ELITE D.C. MOTOR CONTROL

Service Manual Elite Series Drives

CAROTRON

Driven by Excellence

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

Table of Contents

1 ------------ABOUT THIS GUIDE-------------

This guide is meant to supplement the ELITE Instructions Manual and DCM100 Users Guide for the ELITE Series of DC Drives. Installation, wiring and start-up information is found in these manuals. This manual will address problems with operation, drive failure, and how to correct these situations.

2 General Description

The ELITE series of DC motor controls provides full range speed and torque control of 5 – 300 HP DC motors rated for NEMA type "C" power supplies. The E06000 non-regenerative series and the E12000 regenerative series are offered in compact panel mounted assemblies. There are ten basic models in each series.

Each model is customer connectable for operation at 230, 380, or 460 VAC input. Semiconductor line fuses are provided for AC line protection with auxiliary line fuses for optional equipment and the field supply. Fuse protection is also provided for the 115 VAC control voltage input.

Standard relay logic interfaces with customer supplied operators for Emergency Stop, Ramp Stop, Run, and Jog. The E12000 regenerative models also have a Forward/Reverse direction control enabling them to provide full four-quadrant operation. This means direction of motor rotation can be electronically reversed without switching the motor contactor, and motoring or braking torque can be supplied in both the forward and reverse directions.

Additional models include options such as armature contactors, brake resistors, disconnect switches, blower starters, enclosures and field regulator supplies.

An accessory drive circuit monitor, DCM100-000, is available to assist in set-up and troubleshooting by plugging in to the CONTROL board. This allows 20 separate signals to be monitored.

------------------ Features--------------------

- Programmable for 230, 380, or 460 VAC 3 phase line input
- Insensitive to phase rotation of A.C. input
- Full 10 ampere rated field supply with provisions for interfacing the Field Loss circuit to an external supply or regulator
- Automatic Field Economy with customer adjustable "delay after stop" to reduce "idling" field voltage by 35%
- Current transformers for isolated armature current sensing
- High impedance isolation for armature and line voltage sensing
- Electrically isolated power modules rated at 1400 volts PIV and 1000 volts/microsecond dv/dt
- Individual SCR R/C networks for transient protection
- Semiconductor line fuses for power circuit protection
- Thermostatically controlled fan (on forced ventilated models) to extend life of the fan
- Latching FAULT logic for safety shutdown with form "C" contact output and LED indicators for Phase Loss, Field Loss, Heatsink, Overtemp and Overcurrent
- 5 jumper selectable armature current ranges for each model to match motor rated armature current
- Timed Foldback current limiting and Overcurrent Trip with four programmable time periods. Allows operating current up to 150% of selected current range for chosen time period; then after time period, 15, 30, 45 or 60 seconds, "folds back" current to 112%. Continued operation with load sustained above 105% current for the chosen time period, 1 min. 15 sec., 2 min. 30 sec., 3 min. 45 sec., or 5 minutes, will result in Overcurrent Trip.
- Control of positive and negative (regen model only) motor torque from external pot or voltage reference
- Lockout of either direction of motor rotation from external contact (reverse on regen model only)
- Independently adjustable linear acceleration and deceleration for both forward and reverse directions with two ranges, 1 – 8 seconds and 8 – 60 seconds for each
- Speed feedback is jumper selected for Armature Voltage, D. C. Tachometer voltage (7, 50 or 100 V/1000 RPM), A. C. Tachometer voltage (45 or 90 V/1000 RPM) or Digital Encoder (300 PPR)
- D. C. Tachometer voltage is insensitive to polarity
- 12 VDC @ 100mA rated encoder power supply
- Summing input for auxiliary input signals with on-board trim pot for scaling and jumper selection for polarity
- Buffered armature current signal output
- Buffered velocity signal output
- Buffered velocity reference signal output
- Inner current loop type control circuit for responsive and precise control of motor speed and torque
- 115 VAC logic for customer operator interface
- Zero speed logic for controlled ramp-to-stop (braking torque supplied by regen models only)
- Jog Delay circuit to allow rapid jogging with out de-energizing armature contactor to give longer contactor life
- Terminal strip access to velocity loop output and current loop input for versatile control functions
- Additional LED's for operating status, Run, Jog, Zero Speed and Foldback

- All important adjustment potentiometers mounted on de-pluggable "PERSONALITY board" to allow CONTROL board replacement while preserving crucial set-up parameters. Critical pots are multiturn and common customer adjustments are single turn with a knob
- Multilevel construction with hinged cover and sub-panel allows ready access to all printed circuit boards, fuses and power components for ease of service and replacement

3 Specifications

A. C. Input

- 230 VAC ±10%, 3 phase, 50/60 Hz ±2Hz
- 380 VAC ±10%, 3 phase, 50/60 Hz ±2Hz
- 460 VAC ±10%, 3 phase, 50/60 Hz ±2Hz

A. C. Input – Single Phase Control Voltage Supply

- 115 VAC ±10%, 1 phase, 50/60 Hz ±2Hz

Armature Output

- 0 to 240 VDC @ 230 VAC input
- 0 to 415 VDC @ 380 VAC input
- 0 to 500 VDC @ 460 VAC input

Field Output

- 150 VDC, 10 amp max, @ 230 VAC input
- 247 VDC, 10 amps max, @ 380 VAC input
- 300 VDC 10 amps max, @ 460 VAC input

NOTE: With the drive stopped, Field Economy function reduces field voltage by 35% after adjustable time delay.

Horsepower Range: Non-Regenerative Models

- E06020-000: 36 FLA, 10 HP @ 240 VDC
  20 HP @ 500 VDC

Horsepower Range; Non-Regenerative Models (Cont.)

- E06040-000: 71 FLA, 20 HP @ 240 VDC
  40 HP @ 500 VDC
- E06060-000: 107 FLA, 30 HP @ 240 VDC
  60 HP @ 500 VDC
- E06075-000: 140 FLA, 40 HP @ 240 VDC
  75 HP @ 500 VDC
- E06100-000: 174 FLA, 50HP @ 240 VDC
  100HP @500VDC
- E06125-000: 206 FLA, 60HP @ 240 VDC
  125HP @500VDC
- E06150-000: 256 FLA, 75HP @ 240 VDC
  150HP @500VDC
- E06200-000: 340 FLA, 100HP @240VDC
  200HP @500VDC
- E06250-000: 425 FLA, 125HP @240VDC
  250HP @500VDC
- E06300-000: 510 FLA, 150HP @240VDC
  300HP @500VDC

Speed Range

- 20:1 Motor Dependent

Speed Regulation

- Armature Feedback: ±0.1% of base speed
- Tachometer Feedback: ±0.5% of base speed
- Encoder Feedback: ±0.5% of base speed

Torque Regulation

- ± 2.0% of current range selected

Horsepower Range: Regenerative Models

- E12020-000: 36 FLA, 10HP @ 240 VDC
  20HP @ 500 VDC
- E12040-000: 71 FLA, 20HP @ 240 VDC
  40HP @ 500 VDC
- E12060-000: 107 FLA, 30HP @ 240 VDC
  60HP @ 500 VDC
- E12075-000: 140 FLA, 40HP @ 240 VDC
  75HP @ 500 VDC
- E12100-000: 174 FLA, 50HP @ 240 VDC
  100HP @ 500 VDC

- E12125-000: 206 FLA, 60HP @ 240VDC
  125HP @ 500VDC
- E12150-000: 256 FLA, 75HP @ 240VDC
  150HP @ 500VDC
- E12200-000: 340 FLA, 100HP @ 240VDC
  200HP @ 500VDC
- E12250-000: 425 FLA, 125HP @ 240VDC
  250HP @ 500VDC
- E12300-000: 510 FLA, 150HP @ 240VDC
  300HP @ 500VDC

4 Model Identification

The ELITE series controls are offered in basic chassis models and contactor models available with factory installed options. The basic drive will have a model number label with applicable rating information. Contactor models will have an additional level showing the contactor horsepower rating and any additional option dash numbers. These model and option numbers are shown in the following tables.

NOTE: The contactor option chassis models listed below include the control voltage (115 VAC) transformer as well as the armature contactor.

TABLE 1: MODEL NUMBERS

MODEL NUMBERS	HP RATING 230/460 INPUT	DESCRIPTION
E06020-000 E12020-000	5-10/5-20	BASIC CHASSIS MODEL
E06040-000 E12040-000	15-20/25-40	BASIC CHASSIS MODEL
E06060-000 E12060-000	25-30/50-60	BASIC CHASSIS MODEL
E06075-000 E12075-000	40/75	BASIC CHASSIS MODEL
E06100-000 E12100-000	50/100	BASIC CHASSIS MODEL
E06125-000 E12125-000	60/125	BASIC CHASSIS MODEL
E06150-000 E12150-000	75/150	BASIC CHASSIS MODEL
E06200-000 E12200-000	100/200	BASIC CHASSIS MODEL
E06250-000 E12250-000	125/250	BASIC CHASSIS MODEL
E06300-000 E12300-000	150/300	BASIC CHASSIS MODEL
E06020-C20 E12020-C20	5-10/5-20	CONTACTOR OPTION CHASSIS
E06040-C40 E12040-C40	15-20/25-40	CONTACTOR OPTION CHASSIS
E06060-C60 E12060-C60	25-30/50-60	CONTACTOR OPTION CHASSIS

TABLE 1: MODEL NUMBERS (CONT.)		
MODEL NUMBER	**HP RATING 230/460 INPUT**	**DESCRIPTION**
E06075-C75 E12075-C75	40/75	CONTACTOR OPTION CHASSIS
E06100-C100 E12100-C100	50/100	CONTACTOR OPTION CHASSIS
E06125-C125 E12125-C125	60/125	CONTACTOR OPTION CHASSIS
E06150-C150 E12150-C150	75/150	CONTACTOR OPTION CHASSIS
E06200-C200 E12200-C200	100/200	CONTACTOR OPTION CHASSIS
E06250-C250 E12250-C250	125/250	CONTACTOR OPTION CHASSIS
E06300-C300 E12300-C300	150/300	CONTACTOR OPTION CHASSIS

- **NOTE: The options listed in TABLES 2, 3 and 4 are used with and mounted on the chassis of the contactor option chassis models listed above.**

TABLE 2: BLOWER STARTER OPTIONS		
OPTION NUMBER	**BLOWER MODEL USED WITH**	**DESCRIPTION**
E612BS-001	MTP-FVB2180, 230VAC, 1PH.	0.6 TO 1.0 AMP OVERLOAD RANGE FOR 1 PHASE BLOWER
E612BS-002	MTP-FVB3210, 460VAC, 3PH. MTP-FVB3250, 460VAC. 3PH.	0.4 TO 0.6 AMP OVERLOAD RANGE FOR 3 PHASE BLOWER
E612BS-003	MTP-FVB3210, 230VAC, 3PH. MTP-FVB3250, 230VAC, 3PH. MTP-FVB4280, 460VAC. 3PH.	0.6 TO 1.0 AMP OVERLOAD RANGE FOR 3 PHASE BLOWER
E612BS-004	MTP-FVB4280, 230VAC, 3PH. MTP-FVB6320, 460VAC, 3PH. MTP-FVB6400, 460VAC, 3PH.	1.4 TO 1.8 AMP OVERLOAD RANGE FOR 3 PHASE BLOWER
E612BS-005	MTP-FVB6320, 230VAC, 3PH. MTP-FVB6400, 230VAC, 3PH.	2.8 TO 4.0 AMP OVERLOAD RANGE FOR 3 PHASE BLOWER

TABLE 3: FIELD REGULATOR OPTION		
OPTION NUMBER	**MODELS USED WITH**	**DESCRIPTION**
FR1000-000	ALL ELITE MODELS	FIELD REGULATOR UNIT 230/460VAC 1 PH. INPUT

TABLE 4: DISCONNECT SWITCH OPTIONS		
OPTION NUMBER	**MODELS USED WITH**	**DESCRIPTION**
E612DS-150	E06020-C20, E12020-C20 E06040-C40, E12040-C40 E06060-C60, E12060-C60 E06075-C75, E12075-C75	150 AMP 600 VAC MOLDED CASE DISCONNECT SWITCH
E612DS-225	E06100-C100, E12100-C100 E06125-C125, E12125-C125	225 AMP 600 VAC MOLDED CASE DISCONNECT SWITCH
E612DS-400	E06150-C150, E12150-C150 E06200-C200, E12200-C200	400 AMP 600 VAC MOLDED CASE DISCONNECT SWITCH
E612DS-600	E06250-C250, E12250-C250 E06300-C300, E12300-C300	600 AMP 600 VAC MOLDED CASE DISCONNECT SWITCH

TABLE 5: ENCLOSURE OPTIONS		
OPTION NUMBER	**MODELS USED WITH**	**DESCRIPTION**
E612EN-001	E06020-C20, E12020-C20 E06040-C40, E12040-C40 E06060-C60, E12060-C60 E06075-C75, E12075-C75	NEMA 12 ENCL.
E612EN-002	E06100-C100, E12100-C100	NAMA 12 ENCL.
E612EN-003	E06125-C125, E12125-C125 E06150-C150, E12150-C150	NAMA 12 ENCL.
E612EN-004	E06200-C200, E12200-C200 E06250-C250, E12250-C250 E06300-C300, E12300-C300	NAMA 12 ENCL.

TABLE 5: ENCLOSURE OPTIONS (CONT.)

OPTION NUMBER	MODELS USED WITH	DESCRIPTION
E612EN-H01	E06020-C20, E12020-C20 E06040-C40, E12040-C40 E06060-C60, E12060-C60 E06075-C75, E12075-C75	NEMA 12 ENCL. W/ DISCONNECT HANDLE
E612EN-H02	E06100-C100, E12100-C100	NEMA 12 ENCL. W/ DISCONNECT HANDLE
E612EN-H03	E06125-C125, E12125-C125	NEMA 12 ENCL. W/ DISCONNECT HANDLE
E612EN-H04	E06150-C150, E12150-C150	NEMA 12 ENCL. W/ DISCONNECT HANDLE
E612EN-H05	E06200-C200, E12200-C200	NEMA 12 ENCL. W/ DISCONNECT HANDLE
E612EN-H06	E06250-C250, E12250-C250 E06300-C300, E12300-C300	NEMA 12 ENCL. W/ DISCONNECT HANDLE

TABLE 6: DYNAMIC BRAKING OPTIONS

OPTION NUMBER	MOTOR USED WITH	DESCRIPTION
E612BR-205	5 HP, 240 VDC ARM.	NAMA 12 ENCLOSED 10 Ohm 300 WATT BRAKE RESISTOR
E612BR-207	7.5 HP, 240 VDC ARM.	NEMA 12 ENCLOSED 5 Ohm 600 WATT BRAKE RESISTOR
E612BR-210	10 HP, 240 VDC ARM.	NEMA 12 ENCLOSED 4.4 Ohm 750 WATT BRAKE RESISTOR

TABLE 6: DYNAMIC BRAKING OPTIONS (CONT.)		
OPTION NUMBER	**MOTOR USED WITH**	**DESCRIPTION**
E612BR-215	15 HP, 240 VDC ARM.	NEMA 12 ENCLODED 3 Ohm 1000 WATT BRAKE RESISTOR
E612BR-220	20 HP, 240 VDC ARM.	NEMA 12 ENCLOSED 2.2 Ohm 1500 WATT BRAKE RESISTOR
E612BR-225	25 HP, 240 VDC ARM.	NEMA 12 ENCLOSED 1.7 Ohm 2000 WATT BRAKE RESISTOR
E612BR-230	30 HP, 240 VDC ARM.	NEMA 12 ENCLOSED 1.7 Ohm 2000 WATT BRAKE RESISTOR
E612BR-240	40 HP, 240 VDC ARM.	EXPANDED METAL ENCLOSED 1.3 Ohm 2080 WATT BRAKE RESISTOR
E612BR-275	50-75 HP, 240 VDC ARM.	EXPANED METAL ENCLOSED 0.62 Ohm 2232 WATT BRAKE RESISTOR
E612BR-2100	100 HP, 240 VDC ARM.	EXPANED METAL ENCLOSED 0.47 Ohm 4700 WATT BRAKE RESISTOR
E612BR-2125	125 HP, 240 VDC ARM.	EXPANED METAL ENCLOSED 0.37 Ohm 5300 WATT BRAKE RESISTOR
E612BR-2150	150 HP, 240 VDC ARM.	EXPANED METAL ENCLOSED 0.31 Ohm 7000 WATT BRAKE RESISTOR
E612BR-405	5 HP, 500 VDC ARM.	NEMA 12 ENCLOSED 40 Ohm 375 WATT BRAKE RESISTOR

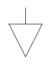
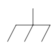
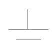
TABLE 6: DYNAMIC BRAKING OPTIONS (CONT.)		
E612BR-407	7.5 HP, 500 VDC ARM.	NEMA 12 ENCLOSED 20 Ohm 750 WATT BRAKE RESISTOR
E612BR-410	10 HP, 500 VDC ARM.	NEMA 12 ENCLOSED 20 Ohm 750 WATT BRAKE RESISTOR
E612BR-415	15 HP, 500 VDC ARM.	NEMA 12 ENCLOSED 14 Ohm 1000 WATT BRAKE RESISTOR
E612BR-420	20 HP, 500 VDC ARM.	NEMA 12 ENCLOSED 10 Ohm 1500 WATT BRAKE RESISTOR
E612BR-425	25 HP, 500 VDC ARM.	NEMA 12 ENCLOSED 7 Ohm 2000 WATT BRAKE RESISTOR
E612BR-430	30 HP, 500 VDC ARM.	NEMA 12 ENCLOSED 6 Ohm 2000 WATT BRAKE RESISTOR
E612BR-440	40 HP, 500 VDC ARM.	NEMA 12 ENCLOSED 5 Ohm 3000 WATT BRAKE RESISTOR
E612BR-450	50 HP, 500 VDC ARM.	NEMA 12 ENCLOSED 3.4 Ohm 4000 WATT BRAKE RESISTOR
E612BR-460	60 HP, 500 VDC ARM.	NEMA 12 ENCLOSED 3.4 Ohm 4000 WATT BRAKE RESISTOR

TABLE 6: DYNAMIC BRAKING OPTIONS (CONT.)		
OPTION NUMBER	**MOTOR USED WITH**	**DESCRIPTION**
E612BR-475	75 HP, 500 VDC ARM.	EXPANDED METAL ENCLOSED 2.6 Ohm 4160 WATT BRAKE RESISTOR
E612BR-4150	100-150 HP, 500 VDC ARM.	EXPANDED ENCLOSED 1.24 Ohm 4464 WATT BRAKE RESISTOR
E612BR-4200	200 HP, 500 VDC ARM.	EXPANDED METAL ENCLOSED 1.02 Ohm 6500 WATT BRAKE RESISTOR
E612BR-4250	250 HP, 500 VDC ARM.	EXPANDED METAL ENCLOSED 0.82 Ohm 11,000 WATT BRAKE RESISTOR
E612BR-4300	300 HP, 500 VDC ARM.	EXPANDED METAL ENCLOSED 0.65 Ohm 14,600 WATT BRAKE RESISTOR

5 Conventions, Glossary & Abbreviations

CONVENTIONS

The following conventions will be used throughout this manual:
All measurements are referenced to circuit common unless otherwise noted. Circuit common is not earth or chassis ground. Please refer to the symbols below.

- **Circuit Common** 
- **Chassis Ground** 
- **Earth Ground** 

All signal level wiring, such as tachometer, encoder, and potentiometer, should use fully insulated shielded cable whether or not shown in this manual. The shield should be connected at one end only to circuit common. The other end of the shield should be clipped and insulated to prevent the possibility of accidental grounding.

All internal relays have suppression devices in parallel with coil whether or not shown in this manual.

The arrows on potentiometer signify the CW terminal. The opposite lead is the CCW terminal, and the middle is the wiper.

OP-AMP IC packages have been given the prefix designation "A" instead of the "IC" found on all other IC packages. Furthermore, many ICs are double, quad, or hex packages. In these cases, each section is given a letter designation to distinguish it from the other OP-AMPs in the same IC package. For example, the first two OP-AMPs in A1 would be A1-A and A1-B.

The bold letters in the schematic diagrams refer to the DCM100-000 check points. Refer to SECTION 10.

GLOSSARY

DRIVE
The electronic device used to control the speed, torque, horsepower, and direction of a DC motor. It is also referred to as the control.

ELECTROMOTIVE FORCE (EMF)
This is another name for the armature voltage generated by the drive. The voltage generated by the motor is called counter EMF or CEMF.

FULL LOAD AMPS (FLA)
The amount of current necessary to produce rated horsepower at full speed.

HORSEPOWER (HP)
The measure of the amount of work a motor can perform during a given time period.
HP = (Torque x RPM)/5250

REGENERATIVE CONTROL
A drive capable of controlling the flow of power to and from the motor. Regeneration occurs when the counter EMF produced by the motor is greater than the voltage applied to the motor by the drive.

SILICON CONTROLLED RECTIFIER (SCR)
A solid-state switch, also called a thyristor, that can be used to provide controlled rectification of large currents at high voltages.

ABBREVIATIONS:

CW	**Clock Wise**
CCW	**Counter Clock Wise**
dv/dt	**Rate of change in voltage versus rate of change in time**

ABBREVIATIONS (CONT.)

Hz	**Hertz**
IC	**Integrated Circuit**
IR	**Internal Resistance**
FET	**Field Effect Transistors**
PIV	**Peak Inverse Voltage**
pot	**Potentiometer**
PPR	**Pulses Per Revolution**
R/C	**Resistor/Capacitor**
RPM	**Revolutions Per Minute**
NL	**No Load**
FL	**Full Load**

6 Description of Operation

6.1 ARMATURE POWER BRIDGE

The armature power bridge of the ELITE E12000 Series is a full wave double converter, type "C" configuration. As seen in FIGURE 1, it consists of six SCRs on the positive bridge and six SCRs on the negative bridge. The bridge being controlled is signified by the POS and NEG LEDs on the CONTROL board. On E06, the NEG LED will light when the POS bridge is turned off.

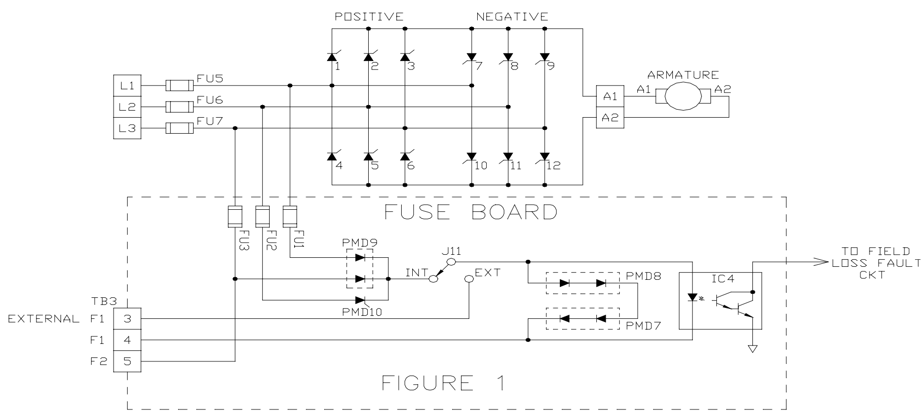


FIGURE 1

Each of the AC lines connects to two SCRs in each bridge. Since the ELITE E06000 Series has only one bridge, it is called a full wave single converter. As a single or double converter, all of the rectifier components (the six SCRs) in the bridge are controlled and give an output rippled frequency equal to six times the AC line frequency – 360 Hz for 60Hz lines and 300 Hz for 50 Hz lines. Refer to FIGURES 2-5 for typical positive bridge output waveforms at various unloaded and loaded speeds.

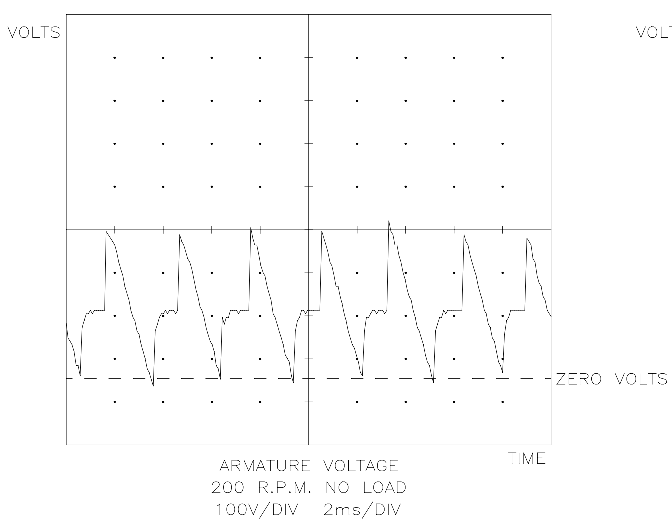


FIGURE 2

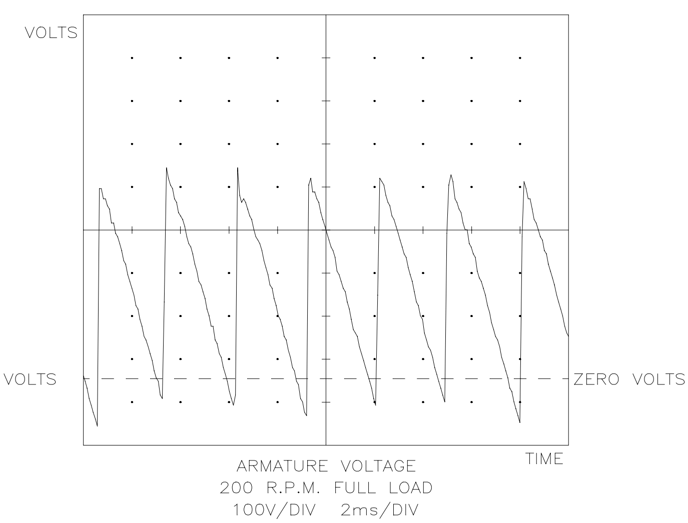


FIGURE 3

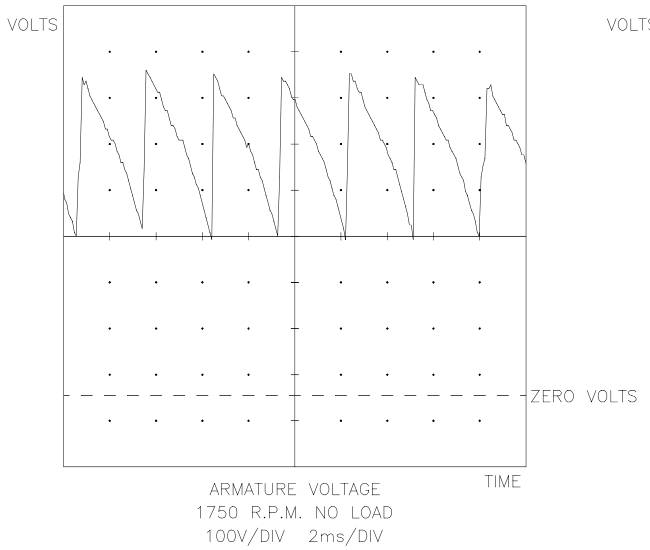


FIGURE 4

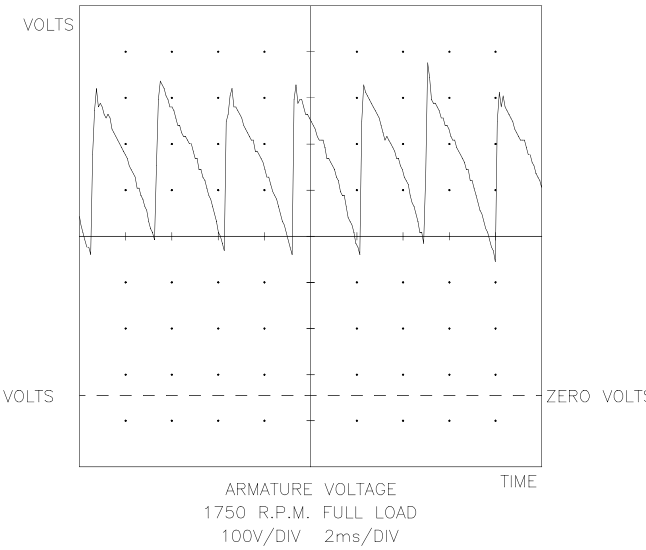


FIGURE 5

The power modules are some of the few components that must be sized according to the horsepower rating of the control. They are all rated at 1400 volts with 1000 volts/microsecond dv/dt to permit reliable operation over a wide range of AC line voltages. They are directly controlled by gating signals from the TRIGGER board and are temperature protected by a thermostat on the same heatsink.

Several vendors can be used as replacements for these parts. Special attention should be paid to the terminal connections for the gate and cathode signal leads coming from CN8A & CN9A on the TRIGGER board. CAROTRON routinely manufactures drives with EUPEC devices. Some manufacturer's have the terminals in a different order and may cause problems if the proper connections are not made. Refer to SECTION 8 for information on testing these components and SECTION 11 for making substitutions.

6.2 FIELD SUPPLY

The field supply is derived from two of the three phase lines, L1 & L2, being half wave rectified with respect to the third line, L3. Refer to FIGURE 1. The rectifier modules, PMD9 & PMD10, are located directly below the armature bridge. Circuitry on the FUSE board connects L1 to one of the diodes in PMD9 and L2 to the SCR in PMD10. The L3 lead, or F2, is connected to the other diode in PMD9. The field voltage level is approximately 0.65 times the AC line to line voltage and can be seen in Figure 6.

The field economy feature is obtained by an adjustable time delay circuit that removes the gating signal from the SCR in PMD10. This essentially removes line L2 from the field supply circuit. The field voltage is now derived from line L1 being half wave rectified with respect to line L3. The economized or reduced field voltage level is now approximately 0.42 times the AC line to line voltage and can be seen in Figure 7.

The presence of field current is sensed by passing the current through four 25 ampere rated diodes to derive a voltage drop that is used to drive an optoisolator. The diodes are enclosed two in each doubler module, PMD7 and PMD8 and mounted on the left side of the heatsink above the FUSE board. Jumper J11 on the FUSE board can break the connection of the F1 circuit from the internal supply to allow an external field supply to be connected through the current sensing circuitry via TB3-3.

