WERTEC CORPORATION

MODEL 1000 REGEN

INSTALLATION & OPERATION INSTRUCTION MANUAL

EFFECTIVE DATE: 9/14/89

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Table of Contents

1.0 General Information

1.1 Introduction

The WERTEC Brushless Motor Controller converts the incoming AC line voltage to DC, then inverts back to 3 phase AC, which is then applied to the stator of the Brushless Motor. The speed of the brushless motor is proportional to the voltage applied. In the WERTEC Control the applied voltage is varied by pulse width modulation of transistor's 4, 5, and 6 in the transistor output bridge. The commutation sequence of the transistors is provided by the Hall sensors mounted in the rear of the motor. The regenerative option provides the ability to control torque in both directions.

1.2 Standard Features

100 to 1 Speed Range.
Absolute Speed Regulation provided by digital locking circuitry (errors are not accumulative under normal loads).
Control circuit is isolated from high voltage power.
Inter-loop current regulator provides fast response.
Fast acting line fuses.
Line transient protection.
LED'S for each power stage for ease of troubleshooting.
LED'S provide memory for fault conditions.
Pulse-by-pulse current limit protects output transistors.
Automatic shutdown when the load exceeds 200%.
Current limit adjustable from 0-150%.
Separately adjustable accel and decel.
Electronic reversing from any speed. The motor will decelerate to zero speed and then accelerate to the set speed in the opposite direction.

1.3 Specifications

Service Conditions

ALTITUDE - TO 3300 ft. without derating
AMBIENT TEMPERATURE 40° C NEMA 1; 55° C CHASSIS
AC LINE VOLTAGE 230/380/460V +10% -5%
AC LINE FREQUENCY (48-62Hz)
Relative Humidity 0-95% without condensation

Application Data

SERVICE FACTOR	1.0	MAX REGEN TORQUE-150%	
MAXIMUM LOAD	150% for 1 minute	MAX REGEN DUTY CYCLE-10%	
REGULATION	Absolute - 0%	OPTIONAL REGEN DUTY CYCLE TO 100%	
SPEED STABILITY	.5% at base speed		

LINEARITY(SPEED REFERENCE ±1% TO OUTPUT SPEED)

ADJUSTMENTS

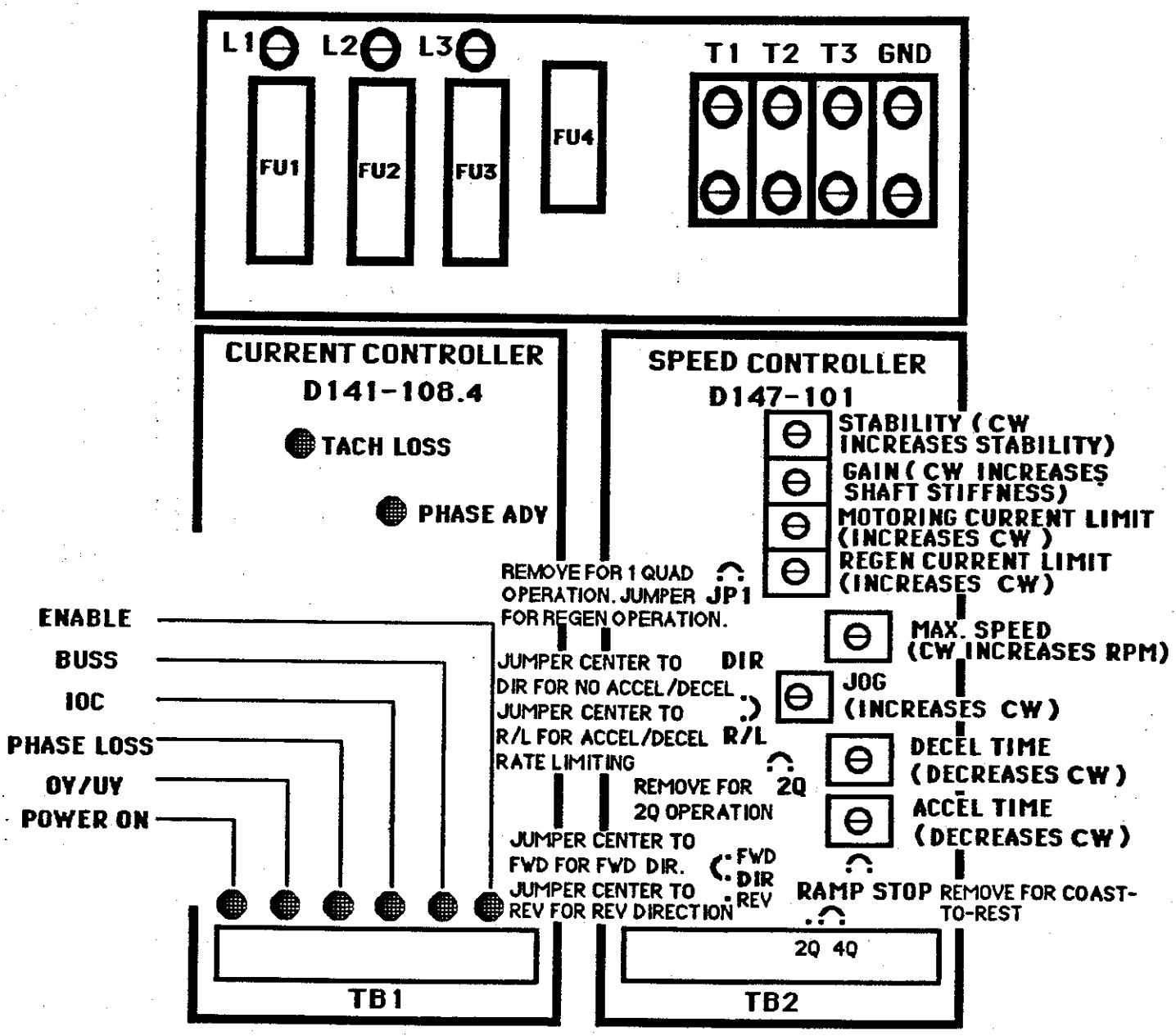
ACCELERATION	Linear 2-30 seconds	GAIN	
DECELERATION	Linear 2-30 seconds	STABILITY	
CURRENT LIMIT	0-150% motoring	MAX. SPEED	70-110% (typical)
	0-150% regenerating	JOG SPEED	0-30%

