EMERSON
Industrial Automation

Equipment Manual

FINCOR

Control Techniques
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Series 2330MKII

Single-Phase

Adjustable-Speed

DC Motor Controllers

(1/6 – 3 HP)

BOOK 0958-B

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BOOK 0958-B

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WARNING

The following must be strictly adhered to at all times.

1. YOU AS THE OWNER OR OPERATOR OF FINCOR EQUIPMENT HAVE THE RESPONSIBILITY TO HAVE THE USERS OF THIS EQUIPMENT TRAINED IN ITS OPERATIONS AND WARNED OF ANY POTENTIAL HAZARDS OF SERIOUS INJURY.

2. THE DRIVE EQUIPMENT SHOULD BE INSTALLED, OPERATED, ADJUSTED, AND SERVICED ONLY BY QUALIFIED PERSONNEL FAMILIAR WITH THE CONSTRUCTION AND OPERATION OF THE EQUIPMENT AND THE HAZARDS INVOLVED INCLUDING THOSE DESCRIBED BELOW. FAILURE TO OBSERVE THIS WARNING CAN RESULT IN PERSONAL INJURY, LOSS OF LIFE, AND PROPERTY DAMAGE.

3. THE NATIONAL ELECTRICAL CODE REQUIRES THAT AN AC LINE FUSED DISCONNECT OR CIRCUIT BREAKER BE PROVIDED IN THE AC INPUT POWER LINES TO THE CONTROLLER. THIS DISCONNECT MUST BE LOCATED WITHIN SIGHT OF THE CONTROLLER. DO NOT OPERATE THE CONTROLLER UNTIL THIS CODE REQUIREMENT HAS BEEN MET.

4. THE DRIVE EQUIPMENT IS AT AC LINE VOLTAGE WHENEVER AC POWER IS CONNECTED TO THE DRIVE EQUIPMENT. CONTACT WITH AN ELECTRICAL CONDUCTOR INSIDE THE DRIVE EQUIPMENT OR AC LINE DISCONNECT CAN CAUSE ELECTRIC SHOCK RESULTING IN PERSONAL INJURY OR LOSS OF LIFE.

5. BE SURE ALL AC POWER IS DISCONNECTED FROM THE DRIVE EQUIPMENT BEFORE TOUCHING ANY COMPONENT, WIRING, TERMINAL, OR ELECTRICAL CONNECTION IN THE DRIVE EQUIPMENT.

6. ALWAYS WEAR SAFETY GLASSES WHEN WORKING ON THE DRIVE EQUIPMENT.

7. DO NOT REMOVE OR INSERT CIRCUIT BOARDS, WIRES, OR CABLES WHILE AC POWER IS APPLIED TO THE DRIVE EQUIPMENT. FAILURE TO OBSERVE THIS WARNING CAN CAUSE DRIVE DAMAGE AND / OR PERSONAL INJURY.

8. ALL DRIVE EQUIPMENT ENCLOSURES, MOTOR FRAMES, AND REMOTE OPERATOR STATIONS MUST BE CONNECTED TO AN UNBROKEN COMMON GROUND CONDUCTOR. AN UNBROKEN GROUNDING CONDUCTOR MUST BE RUN FROM THE COMMON GROUND CONDUCTOR TO A GROUNDING ELECTRODE BURIED IN THE EARTH OR ATTACHED TO A PLANT GROUND. REFER TO THE NATIONAL ELECTRICAL CODE AND LOCAL CODES FOR GROUNDING REQUIREMENTS.

9. THE ATMOSPHERE SURROUNDING THE DRIVE EQUIPMENT MUST BE FREE OF COMBUSTIVE VAPORS, CHEMICAL FUMES, OIL VAPOR, AND ELECTRICALLY CONDUCTIVE OR CORROSIVE MATERIALS.