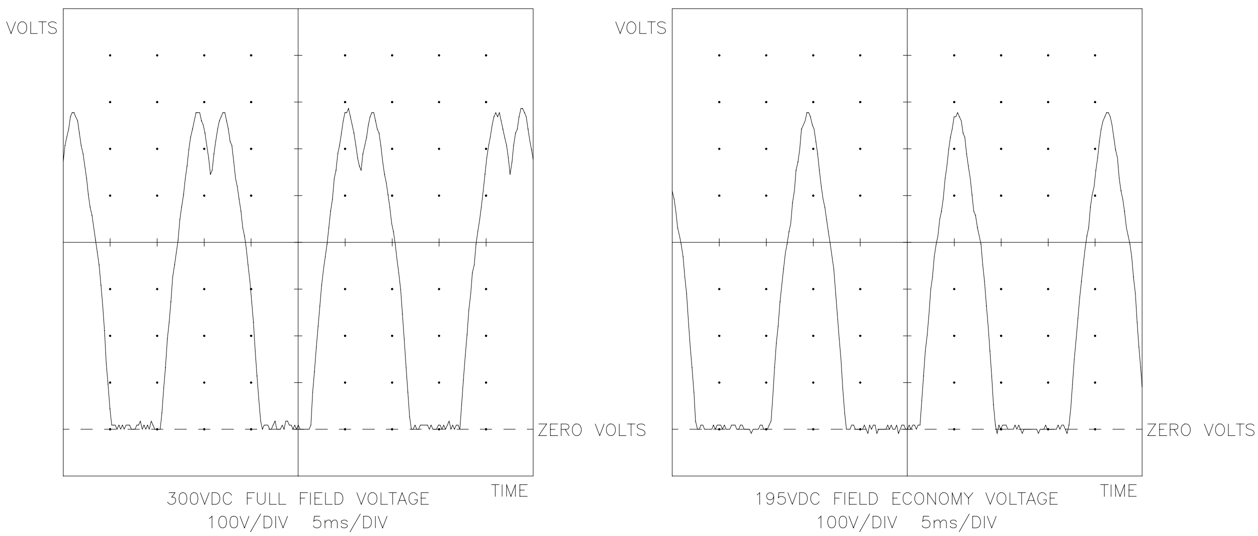


FIGURE 6 FIGURE 7

6.3 CONTROL VOLTAGE SUPPLY AND RELAY LOGIC

The control voltage transformer is supplied by the customer when using basic ELITE models and is included on all contactor models – refer to TABLE 1. When the three-phase power is applied to the drive, the transformer primary voltage should be applied simultaneously to prevent a PHASE LOSS trip condition. CAROTRON recommends connecting the primary of the control transformer to one phase of the auxiliary output at TB3-7 & 8 on the FUSE board. The 115 VAC secondary connects to TB3-1 & 2 and is fused by FU4, an MDA-5A fuse. The fused secondary can be measured at TB1 across terminals 9 & 15 on the RELAY board.

The base ELITE drive includes 10 relays for isolated interfacing of customer operators or logic, such as pushbuttons, selectors, relay contacts, motor thermostats, and the armature contactor. Refer to the RELAY board schematic in Section 12. Most of these relays are located on the RELAY board, and all that are controlled directly by customer supplied logic are powered by the control voltage transformer. The relay circuitry is designed to provide safe sequencing of the armature contactor for emergency stop and ramp to stop. Improper sequencing of the contactor by external logic can cause severe drive problems.

The RUN and JOG relays on the RELAY board are interlocked to prevent the RUN relay from being energized when the JOG relay is being used, and vice versa. These relays are used to control the RUN and JOG logic relays on the CONTROL board and the M PILOT relay that energizes the external contactor. The DIR relay is used to switch the internal reference supply for the speed and jog pots from +10 VDC to –10 VDC.

The CONTROL board operates the FAULT, ZERO SPEED, and JOG DELAY relays on the RELAY board. The FAULT relay is normally energized to supply 115 VAC at TB1-1 for all of the operator, relay and contactor logic. A fault condition causes the relay to de-energize and stop operation. See SECTION 6.12 for information on the fault circuits.

The ZERO SPEED relay allows ramping to stop by holding the armature contactor energized until zero speed is reached. This function is defeated in the event of a fault or emergency stop by the E-STOP relay.

The JOG DELAY relay is timer controlled to keep the armature contactor energized for 3 – 4 seconds after jogging to prevent unnecessary cycling of the contactor during rapid and repeated jogging. See SECTION 6.11 for more information on the zero and jog delay circuits.

6.4 POWER SUPPLIES

The power supplies are located on the POWER SUPPLY board, refer to FIGURE 8. The supplies are isolated by a 48 VA transformer that is powered from the 115 VAC control voltage and is protected by FU8, an MDA 0.5 A fuse.

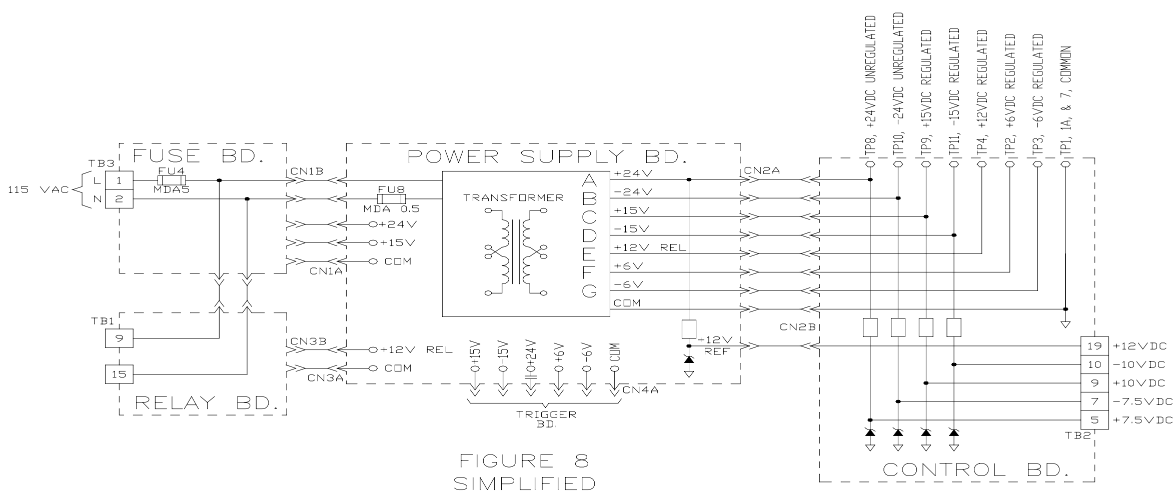


FIGURE 8
SIMPLIFIED
POWER SUPPLY

The dual 17 VAC transformer secondaries are rectified, and filtered to give unregulated ±24 VDC. These supplies are used directly by the pulse transformers and clamping logic on the TRIGGER and CONTROL boards. IC regulators further reduce the supplies to ±15 VDC and ±6 VDC in order to power the remaining drive circuitry. An additional IC regulator is used to supply the ±12 VDC relays. A separate +12 VDC supply from a zener diode is used for an encoder supply.

Also, other zener diodes are used on the CONTROL board to establish ±10 VDC for the speed and jog pots, and ±7.5 VDC for the current limit circuit.

6.5 REFERENCE CIRCUITRY

ELITE drives can make use of several voltage signals to control the speed and direction of motor rotation. Refer to FIGURE 9.

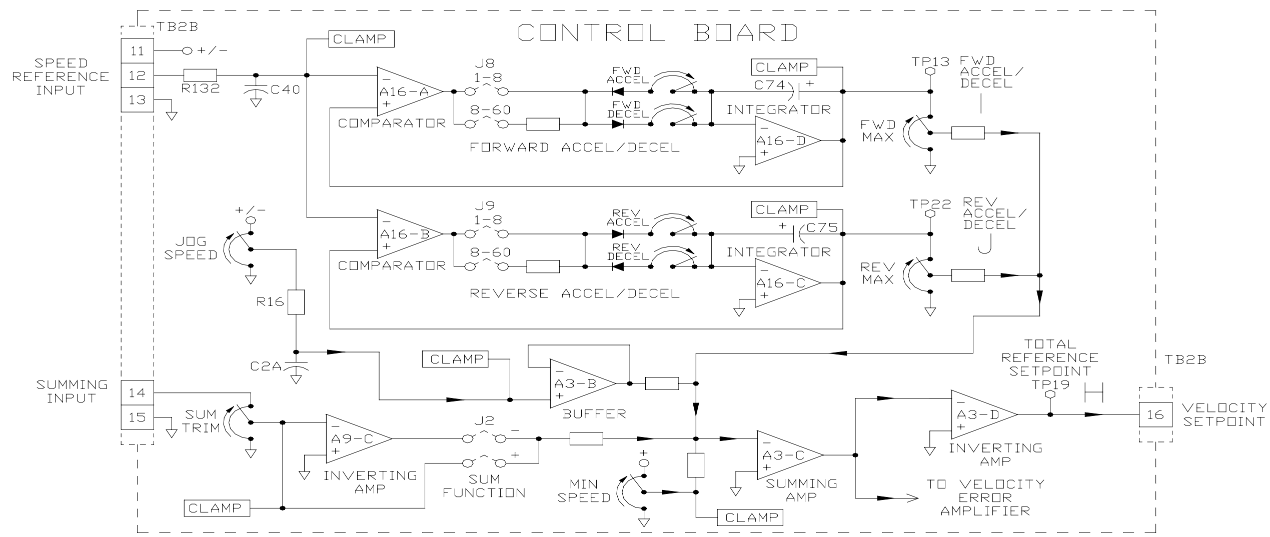


FIGURE 9

Signals from SPEED REFERENCE INPUT, the SUMMING INPUT, the JOG SPEED pot, and the MIN SPEED pot are all summed together to form the TOTAL REFERENCE SETPOINT. **NOTE: MIN SPEED pot is available only on E06 non-regen models manufactured with a revision F or later CONTROL board.**

Normal use with a speed pot connected to TB2B-11, 12 & 13 takes a ±10 VDC signal (+10 VDC in the forward direction, -10 VDC in the reverse direction) from TB2B-11. This signal is trimmed by the speed pot to set the input to the forward or reverse accel/decel circuits at TB2B-12. **NOTE: The polarity of externally connected reference signals will determine the direction of motor rotation, not the FWD/REV selector position.**

The terminal 12 signal is given noise immunity by the R132/C40 R/C network and used as an input to the accel/decel circuits. The forward accel/decel and reverse accel/decel circuits are enabled by the polarity of the armature feedback signal. This polarity signal clamps the reverse accel/decel circuit in the forward direction, and the forward accel/decel circuit in the reverse direction. In the forward accel/decel circuit, OP AMPs A16-A and A16-D form a closed loop circuit that uses the reference level to control the charge and discharge time of capacitor C74. The charge and discharge follows a linear ramp, and the time can be changed by jumper J8 and by varying the resistance of the FWD ACCEL and FWD DECEL pots. This FWD ACCEL/DECEL output, which can be measured at TP13 (I), is connected to the FWD MAX pot and can be clamped when the drive is stopped, in the reverse direction, in the JOG mode, or when the FWD ENABLE contacts are open. Similarly, the reverse accel/decel circuit uses OP AMPs A16-B and A16-C to control the charge on capacitor C75. The REV ACCEL and REV DECEL pots are used in conjunction with jumper J9 to control the charge and discharge time. The REV ACCEL/DECEL output, which can be measured at TP22 (J), is connected to the REV MAX pot and can be clamped when the drive is stopped, in the forward direction, in JOG mode, or when the REV ENABLE contacts are open. See SECTION 6.11 for information on the FET clamps.

The FWD MAX and REV MAX pot wiper signals are summed together at the summing amplifier A3-C. Also summed are the JOG SPEED, MIN SPEED, and the SUM TRIM signals. The JOG SPEED pot trims the ±10 VDC reference signal. It is clamped when the drive is stopped or in the RUN mode. The JOG SPEED pot wiper also has the R16/C2A R/C network to soften start-up in the JOG mode.

The MIN SPEED pot is available only on the E06000 non-regenerative Series. This signal, which allows up to a 30% minimum speed setpoint, is clamped when the drive is stopped.

The SUM TRIM pot receives input from TB2B-14. Its wiper is connected to the A9-C inverting amplifier and to jumper J2 so that the summing signal can be programmed to add or subtract from the TOTAL REFERENCE SETPOINT. This circuit is clamped when the drive is stopped in the JOG mode. **NOTE: Jumper J3 can be used to defeat the clamp when the drive is in the JOG mode.**

Once all of these signals are summed together, they connect to the velocity error amplifier, A4-D. The TOTAL REFERENCE SETPOINT, which measures 10 VDC at 100% reference, can be monitored at TP19 (H) and TB2B-16.

6.6 FEEDBACK CIRCUITRY AND ISOLATION

ELITE drives continuously monitor feedback signals that are related to motor velocity and current. They also precisely sense the AC line voltage and frequency in order to properly synchronize gating of the SCRs. At the same time, the drive is isolated from the sensing signal for ease of interface, noise immunity, and safety.

LINE VOLTAGE SENSING

Sensing of the three-phase line voltage is achieved by connecting impedance isolating resistors and OP AMPs in a delta configuration across the line. Refer to FIGURE 10. The outputs are used to derive synchronized gating signals for the SCRs and for PHASE LOSS protection. Refer to SECTION 6.10 for a description of the trigger-circuit and SECTION 6.12 concerning the PHASE LOSS fault circuit.

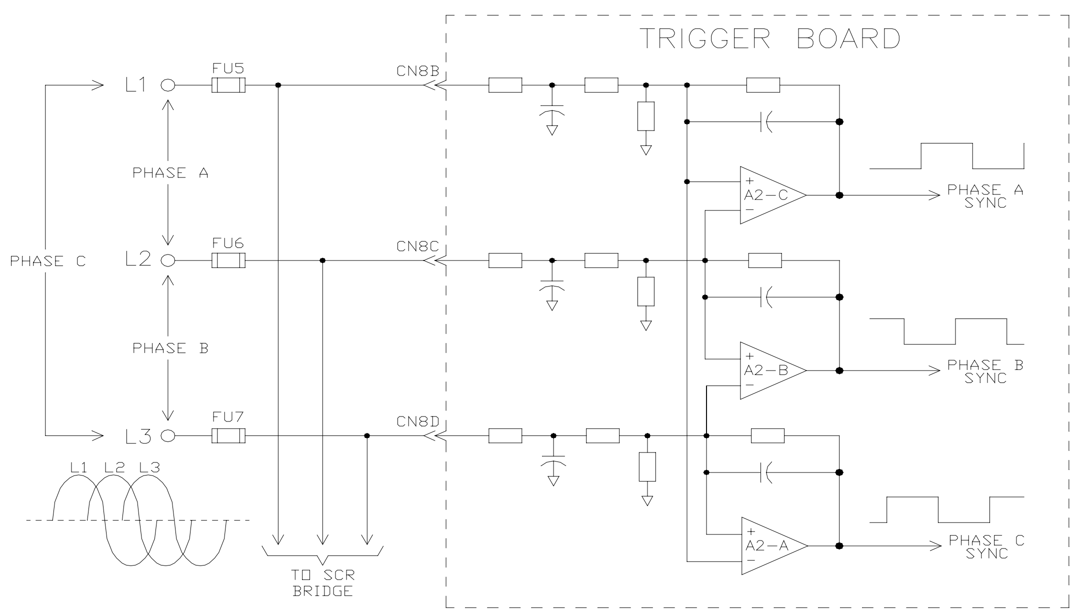


FIGURE 10

LINE VOLTAGE SENSING

ARMATURE CURRENT SENSING

Motor armature current on the ELITE is detected by sensing the AC current in two of the three line inputs. This is possible since all of the motor armature current is taken from the three line phases. The current is sensed by threading two of the three line conductors through current transformers that are located on the C. T. board. The secondaries of the current transformers are rectified to give a DC current signal. Refer to FIGURE 11. The amplitude of this signal is scaled by burden resistors R3 and R4 to +1 VDC at 100% of the drive rating. This signal can be monitored at TP1 on the C. T. board.

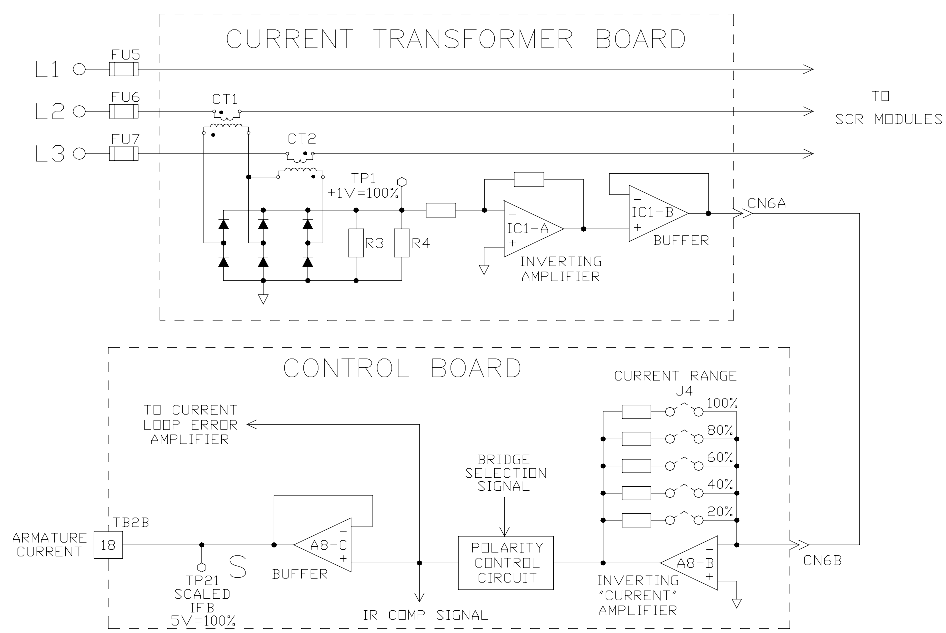


FIGURE 11

Each ELITE horsepower model has its own unique C. T. board to allow for precise scaling of the current feedback signal – see TABLE 7 for a listing.

TABLE 7: CT BOARD CURRENT SCALING RESISTORS

DRIVE MODLE NO.	MODEL FULL LOAD RATING	R3 (Ohms)	R4 (Ohms)	CT BOARD P/N
E06020-000 E12020-000	36 AMPS	243	374	C11126-000
E06040-000 E12040-000	71 AMPS	73.2	NOT USED	C11126-001

TABLE 7: CT BOARD CURRENT SCALING (CONT.)				
DRIVE MODEL NO.	**MODEL FULL LOAD RATING**	**R3 (Ohms)**	**R4 (Ohms)**	**CT BOARD P/N**
E06060-000 E12060-000	107AMPS	100	100	C11126-002
E06075-000 E12075-000	140 AMPS	68	84	C11126-003
E06100-000 E12100-000	174 AMPS	57	57	C11126-004
E06125-000 E12125-000	206 AMPS	47	47	C11126-005
E06150-000 E12150-000	256 AMPS	20	NOT USED	C11126-006
E06200-000 E12200-000	340 AMPS	34	34	C11126-007
E06250-000 E12250-000	425 AMPS	28	28	C11126-008
E06300-000 E12300-000	510 AMPS	23.7	23.7	C11126-009

The current signal is then scaled and buffered before connecting to the CONTROL board. The next stage, A8-B, uses programming jumper J4 to allow amplification of the current signal in 20% increments. This is done to scale the current related circuits to match the rating of the motor.

For example: An E12020-000 drive has a full load rating of 36 amperes or 10 horsepower with a 240 VDC motor. When the drive is used with a 36 amp 10 HP motor, the J4-100% position is used. If used with a 28.1 ampere 7.5 HP motor, 28 divided by 36 equals approximately 78% so the closest range, 80% should be selected. This will make the current feedback signal – measured at TP21 (S) – equal to 5.0 VDC at an armature current of 28.8 amperes.

The polarity of the current signal is controlled by the positive/negative bridge selection signal, which connects to a polarity control circuit. LEDs I1and I2 on the CONTROL board indicate which bridge has been selected and the polarity of the current signal. Refer to SECTION 6.11 for a description of this polarity circuit. The bi-polar current feedback signal connects to the current loop error amplifier and the IR COMP circuit. OP AMP A8-C buffers the current feedback signal, which can be monitored at TP21 (S) and TB2B-18. Refer to FIGURE 12 & 13 for typical waveforms under no load and full load.

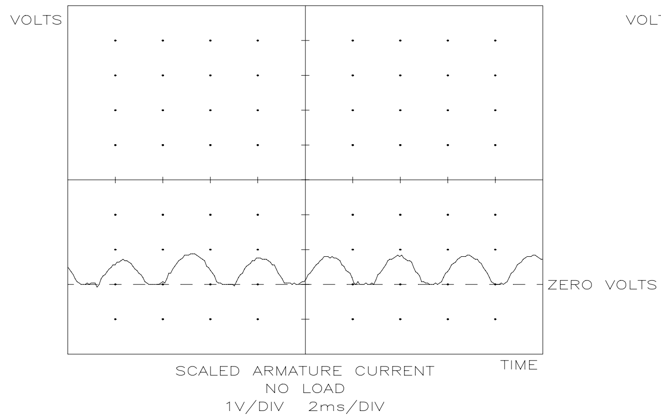


FIGURE 12

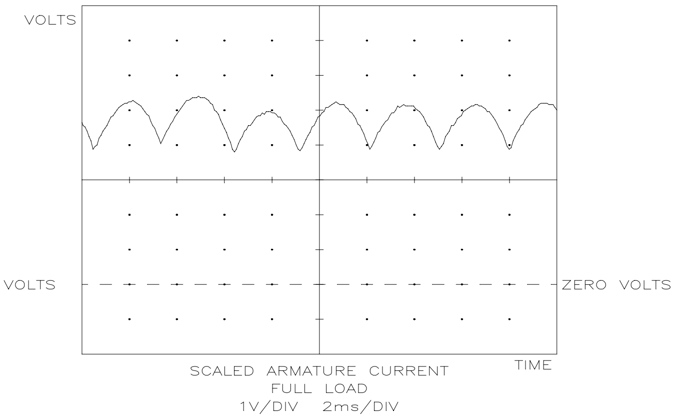


FIGURE 13

ARMATURE VOLTAGE SENSING

The armature voltage sensing circuit uses high impedance, exactly 9.9 megohms, for isolation on the TRIGGER board. 9.9 megohms is the total of three series connected resistors in each of the A1 and A2 sensing inputs on A1-B. Refer to FIGURE 14. The signal then connects to the CONTROL board where it provides a polarity signal to the tach and encoder feedback circuits. Programming jumper J1 selects the gain of A5-C to give 5 VDC output – measured at TP15 (K) – when at the respective full rated armature voltage of 240, 415, or 500VDC. This scaled armature voltage is used for the zero speed circuit input – see SECTION 6.11 – and as input to the armature feedback circuit.

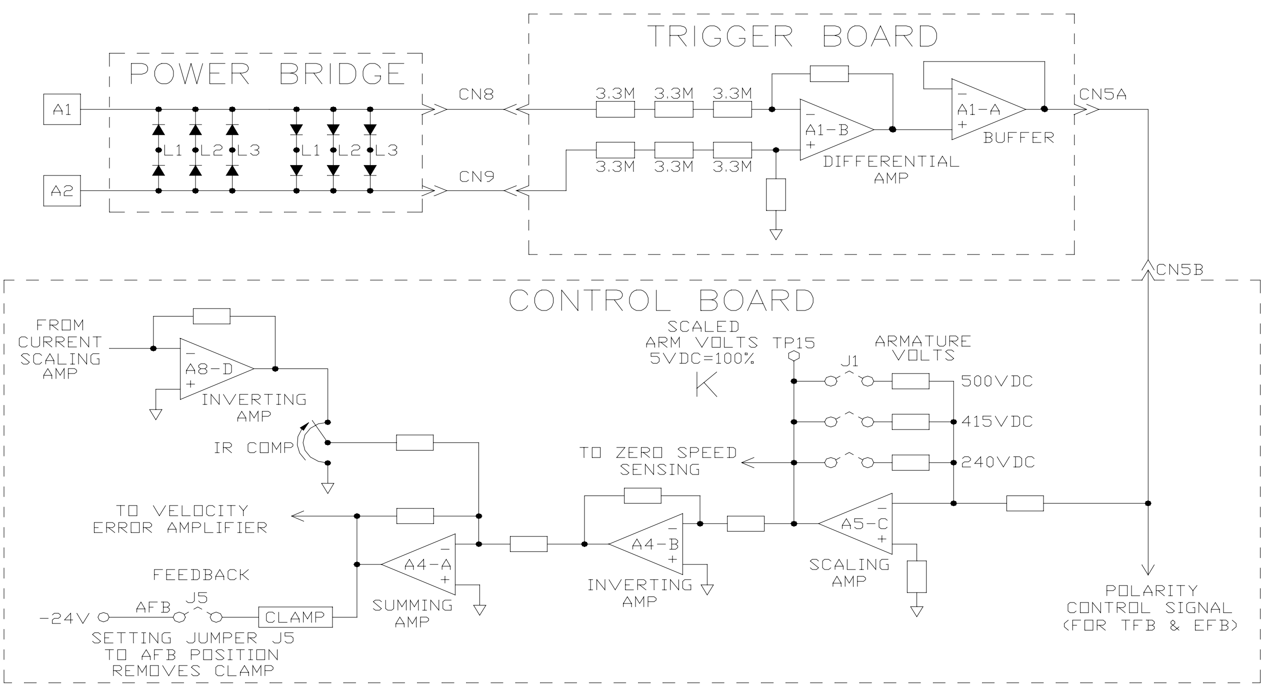


FIGURE 14

ARMATURE FEEDBACK (AFB)

The counter EMF voltage generated by a motor armature is not an ideal velocity feedback. I.R. losses in the armature cause speed to drop as load increases – with armature voltage held constant. To compensate for the losses, the IR COMP pot and circuit uses some of the armature load signal from the current amplifier to subtract from the armature feedback voltage. See FIGURE 14. The reduction in feedback acts the same as an increase in velocity reference and will cause an increase in armature voltage with an increase in load to keep the speed constant. A4-A sums the inverted scaled armature voltage, via A4-B, with the current amplifier output from A8-D. A4-A has a FET clamp to disable it when a tachometer or encoder is used for feedback. When AFB is selected on the J5 jumper, the –24 VDC signal removes the clamp and allows the output signal of A4-A to connect to the velocity error amplifier, A4-D.

TACHOMETER FEEDBACK (TFB)

Another velocity feedback mode selectable by J5 is TACHOMETER FEEDBACK, TFB. Refer to FIGURE 15. An AC or DC tachometer output can be connected to TB2B-22 and common. The tach voltage is noise de-coupled and applied to the A12-C amplifier where the gain is set by jumper J6. The jumper is set to scale the full speed tach voltage to 5 VDC. Following the scaled signal, A5 –B and A5 –A form a precision rectifier circuit which always keeps the output polarity positive regardless of input polarity. The armature feedback signal is used to control the polarity of the tachometer signal by way of a polarity control circuit. Refer to SECTION 6.11 for a description of this circuit. The output connects to jumper J5 and can be measured at TB18 (L).

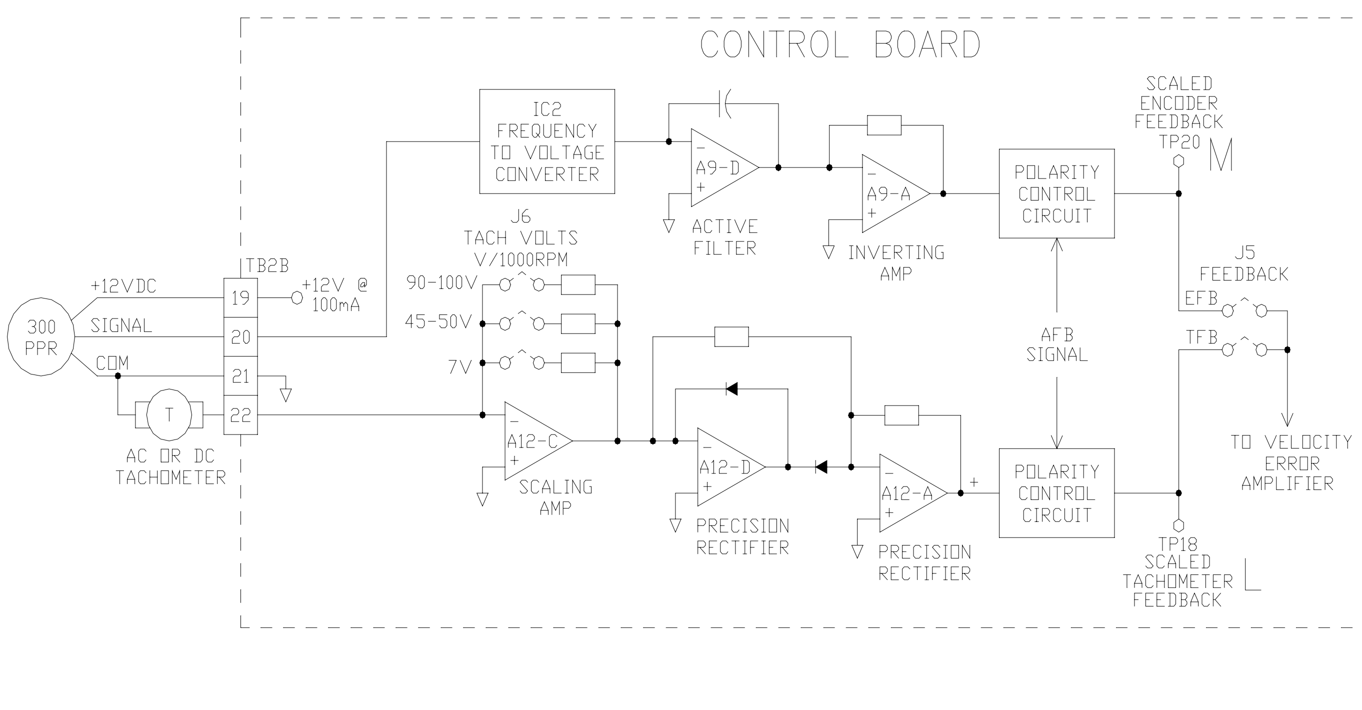


FIGURE 15

ENCODER FEEDBACK (EFB)

A 12 VDC 300PPR encoder connected to TB2B-20 can be selected by J5 in the EFB position – reference FIGURE 15. 1750 RPM equates to an 8750 Hz input that is processed by IC2, a frequency to voltage converter. IC2 sources a current signal into A9-D, an active filter circuit, then through an inverting amplifier, A9-A. Just as above, the armature feedback signal controls the polarity of the encoder feedback by way of a polarity control circuit. The output, which measures 5 VDC at TP20(M) at 1750 RPM, connects to jumper J5.

