle.

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

1. If MOSFETs are shorted or if 1A contactor is welded, the control will not allow the F and R contactor to close.

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

If MOSFETs fail to turn off or if 1A power tips remain closed when they should be open.

When the PMT circuit prevents F and R contactors from closing, the PMT circuit can be reset only by returning to true neutral.

THERMAL PROTECTOR (TP) - These are temperature sensitive devices that are mounted on the MOSFETs heat sink and filter capacitors. If the MOSFETs or capacitors temperature begins to exceed the design limits, the thermal protector will lower the maximum current limit and not allow the devices to exceed its temperature limits. Even at a reduced current limit, the vehicle will normally be able to reach sufficient speed for full 1A operations, thereby allowing the panel to cool. As the panel cools, the thermal protector will automatically return the control to full power.

LOW VOLTAGE - Batteries under load, particularly if undersized or than 80 percent discharged, will produce low voltages at the MOSFET control terminals. The EV-T5 control is designed for use down to 16V. Lower battery volts may cause the control to not operate correctly; however the PMT should open the F and R contactor when battery volts drop below 16 volts.

TOP SPEED (MOTOR VOLTS) LIMIT - This feature provides a means to limit motor volts to a predetermined maximum as adjusted by the speed limit trimpot. The motor volt limit, in effect limits maximum speed of the vehicle. If this input TB8 is at battery positive upon brake switch closure, control will not start up. Speed limit is disabled by closing SW2 after brake is closed which allows for full speed operation. Once at top speed, SW2 may be opened and the vehicle will remain at top speed if the accelerator remains at full speed position.

HIGH FREQUENCY OPERATION - This feature provides a bell shaped oscillation curve that ranges from 5KHZ at creep speed to 15KHZ at mid-speed to 5KHZ at top speed. The high oscillation rate of EV5 allows quieter operation, higher average motor current with lower peak motor currents, less ripple current at the motor, and less motor heating.

EMERGENCY REVERSAL CIRCUIT - The control logic protects against accidental opening of the emergency reversal switch. By monitoring several operating conditions, the control is able to determine if a invalid emergency reversal condition exist. If it does, the control automatically drops out the forward contactor, picks up the reverse and 1A contactors and reverses the vehicle at full battery power until the emergency reversal switch releases. At this time, the control is inopenable. If the emergency reversal switch ? again opened, the control will allow a full power reversal again normal control operation will not be restored until the brake switch is recycled.

REDUCED 1A ARCING - Increased tip life can be expected due to arcless 1A operation when currents are below 250 amps.

TIP BOUNCE TIMER AND ARCLESS 1A - Tip Bounce Timer synchronizes the contactors and the power base so that under normal operating conditions, the forward and reverse contactors do not make or break current.

Under normal operating conditions, the 1A contactor makes current but does not have break current. Arcless interruption greatly increases 1A tip life.

GENERAL MAINTENANCE INSTRUCTIONS

The MOSFET 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; or which will reduce heat dissipating ability of the control, such as restricting air flow.

The following DO'S and DON'TS should be observed:

Any controls that will be used in ambients of 100 F (40 C) or over should be brought to the attention of the truck 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, use low-pressure air to blow off the control. In oily or greasy areas, a mild solution of detergent or denatured alcohol can be used to wash off the control and then blow completely dry with low-pressure air. The control can also be cleaned with Freon TF degreaser.

For the MOSFET panel to be most effective, it must be mounted against the frame of the truck. The truck frame, acting as an additional heat sink, will give improved truck performance by keeping the MOSFET control package cooler. The use of a heat-transfer grease (Dow Corning 340) is recommended.

Terminal boards and other exposed MOSFET control parts should be kept free of dirt and paint that might change the effective resistance between points.

CAUTION: The truck should not be plugged when the truck 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. Unless the terminals of each semiconductor and card are connected together, the control may be damaged. 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.

TROUBLE-SHOOTING INSTRUCTIONS

The pulsing of the main MOSFET is too fast for conventional instruments to measure. When the control is functioning properly, a high pitched hum can be heard.

Malfunctions of the Mosfet will generally fall into one of two categories. They are either no power (Table 1) or full power (Table 2), when operating in the MOSFET range.

These simple and easy-to-follow tables outline the various symptoms and the corrective action to be taken.

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 wheels, disconnect the battery and discharge capacitor 1C. Reconnect the battery as needed for the specific check.

To discharge capacitors before servicing:

1. Unplug battery.
2. Using a 10 ohm, 2 watt resistor. Short between power terminals POS and NEG. Hold the resistor in place for 2 seconds before removing.

Caution: Using a shorting device without the resistor load could cause damage to that device.

