TROOPER IV SERIES REGENERATIVE DC DRIVE

Instruction Manual

Model TRC602-000

Model TRC602-E0C

CAROTRON

Driven by Excellence

D.C. DRIVES, A.C. INVERTERS,
SOLID STATE STARTERS, SYSTEM INTERFACE
CIRCUITS AND ENGINEERED SYSTEMS

Table of Contents

1 General Description

The Carotron Trooper IV Series regenerative motor control provides full range - four quadrant - speed control of shunt wound or permanent magnet D.C. motors from 1/8 to 2 horsepower. Bi-directional current control operation is also possible.

FEATURES

- Operation from 115 or 230 VAC input for 90 or 180 VDC motor armatures.
- Switch selectable armature voltage or tachometer feedback.
- 7 or 50 VDC/1000 RPM feedback tachometer input.
- Independently adjustable Forward and Reverse Acceleration settings. Two time ranges are available: 1-4 or 4-25 seconds.
- A summing input connected directly to the input of the velocity loop which will accept an isolated input signal not to exceed ±10 VDC.
- Single contact stopping by one of three methods:
  1. Coast to stop
  2. Controlled deceleration (Ramp) to stop.
  3. Fast (Current Limit) stop
- Dedicated Coast Stop Input (quick connect terminal).
- Hard firing, high frequency multipulse gating signals.
- I.C. regulated power supplies, metal film resistors, and cermet potentiometers for stable operation under varying conditions of temperature and line voltage.
- On board AC line fuses.
- Oversized power handling components.
- Line transient suppression by MOV and RC snubber.
- Inner current loop type control circuit for fast and stable response under varying load conditions.
- Selectable 2-wire or 3-wire START/STOP control.
- External Current Limit / Current Control input.

2 Specifications

2.1 Electrical

AC Line Voltage Input
115 VAC ±10%, 50/60 Hz ±2%
230 VAC ±10%, 50/60 Hz ±2%

Suitable for use on a circuit capable of delivering not more than 5000 RMS symmetrical amps, 240V maximum.

Motor Armature Voltage Output
- 0 - 90 VDC for 115 VAC input
- 0 - 180 VDC for 230 VAC input

Motor Field Output
- 100 VDC @ 1 Amp for 115 VAC input
- 200 VDC @ 1 Amp for 230 VAC input

Motor Horsepower Range
- 1/8 - 1 HP @ 90 VDC
- 1/4 - 2 HP @ 180 VDC

Ambient Temperature Range
• Chassis: 0-55°C
• Enclosed: 0-40°C

Speed Regulation
• Armature Feedback: ±1% of base speed (with IR Compensation)
• Tachometer Feedback: ±0.5% of base speed

Torque Regulation
• ±1% of range selected

Speed Range
• 20 to 1

2.1.1 Potentiometer Adjustments

Current Limit – P2, FWD & P1, REV
• Independently adjustable
• Range 0 to 150% of current range selected

IR Compensation – P3
• Range set by Arm I (amps) jumper, J1

Integral Null – P4
• Zero to 0.2 volts of Velocity Loop Integrator output

Maximum Speed – P5, FWD & P6, REV
• Independently adjustable
• Range 45% to 110% of rated armature voltage

Acceleration Time – P7, FWD & P8, REV
• Two selectable ranges, 1-4 seconds or 4-25 seconds
(Selected range applies to both FWD and REV)
• FWD Acceleration Time = REV Deceleration Time
REV Acceleration Time = FWD Deceleration Time

2.2 Physical

Refer to dimension drawings C12260 (chassis) and C12259 (enclosed) in Section 5 for complete dimension information.

3 Installation

3 Installation

3.1 Circuit Protection

Trooper IV series drives should be installed in accordance with the National Electric Code and any applicable local or state codes.

Branch circuit protection must be provided externally.
All wiring should be rated at a minimum of 90°C

Field wiring terminals should be tightened as follows:
TB1 (Power Board) – 7.0 Lb-In (0.8 N-M)
TB2 (Control Board) – 4.4 Lb-In (0.5 N-M)

Trooper IV Series Drives do not incorporate overload or overspeed protection. If desired, each must be added externally.

Trooper IV Series Drives are supplied from the factory with line fuses (FU1 & FU2) sized for maximum motor horsepower rating. Fuses for other motor sizes are listed in Table 1.

Table 1: Fuse Sizing				
MODEL	**HP**	**INPUT VOLTAGE**	**AC CURRENT @ FULL LOAD**	**RECOMMENDED FUSE**
TRC602-000 TRC602-E0C	1/8	115VAC	2.4 Amps	3 Amp, MDA
	1/4	115VAC	4.5 Amps	5 Amp, MDA
	1/2	115VAC	8.7 Amps	10 Amp, MDA
	3/4	115VAC	11.7 Amps	15 Amp, MDA
	1	115VAC	15 Amps	20 Amp, MDA
	1/4	230VAC	2.4 Amps	3 Amp, MDA
	1/2	230VAC	4.5 Amps	5 Amp, MDA
	1	230VAC	7.9 Amps	10 Amp, MDA
	1-1/2	230VAC	12.2 Amps	15 Amp, MDA
	2	230VAC	15 Amps	20 Amp, MDA

NOTE: Fuses shown are manufactured by Bussmann. Littelfuse type 326 may be substituted.

3.2 Connection Information

Refer to connection diagram C12255 on page 14.

3.2.1 Wiring Precautions

WARNING!

CIRCUIT COMMON ON THE TROOPER IV SERIES IS NOT EARTH OR CHASSIS GROUND. HIGH VOLTAGE POTENTIALS CAN BE PRESENT BETWEEN EARTH GROUND AND ANY POINT IN THE CIRCUIT. ALL TEST INSTRUMENTS SHOULD BE ISOLATED FROM EARTH GROUND TO PREVENT DAMAGE TO THE INSTRUMENT OR THE CONTROL.

ANY INSTRUMENT CONNECTED TO THE CIRCUIT IS FLOATING AT POTENTIALS THAT APPROACH THE AC LINE VOLTAGE AND SHOULD BE HANDLED WITH CARE.

Ground the control only at the designated grounding terminal.

Use shielded cable for all speed pot, tachometer, summing input, and external current limit circuit wiring. Connect the shield to circuit common at the control end only and insulate the shield at the other end. These wires should be routed away from all AC power, armature, field and relay coil wiring.

WARNING!

CONNECTION OF THE SHIELD TO CIRCUIT COMMON PLACES THE SHIELD AT LINE POTENTIAL WITH RESPECT TO EARTH GROUND AND REQUIRES THAT THE SHIELD BE INSULATED FROM GROUND. FAILURE TO INSULATE PROPERLY CAN CAUSE DAMAGE TO THE CONTROL.

Any relay, contactor, motor starter, solenoid, etc. located in close proximity to or on the same AC line as the TRC602 series control should have a transient suppression device in parallel with the coil to minimize interference with the control.