6.7 VELOCITY LOOP

Speed regulation operations are performed within ELITE drives by individual "loop" control circuits that can be seen in FIGURE 16. They are known as velocity loops because the circuits actively use a feedback signal that is 'looped around" or fed back for comparison to the reference. Faster response and improved speed regulation are the results. This explanation of "loop" is similar to the use of a capacitor or resistor connected from the output to the input of an OP-AMP integrator or amplifier.

VELOCITY ERROR

The TOTAL REFERENCE SETPOINT is summed together at A4-D with the opposite polarity armature, tachometer, or encoder feedback signal, depending on the placement of J5. Also summed is the INTEGRAL NULL signal. Due to the high gain of the velocity loop, motor creepage and/or overshoot when ramping to stop may be noticeable. Adjusting the INTEGRAL NULL pot can reduce this effect by simply using a small amount of the current loop output as negative feedback to the velocity loop. A drawback is a reduction in the speed regulation of the drive. To compensate for this, drives with a revision F or later CONTROL board use the ZERO SPEED logic relay to clamp the INTEGRAL NULL signal above the zero speed setpoint. This allows the INTEGRAL NULL circuit to operate in the only region it is needed, i.e., very low speeds. The output of A4-D is based on the initial difference between the inputs and the continuing level required to minimize the difference. At ideal speed regulation, this output is at zero volts. The signal is the input to the velocity integral and proportional stages.

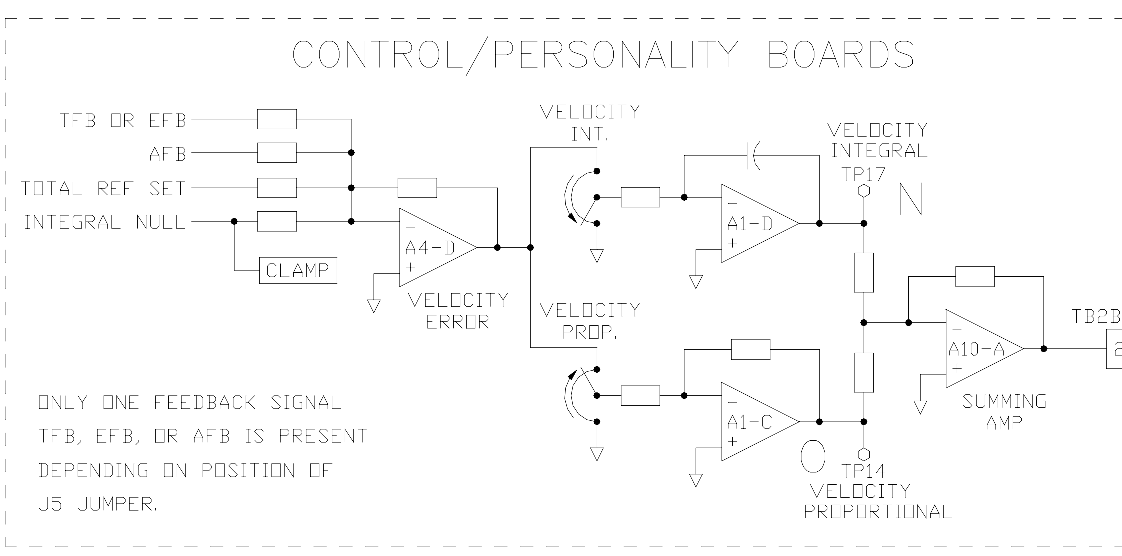


FIGURE 16

VELOCITY INTEGRAL

A1-D is the velocity integral amplifier. Its integrated output (a capacitor charge) is controlled by the input resistance and loop capacitance. The VELOCITY INTEGRAL pot is used to vary the integration time of the signal that can be monitored at TP17(N). At a steady state load condition, this signal equates to the torque required by the motor to make the velocity feedback equal to the velocity reference.

VELOCITY PROPORTIONAL

A1-C is the velocity proportional amplifier. Its output is an initial stepped response based on the input level, the input resistance, and the loop resistance. The VELOCITY PROPORTIONAL pot is used to adjust the amplitude of the incoming signal. Its output can be monitored at TP14(O) and would be close to zero volts at best speed regulation.

The outputs from the velocity integral and velocity proportional amplifiers sum together at A10-A. The output can be monitored at TB2B-25 where it is normally jumpered to TB2B-26. This signal is used as an input to the current loop circuit.

6.8 CURRENT LIMIT AND OVERCURRENT FUNCTIONS

CURRENT LIMIT

The positive and negative current limit voltage outputs are +7.5 VDC and –7.5 VDC, respectively and can be seen in FIGURE 17. Since all ELITE current signals are scaled to 5 VDC at 100%, this 7.5 VDC level corresponds to 150% of the drive's rated armature current. The positive current limit output is at TB2A-5 and is normally jumpered to TB2A-6. Likewise, the negative current limit output at TB2A-7 is normally jumpered to TB2A-8. These voltage levels are the inputs to the positive and negative current limit pots.

The POSITIVE CURRENT LIMIT pot trims the +7.5 VDC signal, and it is then buffered and summed together at A15-D with the current demand signal. When the drive is producing positive motor torque, the current demand signal has a negative polarity. Therefore, the output of A15-D is the difference between the two signals. When the current demand signal is less than the positive current limit signal, the net positive result is inverted at the output of A15-D. This negative polarity signal is blocked by D69, and the current demand signal is not effected.

However, when the current demand signal tries to exceed the positive current limit signal, a net negative result is inverted to positive at A15-D. This positive signal will add to the current demand signal through D69 and clamp it to the level set by the positive current limit pot. The negative current limit circuit works in the same manner, but with opposite polarity signals.

FOLDBACK

As seen in FIGURE 17, the scaled current feedback signal is buffered by A11-A and enters a precision rectifier consisting of A11-D and A11-C. This positive output signal is then compared at A11-B to a +5.25 VDC level, which equates to 105% of rated armature current. The comparator is used to control two current related protection circuits, FOLDBACK and OVERCURRENT FAULT.

The FOLDBACK circuit uses IC1-A, 1/2 of a 556 dual timer, to control the amount of time the drive has exceeded 105% of rated armature current. After a selectable time period the drive will enter the FOLDBACK mode and clamp the output to a maximum of 112%. The timer output is triggered into a high state upon normal power up. This high level exceeds the positive voltage divider level on the non-inverting input of comparator A13-A and causes its output to stay at a negative saturation level. When the IFB signal into the inverting input of A11-B exceeds the 5.25 VDC level on the non-inverting input, the output switches negative and turns off transistor Q23 which was clamping the timing capacitor C51. When the demand has exceeded 105% for the time period selected by J7, C51 completes its charge and drives the timer output low. The low level drives A13-A high and causes Q27 and Q28 to switch the 5.6 volt zener diodes into the current limit circuit. The zener diodes override the current limit pots and limit the current demand signal to 112% which can be monitored at TP5 (R).

OVERCURRENT FAULT

The OVERCURRENT FAULT circuit is similar to the FOLDBACK circuit. Comparator A11-B also controls an identical timer circuit. However, the 105% level must be exceeded for five times as long before the timer output drops low. This signal is used to set a latching fault circuit and shuts the drive off. Refer to SECTION 6.12 for more information on the fault circuits.

NOTE: The timers for FOLDBACK and OVERCURRENT FAULT operate when the current feedback has exceeded 105% continuously for their respective time periods. During timeout, a dip below 105% demand will reset the timers and start the timing cycle over again. A decrease below 105% will automatically bring the control out of a FOLDBACK condition. OVERCURRENT FAULT though is a latched function and must be reset.

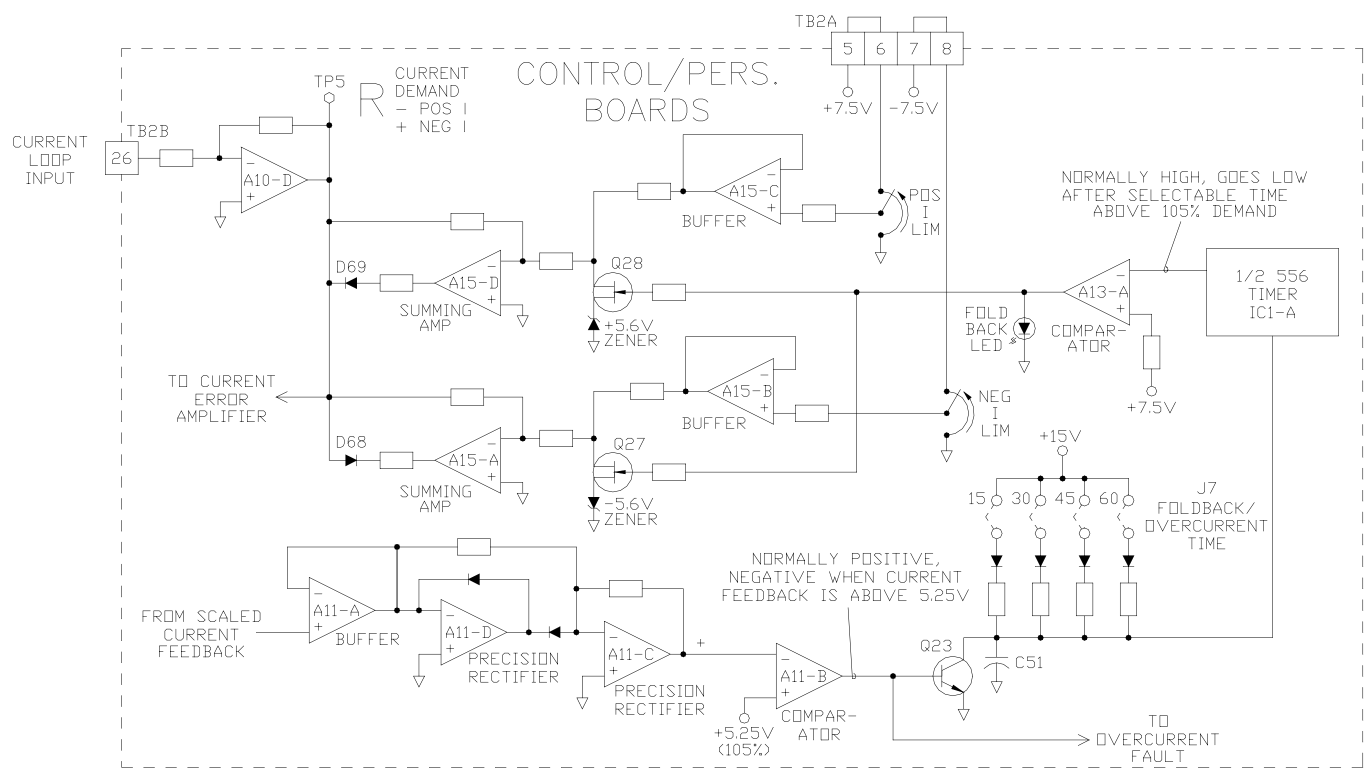


FIGURE 17

6.9 CURRENT LOOP

Armature current in ELITE drives is also controlled by closed "loop" circuitry. Refer to FIGURE 18.

NOTE: For special applications such as center winders that require direct torque control of the motor, the current loop input at TB2B-26 (FIGURE 17) can be connected to an alternate source of reference. The velocity loop section will be non-functional and the drive will have no adjustable maximum speed or armature voltage.

CURRENT ERROR

The opposite polarity current demand and the current feedback signals sum together at A10-B. The output is based on the initial difference between these inputs and the continuing level required to minimize the difference between them. This signal is the input to the current loop and can be monitored at TP23.

CURRENT INTEGRAL

A1-A is the current integral amplifier. The integrated output is controlled by the input resistance and loop capacitance. The CURRENT INTEGRAL pot is used to vary the integration time of this signal that may be monitored at TP12(P).

CURRENT PROPORTIONAL

A1-B is the current proportional amplifier. Its output is a stepped response based on the input level, the input resistance, and the loop resistance. The CURRENT PROPORTIONAL pot is used to vary the amplitude of the input signal. The output can be monitored at TP16(Q).

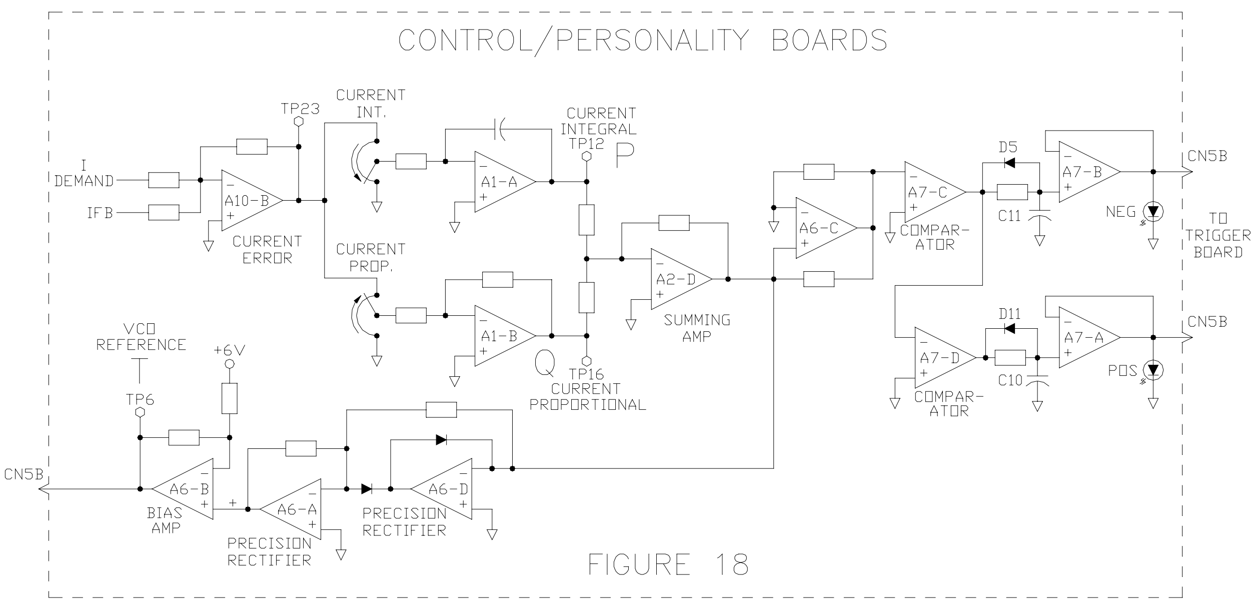


FIGURE 18

BRIDGE SELECTION

The outputs of the current integrator and current proportional amplifiers are summed together by A2-D to produce the SCR conduction angle demand signal. This signal is routed through a precision rectifier and biased down close to the – 6 VDC low state logic level of the TRIGGER board. It can be monitored at TP6 (T). The conduction angle demand signal is also used as an input to the bridge selection circuit. A6-C uses a positive feedback to obtain a very fast changing polarity signal. This signal is used to charge and discharge capacitors C10 and C11. The diodes D5 and D11 allow for rapid discharging of the capacitor with respect to the charge time. This allows for the forward bridge select signal to go low before the reverse bridge signal goes high and vice versa. These signals are used to drive POS and NEG LEDs and connect to the TRIGGER board.

6.10 TRIGGER CIRCUIT

Most of the trigger circuit is powered by the 6VDC supplies. The – 6VDC level is treated as a logic "low" level and the +6VDC as a logic "high" level. This operation above and below zero volts allows symmetry with the AC line signals to be monitored. It also requires that the – 6VDC supply to be used as the reference point for some measurements when servicing the TRIGGER board.

As mentioned in SECTION 6.6 the delta configuration of OP AMPs A2-A, B & C produce three 50% duty cycle "sync" signals. They have been phase shifted to correspond to the phase to phase voltage potentials biasing the power bridge components. Like the line phases, these signals are 120° out of phase with each other. Refer to FIGURE 19. These "sync" pulses are squared up by Schmidt inverters to produce the positive phase A(Ø A+) and negative phase A (Ø A-) signals. Similar signals are also produced for the B and C phases, and each can be monitored at test points 29-34 on the TRIGGER board.

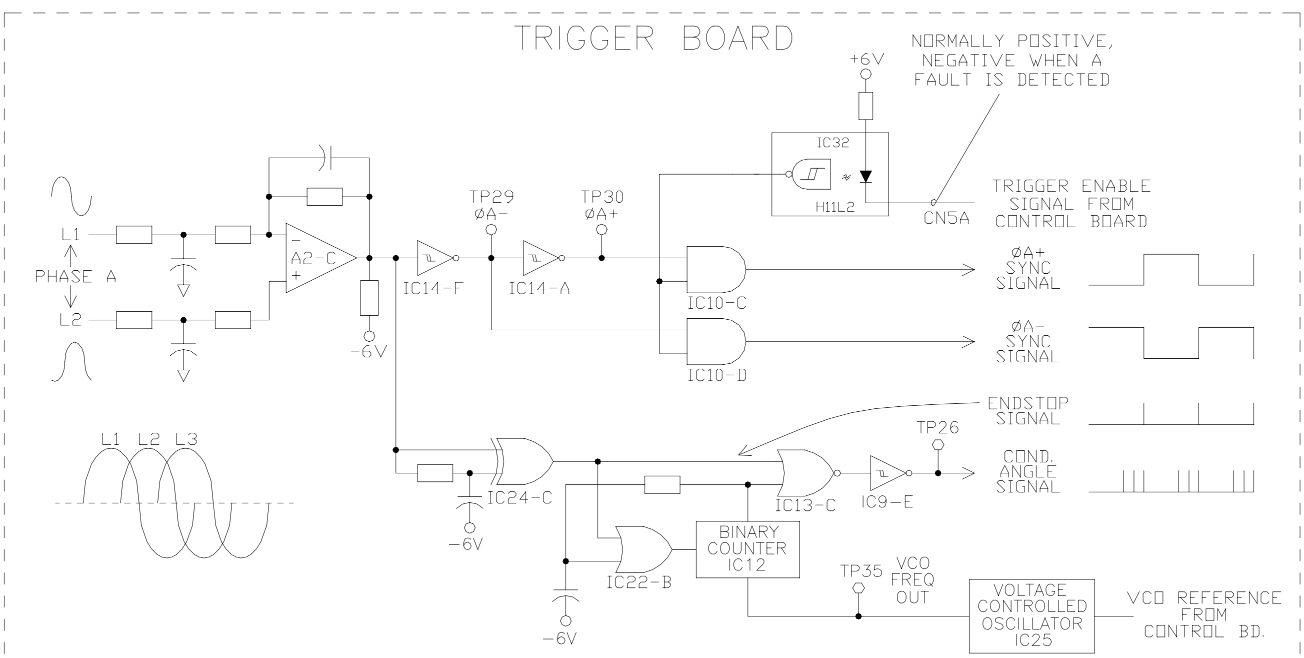


FIGURE 19

The positive and negative phase signals are routed through AND gates that require an enable signal from the CONTROL board. IC32 simply acts as a level changing circuit, from CONTROL board voltage levels to the TRIGGER board voltage levels. During a fault condition, the enable signal is driven low, and the positive and negative phase signals are not passed to the remaining triggering circuitry.

The gating signals produced from the delta configuration are also routed to both inputs of an "EXCLUSIVE OR" gate of IC24. However, one signal is delayed by an R/C time constant. This produces a narrow non-coincidence or "end stop" pulse each time the line to line phase voltage crosses the zero point.

The conduction angle demand voltage signal, or VCO reference signal, from the CONTROL board is applied to IC25, a voltage controlled oscillator. As the input increases in voltage, the output frequency is increased proportionally. This frequency signal is tied to the clock input on the 12-bit binary counter and can be measured at TP35. The normal output range is between 40 and 220 kHz.

This frequency signal causes the binary counter to drive its output momentarily high after accumulating 256 pulses. The output is "ORed" with the end stop signal and serves as a RESET signal to the counter. Thus, the counter will be reset at every end stop pulse, and after it completes a counting cycle. When the VCO output is at low frequencies, the counters cannot complete a cycle before being reset and only the end stop pulse are passed through the NOR gate. As the VCO frequency rises, the counters complete a cycle and start pulse is passed along with the end stop pulse. At higher frequencies, the counter completes its cycle quicker, which causes the start pulse to shift to an earlier starting point. As the start pulse occurs earlier, this allows the counter to complete multiple cycles, and other start pulses will appear in between the first start pulse and the end stop pulse. These pulses can be ignored

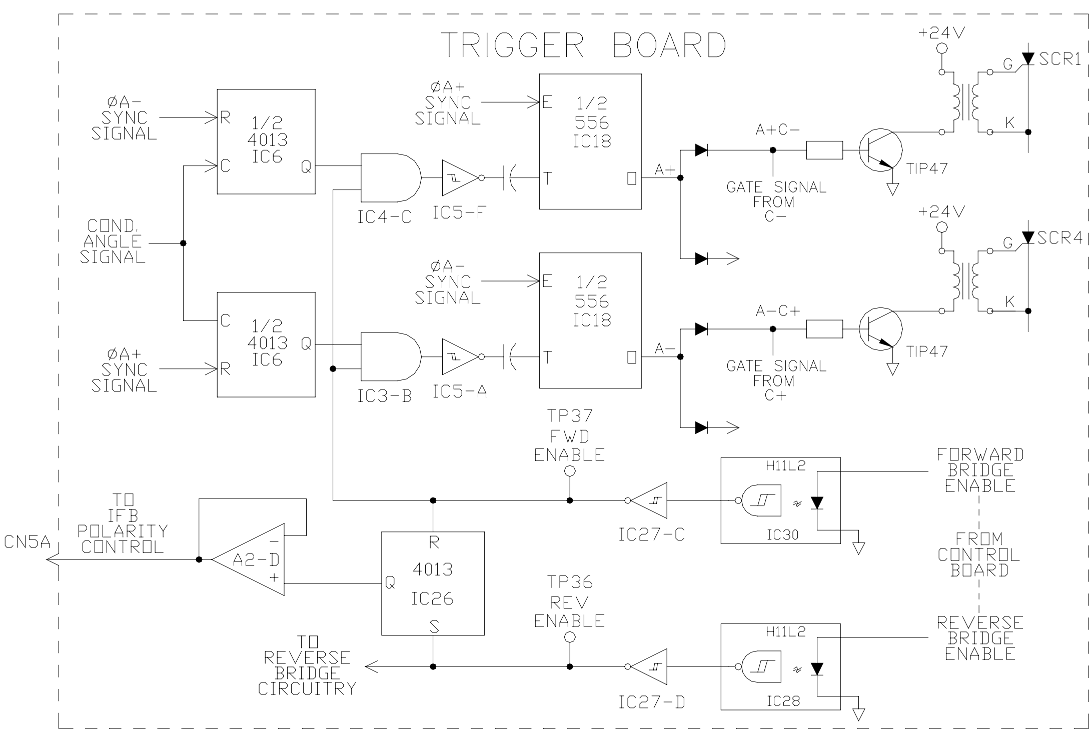


FIGURE 20

since the first start pulse and the end stop pulse are used to control the conduction angle of the SCRs. This signal is squared up, and inverted by the Schmidt inverter gate and used as a clock input to a dual flip-flop. Refer to FIGURE 20.

The dual flip-flop converts the conduction angle signals to a single pulse. By using the positive and negative phase signals as reset signals, two separate conduction angle signals are produced from each dual flip-flop. Each of these signals connects to two "AND" gates. These gates are used in conjunction with a forward or reverse enable signals to operate the forward or reverse bridge circuitry. The forward and reverse bridge select signals (See SECTION 6.9) from the CONTROL board are routed through level changing Schmidt trigger opto-couplers. The signals are inverted and used as the enables to the "AND" gates. The forward and reverse enable signals also connect to an S-R flip-flop. The flip-flop output is buffered and used to control the polarity of the current feedback signal – See SECTION 6.6.

After the forward or reverse bridge has been enabled, the conduction angle is inverted and capacitively coupled to a 556 timer that is configured in the monostable or "one shot" mode. The capacitor causes the input signal to be momentarily negative which drives the 556 output high for 1 ms. Since each SCR is gated in conjunction with two other SCRs per cycle, each SCR requires two gating signals. The appropriate gating signals are "ORed" together through the "steering" diodes. The gating signals are then used to drive a TIP47 transistor into saturation. This TIP47 sinks current through the primary of the trigger transformer. The induced gate pulse on the secondary triggers the SCR. Refer to FIGURE 21for a timing diagram of the TRIGGER board signals and FIGURES 22 & 23 for typical SCR gate pulse with the drive at no load and full load.

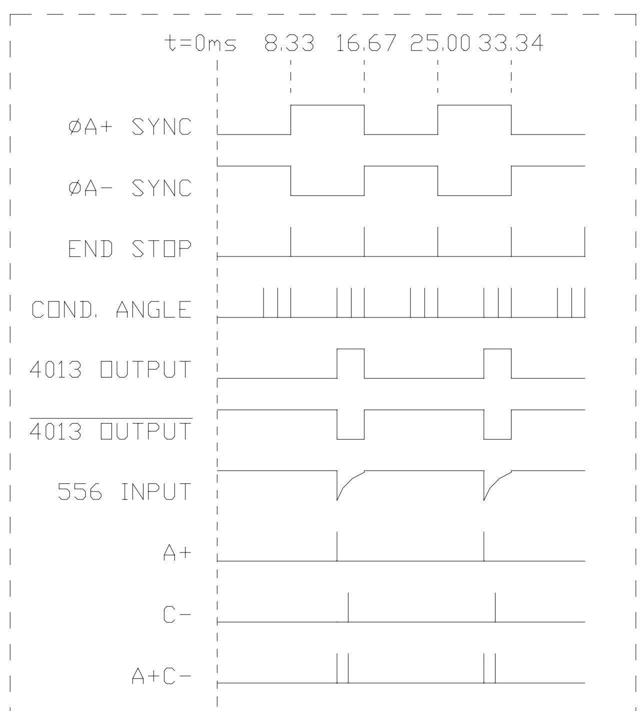


FIGURE 21

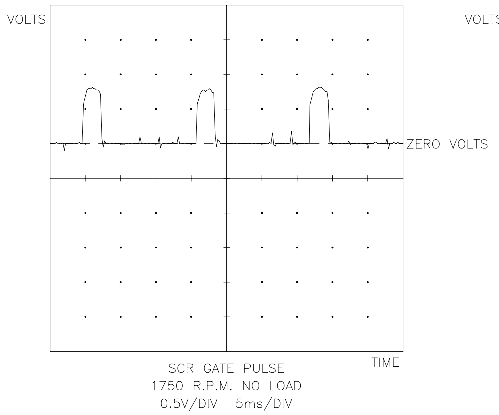


FIGURE 22

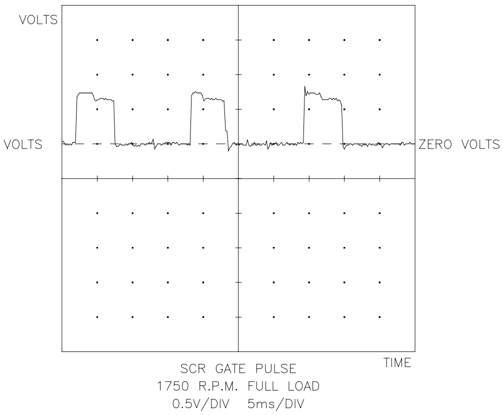


FIGURE 23

6.11 SPECIAL SIGNALS AND CIRCUIT FUNCTIONS:

OPERATING MODE CONTROL

As covered in SECTION 6.3, the RUN and JOG operating modes are commanded by 115 VAC relay logic on the RELAY board. A third operating mode controlled by the ZERO SPEED circuit on the CONTROL board takes over control from the RUN mode when the RAMP STOP pushbutton has been depressed. The mode commands are interfaced with various electronic reference and controlling circuits as depicted in FIGURE 24. There are 12 of these circuits – listed in TABLE 8 – that are shut off or clamped by FETs (field effect transistors) when not turned on or released by the mode control signals as shown in the table.

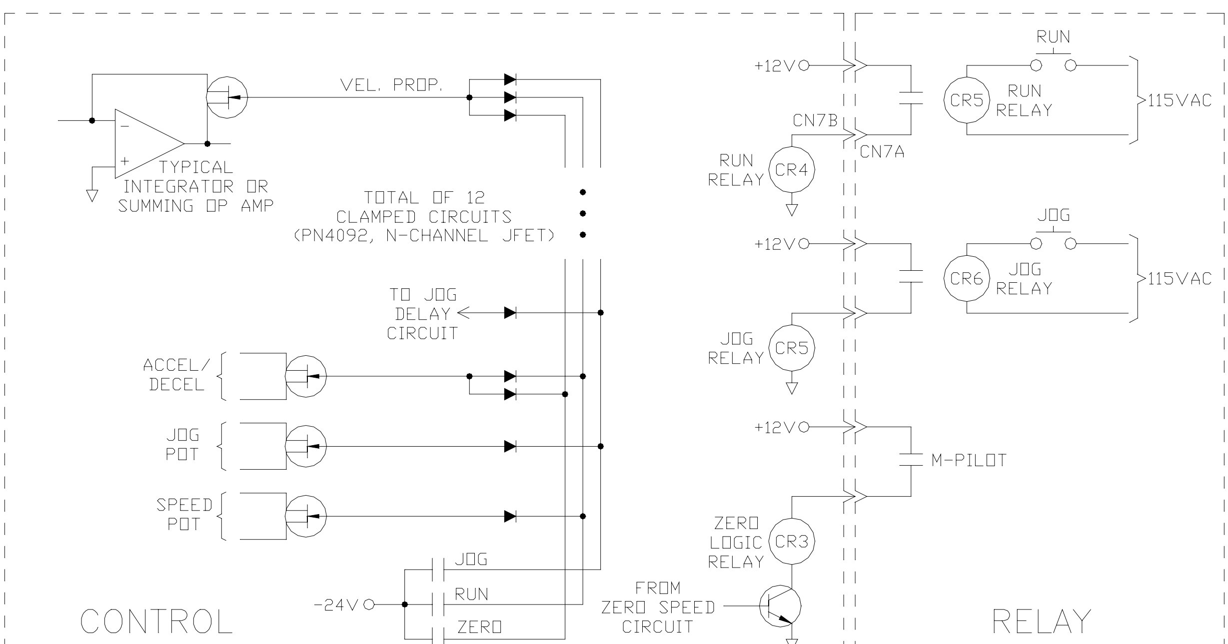


FIGURE 24

The PN4092 FETs that are used are "on" or clamping when their gates are at positive, or zero volts potential. They are turned off by the application of the –24 VDC through the "steering" diodes as shown in the figure.