10. SOLID-STATE DEVICES IN THE CONTROLLER CAN BE DESTROYED OR DAMAGED BY STATIC ELECTRICITY. THEREFORE, PERSONNEL WORKING NEAR THESE STATICSENSITIVE DEVICES MUST BE APPROPRIATELY GROUNDED.

SECTION I

GENERAL INFORMATION

INTRODUCTION

This manual contains installation, operation, and maintenance and repair instructions for Fincor Series 2330 MKII Single-Phase Adjustable-Speed DC Motor Controllers. A parts list, ratings and specifications, and drawings are also included.

GENERAL DESCRIPTION

Series 2330 MKII Controllers statically convert AC line power to regulated DC for adjustable-speed armature control of shunt-wound and permanent-magnet motors.

Series 2330 MKII Controllers comply with applicable standards established by the National Electrical Code and NEMA for motor and industrial control equipment. The controllers are Underwriters Laboratories Listed (File No. E184521) UL/cUL.

MODEL TYPES

TABLE 1. SERIES 2330 MKII MODEL MATRIX

	FUNCTION					CONFIGURATION		OPERATOR CONTROLS		POWER SOURCE[a] & HP RANGE	
MODEL	RUN STOP[b]	RUN-STOP-DB[c]	ARMATURE SWITCH REVERSE[b]	ARMATURE CONTACT AND DB[c]	ARMATURE CONTACT REVERSE AND DB[c]	OPEN CHASSIS	ENCLOSED	LOCAL INTEGRAL	REMOTE	115V	230V
2331 2335	X					X			X	1/6-1	1/3-2
2331P0	X						X		X		
2331P1	X						X	X			
2331P2			X				X	X			
2331A 2335A		X			X	X			X		
2331AP0		X			X		X		X		
2331AP3		X			X[d]		X	X			
2331B		X		X		X			X		
2311BP0		X		X			X		X		
2331BP1		X		X			X	X			
2332 2336	X					X			X	1/6-1	1/3-3
2332A 2336A		X			X	X			X		
2332B		X		X		X			X		

a. Units are reconnectable
b. No armature contactor
c. Includes armature contactor
d. Includes Forward/Reverse switch

MOTOR SELECTION

Series 2330MKII Controllers control the operation of general purpose DC motors designed for use with solid-state rectified power supplies. The motor may be shunt-wound, stabilized shunt-wound, or permanent magnet. For maximum efficiency, the motor should be rated for operation from a NEMA Code K power supply.

SECTION II

INSTALLATION

Before starting the installation, read this section thoroughly. In addition, a thorough review of the Ratings and Specifications (Section VI) is recommended. The following installation guidelines should be kept in mind when installing the controller.

INSTALLATION GUIDELINES

1. CONTROLLER MOUNTING - The controller may be mounted either vertically or horizontally. However, never mount the controller upside down, immediately beside or above heat generating equipment, or directly below water or steam pipes.

The controller must be mounted in a location free of vibration.

Multiple controllers may be mounted side by side, as close to each other as the mounting feet will allow.

The minimum clearance at the top and bottom of the controller may be as narrow as the conduit fittings allow.

2. ATMOSPHERE - The atmosphere surrounding the controller must be free of combustible vapors, chemical fumes, oil vapor, and electrically conductive or corrosive materials.

The air surrounding an enclosed controller must not exceed 40 degrees C (104 degrees F), and the air surrounding an open-chassis controller must not exceed 55 degrees C (131 degrees F). Minimum air temperature is 0 degree C (32 degrees F) for enclosed and open-chassis controllers.

3. CONTROLLER CONSTRUCTION - The controller base is made of die-cast aluminum with a powdered epoxy finish, and the cover is made of a die-cast aluminum alloy.

The controller enclosure is totally enclosed, non-ventilated, and complies with NEMA Type 4 and 12 standards. There is an oil resistant synthetic rubber gasket between the cover and base. Those models with integral operator controls include flexible boots to seal the switches, and a seal for the MOTOR SPEED potentiometer.