3.2.2 Terminal Connections – Power Board

• **TB1-1 (GND):** This is the chassis ground connection.

• **TB1-2 & 3 (L1 & L2):** These terminals are used for the AC line input. Either 115 VAC or 230 VAC can be connected to these terminals. **NOTE**: Jumpers J1 and J2 on the Power Board and J2 on the Control Board must be placed in the positions corresponding to the AC line voltage used.

• **TB1-4 & 5 (A1 & A2):** The motor armature leads, A1 and A2, connect to these terminals.

• **TB1-6 & 7 (F1 & F2)**: The motor field leads, F1 and F2, connect to these terminals. No connection is required when a permanent magnet (PM) type motor is used

3.2.3 Terminal Connections – Control Board

• **TB2-1 & 5 (START)**: A momentary contact closure between these two terminals will START the drive when Jumper J6 is in the 3-WIRE position (factory setting). When J6 is in the 2-WIRE position, the START contact must be maintained closed to operate the drive.

• **TB2-2 & 5 (STOP)**: A connection is always required between these two terminals to operate the drive. When Jumper J6 is in the 3-WIRE position, momentarily breaking this connection will STOP the drive. When J6 is in the 2-WIRE position, these two terminals should be connected together (STOP is accomplished by opening the START contact). The STOP mode is determined by the position of jumper J5 (ref. Section 4.2).

Note: A dedicated COAST STOP input is available at TP12. When this quick connect test point is momentarily connected to +15V, the drive output is disabled and the motor coasts to stop.

• **TB2-3 & 5 (JOG)**: A contact closure between these two terminals will Jog the drive at about 35% speed. The drive must be stopped to enter the JOG mode.

• **TB2-4 & 5 (FWD/REV)**: The polarity of the speed reference signal determines the direction of operation. With no connection between these two terminals, the reference supply (TB2-10) is positive for FWD operation. When the terminals are connected, the reference supply is negative for REV operation. If an external speed reference signal is used, the FWD/REV input at TB2-4 has no effect.

- **TB2-6 (COMMON)**: This terminal is the common circuit for all control board signals; it is not a ground terminal and should not be connected to ground.

- **TB2-7 & 8 (TACHOMETER)**: An optional motor mounted DC Tachometer can be connected here for improved speed regulation. Jumper J4 must be positioned to match tachometer voltage and Switch SW1 must be set for TACH (ref. section 4.2 and 4.3).

- **TB2-9 (SUM INPUT)**: The summing input signal sums with the speed reference signal but bypasses the Accel/Decel ramp circuit.

- **TB2-10, 11, & 12 (SPEED POT INPUT)**: A potentiometer connected to these three terminals controls motor speed in each direction from zero to the level set by the Maximum Speed pot.

  If an external 0-10 VDC speed reference signal is used instead of a potentiometer, connect to TB2-12 (common) and TB2-11 (speed reference: + for FWD, - for REV).

- **TB2-13 & 14 (CURRENT LIMIT / CURRENT CONTROL INPUT)**: The +10 VDC power supply on TB2-13 is factory connected to the Current Limit input on TB2-14. If external Current Limit or Current Control is required, a potentiometer can be connected as shown on Connection Diagram C12255, p.14 (+5 VDC = 100% of selected current range for both Forward and Reverse operation; internal Current Limit pots P1 and P2 should be adjusted clockwise). An isolated voltage signal at TB2-14 can also be used to set the Current Limit level or to control Current directly.

- **TB2-15 (ACCEL/DECEL OUTPUT)**: This terminal provides access to the output of the Accel/Decel circuit for special applications.

- **TB2-16 (COMMON)**: This terminal is the common circuit for all control board signals; it is not a ground terminal and should not be connected to ground.

4 Programming & Adjustments

4.1 Programming Jumpers – Power Board

- **J1 & J2 (AC VOLTAGE INPUT)**: Select 115 or 230 VAC; factory set for 230 VAC.

4.2 Programming Jumpers – Control Board

- **J1 (ACCEL/DECEL TIME):** The range of Accel/Decel Time can be 1-4 or 4-20 seconds and is selected by the position of J1; factory set for 4-20 seconds.

- **J2 (AC VOLTAGE INPUT):** Select 115 or 230 VAC; factory set for 230 VAC.

- **J3 (ARMATURE CURRENT RANGE):** The J3 setting determines the nominal full load armature current available and should match the motor nameplate full load current and/or horsepower; factory set for 1.5A. Refer to TABLE 2.

TABLE 2 – ARMATURE CURRENT / HP SELECTION

Line Input Voltage	J3 Jumper Position				
	1.5 A	3 A	5 A	8 A	10 A
115 VAC	1/8 HP	1/4 HP	1/2 HP	3/4 HP	1 HP
230 VAC	1/4 HP	1/2 HP	1 HP	1-1/2 HP	2 HP

- **J4 (TACHOMETER VOLTAGE):** If a DC Tachometer is used for improved speed regulation, J4 must be positioned to match the voltage rating of the tachometer – 7 VDC or 50 VDC/1000 RPM.

- **J5 (STOP MODE):** The position of this jumper determines the method used to Stop the motor. In Ramp mode, the Stop command causes the motor to Stop following the Deceleration Ramp. In Coast mode, the Stop command turns the drive off and the motor coasts to Stop. In Fast mode, the Stop command instantly brings the speed reference voltage to zero and the motor is driven to Stop as rapidly as possible with the Current Limit setting. Factory setting is for Ramp Stop.

- **J6 (START / STOP OPERATOR CONFIGURATION):** This jumper is positioned to select either momentary contact operation (3 wire) or maintained contact operation (2 wire) for the Start and Stop operators; factory setting is 3 wire (ref. Connection Diagram C12255, p. 14).

4.3 Programming Switch – Control Board

- **SW1 (FEEDBACK SELECTION):** Switch SW1 is factory set in the ARM position for armature voltage feedback. If an optional DC Tachometer is used, SW1 should be changed to the TACH position.

4.4 Adjustment Potentiometers – Control Board

- **P1 & P2 (REV CL & FWD CL):** The Current Limit pots set the maximum allowable armature current level for each direction. Each pot has a range of 0 to 150% of the nominal level selected by Jumper J3. Clockwise rotation increases the Current Limit setting; each pot is factory adjusted for 150%. If an external Current Limit signal is used, P1 and P2 should be set fully clockwise.

- **P3 (IR COMP):** The IR Compensation circuit provides a signal proportional to armature current; the signal is used to increase the armature voltage to compensate for motor losses as the motor load increases. This action improves motor speed regulation when operating with armature voltage feedback. Clockwise rotation of the pot increases the compensation. When tachometer feedback is used the IR COMP pot is not operational.

- **P4 (INTEG NULL):** The Integral Null circuit provides compensation for the small offset voltage present in the velocity loop integrator. If the motor "creeps" slightly when the drive is operated with a zero voltage speed reference signal, P4 should be adjusted clockwise until the motor just stops.