LED INDICATORS

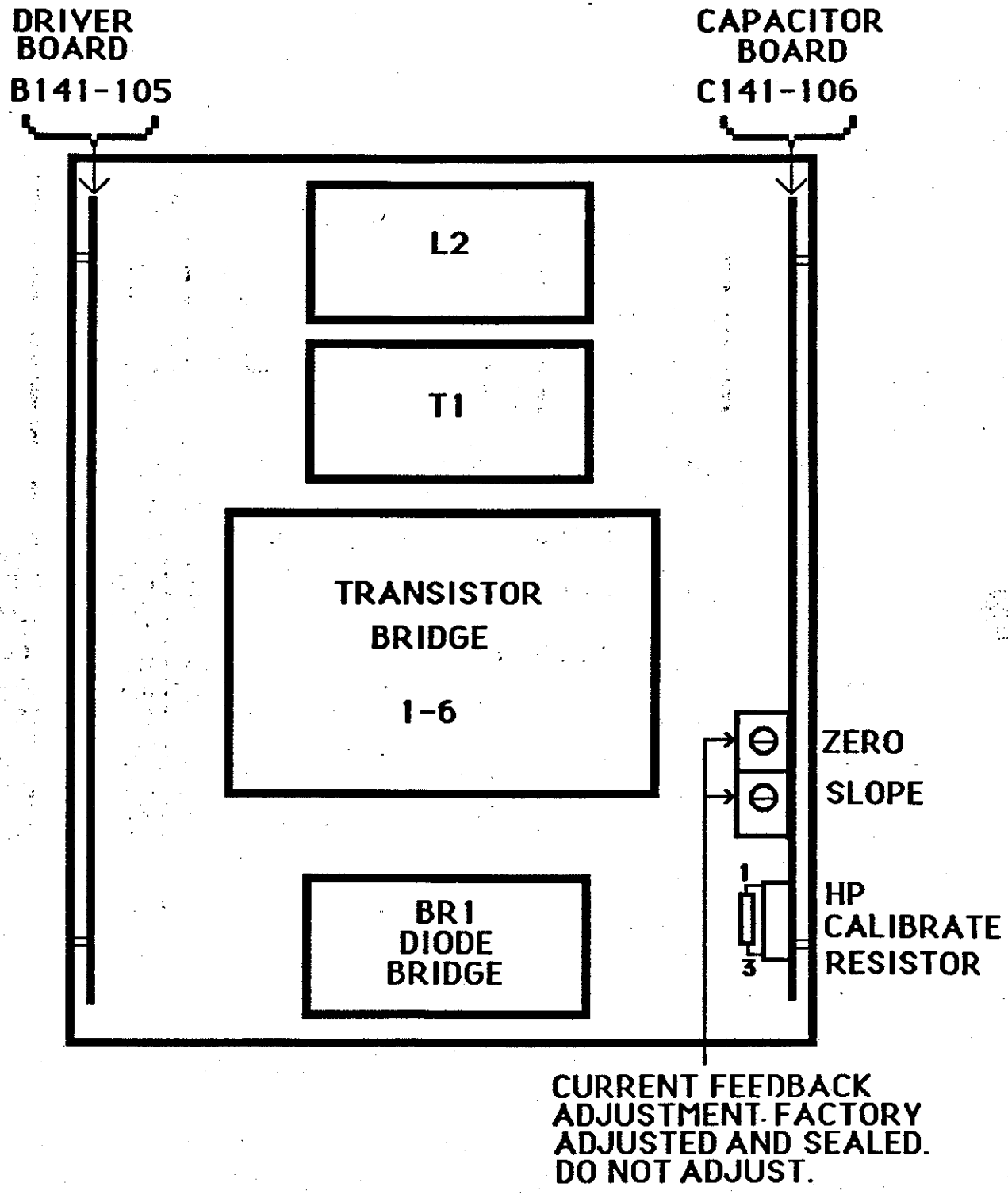
AC POWER ON	CURRENT LIMIT	BUSS CHARGE
ENABLE	REGEN INDICATORS	PHASE ADVANCE**
INSTANTANEOUS OVER CURRENT*	JOG INDICATOR	TACH LOSS**
UNDER VOLTAGE/OVER VOLTAGE *	HOLD INDICATOR	E-STOP INDICATOR
PHASE LOSS *	BUSS CURRENT INDICATOR	

(* MEMORIZE FAULTS, **OPTION)

1.4A) Location of parts -(REGENERATIVE) UPPER LEVEL

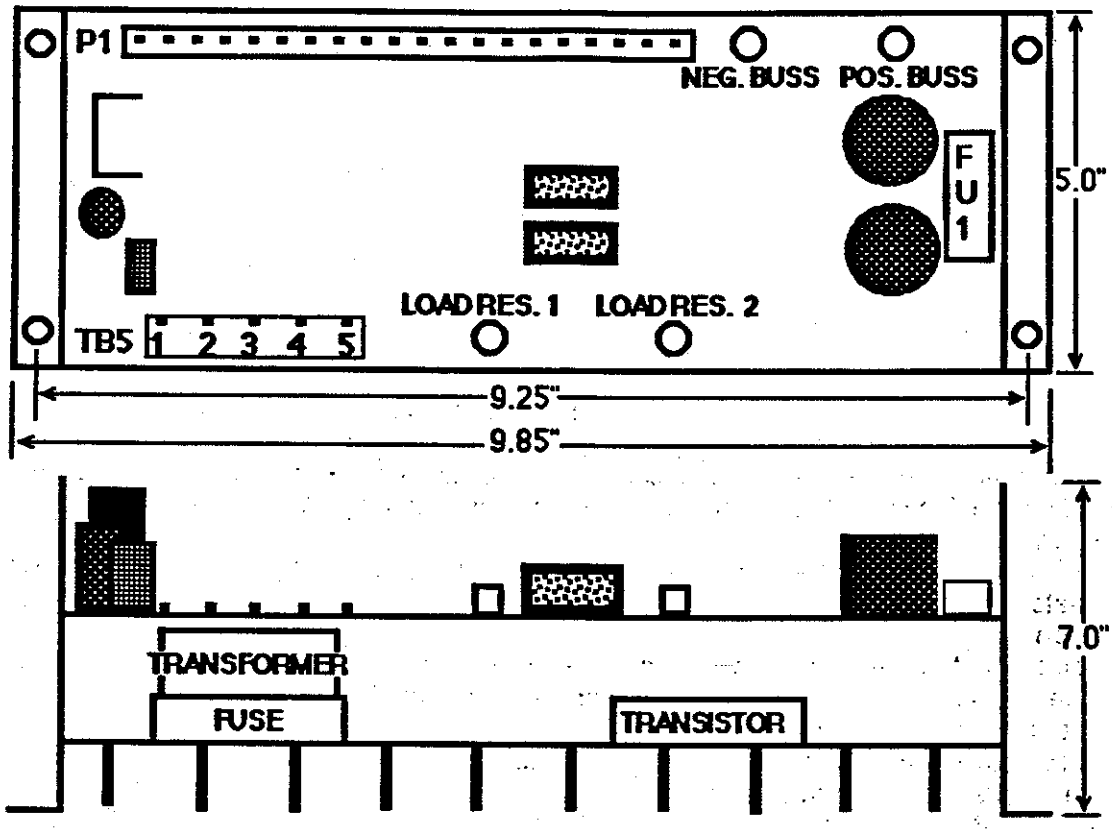


1.4 B) Location of parts, CHASIS BOTTOM LEVEL



1.4 C) LOCATION OF PARTS, SHUNT REGULATOR

NOTE: THE LOAD RESISTOR WHICH IS FURNISHED SHOULD NOT BE ENCLOSED IN AN AREA THAT WILL SUBJECT THE CONTROLLER TO HIGH HEAT.