TABLE 8: OPERATING MODE CONTROL			
MODE	**RUN**	**JOG**	**ZERO SPEED**
SPEED POT	●	X	X
JOG SPEED POT	X	●	X
MIN SPEED POT	●	●	X
SUM TRIM POT	●	J3	X
ACCEL/DECEL	●	X	●
FIELD ECONOMY	●	●	●
IR COMP	●	●	●
VEL. PROP.	●	●	●
VEL. INTEGRAL	●	●	●
I. PROP.	●	●	●
I. INTEGRAL	●	●	●
JOG DELAY	X	●	X

"●" indicates that the respective circuit can be turned on by the MODE control signal. "X" indicates that it has no effect. "J" indicates that control is jumper selectable.

ZERO SPEED FUNCTION

A typical operation in the RUN mode would de-clamp all circuit and signals except for the JOG pot and the JOG delay circuit. When above 5% motor speed, depressing the RAMP STOP button will cause the drive to drop out of the RUN mode and continue in the ZERO SPEED mode. TABLE 8 shows that the SPEED pot is clamped in this mode but the forward and reverse ACCEL/DECEL stays on. Its output will ramp down as controlled by the FWD DECEL or REV DECEL pot until the armature voltage falls below 5% armature voltage, the ZERO SPEED setpoint. At this level the ZERO SPEED circuit will de-energize the armature contactor and cause the remaining circuits and signals to be clamped. FIGURE 25 is a simplified schematic of the ZERO SPEED circuit.

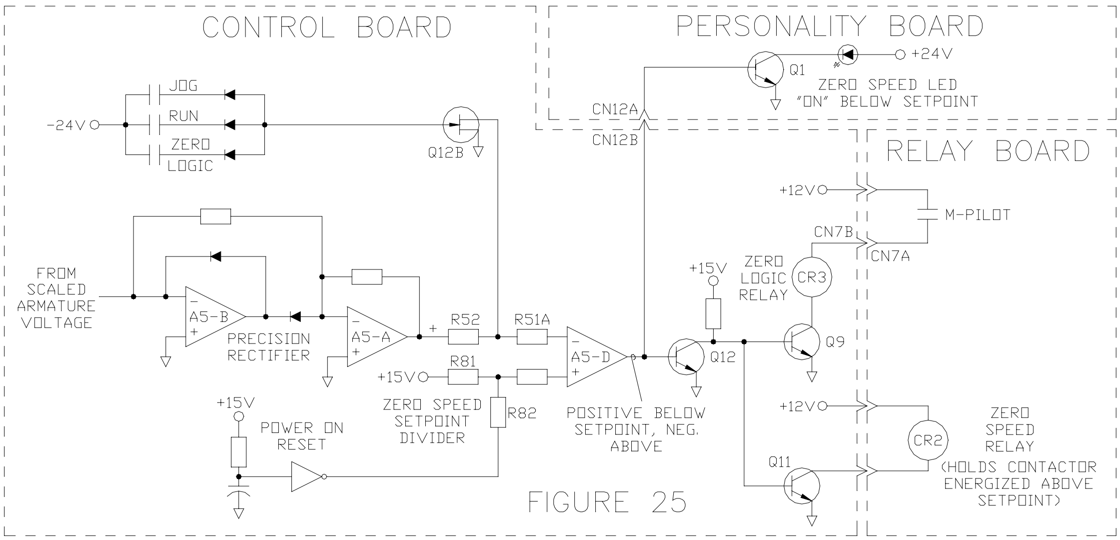


FIGURE 25

The scaled armature voltage signal is rectified by A5-B and A5-A. A RUN or JOG command will remove the clamp and allow the scaled signal to be compared with the R81/R82 resistor divider network. The network controls the ZERO SPEED setpoint and keeps the output of the A5-D comparator positive when the scaled armature voltage is below 5%. The positive voltage saturates Q12 and connects to the PERSONALITY board to control the ZERO SPEED LED. When the scaled armature voltage exceeds the setpoint, A5-D switches negative and causes Q9 to energize the zero logic relay. Refer to FIGURE 24 & 25. Q11 also turns on and energizes the ZERO SPEED relay on the RELAY board. When the RAMP STOP command is given, the ZERO LOGIC relay keeps the clamp removed until the drive falls below the ZERO SPEED setpoint.

JOG DELAY FUNCTION

This function serves to extend the mechanical life of the armature contactor by reducing the number of operations in an application where a high rate of repeat "jogging" is performed. When the JOG button is pressed and then released, the reference is immediately clamped to stop the motor but the contactor is held energized for three to four seconds. Pressing the JOG button again within this "delay" period will cause the motor to immediately jog and will reset the delay. Refer to FIGURES 24 & 26. When the JOG

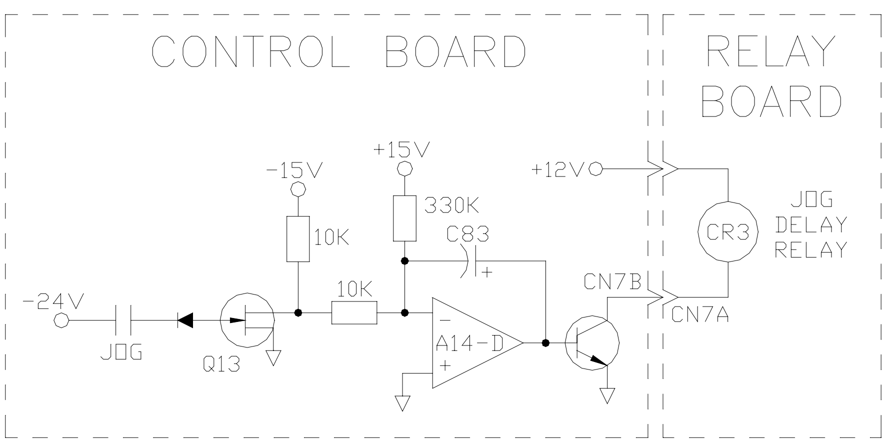


FIGURE 26

button is pressed, the JOG relay is energized, which in turn energizes the JOG relay on the CONTROL board. This de-clamps Q13 by the application of -24 VDC and allows C83 to quickly charge. When the command signal is removed, the +15 VDC causes a slow discharge of the capacitor via a 330K Ohm resistor to produce the delayed drop out of the relay.

POLARITY CONTROL CIRCUIT

The armature current feedback, tachometer feedback, and encoder feedback signals all use a polarity control circuit. This circuit is required on the current and tachometer feedback signals since both are sensed by circuits that are insensitive to polarity. The encoder feedback signal is unipolar and therefore requires polarity control.

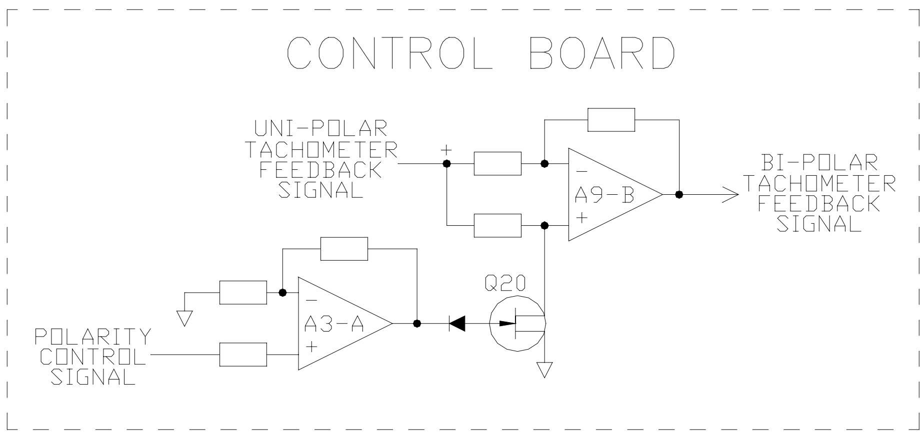


FIGURE 27

As shown in FIGURE 27, a control signal is applied to the non-inverting amplifier, A3-A. Its output is used to turn FET Q20 on or off. When a positive control signal is applied, FET Q20 clamps the non-inverting input of A9-B. This causes the A9-B summing amplifier to have a gain of –1 which inverts the tachometer signal. With a negative control signal, FET Q20 is unclamped and the A9-B amplifier has gains of –1 on the inverting input and +2 on the non-inverting input. Thus, the total gain equates to +1 and the polarity of the tachometer signal is not changed. The tachometer and encoder feedback circuits use the inverted armature feedback signal for polarity control. The current feedback circuit uses the bridge selection signal for control.

6.12 FAULT CIRCUITS

There are four fault conditions on all ELITE control models. Refer to FIGURE 28.

Each fault circuit, OVERCURRENT, FIELD LOSS, PHASE LOSS and OVERTEMP, drives a latching flip-flop circuit high. This in turn lights the specific fault LED, removes the TRIGGER board enable signal, and de-energizes the FAULT relay. The latching circuits also maintain the faulted status of the drive, until it is reset by the RESET pushbutton on the CONTROL board, an external RESET contact connected to TB2B-23 & 24, or by cycling the 115 VAC power to the drive.
The FAULT circuit acts to shut off the armature voltage output and de-energize the

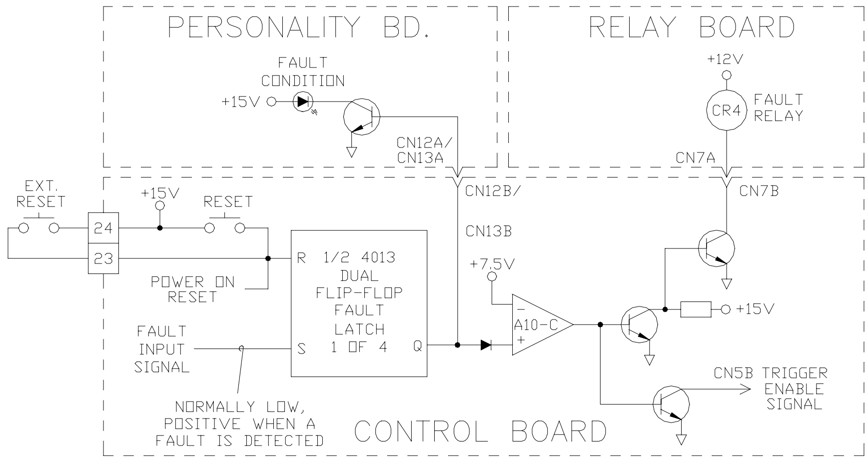


FIGURE 28

armature contactor. The FAULT relay contact de-energizes the RUN, JOG, and ZERO LOGIC relays on the CONTROL board. This removes the –24 VDC used by the mode control circuitry for de-clamping various circuits. This is explained in SECTION 6.11. The FAULT contact also removes the 115 VAC from the pushbutton operator logic and the armature contactor.

OVERCURRENT

The OVERCURRENT FAULT will occur when the control has continuously demanded more than 105% armature current for the programmed time period, it acts in concert with the FOLDBACK circuit and is explained in detail in SECTION 6.8.

FIELD LOSS

The FIELD LOSS circuit detects the presence of field current flow, not voltage, by the circuit shown in FIGURE 1. SECTION 6.2 explains this circuit.

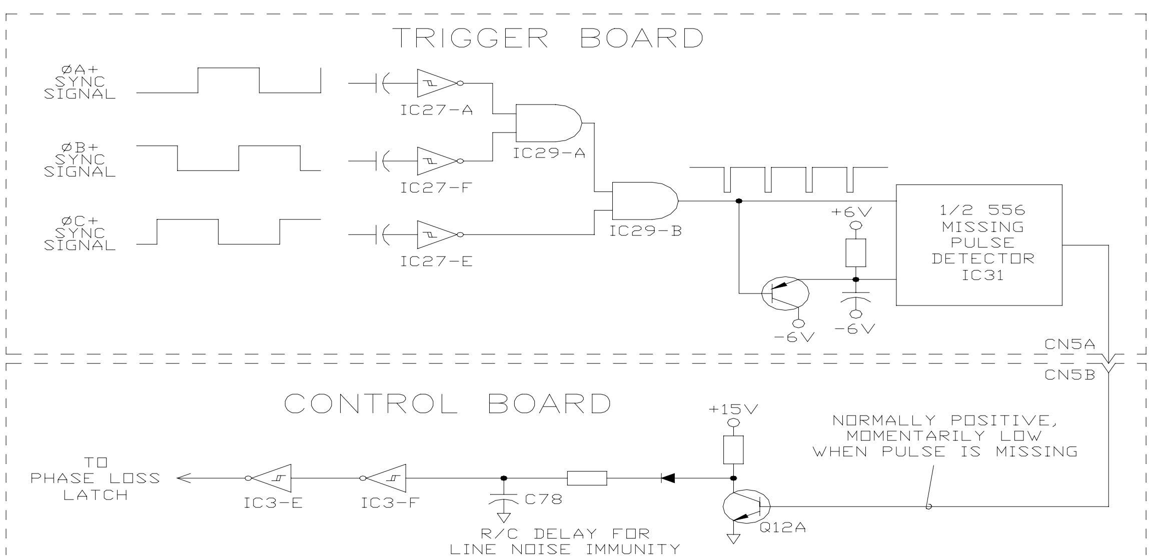


FIGURE 29

PHASE LOSS

The PHASE LOSS circuit is shown in FIGURE 29. Each phase of the line supply is detected by the use of the positive phase signals as shown in FIGURE 10 in SECTION 6.6. The "sync" pulses from this circuit are described with the trigger circuit in SECTION 6.10.

The three 50 or 60 hertz (depending on line frequency) "sync" signals maintain their 120 degrees phase relationship through the IC14 Schmidt trigger logic gates. They are converted to narrow positive going pulses by capacitively coupling the signal to the inputs of IC27. The three sets of pulse are inverted and combined by the IC29 AND gates to give a regular pulse train at three times the line voltage frequency. Each pulse then coincides with one cycle of one of the input phases.

One half of IC31, a 556 dual timer, is used as a missing pulse detector and monitors the pulse train. When powered up, IC31 begins a timing cycle and the output goes high. The train of input pulses continually resets and re-triggers the timer so that it normally cannot complete a timing cycle. One missing pulse gives enough time for a cycle to complete. If this happens, the IC31's output momentarily goes low and turns off Q12A. This allows a delay capacitor, C78, to begin charging. If enough pulses are missing, the capacitor completes its charge and sets the phase loss fault latch.

Experience has shown us that normal industrial line supplies and branch circuits are constantly being subjected to notches or "holes in the line." The delay circuit provides immunity from such intermittent and short losses of line voltage that do not adversely affect drive operation. A capacitor charge must build up from repeated loss of line for a time equal to about 3 cycles or 50-60 milliseconds before reaching the level necessary to operate the fault latch seen in FIGURE 28. Several IC3 inverter gates are used to square up the signal from the detector and into the latch.

OVERTEMP

OVERTEMP operates from a thermostat switch located on the power bridge heatsink. The 77 degrees Centigrade rating and the placement of the thermostat cause it to open if the temperature on the base of the SCR modules exceeds 85 degrees Centigrade. The size of the heatsink and the fan on some models will permit continuous operation at the full armature current rating in a 55 degrees ambient without this happening.

NOTE: The 55 degrees rating refers to the ambient temperature around the heatsink. A totally enclosed drive is specified with a maximum of 40 degrees ambient outside the enclosure to allow for heat trapped within the enclosure.

7 Drive Programming & Calibration

7.1 ADJUSTMENT and PROGRAMMING PRESETS

CAROTRON ELITE controls are all functionally tested and calibrated with motor loads and should only require further calibration to tailor operation for a specific application. The adjustment presets are listed in the event that the condition of the control and its adjustments are unknown or in doubt.

Potentiometer Presets

- **Velocity Integral…………...10 turns CW**
- **Velocity Proportional ……..10 turns CW**
- **I (Current) Integral………..10 turns CW**
- **I (Current) Proportional….10 turns CW**
- **Positive I (Current) Limit……mid-range**
- **Negative I (Current) Limit…. mid-range**
- **IR Comp……………………....full CCW**
- **Sum Trim…………………...…full CCW**
- **Integral Null…………………..full CCW**
- **Fwd Max [Max Speed]……..…mid-range**
- **Fwd Accel [Accel Time]……...mid-range**
- **Rev Accel……………………...mid-range**
- **Jog Speed……………………..mid-range**
- **Rev Max………………………mid-range**
- **Fwd Decel [Decel Time]……...mid-range**
- **Rev Decel………..……………mid-range**
- **Min Speed……………………...full CCW**

Programming Jumper Presets

Jumper J1, J4, J6, J10 and J11 should be placed in the positions appropriate to the line, motor and feedback device rating. J5 should be placed initially in the AFB position until proper encoder or tachometer operation is verified.

Jumper J2, J3, J7, J8, J9 and J12 will be placed according to the specific application requirements.

7.2 Calibration and Fine Tuning

IR COMP

The IR COMP is functional only in the AFB mode and is used to keep motor speed from decreasing as load is increased. Adjustment is best performed when the motor or machine can be loaded normally. If the motor is normally operated at a particular speed, adjust the IR COMP while running at that speed. If the motor operates under load over a wide speed range, pick a speed near mid-range to make the adjustment. Adjust as follows:

Operate the unloaded motor at the normal or mid-range speed and note the exact speed. While still monitoring speed, apply normal load. The reduction in speed of a fully loaded motor will usually fall between 2 and 13% of rated or "Base" speed. Slowly increase the IR COMP adjustment clockwise until the loaded speed equals the unloaded speed measured in the previous step. Making this adjustment may now cause the unloaded speed to be slightly higher. Repeat this procedure until there is no difference between loaded and unloaded speed levels.

Use care to prevent setting the adjustment too high or speed may increase with load and instability may result.

NOTE: For this adjustment, do not use SCALED ARMATURE VOLTAGE to measure speed. Armature voltage is not an exact indication of loaded motor speed!

INTEGRAL NULL

Adjustment of the INTEGRAL NULL pot is sometimes required when the control is continually operated in the RUN mode with a zero speed reference, or when very rapid stopping is required. With maintained zero reference, creeping can occur and depending on dynamics of the load and response of the control, rapid stopping can cause an overshoot through zero speed or back-up in motor rotation at stop. If either of these conditions is apparent, increase the INTEGRAL NULL in the clockwise direction to minimize the symptoms.

Because there is a small reduction in speed regulation, **DO NOT** make this adjustment unless these symptoms are apparent in normal operation. **NOTE: ELITE drives manufactured with a revision F or later CONTROL board incorporate an integral null circuit that is locked out above zero speed. This eliminates the reduction in speed regulation above zero speed.**

I PROPORTIONAL, I INTEGRAL, VELOCITY PROPORTIONAL & VELOCITY INTEGRAL

The INTEGRAL and PROPORTIONAL adjustments, P1 – P4, as preset by CAROTRON will provide stable and responsive performance under most load conditions. When required, the drive performance can be optimized for a particular application or to correct undesirable operation by use of these adjustments. The adjustments are complex and can adversely affect operation if not properly set. In general, the settings that give the most stable operation do not always give the fastest response. Problems correctable by these pots can usually be separated into those related to stability of steady state operation; i.e., constant speed and load conditions; and those that occur with speed or load changes that are related to balanced operation of the SCR power bridge. Refer to the following guidelines when re-adjustment is required.

When instability is observed, it should first be evaluated as a possible load induced condition. Cyclic variation in armature current and in motor speed can indicate mechanical coupling or machine loading conditions. If mechanically induced, the instability repetition rate or frequency can usually be related to a motor or machine rotation rate or loading cycle. In this situation, the instability frequency will change in coincidence with any motor speed change.

Instability in the control output due to incorrect adjustment would usually be present over a range of speed and would not usually change frequency in coincidence with speed. Because the response of the control can sometimes be altered to partially compensate for mechanically induced instability, it is sometimes difficult to determine if the load change is affecting control output stability or if control output is affecting the load stability. De-coupling the load can help make this determination.

If fuse blowing or tripping of breakers should occur, it may be due to unbalanced operation of the power bridge. This would usually be noticeable when rapid changes in output or surges of torque are being called for as opposed to steady state operation. Examples would be when quickly accelerating a load up to speed or when regenerating to prevent overshooting the set speed. Rapid reversing or decelerations are also examples. Excessive proportional gain settings and/or too fast integral settings might cause such unbalanced operation.

Typically, the settings that provide the most stable and balanced bridge operation under all conditions do not give the fastest response. In general, low proportional gains (too far *ccw* rotation) and too slow integral time constants (too far *cw*) would cause instability. Bridge unbalance would usually result from just the opposite setup, too high (*cw*) proportional gains and too fast (*ccw*) integral time.

Keep in mind that the symptoms and corrections could differ from those stated above under certain conditions. For example, if instability or sluggish response resulted from the Velocity Proportional gain setting being too low, adjusting the Velocity Integral might give some improvement during a steady state operation. However, it could make things worse when load or speed changes are introduced. To prevent confusion and minimize anxiety when making loop adjustments, use the following guidelines:

1). Make sure the problems are not due to things other than adjustments. Operation similar to that caused by incorrect adjustment can be caused by but are not limited to the following problems:

A) Leakage due to insulation breakdown in the motor. A motor with insulation breakdown may operate correctly when cool or at light loads but may cause problems when conditions change.

B) Improper wiring of the motor. Does the motor have a SERIES armature winding? If it does, it should not be used with a regenerative drive model. Its polarity is critical on non-regen models. Are the field windings connected correctly? Most motors used with ELITE drive models have dual field windings that must have the same polarity to work properly.

C) Incorrect armature current scaling. Has the proper motor current range been selected at J4 on the CONTROL board? The scaled current range of the control must match the nameplate current rating of the motor.

D) If used, is the velocity feedback tachometer or encoder selected, connected and scaled properly?

E) If in armature feedback, is the IR COMP adjusted too high?

F) Is the speed reference to the control a stable, noise free signal?

2.) Know what your starting point is before making an adjustment. Note the setting of a pot before changing it. If it is a multiturn pot and you are not sure of the setting, turn it down (*ccw)* while counting turns until you hear the clicking sound noting end of rotation or until you've gone more than 25 turns. Then turn it back clockwise for ten turns or to your desired starting point.

3.) Make only one adjustment at a time. If an adjustment has no effect or appears not to help, be sure to return it to its starting point before making any other adjustment.

4.) When loop adjustments are required, start first with the I (current) loop adjustments. The factory presets P1 – P4 at 10 turns clockwise, approximately 33% of their range.

I INTEGRAL

The I INTEGRAL controls a 10 to 1 change in the current loop integral time constant. Clockwise rotation increases the time or decreases the response rate.

I PROPORTIONAL

The I PROPORTIONAL controls a 2 to 1 change in the current loop proportional gain. Clockwise rotation increases the gain and response.

VELOCITY INTEGRAL

The VELOCITY INTEGRAL is a trimming pot that gives a 20 to 1 change in the velocity loop integral time constant. Clockwise rotation increases the time or decreases the response rate.

VELOCITY PROPORTIONAL

The VELOCITY PROPORTIONAL gives a 4 to 1 change in the velocity loop proportional gain. Clockwise rotation increases the gain.

The VELOCITY INTEGRAL and VELOCITY PROPORTIONAL signals are summed to produce the VCO input signal.

CURRENT LOOP ADJUSTMENT

This procedure describes static tuning of the current loop by directly applying a stepped reference and monitoring the current feedback.

The POS C.L. pot can be turned down to permit testing at a lower current level. Remove all power from the drive, and disconnect the motor field wires from TB3 terminals 4 and 5. If you are using an external field current regulator, disconnect the field wires from the regulator. Place the Field Loss jumper J10 in the BYPASS position.

NOTE: The motor can now be operated in the stalled condition. In order to prevent damage the motor, do not run the drive under these conditions longer than a few seconds. Although the field is disconnected from the motor, residual flux in the field windings may cause slight rotation of the motor. In order to prevent this, mechanically lock the motor shaft or apply a load to prevent rotation.

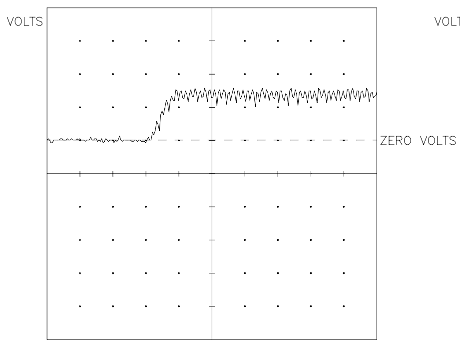
Remove the jumper from TB2B, terminals 25 and 26. A 0 to +10 VDC stepped signal will need to be applied to the Current Loop Input, TB2B terminal 26. This can be accomplished by placing a jumper from TB2A terminal 9 to TB2B terminal 26, and placing a switch from TB2B terminal 26 to TB2B terminal 21. When the switch is closed, the +10 VDC source is shorted to common. By opening the switch, the +10 VDC signal is applied to the current loop. Place the switch in the closed position.

Connect an oscilloscope in the normal or signal sweep mode and monitor the Armature Current Feedback signal at TP21. If using a dual trace scope, it may be helpful to trigger on the TB2B terminal 26 signal. Apply AC power to the drive, and place in the RUN mode by momentarily closing the contacts on the RELAY BOARD. Momentarily open the switch to allow the +10 VDC signal to be applied. The Current Feedback signal should respond quickly without any overshoot as seen in Figure 30. Adjust the Current Integral and Current Proportional pots (P3 & P4) to obtain a critically dampened response. Figure 31 shows an under damped response due to a low proportional gain. Turn P3 *CW* to correct. An over damped response with the integral time too long can be seen in Figure 32. Turn P4 *CCW* to correct.

VELOCITY LOOP ADJUSTMENT

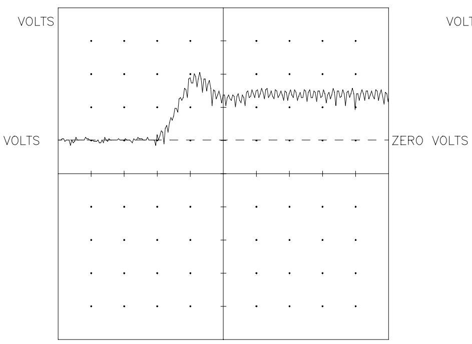
Remove AC power from the drive and reconnect the field wires. Place the Field Loss jumper J10 in the normal position. Remove the mechanical lock from the motor shaft and connect the normal load if possible. Remove the jumper/switch configuration used above and replace jumper at TB2B terminals 25 and 26. Connect a 10k Ohm pot at TB2B across terminals 11 and 13 with the wiper to terminal 14, and adjust to the 60% position. Connect the switch used above across TB2B terminals 14 and 15 and place in the closed position.

Monitor the Scaled Tachometer Feedback signal at TP18 with the oscilloscope and trigger on the TB2B-14 signal. If a tachometer is not used, and the Armature Feedback signal can be monitored at TP15. Note that the armature feedback signal will not be as "clean" as a tachometer signal. Apply AC power to the drive and place in the RUN mode. Open the switch to apply the 60% signal to the SUMMING input, and observe the response of the drive. As before, the signal should respond quickly without any overshoot as seen in Figure 33. Adjust the velocity Integral and Proportional pots (P1 & P2) to obtain a critically dampened waveform. Figure 34 shows the response with the proportional gain to low. Turn P1 *CW* to correct. Too short of an integral time can also cause overshoot as seen in Figure 35. Turn P2 *CW* to correct.



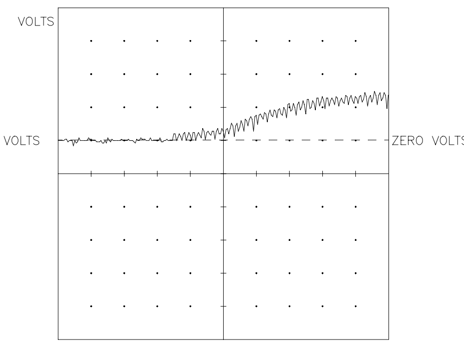
SCALED ARMATURE CURRENT
CRITICALLY DAMPED
5V/DIV 20ms/DIV

FIGURE 30



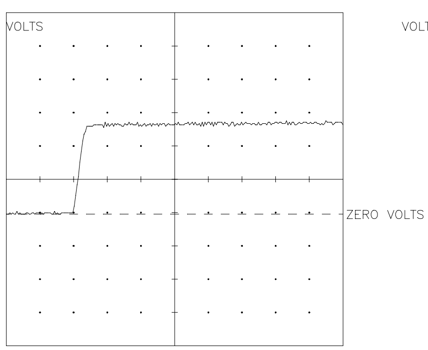
SCALED ARMATURE CURRENT
UNDER DAMPED
5V/DIV 20ms/DIV

FIGURE 31



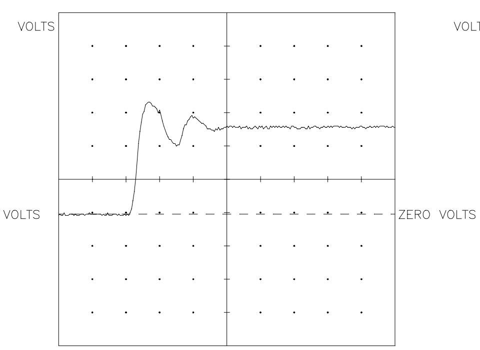
SCALED ARMATURE CURRENT
OVER DAMPED
5V/DIV 20ms/DIV

FIGURE 32



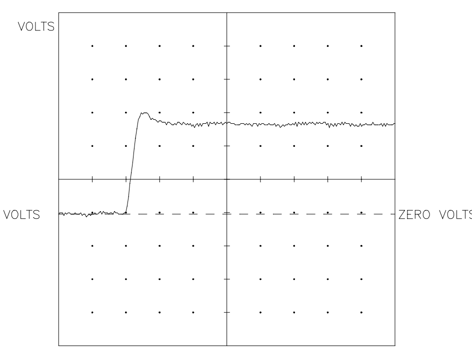
SCALED TACHOMETER VOLTAGE
CRITICALL DAMPED
1V/DIV 2s/DIV

FIGURE 33



SCALED TACHOMETER VOLTAGE
VEL. PROP. GAIN TOO LOW
1V/DIV 2s/DIV

FIGURE 34



SCALED TACHOMETER VOLTAGE
VEL. INT. TIME TOO SHORT
1V/DIV 2s/DIV

FIGURE 35

The current and velocity loop adjustment is now complete. Remove AC power from the drive, and remove all jumpers, pots, and switches that were connected below

8 Component Testing

FUSES

Due to other circuit paths that may interfere with measurements, it is not recommended that fuses be tested with an ohmmeter while still in the circuit. Remove the fuse, and then check the resistance with an ohmmeter. A fuse may also be checked by applying power to the drive and carefully measuring the voltage across the fuse. Remember that a good fuse will not have a voltage drop, while a blown fuse will.