• **P5 & P6 (FWD MAX & REV MAX):** The Max Speed pots determine the maximum armature voltage output (or motor speed) in each direction. Adjustment range is from 45 to 110% of nominal full rated output. Clockwise adjustment increases drive output; each pot is factory adjusted for nominal rated output voltage.

• **P7 & P8 (ACCL FWD & ACCL REV):** The Acceleration Time pots determine the amount of time required for a 0 to 100% change in the internal speed reference signal. Range of adjustment is from 1 to 4 or 4 to 25 seconds (determined by J1 jumper position). P7 sets the forward acceleration and the reverse deceleration time; P8 sets the reverse acceleration and forward deceleration time. P7 and P8 are independently adjustable, but the position of J1 determines the range for both pots. Clockwise rotation increases the time.

4.5 Adjustment Procedure: Speed Regulator

Step 1

• Visually inspect all connections to check for tightness, proper insulation and agreement with the connection diagram. ONLY the grounding terminal (TB1-1) should be connected to the chassis or earth ground.
• Verify the line voltage level and the positions of jumpers J1 and J2 on the Power Board and J2 on the Control Board.
• Verify the connection of the Start / Stop operators. Note: A connection is required between TB2-2 to 5 to run the drive. Refer to connection drawing C12255, p. 14.
• Note the motor nameplate full load current and select the proper range with jumper J3. Place the ARM/TACH switch SW1 in the ARM position even if tachometer feedback is to be used. Select the desired ACCEL time ranges with jumper J1.

• Initially the potentiometers should be preset as follows (or as preset at factory):

INTEG NULL ..... Fully CCW
IR COMP ..... Fully CCW
FWD MAX ..... Mid-Range
REV MAX ..... Mid-Range
FWD CL ..... Fully CW
REV CL ..... Fully CW
ACCL FWD ..... Mid-Range
ACCL REV ..... Mid-Range

Step 2

• Apply line voltage. With no load on the motor or machine, Start the control in the Forward direction and apply maximum reference input. Measure the motor speed or armature voltage, and adjust the FWD MAX pot for the desired maximum speed or armature voltage.

Step 3

• Repeat the Step 2 procedure for the reverse direction by selecting the Reverse direction and adjusting the REV MAX pot.

Step 4 (Armature Feedback Only - Omit this step if tachometer feedback is used.)

• Adjust the speed (either direction) to mid-range, or if known the speed at which the motor will be run most often. Closely note the motor or line speed. Apply rated or normal load to the motor; the speed will usually drop a small percentage. Increase the IR COMP pot rotation clockwise until the loaded speed level matches the unloaded speed. Recheck the unloaded speed level and repeat this step until there is no difference between the no load and full load speeds.

• **NOTE**: The IR COMP signal may affect the maximum speed settings. After setting the IR COMP, recheck the MAX level for each direction and readjust if necessary.

Step 5 (Tachometer Feedback Only - Omit this step if armature feedback is used.)

• Position Jumper J4 to match the tachometer used.

• With SW1 set for Armature feedback, run the motor forward (positive reference) and measure the tachometer voltage at terminals TB2-7 and 8. Verify that terminal 7 is positive with respect to terminal 8. Reverse the leads to correct if necessary.

• Stop the control and change switch SW1 from the ARM position to the TACH position. Start the control and verify proper operation.

NOTE: The maximum speed settings may change slightly due to variations in the tachometer voltage. Recheck and readjust the MAX pots if necessary.