2.0 Installation

2.1 General

Receiving and Unpacking

Our equipment is packaged to protect it from damage during shipment. However, extreme shocks caused by dropping, mishandling, or stacking may cause damage. Unpack the equipment as soon as it is received and carefully inspect it for damage.

If damage is found, notify the carrier and WERTEC immediately. Our equipment is shipped F.O.B.-shipping point. Ownership is transferred when the equipment leaves the WERTEC factory. Therefore, all shipping damage claims must be filed by the consignee directly to the shipping carrier. WERTEC will assist with information necessary to file the claim and to repair the damaged equipment.

Carefully remove all packing materials. Inspect heat sinks for packing materials which may interfere with movement or free air circulation.

2.2 Warning

Improper lifting practices can cause serious injury. Move this equipment only with adequate equipment and trained personnel.

All motor bases and equipment enclosures should be connected to earth ground.

Dangerous high voltages are present in this equipment. Do not assume that circuit breakers and disconnects are off. Remove all power from equipment. Check the wiring diagrams. Use of test equipment with one lead grounded and connected to case must be done with great caution. The ground connection should not be connected to any ungrounded part of the drive.

Caution

Installation wiring must be in accordance with the National Electrical Code and be in compliance with state and local codes.

Caution

Do not connect any external circuits other than shown on the interconnection diagram supplied with the equipment. Extra equipment on outputs may degrade system performance.

Do not megger or hi-pot this equipment without consulting WERTEC.

Do not remove printed circuit cards from this equipment while power is applied. This may cause severe electrical shock, and damage to the equipment.

Capacitors which are in this device, remain charged for about 10 minutes after power is removed. Do not attempt to remove circuit boards until after 10 minute time period.

RFI INTERFERENCE

The motor leads should be run in grounded electrical metal conduit (EMT) or flexible metal conduit by themselves for minimum RFI (radio frequency interference). These leads are switched at high voltage and could cause noise with other equipment if not run in metal conduit.

2.3 Location and Mounting Dimensions

Select a location for the controller in accordance with the following considerations:

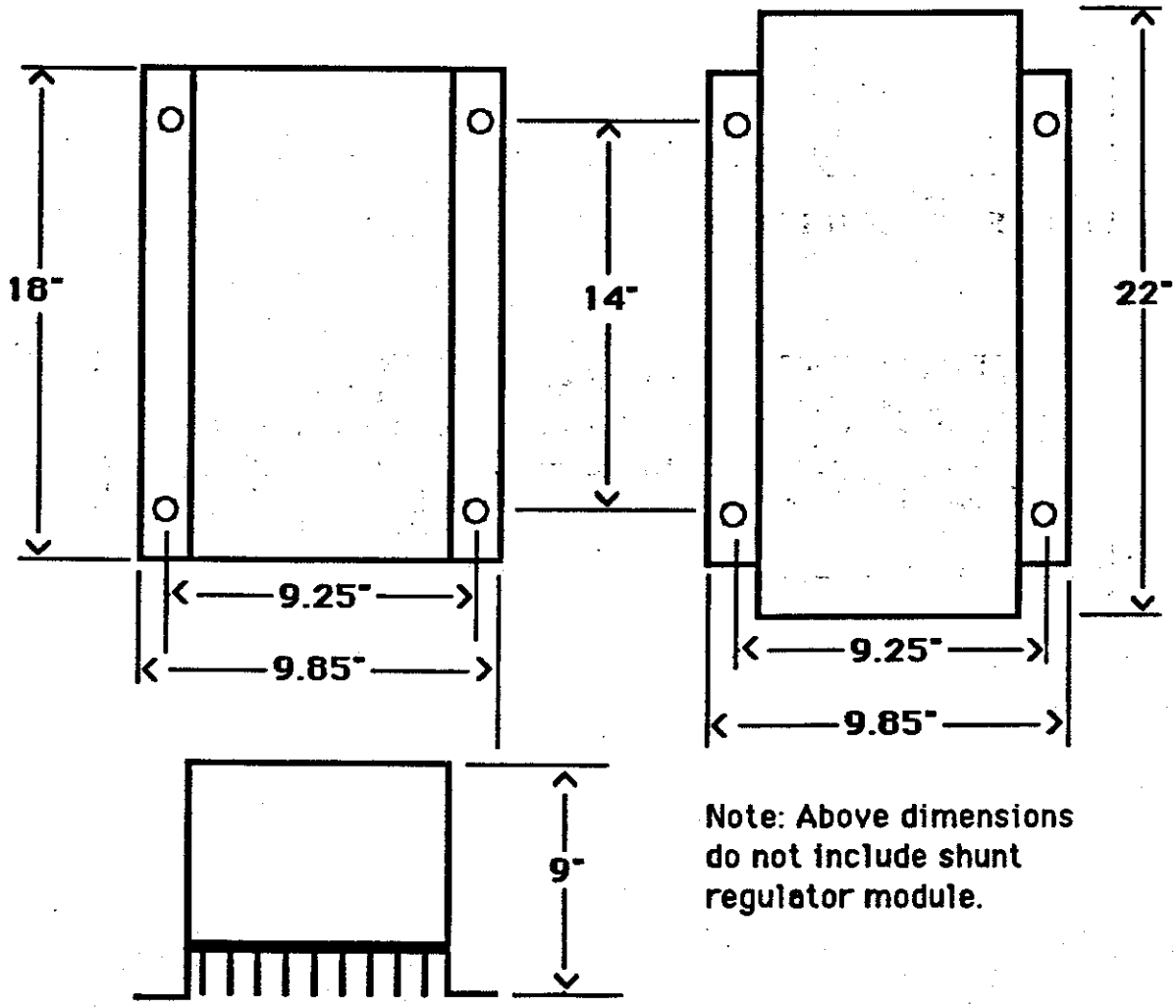
The upright controller unit is designed for mounting upright on a vertical surface to promote air flow through the heat sinks by natural convection.