SCRs

The power devices may be tested with a meter and a small (1.5 or 9V) battery. First remove the component to be tested from the circuit, and simply measure the resistance from the anode to the cathode to check for a shorted SCR. Depending on the current rating of the module, a good SCR will read anywhere from approximately 400k Ohms to an open circuit. Set the meter to the diode check and again read across the anode and cathode terminals. Place the positive meter probe on the anode and the common or negative meter probe on the cathode. Connect the negative of the 9V battery to the cathode terminal. Momentarily connect the positive battery lead to the gate terminal. The diode check voltage should read around 0.6 to 0.7 VDC. NOTE that the SCR may not latch or remain in conduction when the battery is disconnected due to the small amount of current being supplied by the meter.

9 Troubleshooting

When troubleshooting a problem, the first step is to eliminate the motor. This can best be done by substituting another motor or a "dummy" load and checking to see if the problem persist. An emergency "dummy" load can be created by placing two 115 VAC light bulbs in series for 230 VAC operation, or four in series for 480 VAC operation. Higher wattage loads will perform better as dummy loads. Use bulbs of the same wattage so they will have balanced voltage

NOTE: The control must be operated in armature feedback when dummy loads are used.

Drive blows fuses on power up

A drive that blows fuses when applying the 3-phase power likely has a shorted SCR or shorted diode in the armature or field supply bridges. Refer to SECTION 8 for information on testing these devices.

A shorted motor or shorted wiring to the motor can be checked best with a megger. An ohmmeter may also be used, but it may not be able to detect very high potential paths to ground.

Disconnect the motor from the control. Measure the resistance from each motor terminal to machine or earth ground. Place the ohmmeter in the R X 100k or greater scale and be suspicious of any reading less than 500k Ohms.

Shorted or excessively loaded control voltage transformer may cause fuse blowing. The 115 VAC secondary must be rated to handle any customer added auxiliary load in addition to the normal requirements of the control. The external armature contactor in-rush adds to this load upon start-up.

Drive blows fuses when entering RUN or JOG mode

Check the 3-phase supply voltages. Voltages in excess of 506 VAC may cause random fuse blowing. Reduce the supply to approximately 460 VAC.

Improper operation of the armature contactor may cause the ELITE drive to have improper start up. This can happen when the external armature contactor is not being controlled by the internal ELITE relay logic. The normal start up procedure should assure that the contactor is energized before the control loops are enabled. Likewise, the control loops should be allowed to clamp before opening the contactor.

Check for loading faults on control transformer. See previous section.

Transient induced uncontrolled gating of the SCRs may cause fuse blowing. The coils of electromechanical devices such as relays and solenoids that are energized when the drive is started should have transient suppressors. This is achieved by placing MOV's or snubbers in parallel with the coil. All relay coils on ELITE drives are suppressed.

Drive will not RUN or JOG (Run and Jog LEDs will <u>not</u> light)

Check 115 VAC power at TB3-1 & 2 on the FUSE board. If not present, check control voltage transformer and primary supply from two of either FU1, FU2, or FU3 on the FUSE board.

Check 115 VAC power at TB1-1 & 15. If not present, check FU4 on the FUSE board and check status of FAULT LED's.

Verify proper operation of RUN and JOG contacts.

Check power supplies (Refer to SECTION 10.) The power supply is fused by FU8 on the POWER SUPPLY board.

Drive will not RUN or JOG (Run and Jog LED's will light)

Check power supplies (Refer to SECTION 10). Verify presence of the TOTAL REFERENCE SETPOINT signal at TP19(H). If not present, check input at TB2B-12 or 14 depending on speed pot or summing input operation. Positive speed pot reference indicates that forward direction is selected by contact closure at TB1-9 & 10.

Verify that FWD DIR is enabled by jumper at TB2A-1 & 2 or REV DIR is enabled by jumper at TB2A-3 & 4.

Verify presence of POS and NEG CURRENT LIMIT jumpers at TB2A terminals 5 – 8 and that CURRENT LIMIT pots are not adjusted too low.

If non-regen model (E06000 Series), verify jumper at TB1-9 & 10.

Motor runs too fast or runs away

Lack of velocity feedback can cause run away and insufficient feedback can cause excessive speed.

Check position of J1 according to motor armature nameplate rating. The SCALED ARMTURE VOLTAGE, TP15(K) should measure about 5.0 VDC at rated armature output, either 240, 415, or 500 VDC.

Tachometer feedback (TFB) or encoder feedback (EFB) signals can be monitored at TP18(L) and TP20(M), respectively, while the control is operated in armature feedback (AFB). Each signal should measure about 5.0 VDC at rated armature output. Check tightness of the coupling. For TFB, verify that the position of J6 matches the voltage rating of the tachometer being used. For EFB, confirm use of a 300PPR encoder.

Check level of TOTAL REFERENCE SETPOINT, TP19(H). Setting the MAX SPEED pots too high or excessive summing input signals can cause outputs over 100%.

Over-speed when in armature feedback can be caused by improperly wired or defective motor fields. Make sure the polarities of multi-winding fields are correct. Refer below for correct field connections.

Motor runs too slow

Excessive velocity feedback from incorrect programming of J1 or J6 and/or encoder with higher than 300PPR used as feedback. Monitor SCALED ARMATURE, SCALED TACH, or SCALED ENCODER at TP15(K), TP18(L), or TP20(M), respectively, to verify 5.0 VDC at rated speed of motor.

Excessive loading of the motor or wrong current range programmed by J4. Monitor CURRENT FEEDBACK signal at TP21(S), and check for 5.0 VDC level at 100% of range selected by J4. Overloading the motor for the J7 time period will cause FOLDBACK which may limit the motor speed.

Motor drops in speed when loaded

Excessive loading of the motor or wrong current range programmed by J4. Monitor CURRENT FEEDBACK signal at TP21(S), and check for 5.0 VDC level at 100% of range selected by J4.

Incorrect field wiring – SEE NEXT SECTION.

Motor draws a high level of armature current, but will not produce rated torque

One of the dual field winding polarities may be reversed.

When connecting the field in a low voltage operation (150 VDC), the field windings should be connected in parallel. The F1 and F3 leads (positive polarity) should be connected together, and the F2 and F4 (negative polarity) leads should be connected together. For high voltage operation (300 VDC), the field windings should be connected in series. Only the F2 and F3 leads should be connected together.

If the field polarity is unknown or in doubt, a simple test with a voltmeter and a small battery (1.5 or 9V) can be used to determine the proper polarity. Disconnect all wires from the motor and connect the voltmeter across one set of the field windings. Connect the negative battery terminal to one lead of the other field winding. Momentarily connect the other field winding to the positive battery terminal. If the voltage on the field winding initially goes positive and then swings negative, the field leads connected to the positive battery terminal and the positive lead of the voltmeter have the same polarity. If the voltage first swings negative and then positive, reverse one of the windings.

Motor is unstable and becomes worse when load is applied

The series field may be connected incorrectly. Series field winding (S1 and S2 leads) should not be used with regenerative drives (E12 models). Only non-regenerative drives should use the series field by connecting it in series with the armature windings. The polarity of the F1 lead and the S1 lead should be the same.

Velocity and/or current loops not adjusted properly.

Test Points & Check Points

Many signals on the ELITE drive can easily be monitored by test points on the various PC boards. Many of the signals on the CONTROL board are also easily accessible via CAROTON's DCM100-000.

C. T. BOARD

TP1 Parameter: Armature current feedback signal
Level/range: 0 to +1.5 VDC
Condition: Load dependent
+1.0 VDC = 100% of total drive output current
+1.5 VDC = 150% of total drive output current

FUSE BOARD

TP1 Parameter: Field economy feature
Level/range 0 or +13.5 VDC
Condition: Operating mode of drive
0 VDC = Field economy
+13.5 VDC = Full field

TP2 Parameter: Field economy trigger
Level/range: +15V(p-p) 11kHz square wave or +24 VDC
Condition: Operating mode of drive
+24VDC = Field economy
11kHz = Full field

TP3 Parameter: Circuit common

TP4 Parameter: Field loss
Level/range: 0 or +15 VDC
Condition: Presence of field current
0 VDC = Field current present
+ 15 VDC = No field current

CONTROL BOARD

NOTE: Letters refer to DCM100-000 Check Points.

A TP8 Parameter: Unregulated power supply
Level/range: +24 VDC, ±4.0 VDC
Condition; Can very ±4.0 VDC with line and load fluctuations

B TP10 Parameter: Unregulated power supply
Level/range: -24 VDC, ± 4.0 VDC
Condition: Can vary ±4.0 VDC with line and load fluctuations

C TP9 Parameter: Regulated power supply
Level/range: +15 VDC, ±0.75 VDC
Condition: Fixed within line variation of ±10%

D TP11 Parameter: Regulated power supply
Level/range: -15 VDC, ±0.75 VDC
Condition: Fixed with line variation of ±10%

E TP4 Parameter: Regulated power supply
Level/range: +12 VDC, ±0.60 VDC
Condition: Fixed within line variation of ±10%

F TP2 Parameter: Regulated power supply
Level/range: +6 VDC, ±0.30 VDC
Condition: Fixed within line variation of ±10%

G Parameter: Regulated power

TP3		supply
	Level/range	-6 VDC, ±0.30 VDC
	Condition:	Fixed within line variation of ±10%
H	Parameter:	Total reference setpoint
TP19	Level/range:	0 to ±10.6 VDC Polarity = direction
	Condition:	Sum of Run, Jog, Sum and Min Speed signals trimmed by MAX speed pot(s) reference 0 VDC = 0% speed +9 VDC = 100% FWD reference -9 VDC = 100% REV reference
I	Parameter:	Forward Accel/Decel
TP13		output
	Level/range	0 to +10 VDC
	Condition:	Equal to speed pot. setting after ramp time 0 VDC = 0 reference +10 VDC = full reference
J	Parameter:	Reverse Accel/Decel
TP22		output **regen models only**
	Level/range:	0 to –10 VDC
	Condition	Equal to speed pot. setting after ramp time 0 VDC = 0 reference -10VDC = full reference
K	Parameter:	Scaled armature voltage
TP15	Level/range:	0 to ±5 VDC (+pol = FWD, -pol = REV)
	Condition:	0 VDC = 0% rated armature voltage 5 VDC = 100% rated armature voltage

L	Parameter:	Scaled tachometer
TP18		voltage (when used)
	Level/range:	0 to ±5 VDC (+pol = FWD, -pol = REV)
	Condition:	0 VDC = 0% motor speed 5 VDC = 100% rated motor speed
M	Parameter:	Scaled encoder voltage
TP20		(when used)
	Level/range:	0 to 5 VDC (+pol = FWD, -pol = REV)
	Condition:	0 VDC = 0% motor speed 5 VDC = 100% rated motor speed
N	Parameter:	Velocity integrator
TP17	Level/range:	0 to ±13.5 VDC (-pol = +torq, +pol = -torq)
	Condition:	Load and speed dependent 200 rpm N.L.=±0.1VDC 200 rpm F.L.=±5.3VDC 1750 rpm N.L.=±0.2 VDC 1750 rpm F.L.=±5.5 VDC
O	Parameter:	Velocity proportional
TP14	Level/range:	0 to ±13.5 VDC (- pol = +torq, +pol = -torq)
	Condition:	Load and speed dependent 200 *rpm* N. L. = ±10 mVDC 200 *rpm* F. L. = ±20 mVDC 1750 *rpm* N. L. = ±15 mVDC 1750 *rpm* F. L. = ±20 mVDC

P	Parameter:	Current integrator
TP12	Level/range:	0 to ±13.5 VDC (-pol= +torq, +pol = -torq)
	Condition:	Load and speed dependent 200 *rpm* N. L. = ±1.9 VDC 200 *rpm* F. L. =±2.2 VDC 1750 *rpm* N. L. = ±3.5 VDC 1750 *rpm* F. L. = ±4.5 VDC
Q	Parameter:	Current proportional
TP16	Level/range:	0 to ±13.5 VDC (-pol = +torq, +pol = -torq)
	Condition:	Load and speed dependent 200 *rpm* N. L. = ±3 mVDC 200 *rpm* F. L. = ±4 mVDC 1750 *rpm* N. L. = ±3 mVDC 1750 *rpm* F. L. = ±4 mVDC
R	Parameter:	Current demand
TP5	Level/range:	0 to ±7.5 VDC (-pol = +torq, +pol =-torq.)
	Condition:	Load Dependent ±5.0 VDC = 100% demand ±7.5 VDC = 150% demand
S	Parameter:	Current feedback
TP21	Level/range:	0 to ±7.5 VDC (-pol = +torq, +pol = -torq)
	Condition:	Load dependent ±5.0 VDC = 100% demand ±7.5 VDC = 150% demand

T	Parameter:	Voltage controlled
TP6		oscillator reference
	Level/range:	-6 to +6 VDC
	Condition:	Load and speed dependent 200 *rpm* N.L.=-4.0VDC 200 *rpm* F.L.=-3.7VDC 1750 *rpm* N.L.= -2.7 VDC 1750 *rpm* F.L.= -1.2 VDC
TP23	Parameter:	Current loop error signal
	Level/range:	0 to ±13.5 VDC
	Condition:	Sum of current demand and current feedback
TP1	Parameter:	Circuit common
TP1A	Parameter:	Circuit common
TP7	Parameter:	Circuit common

<u>TRIGGER BOARD</u>

NOTE: Voltage levels given are measured with respect to circuit common

TP24	Parameter:	Regulated power supply
	Level/range:	-6 VDC, ±0.30
	Condition:	Fixed within line variation of ±10%
TP25	Parameter:	Circuit common
TP25A	Parameter:	Circuit common
TP26	Parameter:	Phase A conduction angle
	Level/range:	±6 V(p-p) pulses
	Condition:	First start pulse and end stop pulse determine the phase A conduction angle.
TP27	Parameter:	Phase B conduction angle.
	Level/range:	±6 V(p-p) pulses
	Condition:	First start pulse and end stop pulse determine the phase B conduction angle.

TP28	Parameter:	Phase C conduction angle
	Level/range:	±6 V(p-p) pulses
	Condition:	First start pulse and end stop pulse determine the phase C conduction angle.
TP29	Parameter:	Positive phase A sync signal
	Level/range:	±6 V(p-p) 50% duty cycle square wave
	Condition;	+6 V = L1 at higher potential than L2 -6 V = L1 at lower potential than L2
TP30	Parameter:	Negative phase A sync signal
	Level/range:	±6 V(p-p) 50% duty cycle square wave
	Condition:	+6 V = L2 at higher potential than L1 -6 V = L2 at lower potential than L1
TP31	Parameter:	Positive phase B sync signal
	Level/range:	±6 V(p-p) 50% duty cycle square wave
	Condition:	+6 V = L2 at higher potential than L3 -6 V = L2 at lower potential then L3
TP32	Parameter:	Negative phase B sync signal
	Level/range:	±6 V(p-p) 50% duty cycle square wave + 6 V = L3 at higher potential than L2 -6 V = L3 at lower potential than L2

TP33	Parameter:	Positive phase C sync signal
	Level/range:	±6 V(p-p) 50% duty cycle square wave
	Condition	+6 V = L3 at higher potential than L1 -6 V = L3 at lower potential than L1
TP34	Parameter:	Negative phase C sync signal
	Level/range:	±6 V (p-p) 50% duty sync signal
	Condition:	+6 V = L1 at higher potential than L3 -6 V = L1 at lower potential than L3
TP35	Parameter:	Voltage controlled oscillator output
	Level/range:	±6 (p-p) 50% duty cycle square wave 0 to 220 kHz
	Condition:	Load and speed dependent 200 *rpm* N.L.= 46 kHz 200 *rpm* F.L.= 55 kHz 1750 *rpm* N.L.= 85 kHz 1750 *rpm* F.L.= 106 kHz
TP36	Parameter:	Reverse power bridge enable
	Level/range:	-6 to +6 VDC
	Condition:	+6 VDC = reverse bridge enable -6 VDC = reverse bridge disabled
TP37	Parameter:	Forward power bridge enable
	Level/range:	-6 to +6 VDC
	Condition:	+6 VDC = forward bridge enabled -6 VDC = forward bridge disabled

11 Replacement Parts & Component Substitution

11.1 COMPONENT SUBSTUTION

Many components of an ELITE drive are interchangeable with other ELITE horsepower models. The following section lists CAROTRON's part number and the manufacturer's part number (if applicable) of the drive's major components. This section can be used to order additional parts or to determine if a component from one drive may be substituted on another.

If needed, the E12000 Series regenerative PERSONALITY board and TRIGGER board can be substituted on an E06000 non-regenerative drive. However, the reverse direction adjustments will have no affect on the drive.

The C.T. board can be modified with minimal effort to operate on any model. The value of resistors R3 and R4 on the C.T. board determine the current scaling. Please refer to Table 7 for the correct values.

The transient surge suppression resistor/capacitor networks on the FUSE board can also be easily modified to be compatible with other models. Please refer to the chart on the FUSE board Schematic in Section 12 for the proper resistor values.

All armature bridge devices are dual SCR isolated power modules rated at 1400 volts repetitive peak off state and inverse voltage and have 1000 volts/microsecond dv/dt. There are 3 each on the E06000 Series, PMD1-3, and an additional 3 on the E12000 Series, PMD4-6. The power modules listed below are pin-for-pin compatible with all ELITE drives. SEMIKRON, IR (International Rectifier) and CRYDON manufacture power modules with similar ratings but are not all pin-for-pin compatible. The gate and cathode signal leads are reversed on the second SCR device. Consult the factory for assistance in making substitutions with components other that the recommended spare listed below.

A higher rated current and/or voltage component may be substituted for any given power component. For example, the E12020-000 model uses a 31ampere, 1400 volts dual SCR module. If this module is not available, a 56 ampere 1400 volts or a 31 ampere 1600 volts dual SCR module could be substituted.

NOTE: A higher current rated module may have a higher latching current rating. Under light load conditions, this may cause the SCR to drop out of conduction or to not conduct at all. However, this problem is easily eliminated by the application of the load and/or choosing a substitute device with a minimal difference in the current rating.

11.2 PRINTED CIRCUIT ASSEMBLIES

CONTROL BOARD
All E06000 and E12000 Series models..D11111-000

PRESONALITY BOARD
All E06000 Series models.............C11135-000
All E12000 Series models.............C11114-000

RELAY BOARD
All E06000 and E12000 Series models..D11117-000

POWER SUPPLY BOARD
All E06000 and E12000 Series models..C11120-000

TRIGGER BOARD
All E06000 Series models..D11123-000
All E12000 Series models..D11123-001

FUSE BOARD
Models E06020-000 and E06040-000 ....D11129-000
Models E12020-000 and E12040-000 ....D11129-000
All other models...........................D11129-001

C. T. (CURRENT TRANSFORMER) BOARD
Models E06020-000 and E12020-000 ....C11126-000
Models E06040-000 and E12040-000 ....C11126-001
Models E06060-000 and E12060-000 ....C11126-002
Models E06075-000 and E12075-000 ....C11126-003
Models E06100-000 and E12100-000 ....C11126-004
Models E06125-000 and E12125-000 ....C11126-005

Models E06150-000 and E12150-000 ....C11126-006
Models E6200-000 and E12200-000 ....C11126-007
Models E06250-000 and E12250-000 ....C11126-008
Models E06300-000 and E12300-000 ....C11126-009

11.3 CONNECTOR/CABLE ASSEMBLIES

SAME FOR ALL MODELS
Cable 1..A11178-000
Cable 2...CNT1065-00
Cable 3..A11179-000
Cable 4...CNT1066-00
Cable 5...CNT1066-00
Cable 6...CNT1067-00
Cable 7...CNT1065-00

MODEL DEPENDENT
Cable 8
All E06000 Series 20-150 HP Models A11180-001
All E12000 Series 20-150 HP Models A11180-000
All E06000 Series 200-300 HP Models A11523-000
All E12000 Series 200-300 HP Models A11524-000

Cable 9
All E06000 Series 20-150 HP Modes A11181-000
All E12000 Series 20-150 HP Models A11182-000
All E06000 Series 200-300 HP Models A11525-000
All E12000 Series 200-300 HP Models A11526-000

Cable 10
All E06000 Series 40-75 HP Models A11183-000
All E12000 Series 60-75 HP Models A11183-00
All E06000 Series 100-150 HP Models A11183-001
All E12000 Series 100-150 HP Models A11183-001

Cable 10 (cont.)
All E06000 Series 200-300 HP Models
....A11527-000
All E12000 Series 200-300 HP Models
....A11528-000

Cable 11
All E06000 Series 20-75 HP Models
....A11184-000
All E12000 Series 20-75 HP Models
....A11184-000
All E06000 Series 100-150 HP Models
....A11184-001
All E12000 Series 100-150 HP Models
....A11184-001
All E06000 Series 200-300 HP Models
....A111529-000
All E12000 Series 200-300 HP Models
....A11530-000

11.4 FUSES

SAME FOR ALL MODELS
FU1, FU2, FU3: 10 ampere, dual element, time delay, 500 VAC located on the FUSE board
CAROTRON................................FUS1008-03
BUSSMANN..FNQ-10
LITTELFUSE......................................FLQ-10

FU4: 5 ampere, 250 VAC, dual element, time delay located on the FUSE board
CAROTRON................................FUS1005-01
BUSSMANN..MDA-5
LITTELFUSE.......................................326005

FU8: 0.5 ampere, 120 VAC, dual element, time delay located on the POWER SUPPLY board
CAROTRON................................FUS1006-05
BUSSMANN......................................MDL-1/2
LITTELFUSE......................................313.500

MODEL DEPENDENT
FU5, FU6, FU7 current rating per model, 500 VAC semiconductor types

Model E12020-000 and E06020-000: 50 amp
CAROTRON................................FUS1009-00
BUSSMANN..FWH50
SHAWMUT...................................A50QS50-4

Model E12040-000 and E06040-000: 100 amp
CAROTRON................................FUS1009-01
BUSSMANN......................................FWH100
SHAWMUT.................................A50QS100-4

Model E12060-000 and E06060-000: 150 amp
CAROTRON................................FUS1009-02
BUSSMANN......................................FWH150
SHAWMUT.................................A50QS150-4

Model E12075-000 and E06075-000: 175 amp
CAROTRON................................FUS1009-03
BUSSMANN......................................FWH175
SHAWMUT.................................A50QS175-4

Models E12100-000 & E06100-000: 250 amp
CAROTRON................................FUS1009-05
BUSSMANN......................................FWH250
LITTELFUSE....................................L50S250

Models E12125-000 & E06125-000: 300 amp
CAROTRON................................FUS1009-06
BUSSMANN......................................FWH300
LITTELFUSE....................................L50S300

Models E12150-000 & E06150-000: 350 amp
CAROTRON................................FUS1009-04
BUSSMANN......................................FWH350
LITTELFUSE....................................L50S350

Models E12200-000 & E06200-000: 450 amp
CAROTRON................................FUS1009-07
BUSSMANN......................................FWH450
LITTELFUSE....................................L50S450

Models E12250-000 & E06250-000: 600 amp
CAROTRON................................FUS1009-08
BUSSMANN......................................FWH600
LITTELFUSE....................................L50S600

Models E12300-000 & E06300-000: 700 amp
CAROTRON................................FUS1009-09
BUSSMANN......................................FWH700
LITTELFUSE....................................L50S700

11.5 POWER COMPONENTS

NOTE: For any AEG/EUPEC KOF type device listed, the equivalent LOF type device may be substituted.

ARMATURE BRIDGE

Model E12020-000 & E06020-000: 31 amp
CAROTRON................................PMD1025-00
AEG/EUPEC.............................TT31N14KOF
SEMIKRON................................SKKT42/14E

Model E12040-000 & E06040-000: 56 amp
CAROTRON................................PMD1026-00
AEG/EUPEC.............................TT56N14KOF
SEMIKRON................................SKKT57/14E

Model E12060-000 & E06060-000: 91 amp
CAROTRON................................PMD1027-00
AEG/EUPEC.............................TT92N14KOF
SEMIKRON................................SKKT92/14E

Model E12075-000 & E06075-000: 105 amp
CAROTRON...............................PMD1019-00
AEG/EUPEC...........................TT105N14KOF
SEMIKRON.............................SKKT106/14E

Model E12100-000 & E06100-000: 131 amp
CAROTRON...............................PMD1019-00
AEG/EUPEC...........................TT105N14KOF
SEMIKRON.............................SKKT106/14E

Models E12125-000, E12150-000, E06125-000 & E06150-000: 162 amp
CAROTRON...............................PMD1021-00
AEG/EUPEC...........................TT162N14KOF
IR...IRKT162-14

Models E12200-000 & E06200-000: 210 amp
CAROTRON................................PMD1030-00
AEG/EUPEC...........................TT210N14KOF
SEMIKRON.............................SKKT210/14E

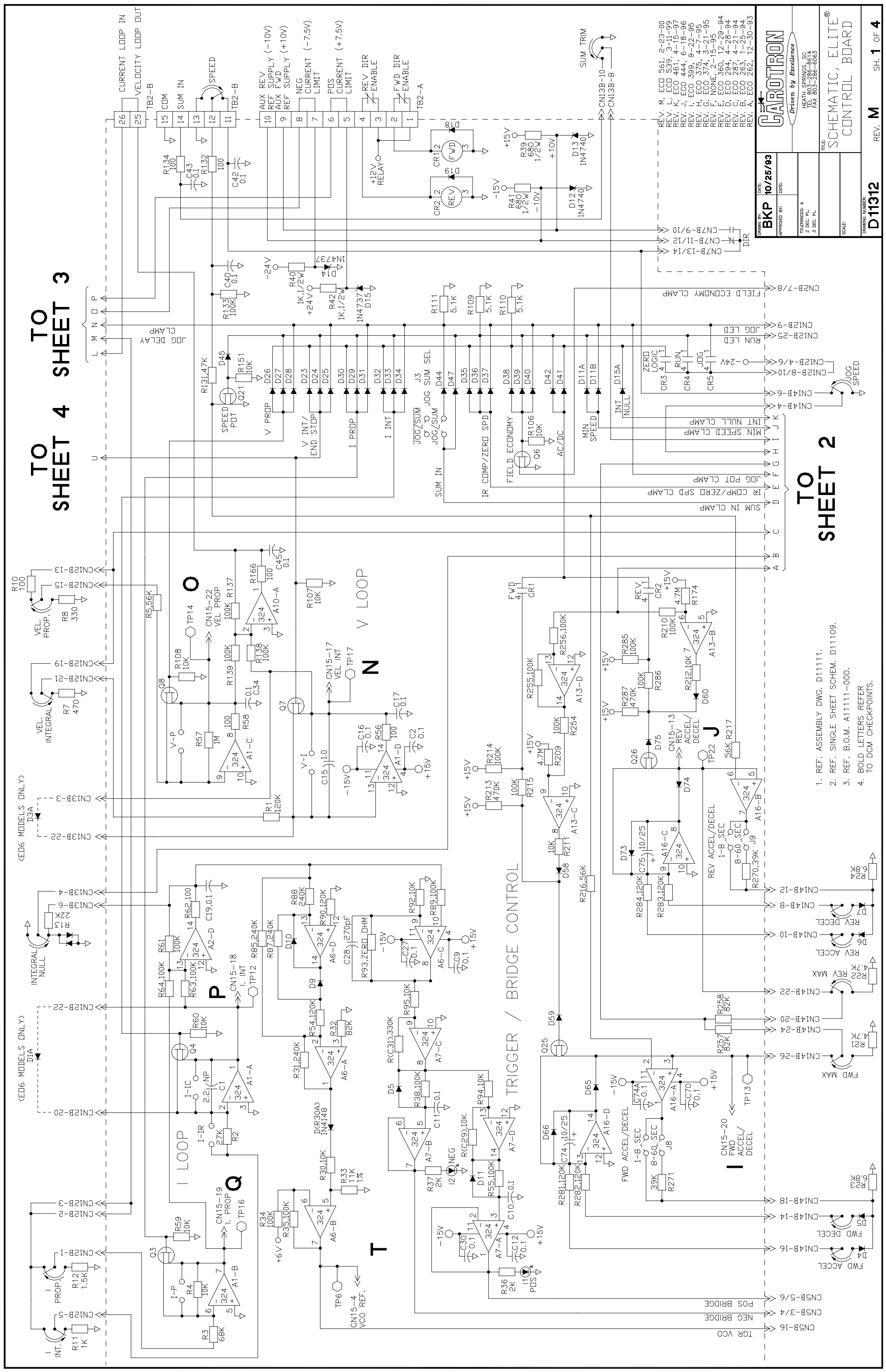
Models E12250-000, E12300-000, E06250-000 & E06300-000: 251 amp
CAROTRON...............................PMD1031-00
AEG/EUPEC...........................TT251N14KOF
SEMIKRON.............................SKKT250/14E