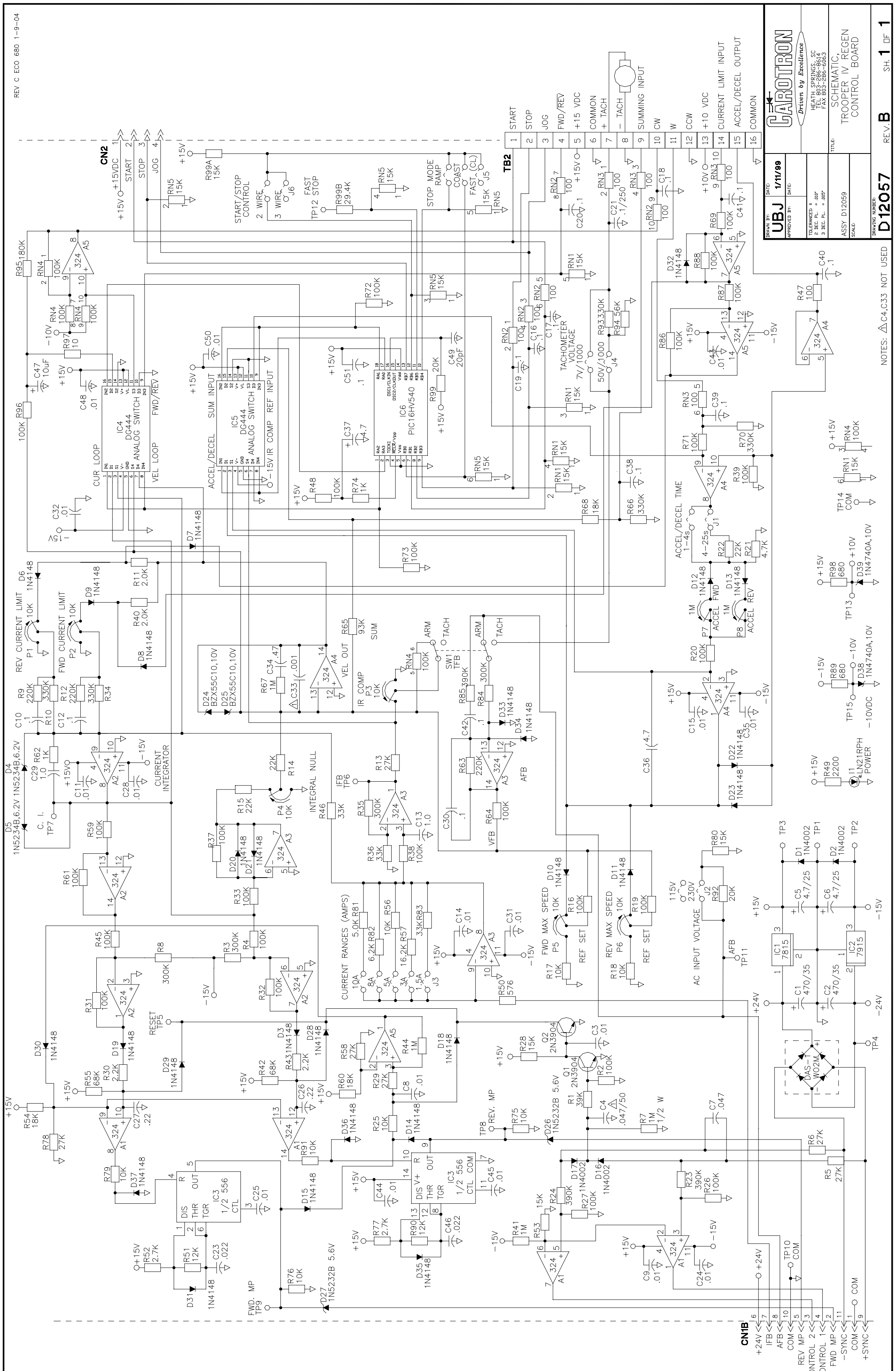
Step 6

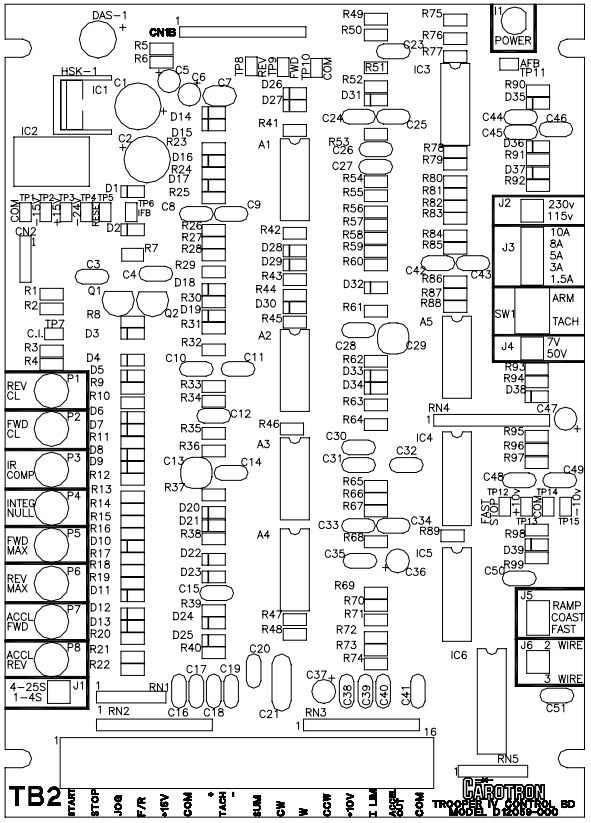
• The CL (CURRENT LIMIT) pots are normally adjusted to full clockwise to allow 150% of the current range selected by J1. Trooper IV motor controls can safely handle this current level on an intermittent basis, i.e. during rapid accelerations and decelerations or upon application of a cyclic or stepped load. If desired, the maximum current levels can be limited to a lower level by rotating the CL pots counter clockwise.

NOTE: Precise adjustment of the Current Limit settings requires the insertion of a D.C. ammeter in series with the motor armature.

Step 7

• Adjust the ACCEL pots as required to achieve the desired rate of speed change. Clockwise rotation increases time.


CAROTRON
Driven by Excellence
HEATH SPRINGS, SC
TEL 803-286-8614
FAX 803-286-6063
SCHEMATIC, TROOPER IV REGEN CONTROL BOARD
ASSY D12059
DRAWN BY: UBJ
DATE: 1/11/99
DRAWING NUMBER: D12057
REV. B
SH. 1 OF 1
REV C ECO 680 1-9-04
NOTES: C4,C33 NOT USED



NOTES:
1. REF. SCHEMATIC D12057.
2. REF. B.O.M. D12059-000.

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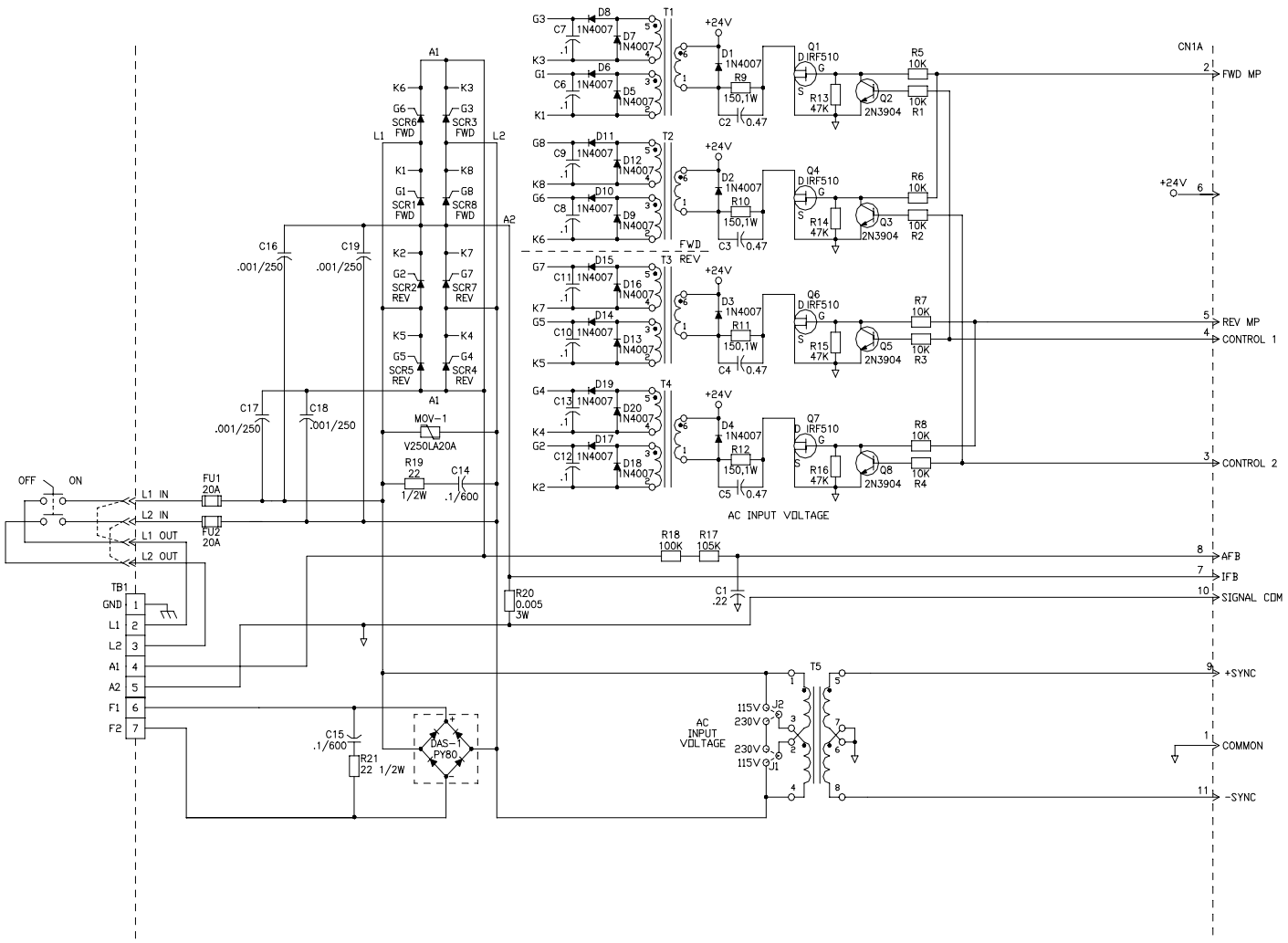
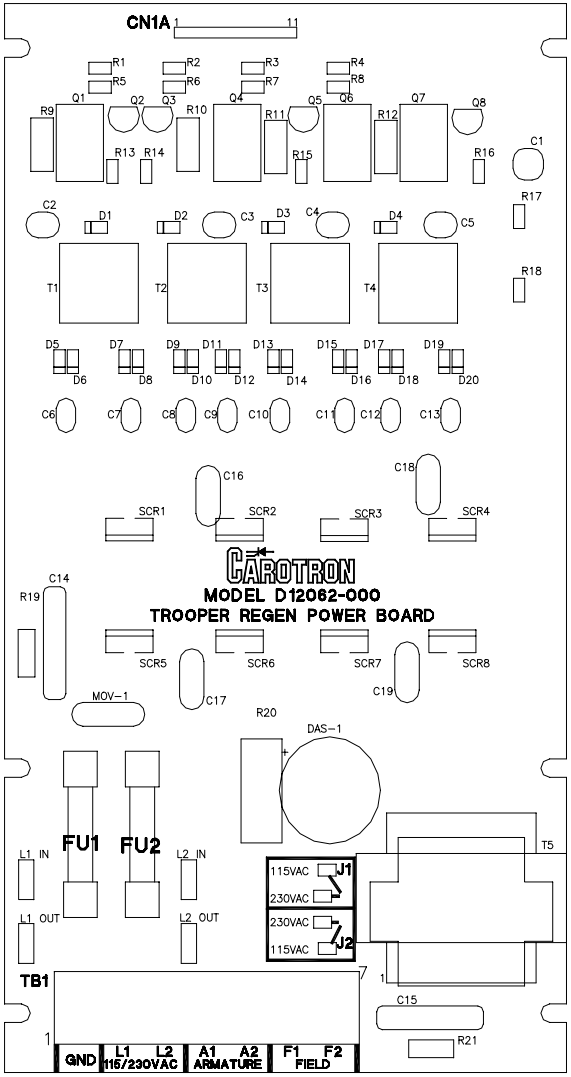
APPROVED BY:	DATE:	HEATH SPRINGS, SC TEL 803-286-8612 FAX 803-286-6063
TOLERANCES: 2 DEC. PL. = .010" 3 DEC. PL. = .005"		TITLE: ASSEMBLY, TROOPER REGEN CONTROL BOARD
	SCALE:	
DRAWING NUMBER: D12059	REV. B	SH. 1 OF 1