To ensure proper cooling, the unit requires the free circulation of clean, dry air over the heat sinks. The maximum allowable air temperature for chassis mounted units is 55 Deg. C. The maximum ambient air temperature for an enclosed controller is 40 Deg. C. Do not locate the unit over or near a heat source.

The controller must not be mounted where it will experience excessive shock or vibrations.

Select a dry location where the controller will not be subjected to dripping or splashing.

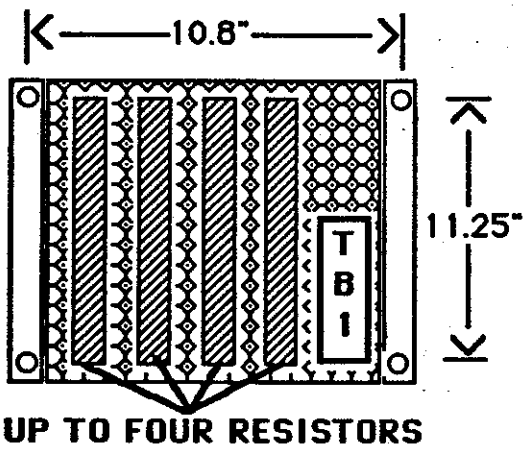
CHASSIS MOUNT **NEMA 1 ENCLOSURE**

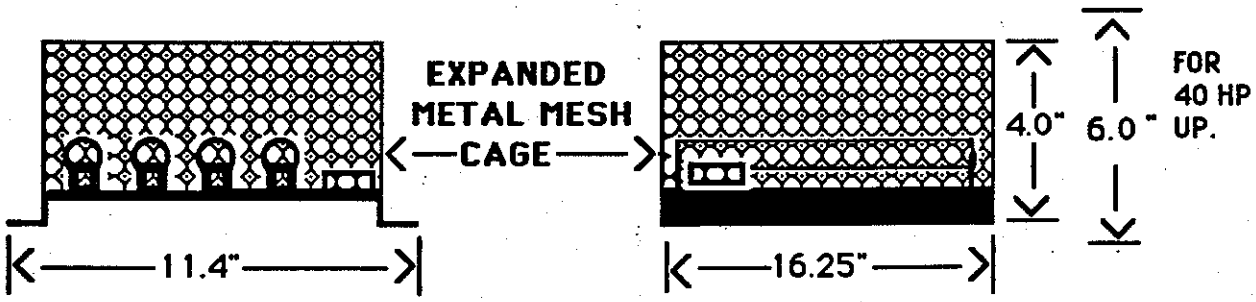


Note: Above dimensions do not include shunt regulator module.

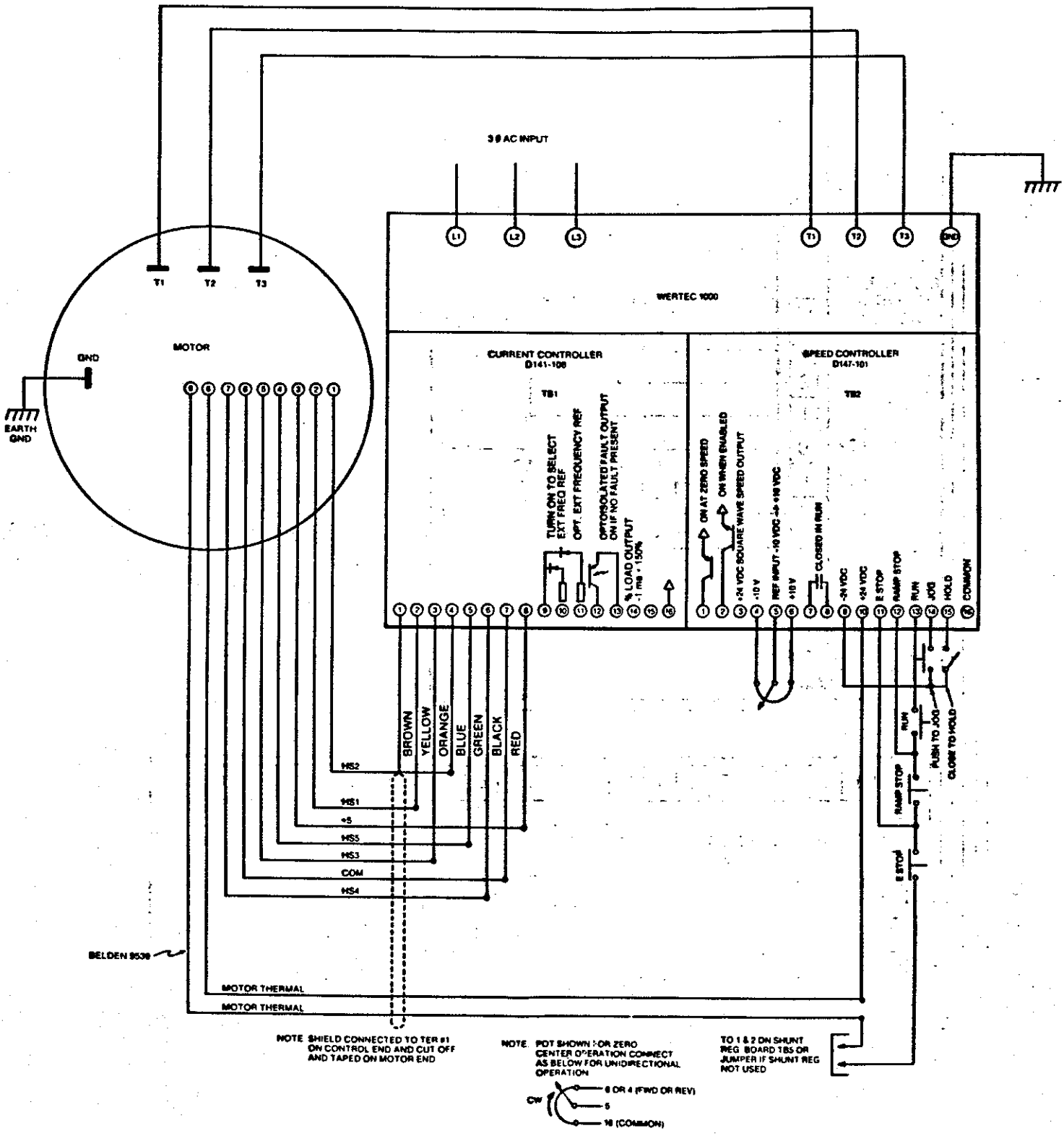
2.3B) Location and Mounting of Loading Resistor Assembly

This assembly is required for 3 HP and larger drives and when the Regenerative duty cycle exceeds ten percent (10%).