4. LINE SUPPLY - The controller should not be connected to a line supply capable of supplying more than 100,000 amperes short-circuit current. Short-circuit current can be limited by using an input supply transformer of 50 KVA or less, or by using correctly sized current limiting fuses in the supply line ahead of the controller. Do not use a transformer with less than the minimum transformer KVA listed in Table 8, page 31.

If rated line voltage is not available, a line transformer will be required. If the line supply comes directly from a transformer, place a circuit breaker or disconnect switch between the transformer secondary and the controller. If power is switched in the transformer primary, transients may be generated which can damage the controller. See Table 8 (page 31) for minimum transformer KVA.

Do not use power factor correction capacitors on the supply line to the controller.

A 20 Joule metal oxide varistor (MOV) is connected across the controller terminals. If higher energy transients are present on the line supply, additional transient suppression will be required to limit transients to 150% of peak line voltage.

When a 115 VAC line supply is used, connect the white (common) wire to Terminal L2 and connect the remaining (hot) wire to Terminal L1.

5. ISOLATION TRANSFORMER - While not required, an isolation transformer can provide the following advantages:

a. Reduce the risk of personal injury if high voltage drive circuits are accidentally touched.

b. Provide a barrier to externally generated AC supply transients. This can prevent controller damage from abnormal line occurrences.

c. Reduce the potential for damaging current if the motor armature, motor field, or motor wiring becomes grounded.

6. GROUNDING - Connect the green or bare (ground) wire of the line supply to the ground screw located near the top conduit entry hole in the controller base. Then ground the controller base by connecting the ground screw to earth ground.

The motor frame and operator control stations must also be grounded.

Personal injury may occur if the controller, motor, and operator stations are not properly grounded.

7. WIRING PRACTICES - The power wiring must be sized to comply with the National Electrical Code, CSA, or local codes. Refer to the controller data label for line and motor current ratings.

Do not use solid wire.

Signal wiring refers to wiring for potentiometers, tachometer generators, and transducers. Control wiring refers to wiring for operator controls, e.g., switches and pushbuttons. Signal and control wiring may be run in a common conduit, but not in the same conduit as the power wiring. In an enclosure, signal and control wiring must be kept separated from power wiring and only cross at a 90 degree angle to reduce electrical noise.

If shielded wire (such as Alpha 2422 - two conductor, 2423 - three conductor, 2424 - four conductor) is used for the signal and control wiring, connect the shields to chassis ground (ground screw on the controller base) and tape the opposite ends of the shields. Twisted cable is also suitable for signal and control wiring.

Two 3/4-14 NPT threaded holes are provided for conduit entry, one each in the top and bottom of the controller.

INSTALLING THE CONTROLLER

1. Remove the controller front cover (if used) by removing the four cover screws.

2. Check components in the controller for shipping damage. Report shipping damage to the carrier.

3. Check the controller and motor data labels to be sure the units are electrically compatible.

4. Be sure the controller has been calibrated correctly for the motor being used. Calibration is performed by changing the position of a Jumper J4 on the controller control board to comply with Table 2. To change the position of Jumper J4, pull the jumper from the control board and then push it onto the appropriate two pins on the board. For the location of J4, see Figure 20 (page 37).

TABLE 2. JUMPER J4 POSITION

JUMPER POSITION[a]	MOTOR ARMATURE CURRENT RATING (AMPERES)	
	2 HP Maximum	3 HP Maximum
100%	10	15
80%	8	12
60%	6	9
40%	4	6
20%	2	3

a. Select the position closest to the motor nameplate armature current rating.

5. Check the positions of Jumpers J1, J2, and J3 on the control board. For the locations of J1, J2, and J3, see Figure 20, page 37. For a 230 VAC line supply and a 180V armature motor, Jumper J1 must be in the 230V position, and Jumpers J2 and J3 must be in the 180V position. For a 115 VAC line supply and a 90V armature motor, J1 must be in the 115V position, and J2 and J3 must be in the 90V position. To change the position of J1, J2, or J3 pull the jumper from the control board and then push it onto the appropriate pins on the board.