NOTES:
1. ALL DIODES 1N4148 UNLESS NOTED.
2. ALL CAPACITORS IN uf/50VDC UNLESS NOTED.
3. REF. ASSEMBLY D12062 AND B.O.M. D12062-000.

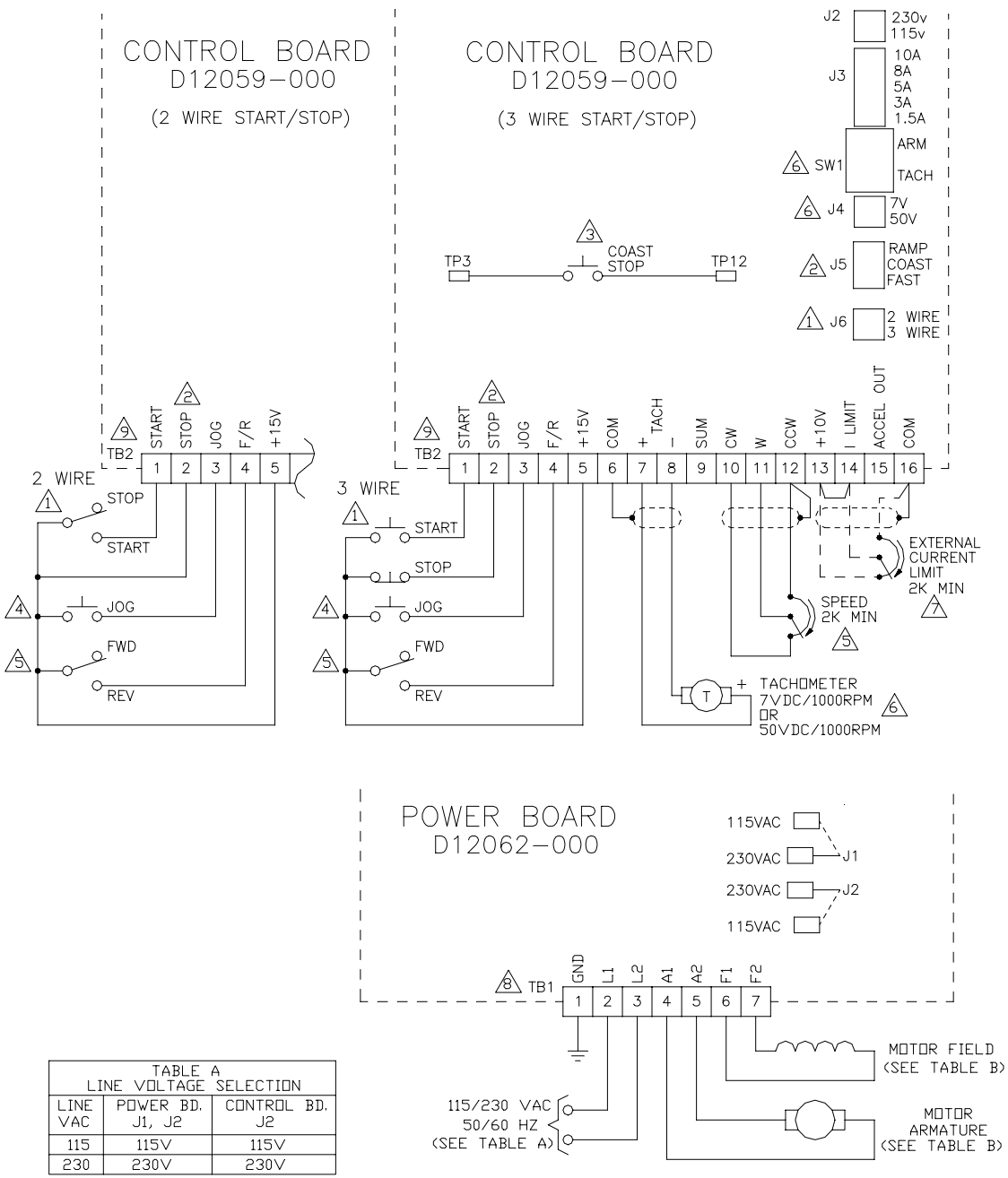
REV B, 2-28-00, For PCBD12061B

DRAWN BY:	DATE: 1-18-99
APPROVED BY:	DATE:
TOLERANCES: ± 2 DEC. PL. ± 3 DEC. PL.	CAROTRON Driven by Excellence
	HEATH SPRINGS, SC TEL 803-286-8614 FAX 803-286-6063
ASSY D12062	TITLE: SCHEMATIC, 2 HP TROOPER IV REGEN POWER BOARD
SCALE: ---	
DRAWING NUMBER: D12060	REV. B SH. 1 OF 1



NOTES:
1. REF. SCHEMATIC D12060.
2. REF. B.O.M. D12062-000.