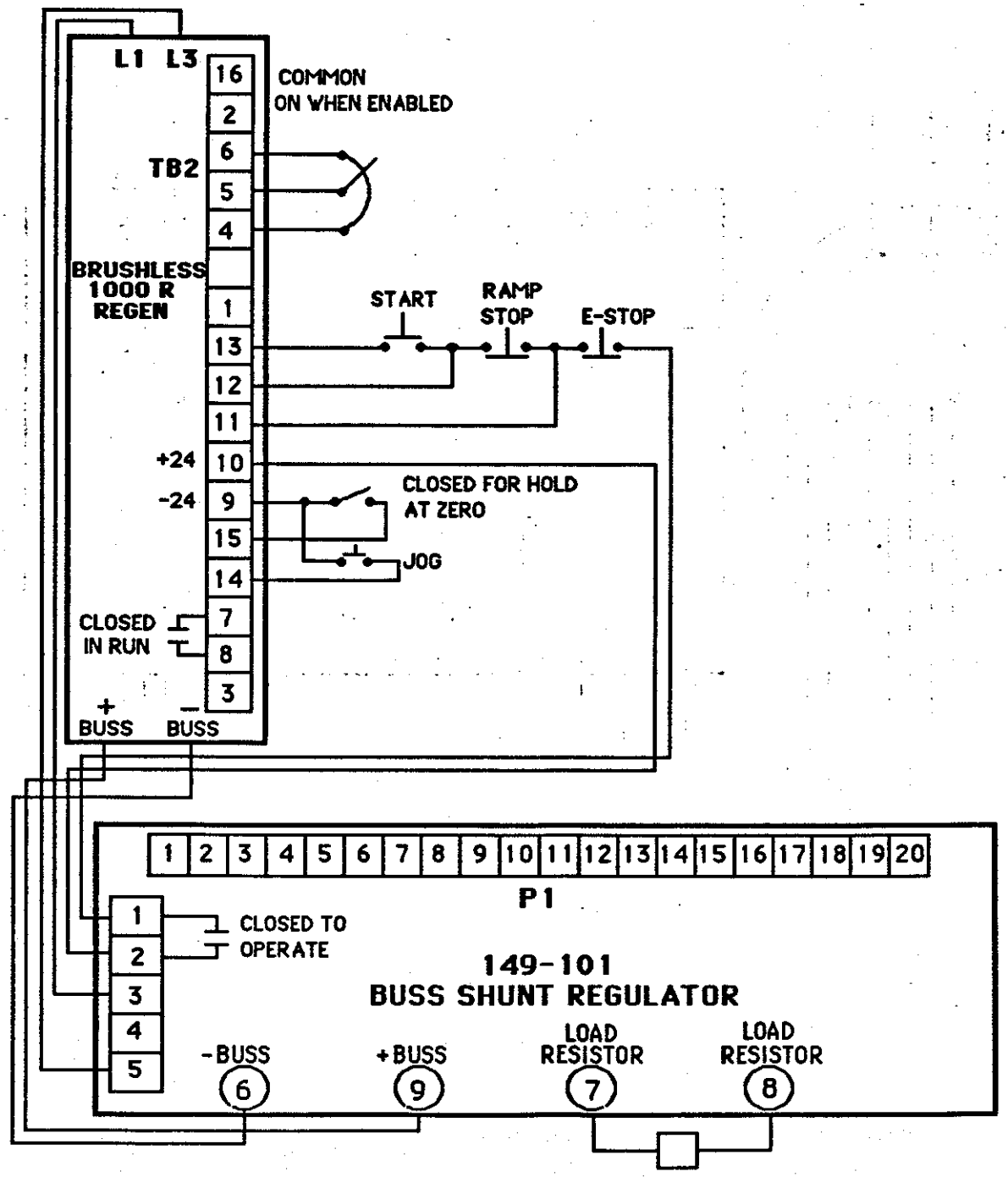




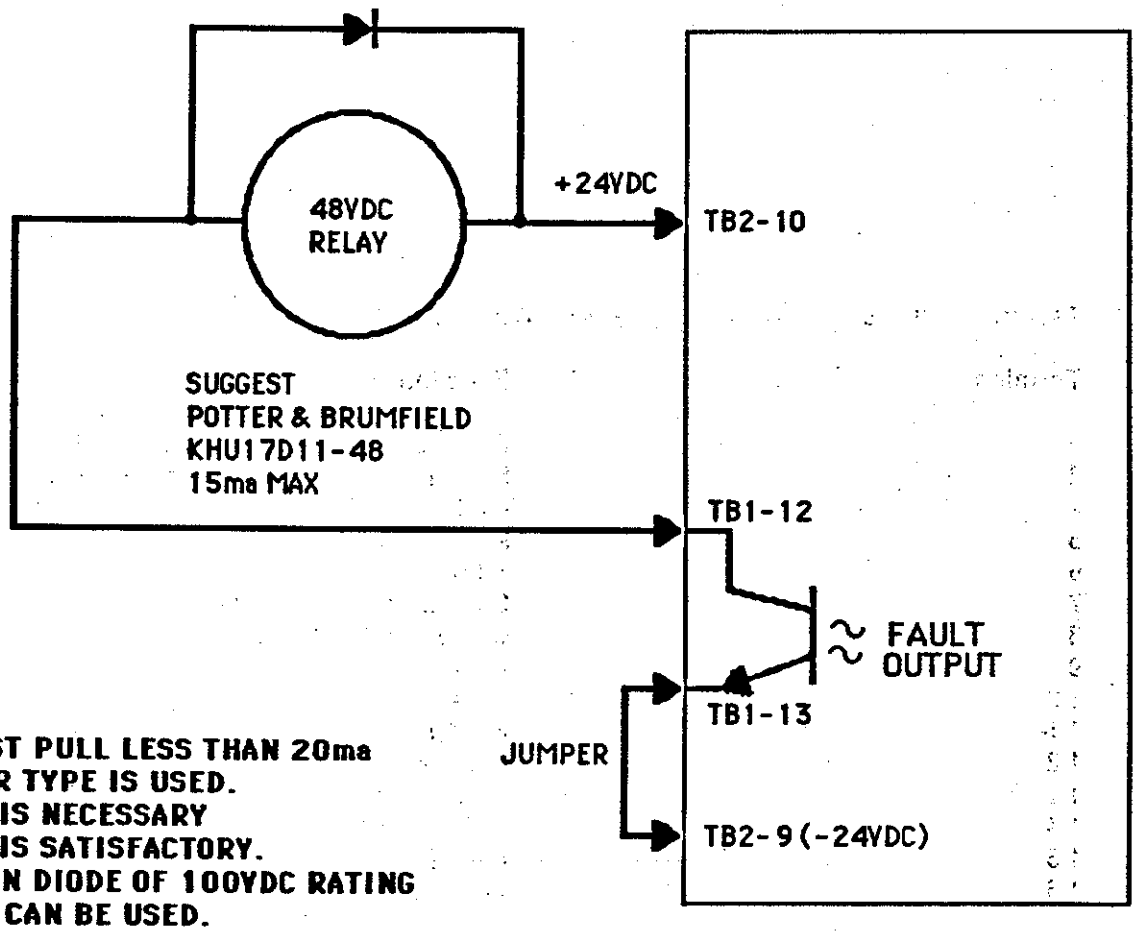
Item No. 2.4 Wiring — Regenerative



2.4A) Wiring for Regenerative Shunt Regulator



WIRING INSTRUCTIONS FOR A FAULT RELAY



NOTES:

1. RELAY MUST PULL LESS THAN 20ma IF ANOTHER TYPE IS USED.
2. DIODE "D" IS NECESSARY A 1N4001 IS SATISFACTORY. ANY SILICON DIODE OF 100VDC RATING OR HIGHER CAN BE USED.