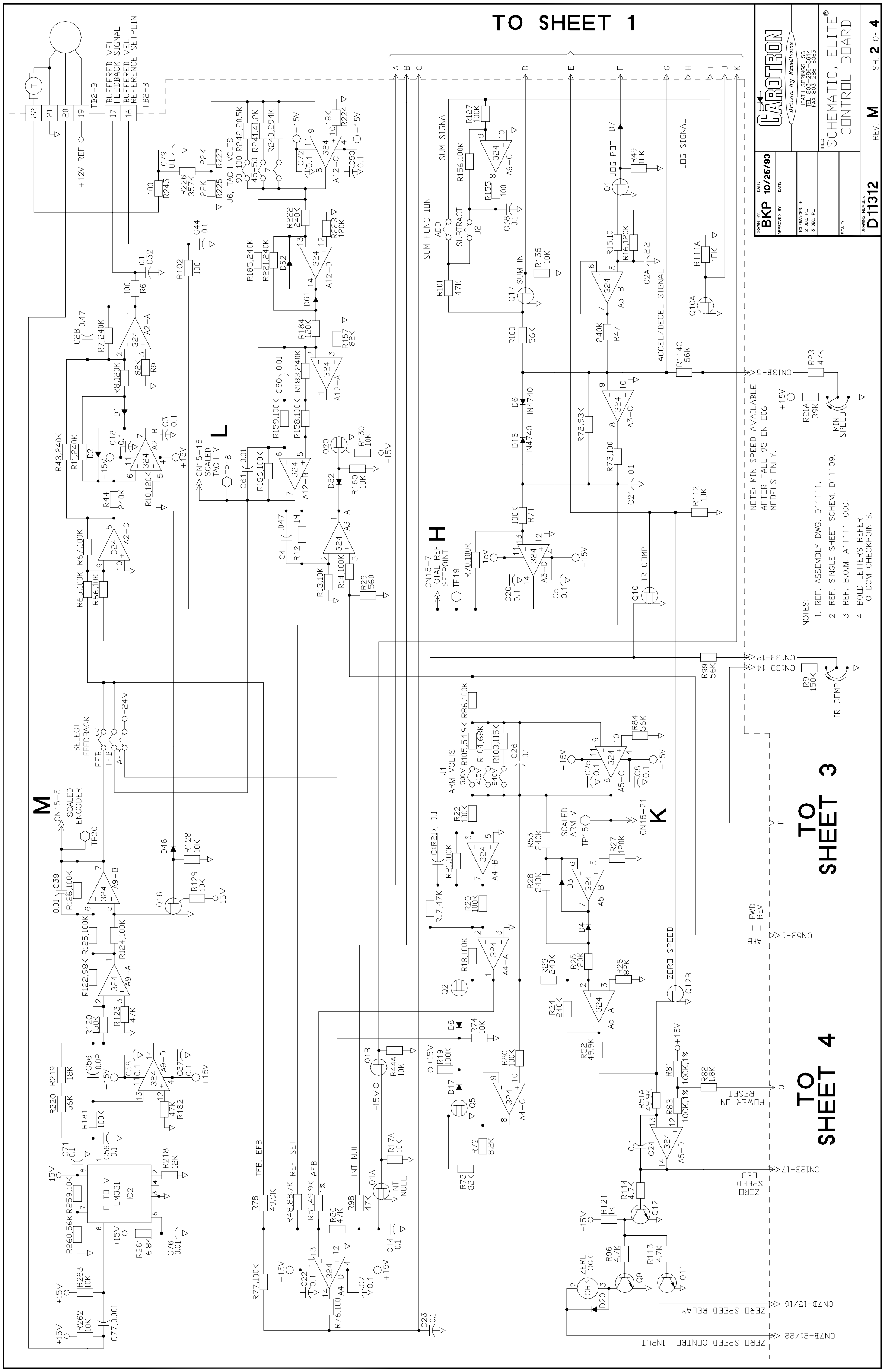
FIELD SUPPLY

The field supply uses the same power components for all models.
PMD9, dual diode, 22 ampere, 1400 volts
CAROTRON................................PMD1024-00
AEG/EUPEC..............................DD22S14K-K
IR...IRKC61/14

PMD10, SCR/diode, 25 ampere, 1400 volts
CAROTRON................................PMD1010-02
AEG/EUPEC............................TD25N14KOF
SEMIKRON...............................SKKH26/14E

PMD7 and PMD8, diode doubler, 25 amp, 50 volts
CAROTRON................................PMD1009-00
EDI..FPID2505


TO SHEET 3
TO SHEET 4
TO SHEET 2
V LOOP
I LOOP
TRIGGER / BRIDGE CONTROL
1. REF. ASSEMBLY DWG. D11111.
2. REF. SINGLE SHEET SCHEM. D11109.
3. REF. B.O.M. A11111-000.
4. BOLD LETTERS REFER TO DCM CHECKPOINTS.
CAROTRON
Driven by Excellence
BKP
10/25/93
SCHEMATIC, ELITE® CONTROL BOARD
D11312
REV. M
SH. 1 OF 4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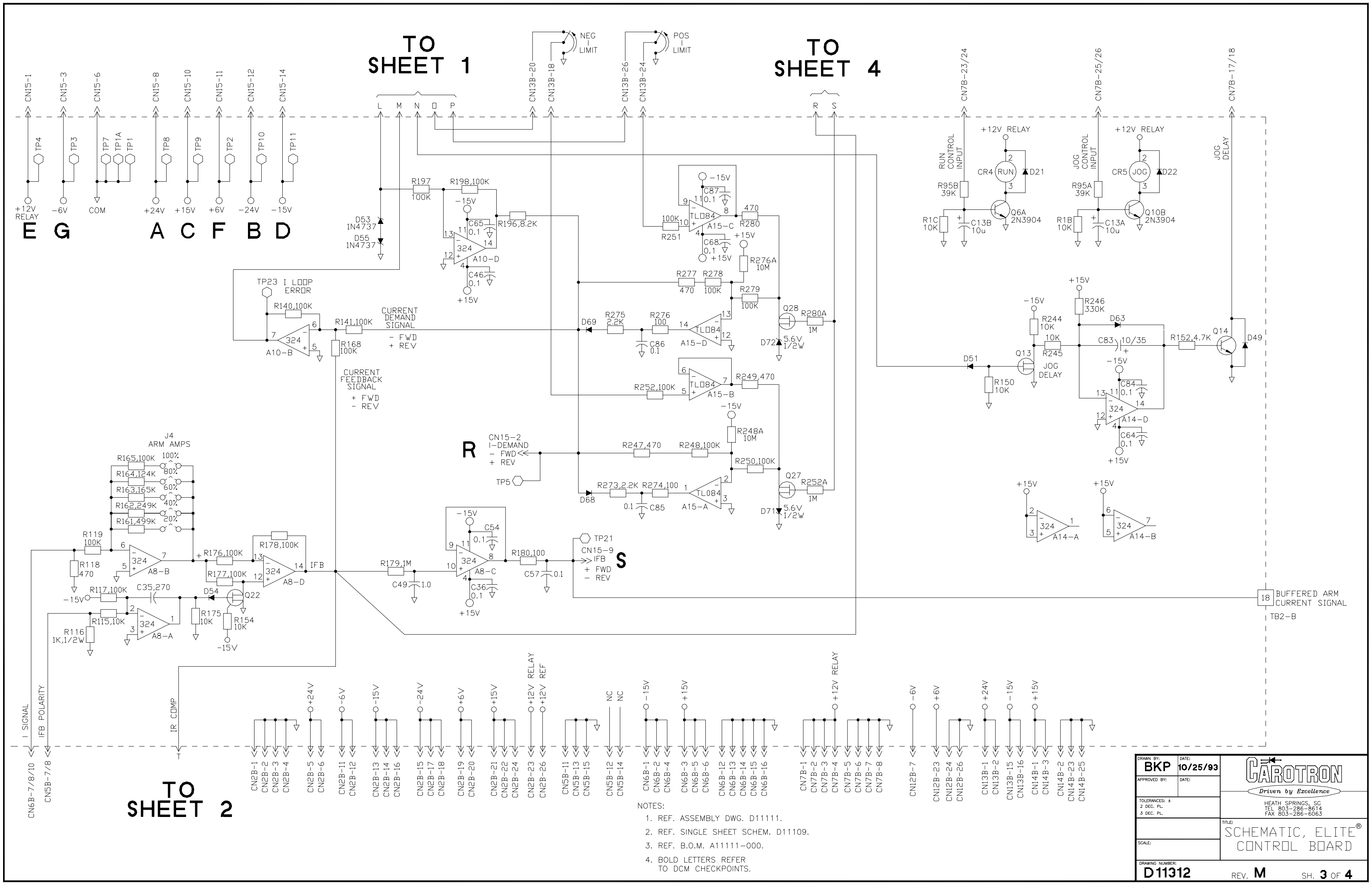
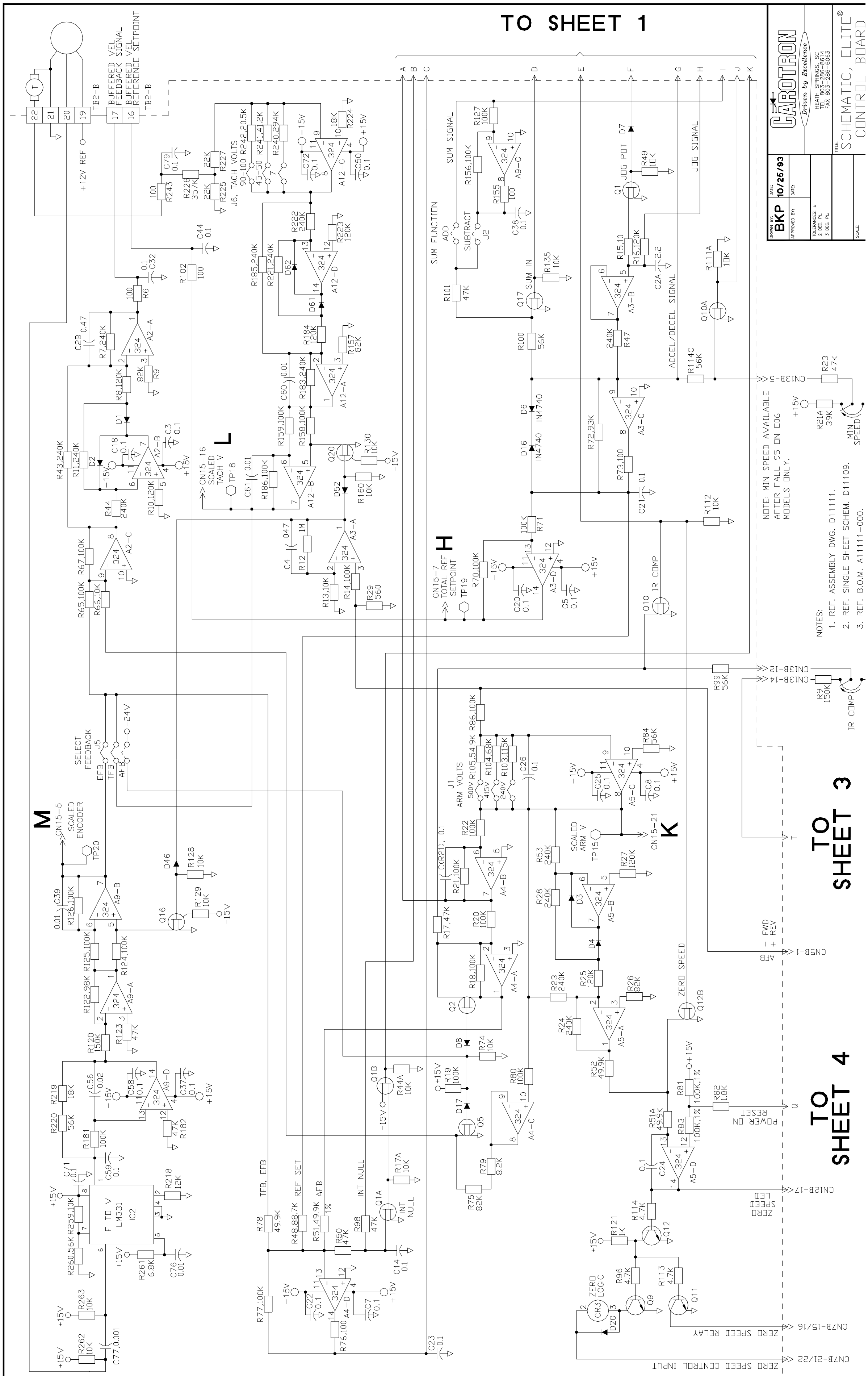
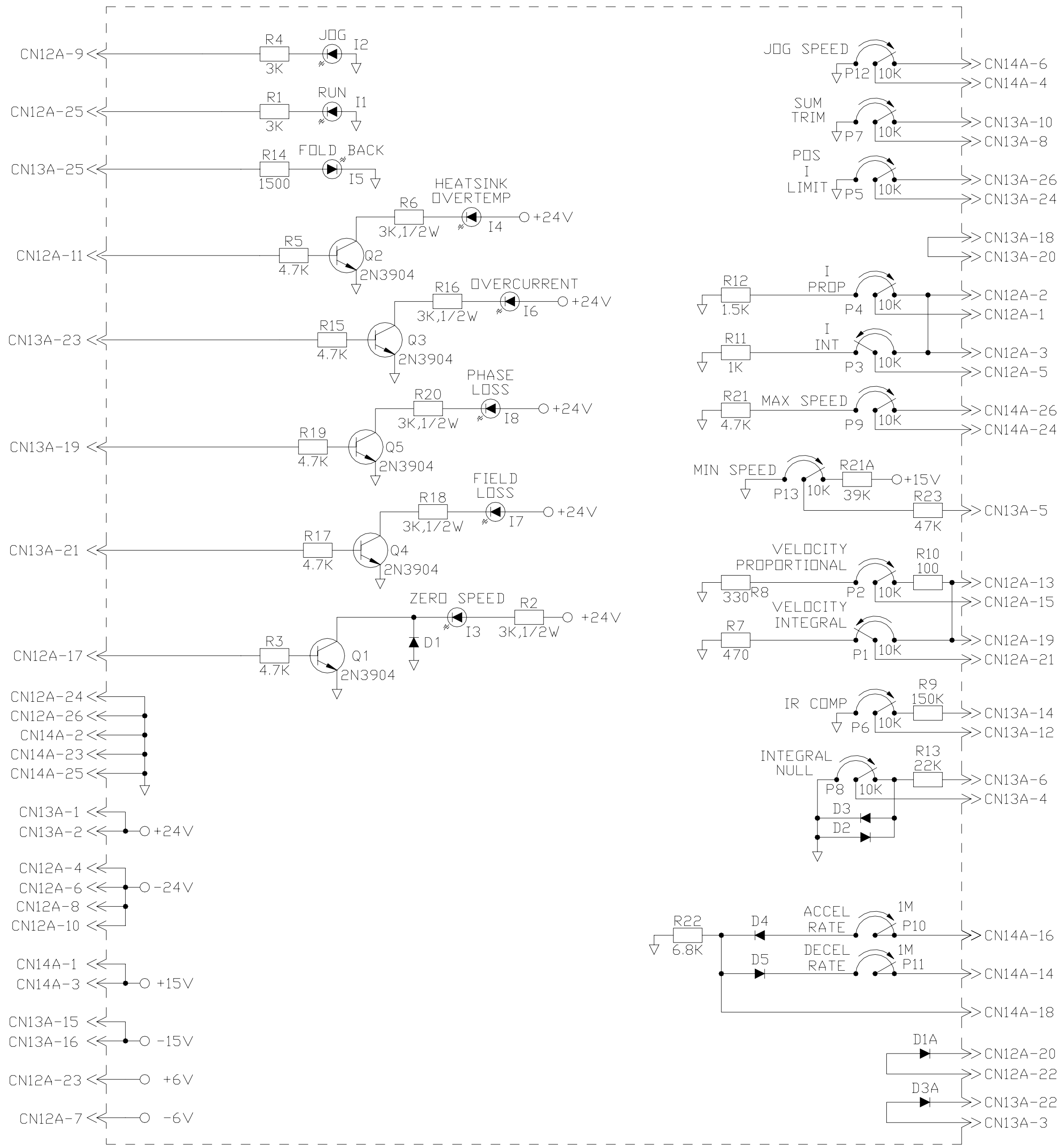
TO SHEET 3
TO SHEET 4
NOTE: MIN SPEED AVAILABLE AFTER FALL 95 ON E06 MODELS ONLY.
NOTES:
1. REF. ASSEMBLY DWG. D11111.
2. REF. SINGLE SHEET SCHEM. D11109.
3. REF. B.O.M. A11111-000.
4. BOLD LETTERS REFER TO DCM CHECKPOINTS.
CAROTRON
Drivers by Excellence
HEATH SPRINGS, SC
TEL 803-286-8614
FAX 803-286-6063
SCHEMATIC, ELITE® CONTROL BOARD
DRAWN BY: BKP
DATE: 10/25/93
REV. M
SH. 2 OF 4
D11312


TO SHEET 1
L M N O P
TO SHEET 4
R S
TO SHEET 2
NEG I LIMIT
POS I LIMIT
CN15-1 CN15-3 CN15-6 CN15-8 CN15-10 CN15-11 CN15-12 CN15-14
+12V RELAY -6V COM +24V +15V +6V -24V -15V
E G A C F B D
CN13B-20 CN13B-18 CN13B-26 CN13B-24
CN7B-23/24 CN7B-25/26 CN7B-17/18
RUN CONTROL INPUT
JOG CONTROL INPUT
JOG DELAY
TP23 I LOOP ERROR
CURRENT DEMAND SIGNAL
- FWD
+ REV
CURRENT FEEDBACK SIGNAL
+ FWD
- REV
J4
ARM AMPS
100% 80% 60% 40% 20%
R
CN15-2
I-DEMAND
- FWD
+ REV
TP5
S
TP21
CN15-9
IFB
+ FWD
- REV
IFB
BUFFERED ARM CURRENT SIGNAL
TB2-B
I SIGNAL
IFB POLARITY
IR COMP
CN6B-7/8/10
CN5B-7/8
NOTES:
1. REF. ASSEMBLY DWG. D11111.
2. REF. SINGLE SHEET SCHEM. D11109.
3. REF. B.O.M. A11111-000.
4. BOLD LETTERS REFER TO DCM CHECKPOINTS.
DRAWN BY: BKP
DATE: 10/25/93
APPROVED BY:
DATE:
TOLERANCES: ±
2 DEC. PL.
3 DEC. PL.
SCALE:
CAROTRON
Driven by Excellence
HEATH SPRINGS, SC
TEL 803-286-8614
FAX 803-286-6063
TITLE:
SCHEMATIC, ELITE®
CONTROL BOARD
DRAWING NUMBER:
D11312
REV. M
SH. 3 OF 4


TO SHEET 1
TO SHEET 3
TO SHEET 4
NOTE: MIN SPEED AVAILABLE
AFTER FALL 95 ON E06
MODELS ONLY.
NOTES:
1. REF. ASSEMBLY DWG. D11111.
2. REF. SINGLE SHEET SCHEM. D11109.
3. REF. B.O.M. A11111-000.
CAROTRON
Driven by Excellence
HEATH SPRINGS, SC
TEL 803-286-8614
FAX 803-286-6063
DRAWN BY: BKP
DATE: 10/25/93
SCHEMATIC, ELITE®
CONTROL BOARD

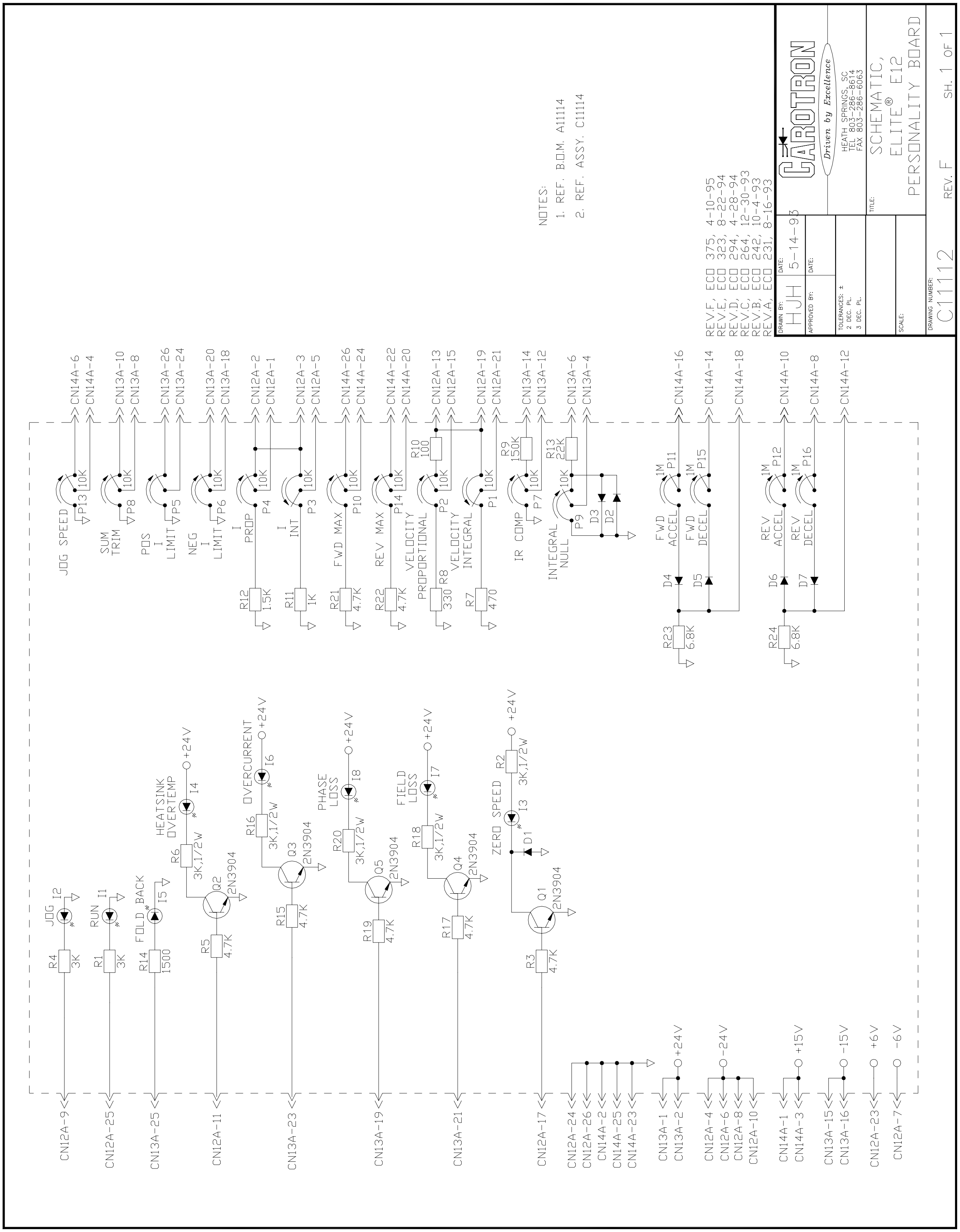


NOTES:

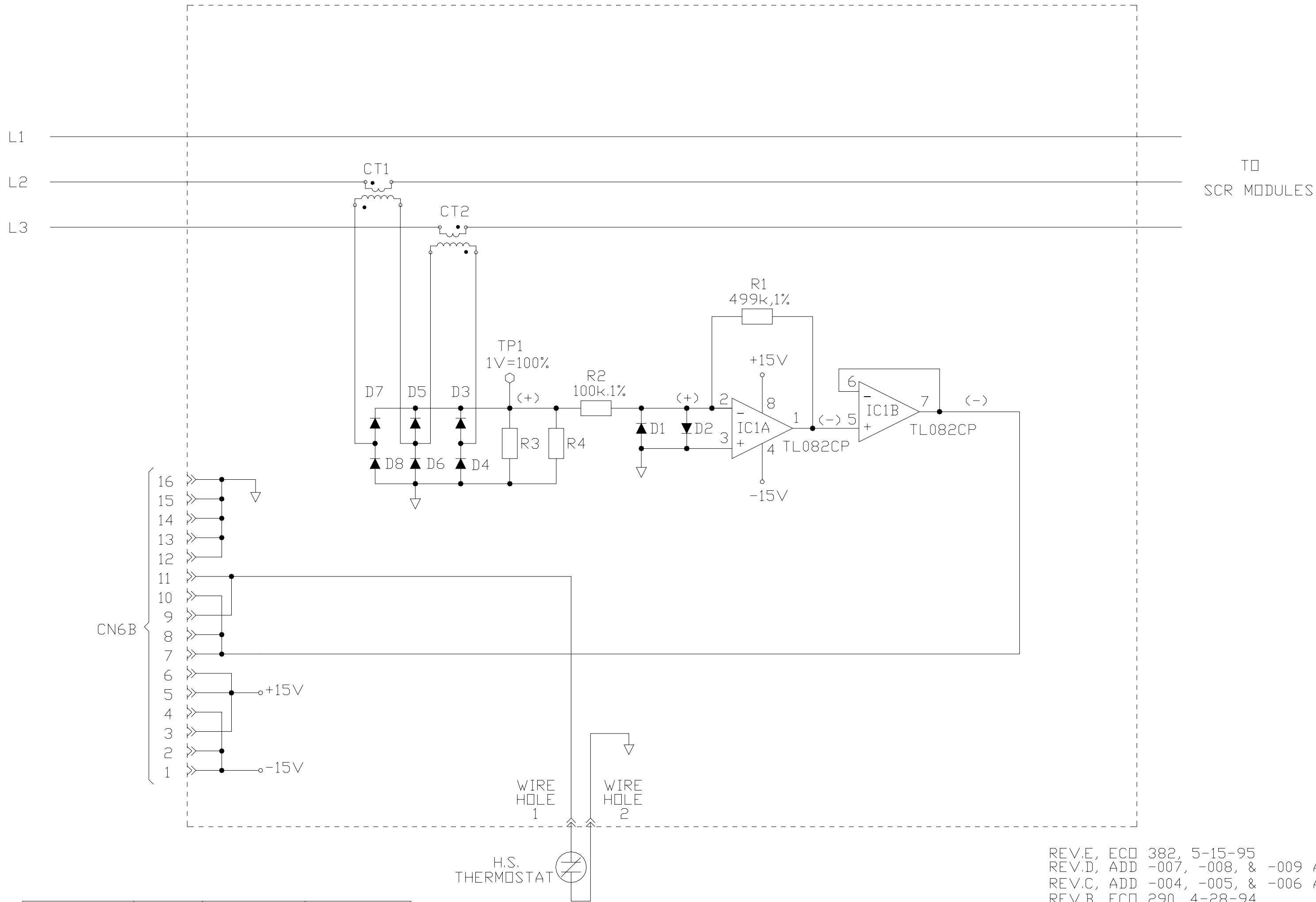
1. REF. B.O.M. A11135.
2. REF. ASSY. C11135.

REV.G, ECO 376, 4-7-95
REV.F, ECO 323, 8-21-94
REV.E, ECO 294, 4-28-94
REV.D, ECO 268, 1-13-94
REV.C, ECO 264, 12-30-93
REV.B, ECO 242, 10-4-93
REV.A, ECO 230, 8-17-93

DRAWN BY: BKP	DATE: 5-7-93	CAROTRON Driven by Excellence HEATH SPRINGS, SC TEL 803-286-8614 FAX 803-286-6063
APPROVED BY:	DATE:	
TOLERANCES: ± 2 DEC. PL. 3 DEC. PL.		
		TITLE: SCHEMATIC, ELITE® E06 PERSONALITY BOARD
SCALE:		
DRAWING NUMBER: C11133	REV. G	SH. 1 OF 1



CAROTRON
Driven by Excellence
HEATH SPRINGS, SC
TEL 803-286-8614
FAX 803-286-6063
TITLE:
SCHEMATIC,
ELITE® E12
PERSONALITY BOARD
DRAWN BY: HJH
DATE: 5-14-93
APPROVED BY:
DATE:
TOLERANCES: ±
2 DEC. PL.
3 DEC. PL.
SCALE:
DRAWING NUMBER: C11112
REV. F
SH. 1 OF 1
REV.F, ECO 375, 4-10-95
REV.E, ECO 323, 8-22-94
REV.D, ECO 294, 4-28-94
REV.C, ECO 264, 12-30-93
REV.B, ECO 242, 10-4-93
REV.A, ECO 231, 8-16-93
NOTES:
1. REF. B.O.M. A11114
2. REF. ASSY. C11114
JOG SPEED
SUM TRIM
POS I LIMIT
NEG I LIMIT
I PROP
I INT
FWD MAX
REV MAX
VELOCITY PROPORTIONAL
VELOCITY INTEGRAL
IR COMP
INTEGRAL NULL
FWD ACCEL
FWD DECEL
REV ACCEL
REV DECEL
JOG
RUN
FOLD BACK
HEATSINK OVERTEMP
OVERCURRENT
PHASE LOSS
FIELD LOSS
ZERO SPEED



ASSY.	HP	R3	R4
A11126-000	10/20	243 OHMS	374 OHMS
A11126-001	20/40	73.2 OHMS	NOT USED
A11126-002	30/60	100 OHMS	100 OHMS
A11126-003	40/75	68 OHMS	84 OHMS
A11126-004	50/100	57 OHMS	57 OHMS
A11126-005	60/125	47 OHMS	47 OHMS
A11126-006	75/150	20 OHMS	NOT USED
A11126-007	100/200	34 OHMS	34 OHMS
A11126-008	125/250	28 OHMS	28 OHMS
A11126-009	150/300	23.7 OHMS	23.7 OHMS

NOTES:
1. REF. B.O.M. A11126-XXX.
2. REF. ASSY. C11126.
3. CT'S 1 AND 2 NOT USED ON -007, -008, & -009 ASSEMBLIES.