DRAWN BY	DATE 9-27-99	CAROTRON Driven by Excellence
APPROVED BY	DATE	HEATH SPRINGS, SC TEL 803-286-8614 FAX 803-286-6063
TOLERANCES: ± 2 DEC. PL. = .020" ± 3 DEC. PL. = .005"		TITLE: ASSEMBLY TROOPER REGEN POWER BOARD
SCALE		
DRAWING NUMBER D12062	REV. B	SH. 1 OF 1



NOTES:

1. START/STOP CONFIGURATION IS DETERMINED BY J6 POSITION:
   J6 - 2 WIRE = START/STOP BY MAINTAINED CONTACT
   J6 - 3 WIRE = START/STOP BY MOMENTARY CONTACT
2. TB2 STOP MODE IS DETERMINED BY J5 POSITION:
   J5 - RAMP = REGEN TO STOP WITH DECEL RAMP
   J5 - COAST = COAST TO STOP
   J5 - FAST = REGEN TO STOP WITH NO RAMP
3. MOMENTARY CONTACT CLOSURE BETWEEN +15V (TP3 OR TB2-5) & TP12 CAUSES COAST TO STOP REGARDLESS OF J5 POSITION.
4. JOG IS BY MAINTAINED CONTACT @ 35% BASE SPEED.
5. FWD/REV SWITCH CONTROLS THE POLARITY OF TB2-10 SPEED POT SUPPLY: FWD = POSITIVE, REV = NEGATIVE.
6. OPTIONAL DC TACHOMETER FOR IMPROVED SPEED REGULATION: SET SW1 TO TACH, SET J4 TO MATCH TACH VOLTAGE.
7. OPTIONAL EXTERNAL CURRENT LIMIT POT: JUMPER TB2-13 TO 14 IF NOT REQUIRED.
8. TB1 SCREW TORQUE: 7.0 LB-IN (0.79 N-M).
9. TB2 SCREW TORQUE: 4.4 LB-IN (0.5 N-M).

TABLE B
MOTOR HP SELECTION

LINE VAC	CONTROL BD. J3	MOTOR FIELD VDC	MOTOR ARM VDC	MOTOR HP
115	1.5A	100	0-90	1/8
	3A	100	0-90	1/4
	5A	100	0-90	1/2
	8A	100	0-90	3/4
	10A	100	0-90	1
230	1.5A	200	0-180	1/4
	3A	200	0-180	1/2
	5A	200	0-180	1
	8A	200	0-180	1 1/2
	10A	200	0-180	2

TABLE A
LINE VOLTAGE SELECTION

LINE VAC	POWER BD. J1, J2	CONTROL BD. J2
115	115V	115V
230	230V	230V

REV. A, 1-13-04

DRAWN BY: HJH	DATE: 6-27-00
APPROVED BY:	DATE:
TOLERANCES: ± 2 DEC. PL. = .010" 3 DEC. PL. = .005"	
SCALE: ---	

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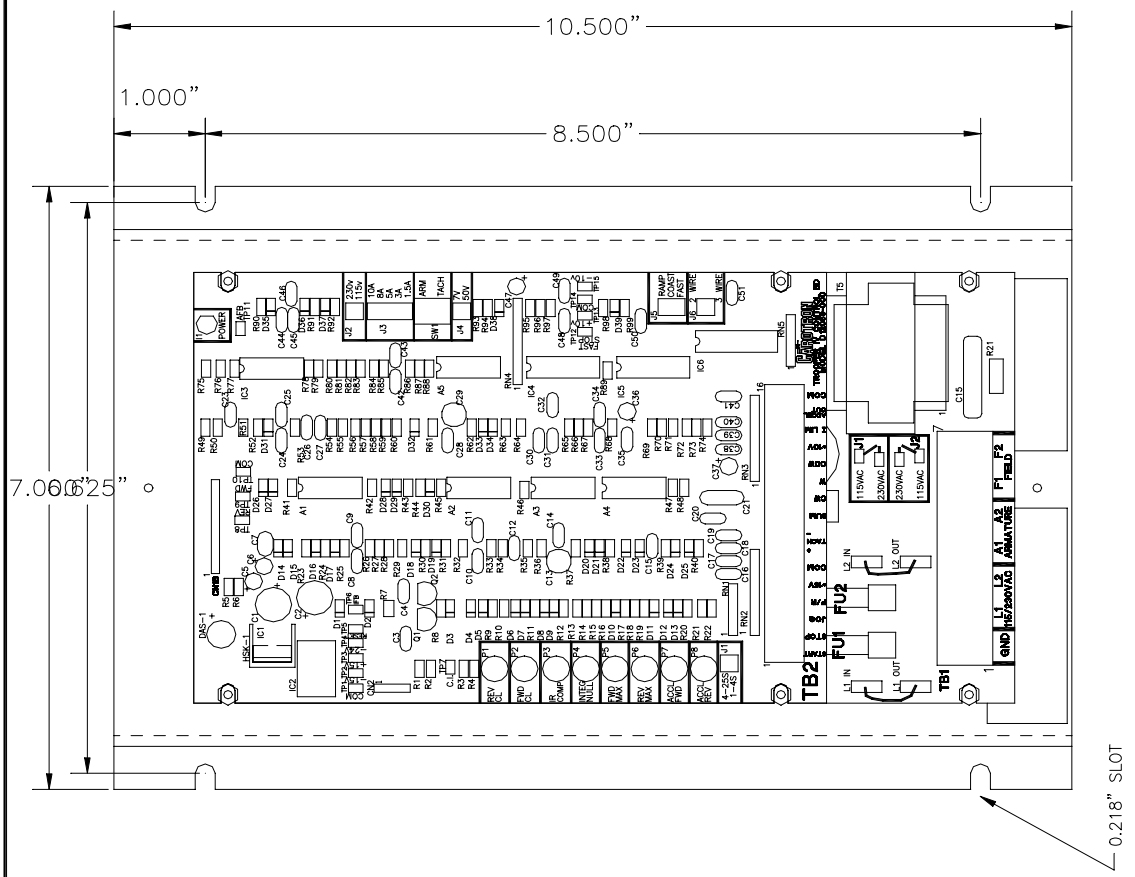
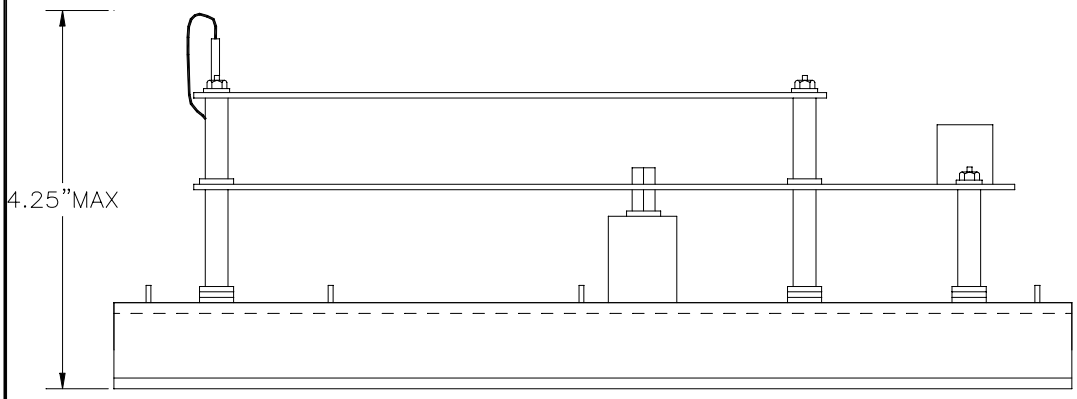
FAX 803-286-6063