Before proceeding, visually check for loose wiring, misadjusted linkage to the accelerator switch, sign of overheating of components, etc.

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

SYMPTOM

PROBABLE CAUSE

1A. Contactors do not pick up. No control voltage from positive to negative.

1B. Line contactor does not pick up when key and brake switch are closed.

1C. Line contactor closes, forward and reverse contactors do not close.

Note: When battery plug is first connected to battery, operator must wait approximately 2 seconds before closing the key and brake switches.

- * Check power and control fuses.
- * Check battery for low specific gravity and connections for looseness or broken connections.
- * TB1 and TB3 should be at battery volts.
- * Positive side of line contactor coil should be at battery volts.
- * Check volts at TB2: If near zero volts:
 - 1) Check for continuity of wire 24 from line contactor.(negative) to TB2
 - 2) Check for defective/binding line contactor
 - 3) Check resistance of line contactor coil approximately 24 ohms.

If TB2 measures Battery volts:

 - 4) Check for battery volts at positive control power terminal. If not check for shorted 1C.
- * TB4 and TB5 should be at battery volts. If not check continuity of wire 7 to F and R coils. Check continuity of wires 23 and 27.
- * Check for defective/binding F and R contactors.
- * Check resistance of F and R contactor coils (should be approximately 12 ohms).
- * In neutral, check that TB6, TB7, and TB8 are at zero volts. If not, check for defective wiring or defective F,R, and SW2 switches.
- * TB9 should be at battery volts. If not check for defective SW3 or defective wiring.
- * Voltage on TB12 must be greater than 2.5 volts. If not check for defective or misadjusted accelerator pot. (Accelerator pot should be between 4K and 6K ohms.
- * Check volts at T2: voltage should be between 6 to 20 volts.

SYMPTOM**PROBABLE CAUSE**

1C. continued

If less than 6 volts:

- 1) Check for shorted FET or welded 1A contactor.
- 2) Check for shorted 1A driver by measuring voltage at TB11. Battery volts should be present, if 0 volts 1A driver is shorted. (This check applies to the 1A contactor if part of the system and is properly wired).

If > 20 volts:

- 1) Check for shorted 3REC.
- 2) Check for welded forward and reverse contactors.
- 3) A2 and T2 power connections are connected wrong.

1D. Contactors close. No power and no sound with accelerator in FET range.

- * Check volts at T2. Should be battery volts, if not check volts at S1, S2, A1, A2 for open motor circuit.
- * Check volts at TB12. Should be 3 to 4 volts at creep speed and less than .5 volts at full acceleration. If not check accelerator pot.
- * Check for open thermal protector.
- * Check for loose/broken connection green wire of current sensor
- * Replace control card.

1E. One contactor closes with normal operation but opposite contactor will not close.

- * Close key and brake switches (all switches needed to close F or R contactor except the direction switch). Volts on TB6 and TB7 should be near zero volts. Wait one second, then close the directional switch of the contactor that will not close. Volts at the other direction input (TB6 or TB7) should remain at zero volts. Volts at non-closing direction (TB6 or TB7) and top of the contactor coil should be battery volts. If not, check wiring and switches.
- * Check for open contactor driver. If driver volts of non-closing direction (TB4 or TB5) remains at battery and all other checks above are normal, replace control card.

SYMPTOM

1F. PMT trip after operating in 1A then returning to FET range.

1G Contactors close once and then remain open. PMT trip.

2A Contactors close. Full FET speed immediately with audible hum. No PMT trip.

2B Contactor close. Stall currents, under FET operation, higher than normal and uncontrollable with C/L trimpot. Contactors may open once and then remain open.

3A 1A will not close operating at top speed.

3B 1A will not close at all.

PROBABLE CAUSE

* Check for cause of long 1A dropout.

- 1) Wrong coil
- 2) Defective coil (low ohms)
- 3) Binding mechanically
- 4) Defective control card

* Check for line contactor not closing when key and brake switches close. Refer to 1B.

* Key switch on.

Check volts at TB12. Should be 3 to 4 volts with accelerator at creep speed position. If near zero volts, check accelerator output (4K-6K ohms or 3- 4 volts depending on type of accelerator switch).

* Replace control card.

* Check current sensor yellow lead and green lead. Sen + = yellow sen - = green. Check for loose/broken connection.

* Check for shorted 4REC.

* Replace control card.

* TB11 should be at battery volts, if not check continuity of wire 41 to 1A coil and wire 7 to battery positive.

* Check 1A contactor is not binding mechanically. Coil resistance should be approximately 12 ohms.

* Check that voltage at TB12 is reduced to less than .5 volts when accelerator pot is at full travel, (top speed). If not, check accelerator pot for proper adjustment.