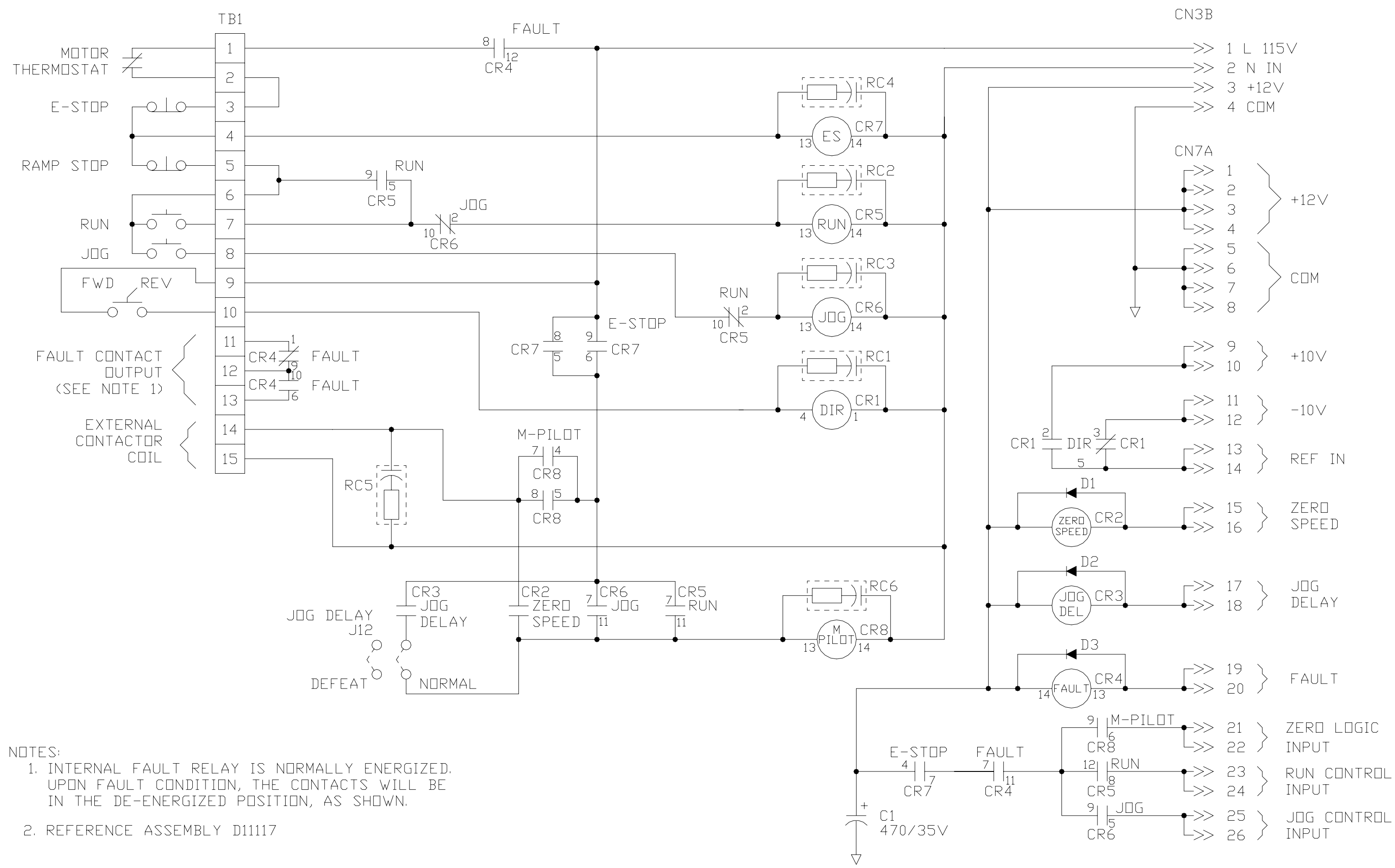
REV.E, ECO 382, 5-15-95
REV.D, ADD -007, -008, & -009 ASSY, 9-12-94
REV.C, ADD -004, -005, & -006 ASSY, 6-29-94
REV.B, ECO 290, 4-28-94

DRAWN BY: BKP DATE: 5-27-93
APPROVED BY: DATE:
TOLERANCES: ± 2 DEC. PL. 3 DEC. PL.
SCALE:

CAROTRON
Driven by Excellence
HEATH SPRINGS, SC
TEL 803-286-8614
FAX 803-286-6063

TITLE: SCHEMATIC, ELITE®
C.T. BOARD

DRAWING NUMBER: C11124 REV. E SH. 1 OF 1



NOTES:
1. INTERNAL FAULT RELAY IS NORMALLY ENERGIZED. UPON FAULT CONDITION, THE CONTACTS WILL BE IN THE DE-ENERGIZED POSITION, AS SHOWN.

2. REFERENCE ASSEMBLY D11117

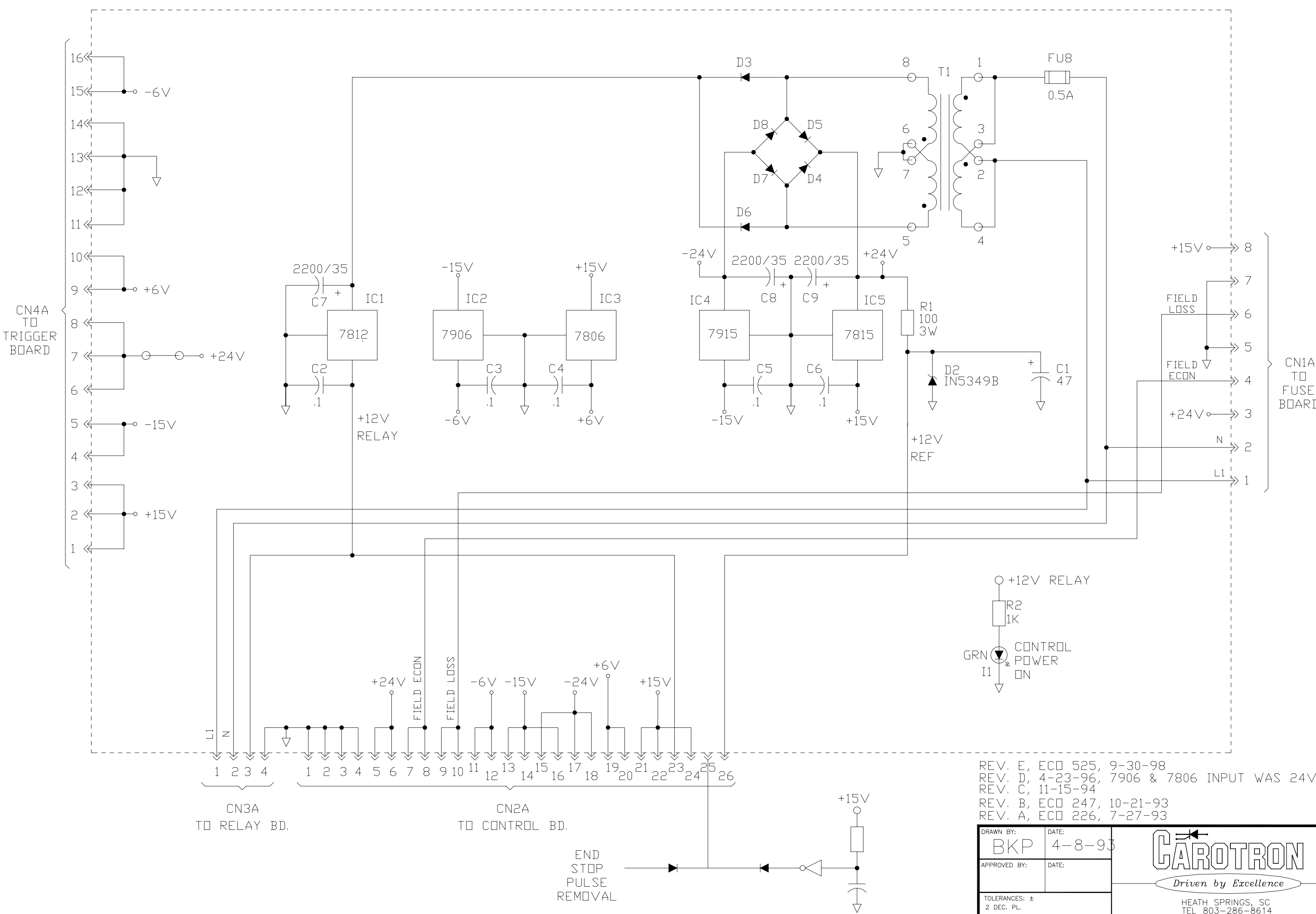
REV.B, ECO 392, 8-17-95
REV.A, ECO 233, 8-16-93

DRAWN BY: UBJ	DATE: 4/6/93
APPROVED BY:	DATE:
TOLERANCES: ± 2 DEC. PL. 3 DEC. PL.	
SCALE:	

CAROTRON
Driven by Excellence
HEATH SPRINGS, SC
TEL 803-286-8614
FAX 803-286-6063

TITLE: SCHEMATIC, ELITE®
RELAY PC BOARD

DRAWING NUMBER: C11115 REV. B SH. 1 OF 1



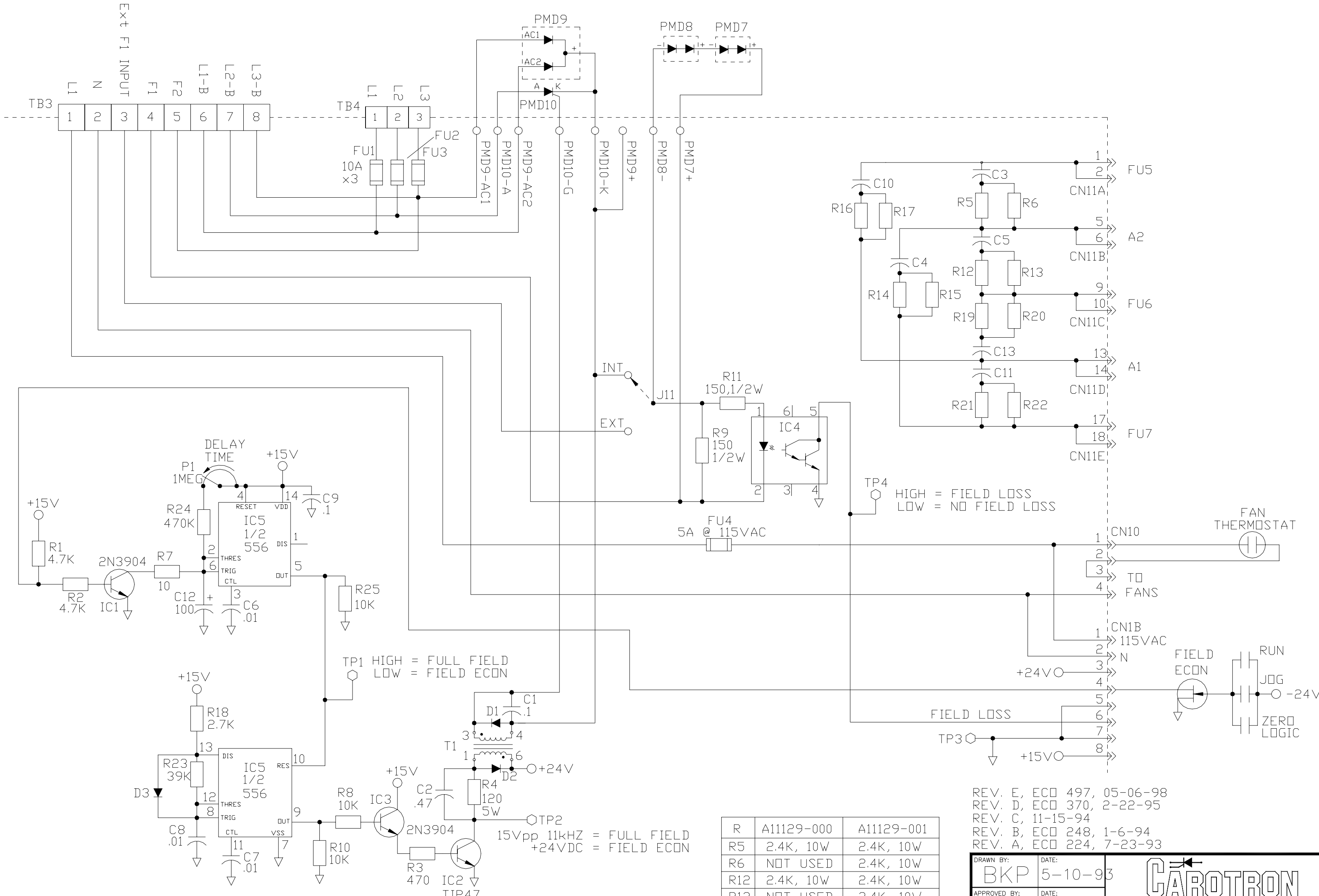
REV. E, ECO 525, 9-30-98
REV. D, 4-23-96, 7906 & 7806 INPUT WAS 24V
REV. C, 11-15-94
REV. B, ECO 247, 10-21-93
REV. A, ECO 226, 7-27-93

DRAWN BY: BKP	DATE: 4-8-93
APPROVED BY:	DATE:
TOLERANCES: ± 2 DEC. PL. 3 DEC. PL.	
SCALE:	
DRAWING NUMBER: C11118	REV. E SH. 1 OF 1

CAROTRON
Driven by Excellence
HEATH SPRINGS, SC
TEL 803-286-8614
FAX 803-286-6063

TITLE: SCHEMATIC, ELITE® POWER SUPPLY BOARD

NOTES:
1. REF. B.O.M. A11120-000
2. REF. ASSY. C11120



REV. E, ECO 497, 05-06-98
REV. D, ECO 370, 2-22-95
REV. C, 11-15-94
REV. B, ECO 248, 1-6-94
REV. A, ECO 224, 7-23-93

R	A11129-000	A11129-001
R5	2.4K, 10W	2.4K, 10W
R6	NOT USED	2.4K, 10W
R12	2.4K, 10W	2.4K, 10W
R13	NOT USED	2.4K, 10W
R14	2.4K, 10W	2.4K, 10W
R15	NOT USED	2.4K, 10W
R16	2.4K, 10W	2.4K, 10W
R17	NOT USED	2.4K, 10W
R19	2.4K, 10W	2.4K, 10W
R20	NOT USED	2.4K, 10W
R21	2.4K, 10W	2.4K, 10W
R22	NOT USED	2.4K, 10W

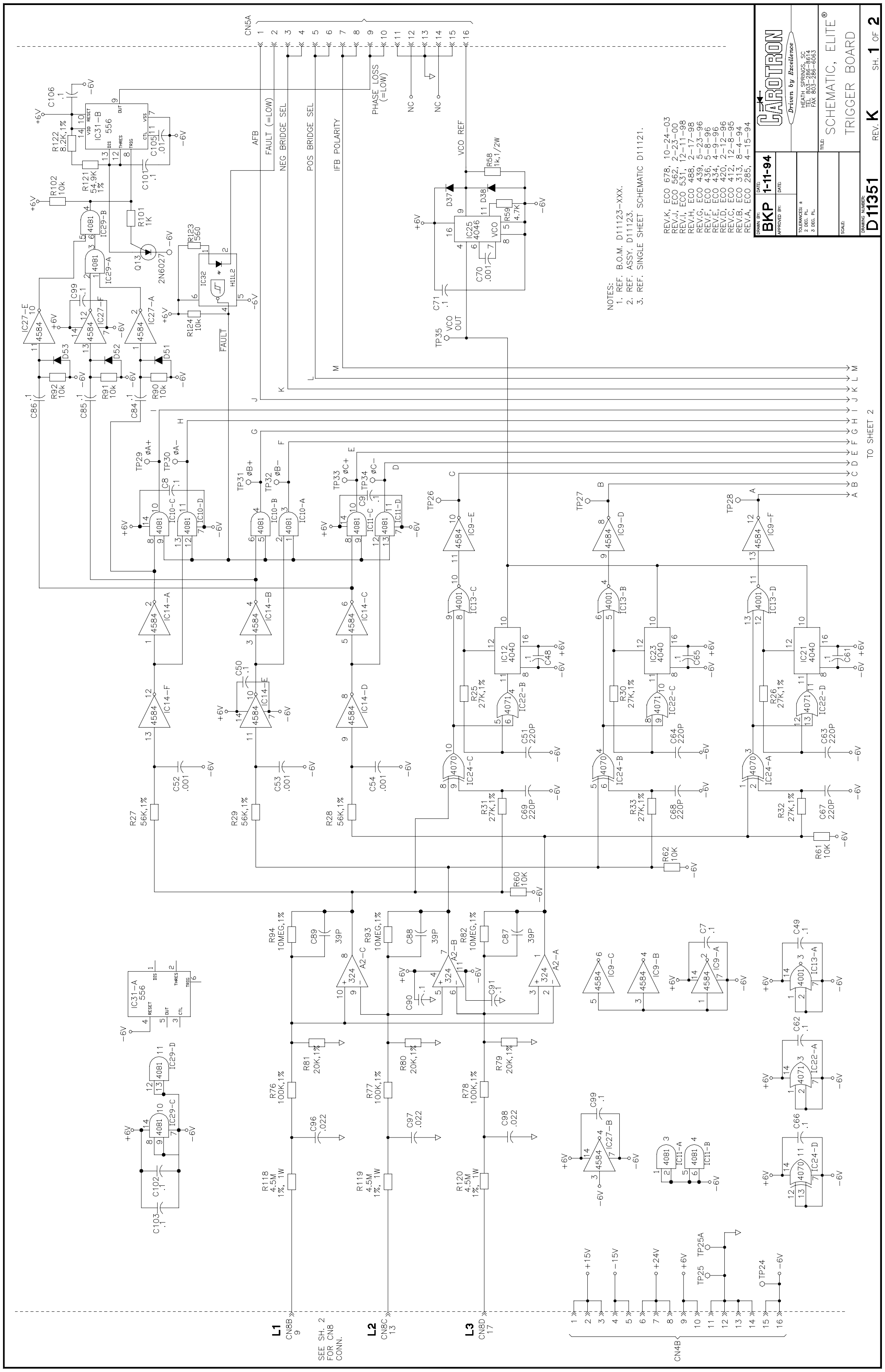
NOTES:
1. REF. B.O.M. A11129-000 FOR 20 & 40 HP MODELS.
REF. B.O.M. A11129-001 FOR 60-300 HP MODELS.
2. REF. ASSY. D11129.

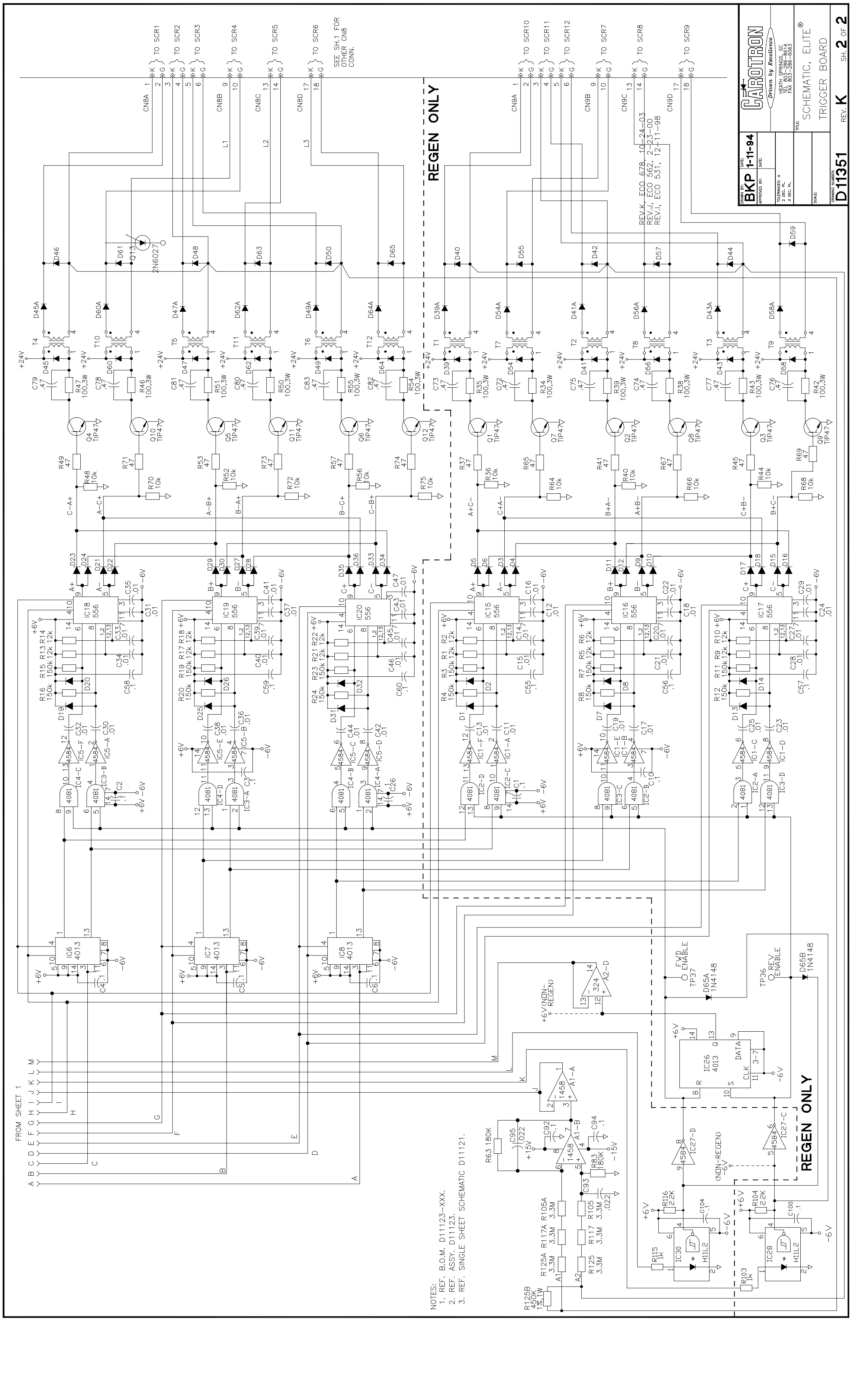
DRAWN BY: BKP DATE: 5-10-93
APPROVED BY: DATE:
TOLERANCES: ± 2 DEC. PL. 3 DEC. PL.
SCALE:

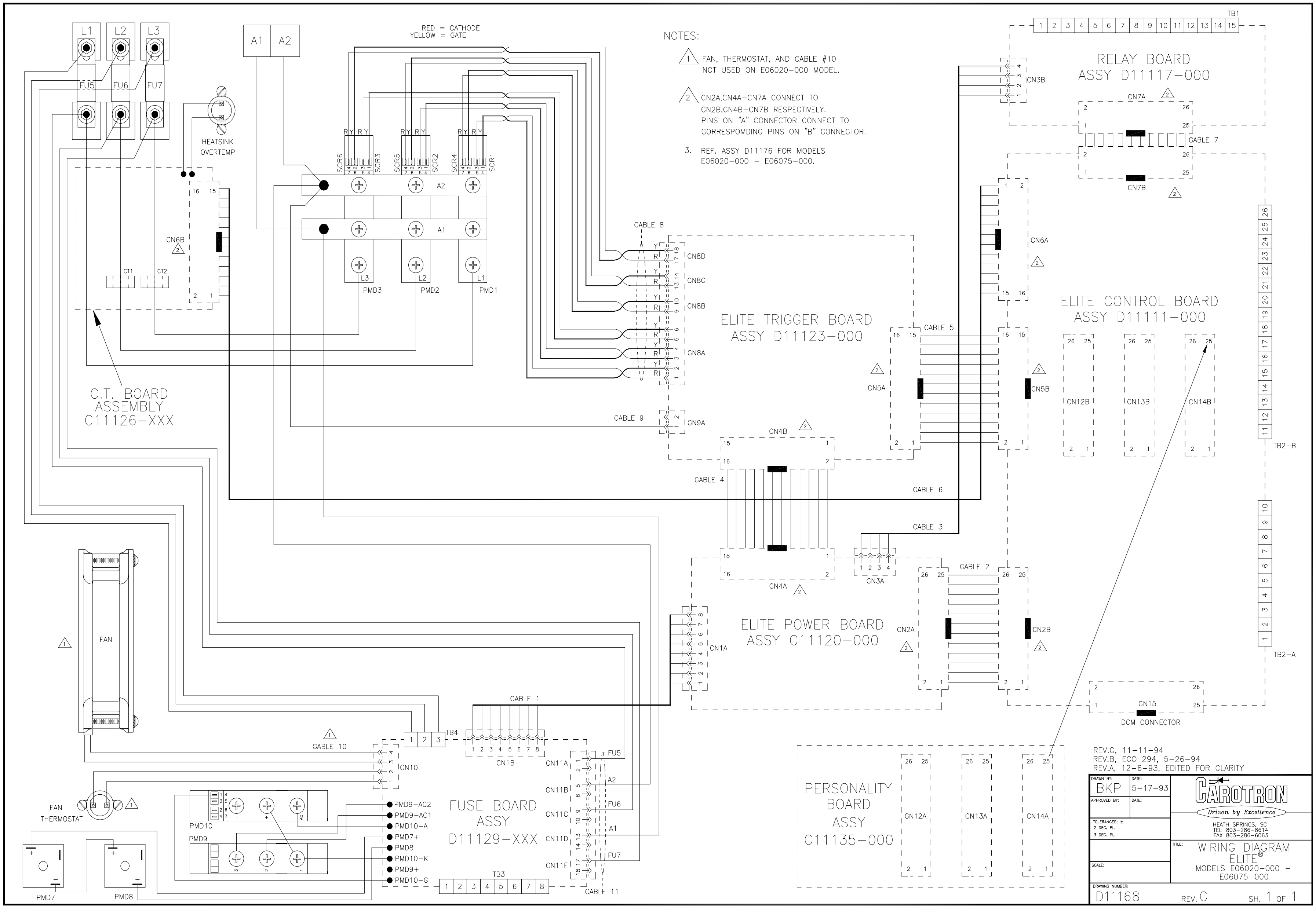
CAROTRON
Driven by Excellence
HEATH SPRINGS, SC
TEL 803-286-8614
FAX 803-286-6063

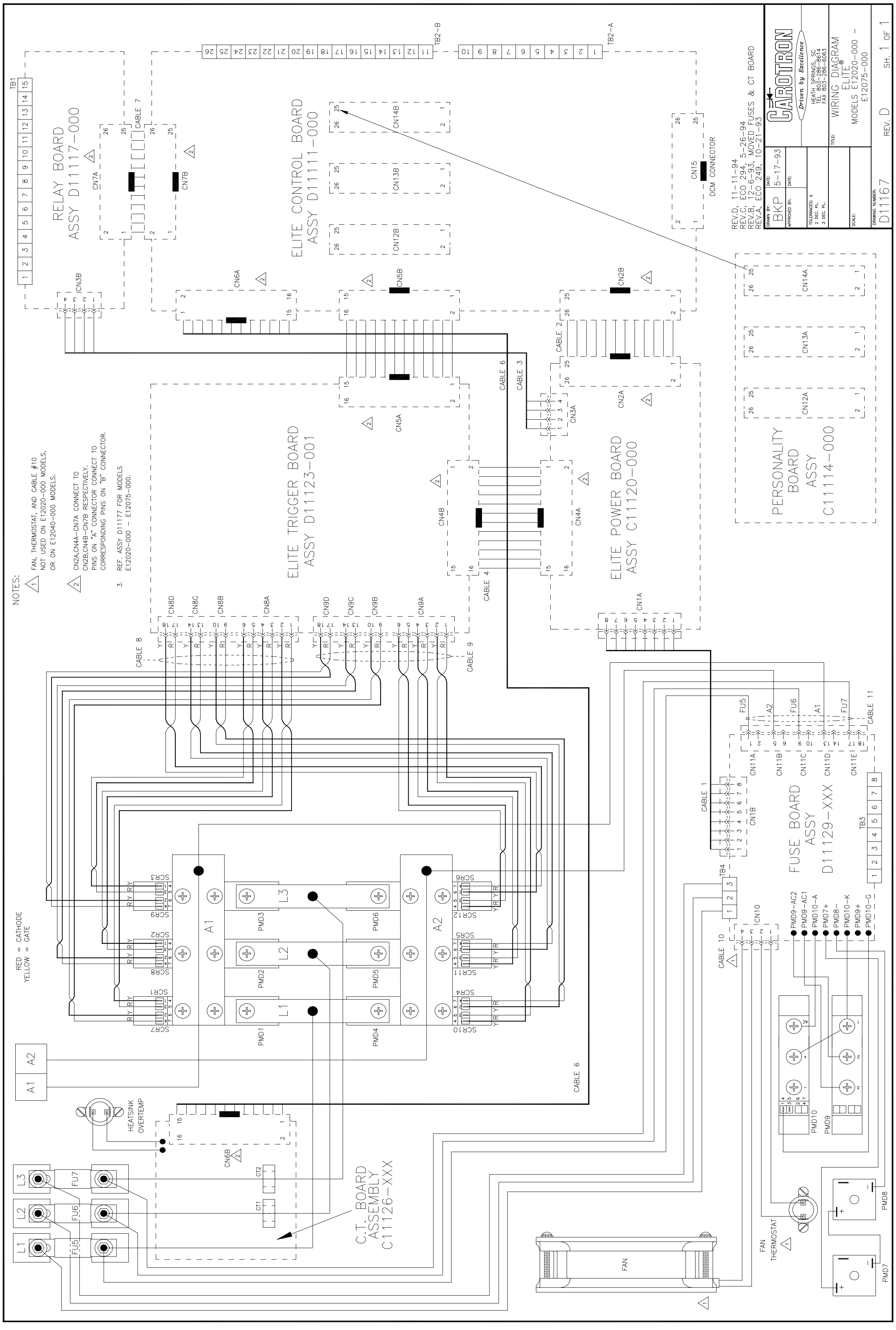
TITLE: SCHEMATIC, ELITE® FUSE BOARD

DRAWING NUMBER: C11127 REV. E SH. 1 OF 1

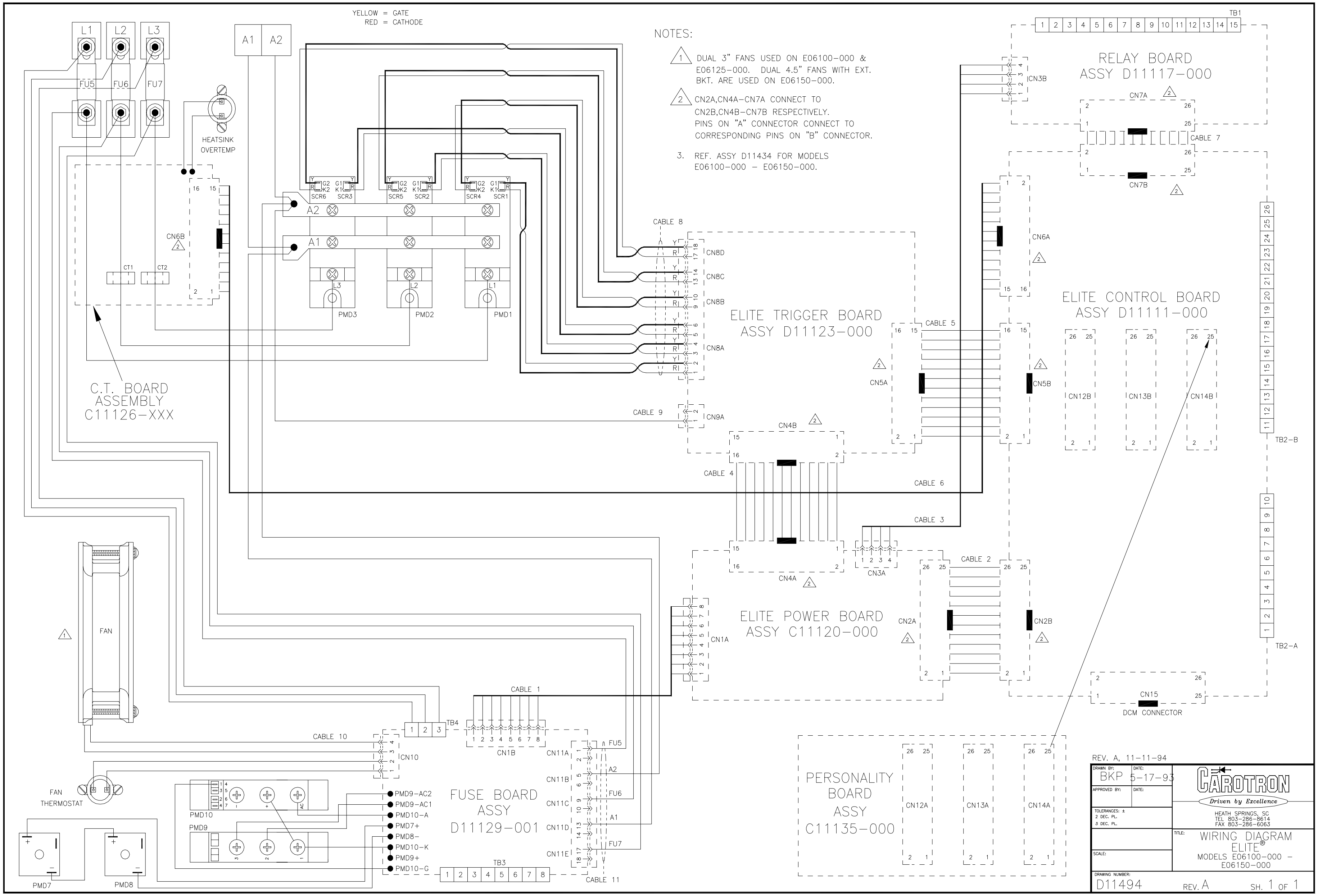

CAROTRON
Driven by Excellence
SCHEMATIC, ELITE®
TRIGGER BOARD
D11351
REV. K
SH. 1 OF 2
BKP
1-11-94
NOTES:
1. REF. B.O.M. D11123-XXX.
2. REF. ASSY. D11123.
3. REF. SINGLE SHEET SCHEMATIC D11121.
REV.K, ECO 678, 10-24-03
REV.J, ECO 562, 2-23-00
REV.I, ECO 531, 12-11-98
REV.H, ECO 488, 2-17-98
REV.G, ECO 439, 5-23-96
REV.F, ECO 436, 5-8-96
REV.E, ECO 434, 4-9-96
REV.D, ECO 420, 2-12-96
REV.C, ECO 412, 12-8-95
REV.B, ECO 313, 8-4-94
REV.A, ECO 285, 4-15-94
TO SHEET 2
SEE SH. 2 FOR CN8 CONN.