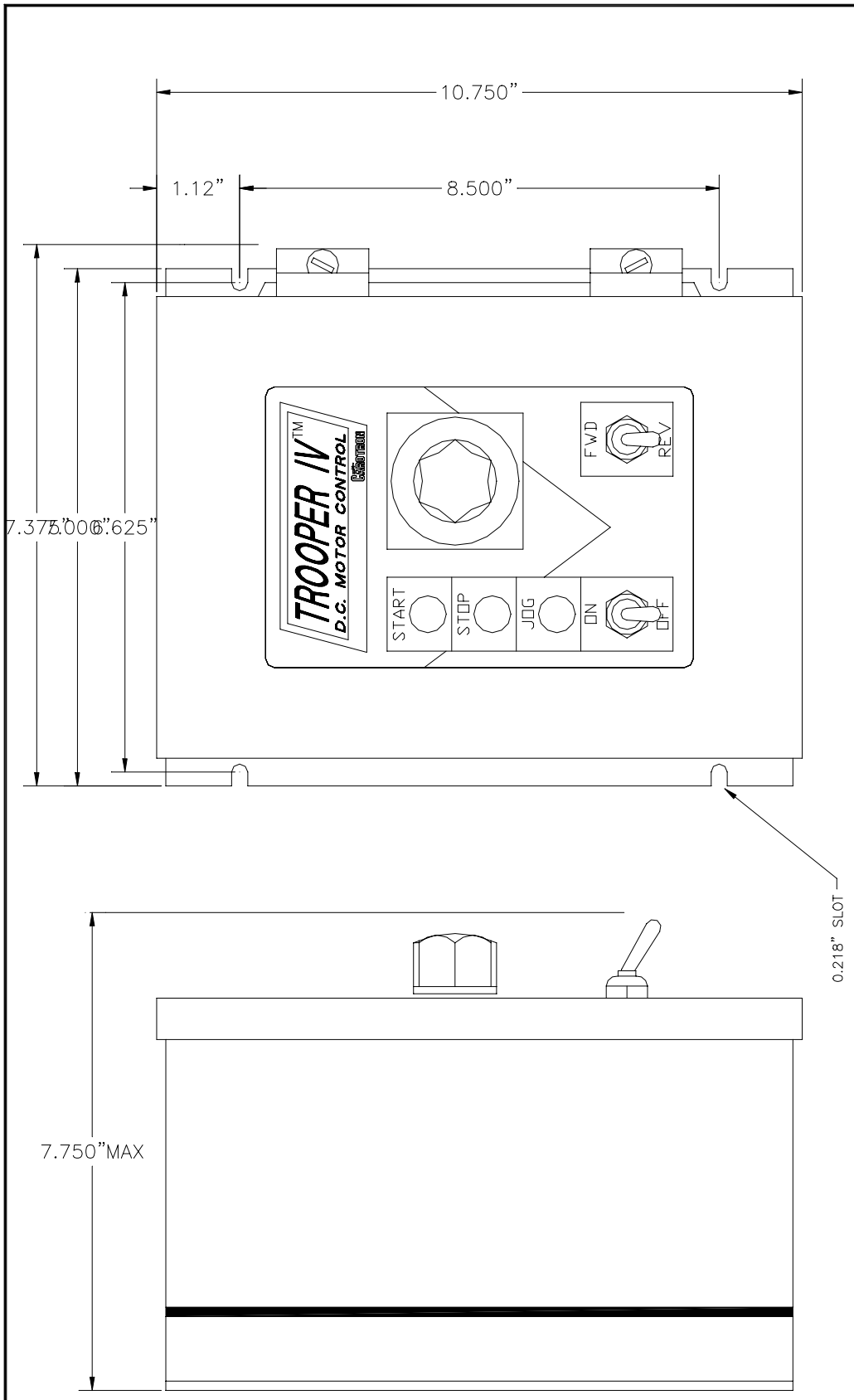
TITLE: CONNECTION DIAGRAM
TROOPER IV SERIES
TRC602-000

DRAWING NUMBER: C12255 REV. A SH. 1 OF 1





DRAWN BY:	DATE: 6-30-00	CARLTRON Driven by Excellence	HEATH SPRINGS, SC TEL 803-286-8614 FAX 803-286-6063	TITLE: DIMENSION TROOPER IV® MODEL TRC602-000	
APPROVED BY:	DATE:				
TOLERANCES: ± 2 DEC. PL. 3 DEC. PL.					
		SCALE: ----		DRAWING NUMBER: C12260	REV. SH. 1 OF 1



DRAWN BY:	DATE: 6-30-00	CARTRON Driven by Excellence	HEATH SPRINGS, SC TEL 803-286-8614 FAX 803-286-8063
APPROVED BY:	DATE:		
TOLERANCES: ± 2 DEC. PL. 3 DEC. PL.		TITLE: DIMENSIONS, TROOPER IV® TRC602-EDC	
	SCALE: ----	REV.	SH. 1 OF 1
		DRAWING NUMBER: C12259	

Notes:

Standard Terms & Conditions of Sale

1. General
The Standard Terms and Conditions of Sale of Carotron, Inc. (hereinafter called "Company") are set forth as follows in order to give the Company and the Purchaser a clear understanding thereof. No additional or different terms and conditions of sale by the Company shall be binding upon the Company unless they are expressly consented to by the Company in writing. The acceptance by the Company of any order of the Purchaser is expressly conditioned upon the Purchaser's agreement to said Standard Terms and Conditions. The acceptance or acknowledgement, written, oral, by conduct or otherwise, by the Company of the Purchaser's order shall not constitute written consent by the Company to addition to or change in said Standard Terms and Conditions.