2.5 Terminal Description TB1 (Current Controller)

Terminal	Function
1	Shield for hall sensors
2	HS1 } Position
3	HS2 } Position
4	HS3 } Position
5	HS4 } Speed
6	HS5 } Speed
7	Hall Sensor Common
8	+ 5V Supply to Hall Sensors
9	Common LED for 10 & 11
10	Auto/Manual Select
11	Auto Reference Pulse Input
12	Opto-Isolated Fault (collector)
13	Output Transistor ON if no fault present (emitter)
14	% LOAD OUTPUT, 2V or 1ma = 150% Full Load
15	Spare
16	COMMON

Terminal Description TB2 (Speed Controller)

Terminal	Function
1	On at zero speed (open collector to common)
2	On when enabled (open collector to common)
3	Speed output (120 pulses per revolution)
4	-10
5	Reference input -10v to +10v
6	+10
7	Customer run contacts
8	Customer run contacts
9	-24
10	+24
11	E Stop
12	Ramp Stop
13	Run
14	Jog (connect to 9 for jog function)
15	Hold (connect to 9 for hold function)
16	Common

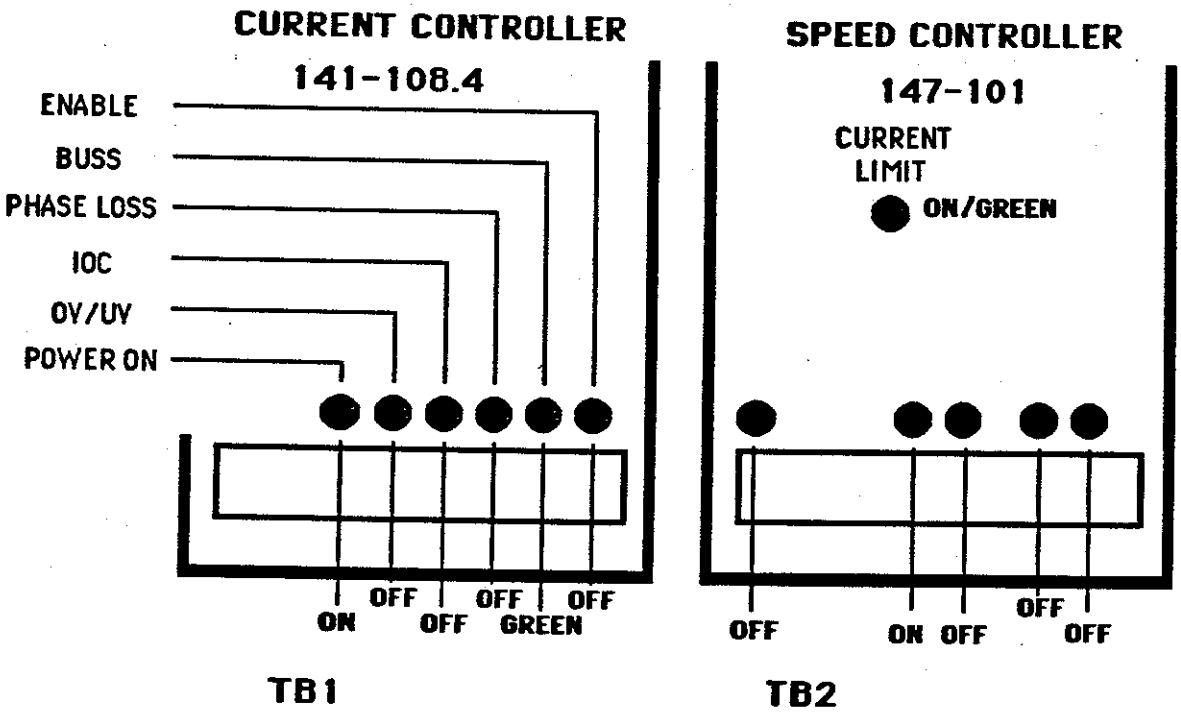
3.0 Start-up

3.1 Preliminary checks

A. Before applying AC power, measure the incoming voltage and verify that it is the same as listed on the name plate of the control.
B. With an ohmmeter make sure that none of the wires connected to the drive are shorted to ground. Note that drive common may be connected to ground if desired.
C. Check T1, T2, T3 leads to the motor to insure that there are no shorts or grounds.
D. Be sure that the cabinet is earth grounded. A ground terminal is provided in the upper right hand side of the control and is labeled GND.
E. Before the AC power is applied caution must be used so that personal injury or equipment damage will not occur if the motor runs away or turns backwards.
F. Recheck the wiring.

3.2 Turn On

Before pushing the run button, turn both the "Current Limit" pots full counter clockwise. Insure that the LED indicators are lit as follows:



If the indicators are different refer to the trouble shooting guide.
Push the RUN button and advance the SPEED POT approximately a 1/4 turn. The following lights should come ON: ENABLE, RUN, CURRENT LIMIT, AND REGEN. Slowly turn the "MCL" CURRENT LIMIT POT clockwise until motor turns. If it runs in the correct direction, continue. If the motor runs in the wrong direction, and the operator station has a direction switch; reverse the switch. If no reverse switch is installed, refer to wiring diagram to change pot polarity. Do not reverse the motor power leads T1, T2, or T3 to change rotation. These leads must be connected as shown in Item No.2.4 -Wiring, otherwise the correct commutation relationship between rotor position and the stator flux will be altered. Turn both CURRENT LIMIT POTS back to 100% clockwise, start the motor, and proceed to adjustments (Item 3.3).
Caution: If the shaft does not turn with 100% current, turn off immediately and refer to section 5.0.

3.3 Adjustments

Gain: Turn clockwise to increase shaft stiffness.

Stability: If motor is unstable or hunts, turn clockwise until motor is stable. Try 50%.