CAROTRON
Driven by Excellence
HEATH SPRINGS, SC
SCHEMATIC, ELITE®
TRIGGER BOARD
D11351
REV. K
SH. 2 OF 2
BKP 1-11-94
REV.K, ECO 678, 10-24-03
REV.J, ECO 562, 2-23-00
REV.I, ECO 531, 12-11-98
REGEN ONLY
FROM SHEET 1
NOTES:
1. REF. B.O.M. D11123-XXX.
2. REF. ASSY. D11123.
3. REF. SINGLE SHEET SCHEMATIC D11121.

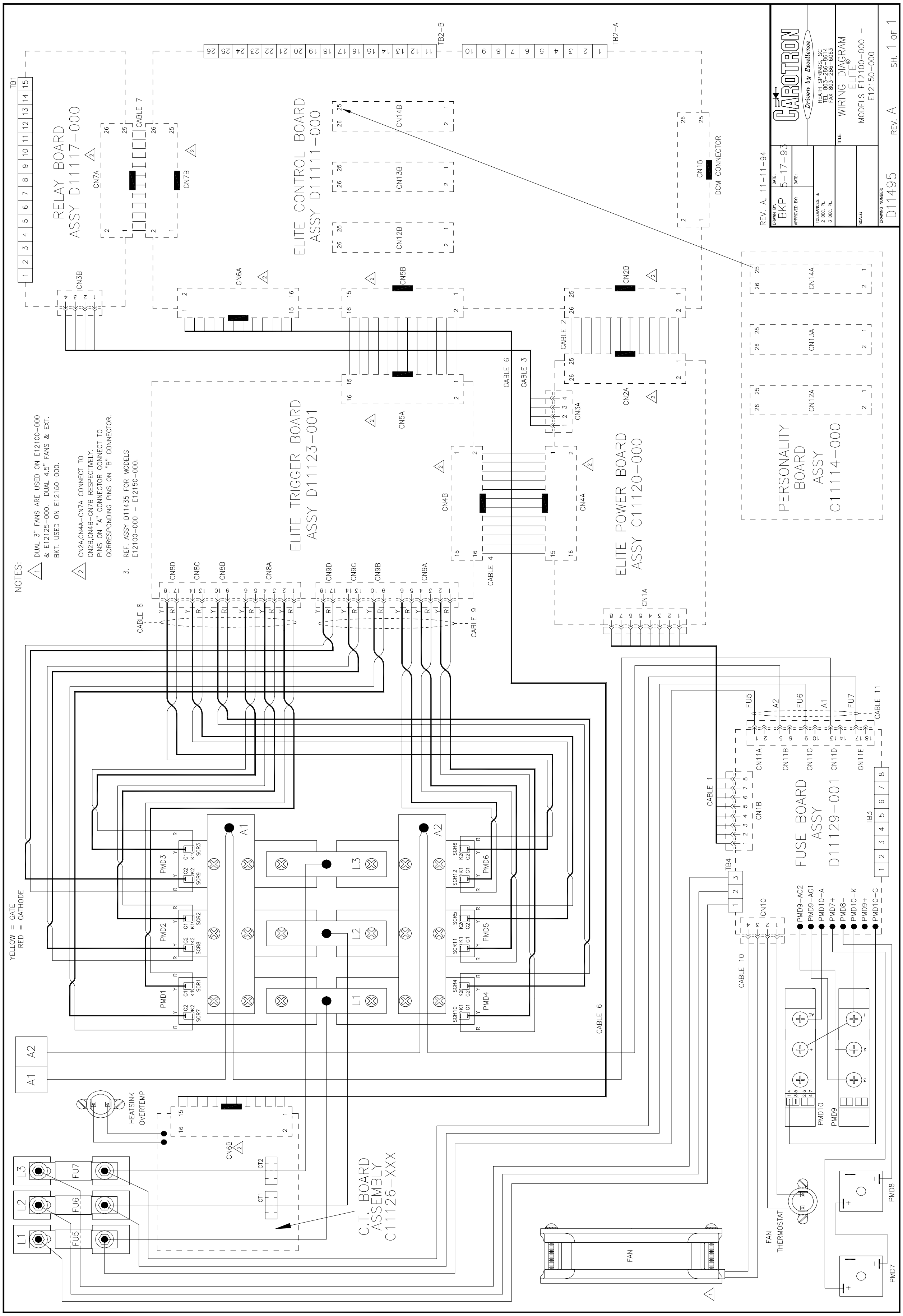

NOTES:
1 FAN, THERMOSTAT, AND CABLE #10 NOT USED ON E06020-000 MODEL.
2 CN2A,CN4A-CN7A CONNECT TO CN2B,CN4B-CN7B RESPECTIVELY. PINS ON "A" CONNECTOR CONNECT TO CORRESPOMDING PINS ON "B" CONNECTOR.
3. REF. ASSY D11176 FOR MODELS E06020-000 - E06075-000.
RED = CATHODE
YELLOW = GATE
RELAY BOARD
ASSY D11117-000
ELITE CONTROL BOARD
ASSY D11111-000
ELITE TRIGGER BOARD
ASSY D11123-000
ELITE POWER BOARD
ASSY C11120-000
FUSE BOARD
ASSY
D11129-XXX
PERSONALITY
BOARD
ASSY
C11135-000
C.T. BOARD
ASSEMBLY
C11126-XXX
HEATSINK
OVERTEMP
FAN
FAN
THERMOSTAT
DCM CONNECTOR
CABLE 1
CABLE 2
CABLE 3
CABLE 4
CABLE 5
CABLE 6
CABLE 7
CABLE 8
CABLE 9
CABLE 10
CABLE 11
PMD1
PMD2
PMD3
PMD7
PMD8
PMD9
PMD10
PMD9-AC2
PMD9-AC1
PMD10-A
PMD7+
PMD8-
PMD10-K
PMD9+
PMD10-G
REV.C, 11-11-94
REV.B, ECO 294, 5-26-94
REV.A, 12-6-93, EDITED FOR CLARITY
DRAWN BY: BKP
DATE: 5-17-93
APPROVED BY:
DATE:
TOLERANCES: ±
2 DEC. PL.
3 DEC. PL.
SCALE:
CAROTRON
Driven by Excellence
HEATH SPRINGS, SC
TEL 803-286-8614
FAX 803-286-6063
TITLE: WIRING DIAGRAM
ELITE®
MODELS E06020-000 -
E06075-000
DRAWING NUMBER: D11168
REV. C
SH. 1 OF 1

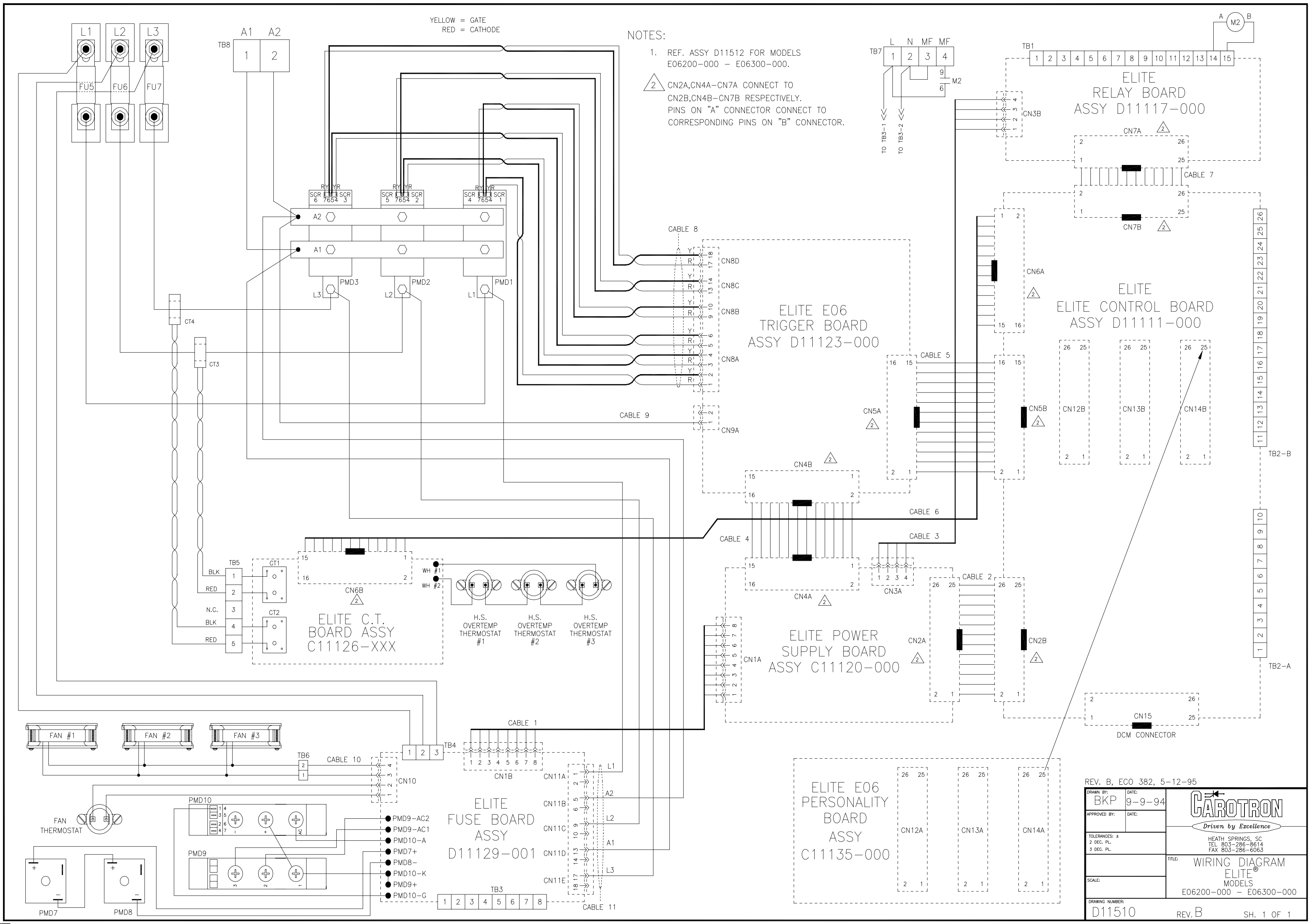


NOTES:
1. FAN, THERMOSTAT, AND CABLE #10 NOT USED ON E12020-000 MODELS, OR ON E12040-000 MODELS.
2. CN2A,CN4A-CN7A CONNECT TO CN2B,CN4B-CN7B RESPECTIVELY. PINS ON "A" CONNECTOR CONNECT TO CORRESPONDING PINS ON "B" CONNECTOR.
3. REF. ASSY D11177 FOR MODELS E12020-000 - E12075-000.
RED = CATHODE
YELLOW = GATE
RELAY BOARD ASSY D11117-000
ELITE CONTROL BOARD ASSY D11111-000
ELITE TRIGGER BOARD ASSY D11123-001
ELITE POWER BOARD ASSY C11120-000
PERSONALITY BOARD ASSY C11114-000
FUSE BOARD ASSY D11129-XXX
C.T. BOARD ASSEMBLY C11126-XXX
DCM CONNECTOR
HEATSINK OVERTEMP
FAN
FAN THERMOSTAT
REV.D, 11-11-94
REV.C, ECO 294, 5-26-94
REV.B, 12-6-93, MOVED FUSES & CT BOARD
REV.A, ECO 249, 10-21-93
DRAWN BY: BKP
DATE: 5-17-93
CAROTRON
Driven by Excellence
HEATH SPRINGS, SC
TEL 803-286-8614
FAX 803-286-6063
TITLE: WIRING DIAGRAM ELITE® MODELS E12020-000 - E12075-000
DRAWING NUMBER: D11167
REV. D
SH. 1 OF 1

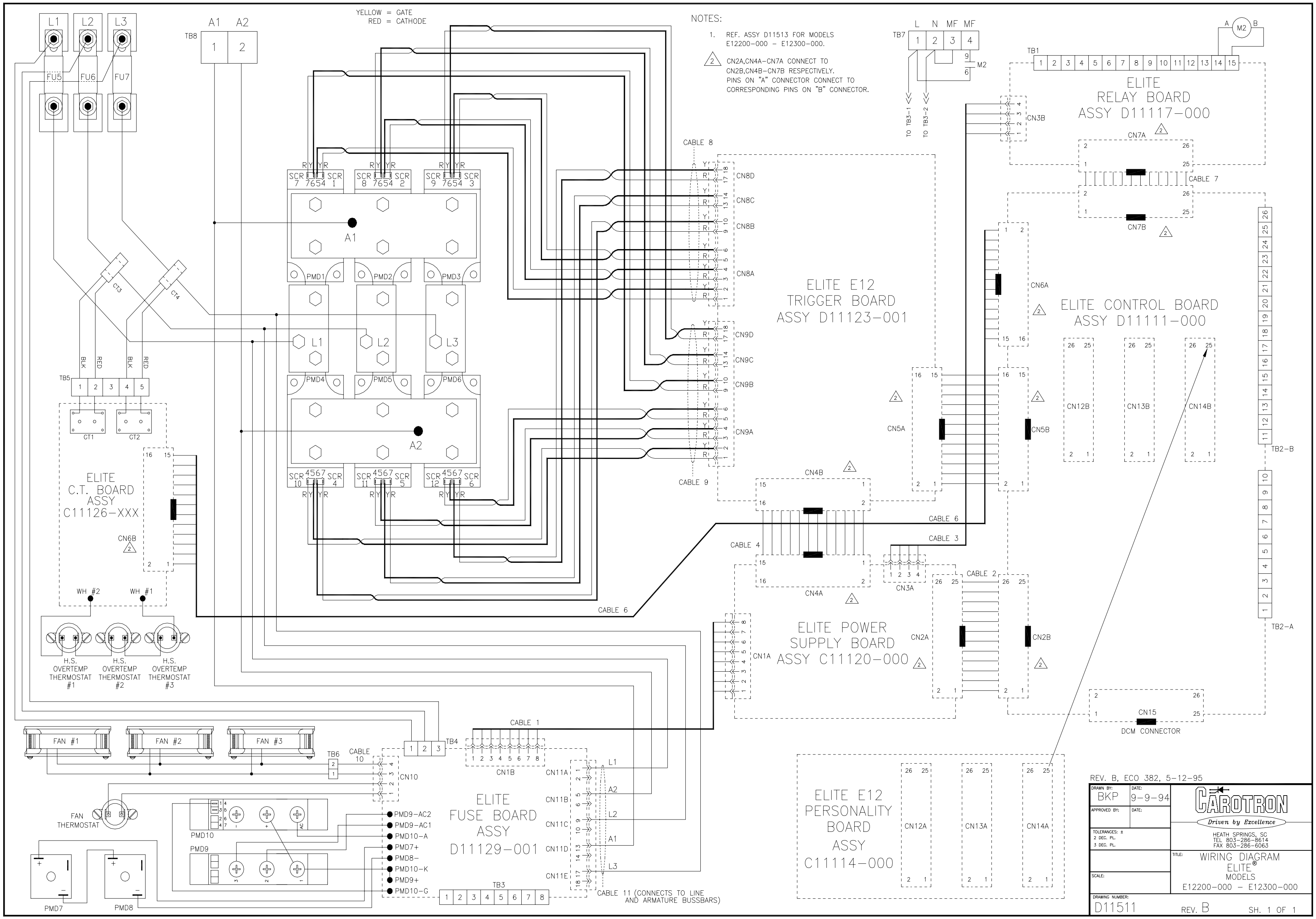


YELLOW = GATE
RED = CATHODE
NOTES:
1 DUAL 3" FANS USED ON E06100-000 & E06125-000. DUAL 4.5" FANS WITH EXT. BKT. ARE USED ON E06150-000.
2 CN2A,CN4A-CN7A CONNECT TO CN2B,CN4B-CN7B RESPECTIVELY. PINS ON "A" CONNECTOR CONNECT TO CORRESPONDING PINS ON "B" CONNECTOR.
3. REF. ASSY D11434 FOR MODELS E06100-000 - E06150-000.
RELAY BOARD
ASSY D11117-000
ELITE CONTROL BOARD
ASSY D11111-000
ELITE TRIGGER BOARD
ASSY D11123-000
ELITE POWER BOARD
ASSY C11120-000
PERSONALITY BOARD ASSY C11135-000
FUSE BOARD ASSY D11129-001
C.T. BOARD ASSEMBLY C11126-XXX
HEATSINK OVERTEMP
FAN
FAN THERMOSTAT
DCM CONNECTOR
REV. A, 11-11-94
DRAWN BY: BKP
DATE: 5-17-93
CAROTRON
Driven by Excellence
HEATH SPRINGS, SC
TEL 803-286-8614
FAX 803-286-6063
WIRING DIAGRAM
ELITE®
MODELS E06100-000 - E06150-000
DRAWING NUMBER: D11494
REV. A
SH. 1 OF 1

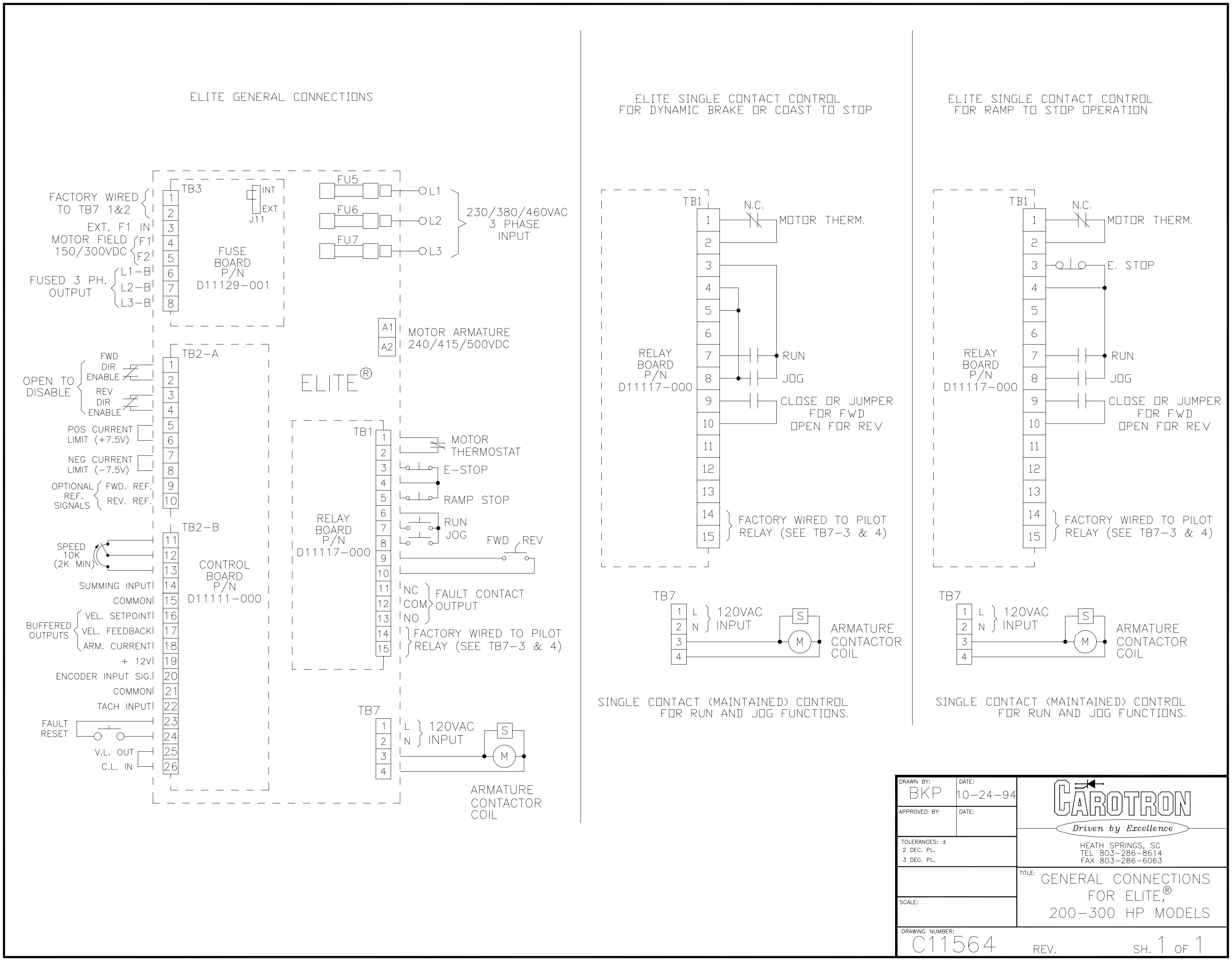

RELAY BOARD
ASSY D11117-000
ELITE CONTROL BOARD
ASSY D11111-000
ELITE TRIGGER BOARD
ASSY D11123-001
ELITE POWER BOARD
ASSY C11120-000
PERSONALITY
BOARD
ASSY
C11114-000
FUSE BOARD
ASSY
D11129-001
C.T. BOARD
ASSEMBLY
C11126-XXX
DCM CONNECTOR
HEATSINK
OVERTEMP
FAN
THERMOSTAT
FAN
YELLOW = GATE
RED = CATHODE
NOTES:
1. DUAL 3" FANS ARE USED ON E12100-000 & E12125-000. DUAL 4.5" FANS & EXT. BKT. USED ON E12150-000.
2. CN2A,CN4A-CN7A CONNECT TO CN2B,CN4B-CN7B RESPECTIVELY. PINS ON "A" CONNECTOR CONNECT TO CORRESPONDING PINS ON "B" CONNECTOR.
3. REF. ASSY D11435 FOR MODELS E12100-000 - E12150-000.
CAROTRON
Driven by Excellence
HEATH SPRINGS, SC
TEL 803-286-8614
FAX 803-286-6063
REV. A, 11-11-94
DRAWN BY: BKP
DATE: 5-17-93
TITLE: WIRING DIAGRAM
ELITE®
MODELS E12100-000 - E12150-000
DRAWING NUMBER: D11495
REV. A
SH. 1 OF 1



YELLOW = GATE
RED = CATHODE
NOTES:
1. REF. ASSY D11512 FOR MODELS E06200-000 – E06300-000.
2 CN2A,CN4A–CN7A CONNECT TO CN2B,CN4B–CN7B RESPECTIVELY. PINS ON "A" CONNECTOR CONNECT TO CORRESPONDING PINS ON "B" CONNECTOR.
ELITE RELAY BOARD ASSY D11117-000
ELITE ELITE CONTROL BOARD ASSY D11111-000
ELITE E06 TRIGGER BOARD ASSY D11123-000
ELITE POWER SUPPLY BOARD ASSY C11120-000
ELITE C.T. BOARD ASSY C11126-XXX
ELITE FUSE BOARD ASSY D11129-001
ELITE E06 PERSONALITY BOARD ASSY C11135-000
H.S. OVERTEMP THERMOSTAT #1
H.S. OVERTEMP THERMOSTAT #2
H.S. OVERTEMP THERMOSTAT #3
FAN #1
FAN #2
FAN #3
FAN THERMOSTAT
DCM CONNECTOR
TO TB3-1
TO TB3-2
CABLE 1
CABLE 2
CABLE 3
CABLE 4
CABLE 5
CABLE 6
CABLE 7
CABLE 8
CABLE 9
CABLE 10
CABLE 11
PMD9-AC2
PMD9-AC1
PMD10-A
PMD7+
PMD8-
PMD10-K
PMD9+
PMD10-G
REV. B, ECO 382, 5-12-95
DRAWN BY: BKP
DATE: 9-9-94
APPROVED BY:
DATE:
TOLERANCES: ± 2 DEC. PL. 3 DEC. PL.
SCALE:
CAROTRON
Driven by Excellence
HEATH SPRINGS, SC
TEL 803-286-8614
FAX 803-286-6063
TITLE: WIRING DIAGRAM ELITE® MODELS E06200-000 – E06300-000
DRAWING NUMBER: D11510
REV. B
SH. 1 OF 1



YELLOW = GATE
RED = CATHODE
NOTES:
1. REF. ASSY D11513 FOR MODELS E12200-000 - E12300-000.
2 CN2A,CN4A-CN7A CONNECT TO CN2B,CN4B-CN7B RESPECTIVELY. PINS ON "A" CONNECTOR CONNECT TO CORRESPONDING PINS ON "B" CONNECTOR.
ELITE RELAY BOARD ASSY D11117-000
ELITE E12 TRIGGER BOARD ASSY D11123-001
ELITE CONTROL BOARD ASSY D11111-000
ELITE C.T. BOARD ASSY C11126-XXX
ELITE POWER SUPPLY BOARD ASSY C11120-000
ELITE FUSE BOARD ASSY D11129-001
ELITE E12 PERSONALITY BOARD ASSY C11114-000
H.S. OVERTEMP THERMOSTAT #1
H.S. OVERTEMP THERMOSTAT #2
H.S. OVERTEMP THERMOSTAT #3
FAN THERMOSTAT
FAN #1
FAN #2
FAN #3
DCM CONNECTOR
CABLE 11 (CONNECTS TO LINE AND ARMATURE BUSSBARS)
REV. B, ECO 382, 5-12-95
DRAWN BY: BKP
DATE: 9-9-94
CAROTRON
Driven by Excellence
HEATH SPRINGS, SC
TEL 803-286-8614
FAX 803-286-6063
TITLE: WIRING DIAGRAM ELITE® MODELS E12200-000 - E12300-000
DRAWING NUMBER: D11511
REV. B
SH. 1 OF 1


ELITE GENERAL CONNECTIONS
FACTORY WIRED TO TB7 1&2
EXT. F1 IN
MOTOR FIELD 150/300VDC F1 F2
FUSED 3 PH. OUTPUT L1-B L2-B L3-B
TB3
INT EXT J11
FUSE BOARD P/N D11129-001
FU5 FU6 FU7
L1 L2 L3
230/380/460VAC 3 PHASE INPUT
A1 A2 MOTOR ARMATURE 240/415/500VDC
ELITE®
OPEN TO DISABLE
FWD DIR ENABLE
REV DIR ENABLE
POS CURRENT LIMIT (+7.5V)
NEG CURRENT LIMIT (-7.5V)
OPTIONAL REF. SIGNALS FWD. REF. REV. REF.
TB2-A
TB2-B
SPEED 10K (2K MIN)
SUMMING INPUT
COMMON
BUFFERED OUTPUTS VEL. SETPOINT VEL. FEEDBACK ARM. CURRENT
+ 12V
ENCODER INPUT SIG.
COMMON
TACH INPUT
FAULT RESET
V.L. OUT
C.L. IN
CONTROL BOARD P/N D11111-000
RELAY BOARD P/N D11117-000
TB1
MOTOR THERMOSTAT
E-STOP
RAMP STOP
RUN
JOG
FWD REV
NC COM NO FAULT CONTACT OUTPUT
FACTORY WIRED TO PILOT RELAY (SEE TB7-3 & 4)
TB7
L N 120VAC INPUT
S M
ARMATURE CONTACTOR COIL
ELITE SINGLE CONTACT CONTROL
FOR DYNAMIC BRAKE OR COAST TO STOP
TB1
N.C.
MOTOR THERM.
RUN
JOG
CLOSE OR JUMPER FOR FWD OPEN FOR REV
FACTORY WIRED TO PILOT RELAY (SEE TB7-3 & 4)
RELAY BOARD P/N D11117-000
TB7
L N 120VAC INPUT
ARMATURE CONTACTOR COIL
SINGLE CONTACT (MAINTAINED) CONTROL FOR RUN AND JOG FUNCTIONS.
ELITE SINGLE CONTACT CONTROL
FOR RAMP TO STOP OPERATION
TB1
N.C.
MOTOR THERM.
E. STOP
RUN
JOG
CLOSE OR JUMPER FOR FWD OPEN FOR REV
FACTORY WIRED TO PILOT RELAY (SEE TB7-3 & 4)
RELAY BOARD P/N D11117-000
TB7
L N 120VAC INPUT
ARMATURE CONTACTOR COIL
SINGLE CONTACT (MAINTAINED) CONTROL FOR RUN AND JOG FUNCTIONS.
DRAWN BY: BKP
DATE: 10-24-94
APPROVED BY:
DATE:
TOLERANCES: ± 2 DEC. PL. 3 DEC. PL.
SCALE:
CAROTRON
Driven by Excellence
HEATH SPRINGS, SC
TEL 803-286-8614
FAX 803-286-6063
TITLE: GENERAL CONNECTIONS FOR ELITE®, 200-300 HP MODELS
DRAWING NUMBER: C11564
REV.
SH. 1 OF 1

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.

3. 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.

CAROTRON

Driven by Excellence

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

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