2. Prices
Prices, discounts, allowances, services and commissions are subject to change without notice. Prices shown on any Company published price list and other published literature issued by the Company are not offers to sell and are subject to express confirmation by written quotation and acknowledgement. All orders of the Purchaser are subject to acceptance, which shall not be effective unless made in writing by an authorized Company representative at its office in Heath Springs, S.C. The Company may refuse to accept any order for any reason whatsoever without incurring any liability to the Purchaser. The Company reserves the right to correct clerical and stenographic errors at any time.

3. Shipping dates
Quotation of a shipping date by the Company is based on conditions at the date upon which the quotation is made. Any such shipping date is subject to change occasioned by agreements entered into previous to the Company's acceptance of the Purchaser's order, governmental priorities, strikes, riots, fires, the elements, explosion, war, embargoes, epidemics, quarantines, acts of God, labor troubles, delays of vendors or of transportation, inability to obtain raw materials, containers or transportation or manufacturing facilities or any other cause beyond the reasonable control of the Company. In no event shall the Company be liable for consequential damages for failure to meet any shipping date resulting from any of the above causes or any other cause.

In the event of any delay in the Purchaser's accepting shipment of products or parts in accordance with scheduled shipping dates, which delay has been requested by the Purchaser, or any such delay which has been caused by lack of shipping instructions, the Company shall store all products and parts involved at the Purchaser's risk and expense and shall invoice the Purchaser for the full contract price of such products and parts on the date scheduled for shipment or on the date on which the same is ready for delivery, whichever occurs later.

4. Warranty
The Company warrants to the Purchaser that products manufactured or parts repaired by the Company, will be free, under normal use and maintenance, from defects in material and workmanship for a period of one (1) year after the shipment date from the Company's factory to the Purchaser. The Company makes no warranty concerning products manufactured by other parties.

As the Purchaser's sole and exclusive remedy under said warranty in regard to such products and parts, including but not limited to remedy for consequential damages, the Company will at its option, repair or replace without charge any product manufactured or part repaired by it, which is found to the Company's satisfaction to be so defective; provided, however, that (a) the product or part involved is returned to the Company at the location designated by the Company, transportation charges prepaid by the Purchaser; or (b) at the Company's option the product or part will be repaired or replaced in the Purchaser's plant; and also provided that Cc) the Company is notified of the defect within one (1) year after the shipment date from the Company's factory of the product or part so involved.

The Company warrants to the Purchaser that any system engineered by it and started up under the supervision of an authorized Company representative will, if properly installed, operated and maintained, perform in compliance with such system's written specifications for a period of one (1) year from the date of shipment of such system.
As the Purchaser's sole and exclusive remedy under said warrant in regard to such systems, including but not limited to remedy for consequential damages, the Company will, at its option, cause, without charges any such system to so perform, which system is found to the Company's satisfaction to have failed to so perform, or refund to the Purchaser the purchase price paid by the Purchaser to the Company in regard thereto; provided, however, that (a) Company and its representatives are permitted to inspect and work upon the system involved during reasonable hours, and (b) the Company is notified of the failure within one (1) year after date of shipment of the system so involved.

The warranties hereunder of the Company specifically exclude and do not apply to the following:

a. Products and parts damaged or abused in shipment without fault of the Company.
b. Defects and failures due to operation, either intentional or otherwise, (l) above or beyond rated capacities, (2) in connection with equipment not recommended by the Company, or (3) in an otherwise improper manner.
c. Defects and failures due to misapplication, abuse, improper installation or abnormal conditions of temperature, humidity, abrasives, dirt or corrosive matter.
d. Products, parts and systems which have been in any way tampered with or altered by any party other than an authorized Company representative.
e. Products, parts and systems designed by the Purchaser.
f. Any party other than the Purchaser.

The Company makes no other warranties or representation, expressed or implied, of merchantability and of fitness for a particular purpose, in regard to products manufactured, parts repaired and systems engineered by it.

5. Terms of payment
Standard terms of payment are net thirty (30) days from date of the Company invoice. For invoice purposed, delivery shall be deemed to be complete at the time the products, parts and systems are shipped from the Company and shall not be conditioned upon the start up thereof. Amounts past due are subject to a service charge of 1.5% per month or fraction thereof.

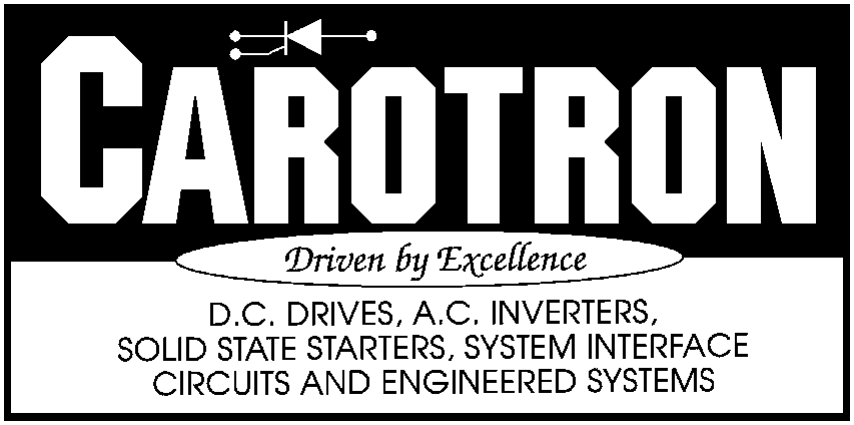
6. Order cancellation
Any cancellation by the Purchaser of any order or contract between the Company and the Purchaser must be made in writing and receive written approval of an authorized Company representative at its office in Heath Springs, S.C. In the event of any cancellation of an order by either party, the Purchaser shall pay to the Company the reasonable costs, expenses, damages and loss of profit of the Company incurred there by, including but not limited to engineering expenses and expenses caused by commitments to the suppliers of the Company's subcontractors, as determined by the Company.

7. Changes
The Purchaser may, from time to time, but only with the written consent of an authorized Company representative, make a change in specifications to products, parts or systems covered by a purchase order accepted by the company. In the event of any such changes, the Company shall be entitled to revise its price and delivery schedule under such order.

8. Returned material
If the Purchaser desires to return any product or part, written authorization thereof must first be obtained from the Company which will advise the Purchaser of the credit to be allowed and restocking charges to be paid in regard to such return. No product or part shall be returned to the Company without a "RETURNTAG" attached thereon which has been issued by the Company.

9. Packing
Published prices and quotations include the Company's standard packing for domestic shipment. Additional expenses for special packing or overseas shipments shall be paid by the Purchaser. If the Purchaser does not specify packing or accepts parts unpacked, no allowance will be made to the Purchaser in lieu of packing.

10. Standard transportation policy
Unless expressly provided in writing to the contrary, products, parts and systems are sold f.o.b. first point of shipment. Partial shipments shall be permitted, and the Company may invoice each shipment separately. Claims for non-delivery of products, parts and systems, and for damages thereto must be filed with the carrier by the Purchaser. The Company's responsibility therefor shall cease when the carrier signs for and accepts the shipment.



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