Motoring and Regen Current Limit: To increase current, turn pot clockwise. Maximum counter clockwise rotation will result in 0% current limit. Normally set to 100% clockwise.

Acceleration: Adjust ACCEL POT until desired acceleration rate is obtained. Turning pot counter clockwise increases the acceleration time.

Deceleration: Adjust the DECEL POT until the desired deceleration rate is obtained. Counter clockwise rotation increases the deceleration time.

Jog Speed: With control in the jog mode, adjust the JOG SPEED to the desired level (0-30%). Clockwise rotation increases speed.

Max. Speed: With SPEED POT full counter clockwise, adjust MAX. SPEED until desired maximum speed is obtained. Turning pot clockwise increases the max. speed. **Caution:** The maximum speed should not be adjusted higher than 10% above the nameplate rating of motor.

4.0 THEORY OF OPERATION

The WERTEC Brushless DC Motor operates the same as a normal DC Brush type motor with the following differences:

A. The field is stationary on the DC Brush motor, whereas the field of the brushless motor is caused to rotate by sequentially switching (commutating) current from one lead to the next of the stationary armature.

B. The commutation in the Brushless motor is done by transistors which are turned on and off by Hall sensors. These sensors monitor the rotor position. Figure (2) shows the relationship between the position of the Hall sensors and the sequencing of the transistors.

C. As in the DC motor, the speed of our Brushless DC motor is directly proportional to the applied voltage and the torque is directly proportional to current. The voltage to the motor is varied by pulse width modulation at transistors 4, 5, and 6. At 50% speed, this modulation is shown in Figure (3) for the period from 360 to 720 Electrical Degrees.

The Control Electronics for the Brushless 1000 is contained on 4 circuit boards as described below:

A. CAPACITOR CARD D141-106 has the following circuits:

1. Filter capacitors C1-C8 for the DC voltage
2. Relay CR2 to short out the Buss charging resistor R37 when the Buss voltage reaches 256 or 520 volts.
3. Fault detection circuit for Buss over voltage, Buss under voltage, and excessive Buss ripple voltage.
4. DC Buss current monitor consisting of Inductor 1 and two Hall sensors (HS). The voltage output from the hall sensors is standardized, using the Horsepower (which is mounted on C141-106) select resistor, so that + 5V out is equal to 200% motor current. The resistor value is calculated by the formula below.
   RCAL(K) = 100 /motor current (Avg.)
   The resistor is located on Terminals 1 and 3 at the bottom of the terminal strip mounted on the capacitor board.

B. DRIVER CARD D141-105 provides the optical isolation between the control electronics and the power bridge. There are LED's on the board that indicate when the transistors are turned on and for troubleshooting the unit.

C. If the drive is a stand-alone drive, it must have the shunt regulator package. This deals with regenerated buss energy when there is no way to connect busses between multiple drives.

C. CURRENT CONTROLLER D141-108 regulates the current in the motor and decodes the signals from the position of the Hall Sensors to provide the proper sequencing of the power transistors. The current command signal (from the velocity regulator) is summed with the actual motor current to develop an error signal which commands the pulse width modulation of the bottom transistors (4, 5, and 6) in the output bridge. The board also has the following LED indicators:

1. PWR (POWER ON LED) - When lit it indicates that the 3 phase input power is present on L1 and L3 and that the fuses FU1, FU3, and FU4 are not blown. The LED is powered by the 24V DC power supply.

2. RUN (DRIVE ENABLE LED) is on only when the current is allowed to flow thru the motor.

3. BUSS (CHARGE LED) is red for a low buss voltage condition and green for normal buss voltage conditions.

4. PHASE ADVANCE is an option for applications requiring constant HP above base speed.

   The following fault indicators are memorized and must be reset by pushing the stop button and restarting the drive.

5. IOC (INSTANTANEOUS OVER CURRENT LED) - This will trip whenever the motor current exceeds 300% of the rated motor current.

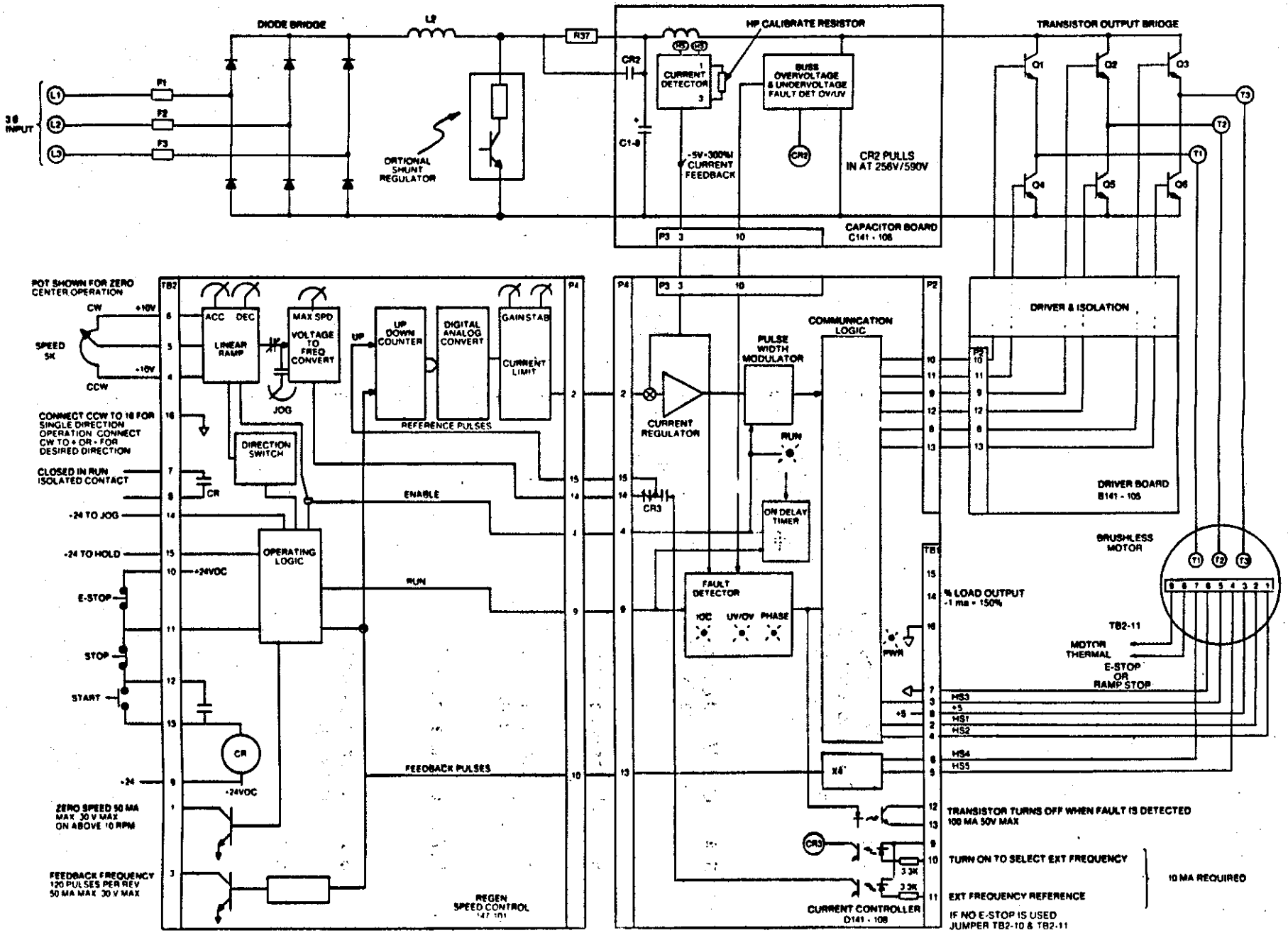
6. OV/UV (BUSS OVERVOLTAGE/UNDERVOLTAGE LED) - This will trip whenever the Buss voltage is outside the preset limits (See 1.3 specifications)which is usually the most common trip. However this indicator also monitors the capacitor bank ripple and will trip if the capacitor ripple is too high. High capacitor ripple could be caused by:
   a) An open diode BR1.
   b) A loss of one phase of incoming line.
   c) A blown fuse FU1, FU2 or FU3.
   d) An excessive motor current.