* Volts from P to T2 must be greater than 6 volts (must pulse to time not release 1A unless volts at motor > 20% of battery volts).

If volts are too low check for:

- A) C/L setting low
- B) Defective T.P.
- C) Hot control thermal protector.

SYMPTOM**PROBABLE CAUSE**

3C Will not go to top speed when SW2 switch closed and accelerator at full travel.

- * Check that TB8 goes to battery volts when SW2 switch is closed.
- * Check accelerator volts equals or less than .5 volts at full travel.

3D Stiff plug. (Severe reversal)

- * Check plug adjustment setting on control card.
- * Check continuity of yellow and green wires to control card.
- * Check 4REC for open circuit.
- * Replace control card.

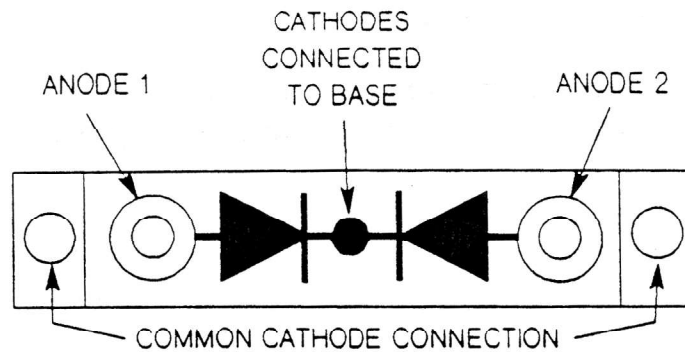
3E Very soft reversal.

- * Check plug adjustment setting on control card.
- * Replace control card.

LOOSE COMPONENT TESTING

3REC AND 4REC TEST

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



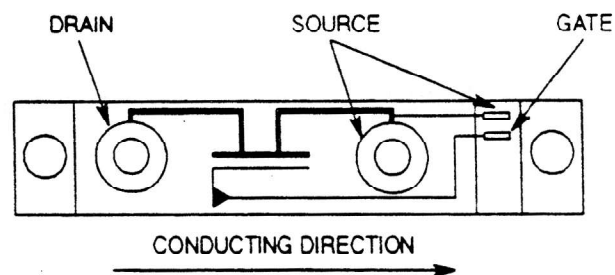
DIODE ASSEMBLY 3REC AND 4REC

LOOSE FET1/2 TEST

FET1 and FET2 are MOSFET power modules and should be measure infinity ohms on any scale in the conduction direction. In the non conducting direction from 5K to 20K should be read on the RX 10000 scale.

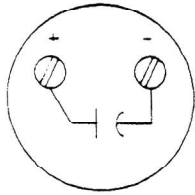
2nd test RX 10000 scale from gate to drain should read infinity in both directions.

3rd test RX 10000 scale from gate to source should read infinity in both directions.



MOSFET

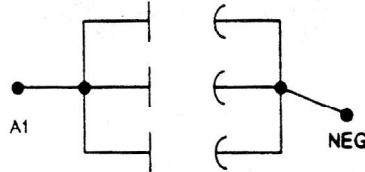
LOOSE CAPACITOR TEST



C1, C2, C3 are electrolytic capacitor which can store a significant amount of charge (energy) and must be shorted by placing a 100ohm 2watt resistor between positive(+) and negative(-) for three seconds or greater.

Measure ohms thru the capacitor using the rx100 scale. Meter should swing toward zero then reverse and swing slowly to above 2000ohms. Meter polarity is not critical.

Loose EV-5 Test



Remove panel from truck and remove cards and wires

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

Caution: One shorted of three looks bad.
One open of three looks OK. Must check individually.


THERMAL PROTECTOR TEST

Thermal Protector Test: Read the resistance between the gray and black wires at the card plug (inside female connector) for each Thermal Protector reading should be less than 200 ohms at room temperature.

Current Sensor Test: Should read zero ohms from green to yellow wires on the Rx1 scale if not (open wire) replace.

SNUB1 TEST

Snub1 Test is a resistor/capacitor filter assembly. Using a Rx100 scale across the two terminals the meter will briefly swing toward zero and quickly back to infinite.

Snub:  Loose test only

CAUTION

- Capacitor polarity must be observed.
- Capacitor bank must be torqued between 6-8 inch pounds.
- Thermal grease under 3REC and 4REC, FET1 and FET2, between 3 and 4 co-therm and base.
- Thermistors and other wires should be measured at plug. Do not remove wires form plug without proper tool to reconnect.
- FET's must be replaced in pairs.
- Capacitors must be replaced in banks (3's).



TECHNICAL SERVICES