7. PH (PHASE LOSS LED) -This indicator lights up whenever there is a problem with the 24V power supply. Possible reasons for this could be:
   a) Loss of phase L2
   b) Blown fuse FU2.
   c) Failure of transformer T1.
   d) Power is lost for 1/2 cycle or more.

8. TACH LOSS is activated with the phase advance option. When a tach loss occurs the LED comes on and the control goes into a trip condition.

D. SPEED CONTROLLER D147-101 input is a 0 to $\pm$10 V reference on terminal 5 at TB2. This reference is connected to the linear ramp circuit which provides for a timed ramp on the output whenever the input signal is changed. The ramp rate is set by independent acceleration and deceleration rate control pots. A direct input jumper is provided to allow the ramp to be bypassed. The ramp output connects to a precision voltage controlled oscillator (VCO) which generates a frequency proportional to the input voltage. This frequency is the UP input to an UP/DOWN counter. As the counter counts up, the count is applied to a digital-to-analog converter whose output is the current reference to the current controller. As the current reference increases, the motor starts to turn until the frequency of the feedback pulses, which are applied to the down input of up/down counter, are exactly the same as the reference frequency. By using this digital comparison, the drive will provide 0 % regulation.
There is a clamp on the current reference voltage which is set by the current limit pot. There are also provisions for an external frequency reference to be used in place of the output from the

Item No. 4.1 Block Diagram — Regenerative



VCO for applications requiring digital set point or precise draw control. Hall effect commutation is changed to provide regen or motoring as detected by logic circuits in the drive.

5.0 Trouble Shooting

	Problem	Probable Cause	Corrective Action
5.1	FU1, FU2, or FU3 Fuses blow when AC power applied.	Shorted diode bridge BR1.	Replace bridge BR1.
5.2	FU1, FU2, or FU3 fuse blows when run is initiated.	Shorted Transistor in output bridge.	Replace transistor bridge and driver card.
5.3	OV/UV light comes on 30-40 sec after AC power is applied.	Charging Resistor R37 open. Cap C1-8 shorted or leaky. Line voltage too high or too low.	Replace. Replace. Check power source.
5.4	OV/UV light comes on while drive is running.	High or low input line voltage. Loss of a phase or open diode in diode bridge causing high ripple voltage on caps.	Check power source. Check FU1, FU2, FU3 and diode bridge.
5.5	Motor does not turn.	Problem with Hall sensor circuitry.	Check wiring and Hall sensor.
5.6	Motor does not run fast enough.	If current limit LED is on, motor is overloaded. Max speed set too low.	Reduce load or low line voltage. Readjust max speed.
5.7	Unstable speed.	Hp resistor is of a wrong value Gain/stability adjustment	Check value against chart. Adjust gain and stability.
5.8	Motor stops while running.	IOC,UV/OV or phase fault shut down.	Eliminate cause of trip.
5.9	Drive will not energize.	Stop/start wiring incorrect. Permissive contact in shunt regulator open.	Check wiring. Check for closed contact on shunt regulator TBS1-2.

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5.4	OV/UV light comes on while drive is running.	High or low input line voltage. Loss of a phase or open diode in diode bridge causing high ripple voltage on caps.	Check power source. Check FU1, FU2, FU3 and diode bridge.
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5.6	Motor does not run fast enough.	If current limit LED is on, motor is overloaded. Max speed set too low.	Reduce load or low line voltage. Readjust max speed.
5.7	Unstable speed.	Hp resistor is of a wrong value Gain/stability adjustment	Check value against chart. Adjust gain and stability.
5.8	Motor stops while running.	IOC,UV/OV or phase fault shut down.	Eliminate cause of trip.
5.9	Drive will not energize.	Stop/start wiring incorrect. Permissive contact in shunt regulator open.	Check wiring. Check for closed contact on shunt regulator TBS1-2.

6.0 Recommended Spare Parts

Quantity	Description	Part NO.
1	Current control PC board	141-108R
1	Speed control PC board	147-101
1	Driver Card	141-105
1	Capacitor card	141-106
3	Fuses FU1-FU3	See Chart
1	Fuse FU4	MDA8/10
1	Power transistor bridge	See Chart
1	Diode Bridge	See Chart
1	Transformer T1	141-004
1	Shunt regulator board	149-101

HP	Voltage	Diode	Transistor	Fuse
1	230	ME400803	KE724503	FLQ30
2	230	ME400803	KE724503	FLQ30
3	230	ME400803	KE724503	FLQ30
5	230	ME500806	KE924505	FLQ30
1	380	ME701203	KE721K03	FLQ30
2	380	ME701203	KE721K03	FLQ30
3	380	ME701203	KE721K03	FLQ30
5	380	ME701204	KD221K05	FLQ30
7.5	380	ME701204	KD221K05	FLQ30
1	460	ME701203	KE721K03	FLQ30
2	460	ME701203	KE721K03	FLQ30
3	460	ME701203	KE721K03	FLQ30
5	460	ME701203	KE721K03	FLQ30
7.5	460	ME701204	KD221K05	FLQ30
10	460	ME701204	KD221K05	FLQ30

SHUNT REGULATOR SPARES

HP	Voltage	Transistor
1-7.5	230	KS524505
1-10	460	KS221K05