NOTE: If Option 1001 (Armature Contactor, Unidirectional), 1004 (Armature Contactor, Reversing), or 1775 (Signal Interface) is to be installed in the controller, do not offset the five-position plug (supplied with the option) at Connector J1 on the control board. Do not confuse Connector J1 with Jumper J1. Refer to the Instruction Sheet (ISP0703, ISP0666, ISP0653, respectively) supplied with the option for connection instructions.

6. The controller may be surface mounted or panel mounted as shown in Figure 1, page 7. Mount the controller. Mounting dimensions are shown in Figure 2, page 8.

7. Conduit entry is made by punching out the knockout at the top or bottom of the controller base. To prevent component damage from knockout fragments, apply masking tape to the inside of the knockout before punching.

8. Connect the power wiring to Terminals L1, L2, A1 (+), A2 (-), F+ and F-. Be sure to observe Installation Guidelines 4 and 7 on pages 3 and 4. If half-wave shunt field voltage is desired, connect one of the motor shunt field leads to Terminal F/2 (see Table 12 on page 33).

NOTE: Low inductance motors require a full-wave field to prevent current instability.

9. If the controller contains any options that require external wiring, follow the wiring instructions in the instruction sheet supplied with the option.

10. If remote operator control wiring and/or signal wiring is required, connect the controller as shown in the appropriate connection diagram (Figures 3 through 18). Figures 3 through 11 show operator control connections, and Figures 12 through 18 show signal connections.

11. The controller can be programmed for various applications by throwing switches on dip switch SW3

TABLE 3. DIP SWITCH (SW3)

FACTORY DEFAULT SETTING IS ALL SWITCHES "ON"		
Switch Position		
1	**ON** **OFF**	Low voltage (3Vdc - 30Vdc) tachometer scaling High voltage (31 Vdc - 175Vdc) tachometer scaling.
2	**ON** **OFF**	Selects internal burden resistor for 4-20ma input. Selects 0 to 5V speed reference input or external burden resistor (i.e. 10 to 50ma)
3	**ON** **OFF**	Selects internal current (torque) reference pot. Selects use of an external current (torque) reference pot.
4	**ON** **OFF**	Selects Min Speed pot adjustment. Selects Offset adjustment (for 4-20ma input) with Min Speed pot.
5	**ON** **OFF**	Selects anti-restart mode. Prevents controller from restarting automatically after an AC line power interruption. Disables anti-restart mode. Used for line starting applications (jumper TB2:9 to TB2:8 to enable drive).

12. Install the controller cover, if used.

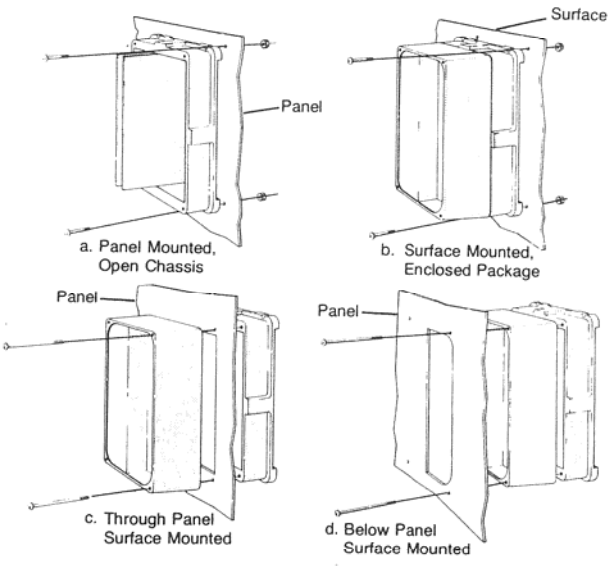


FIGURE 1. CONTROLLER MOUNTING CONFIGURATIONS

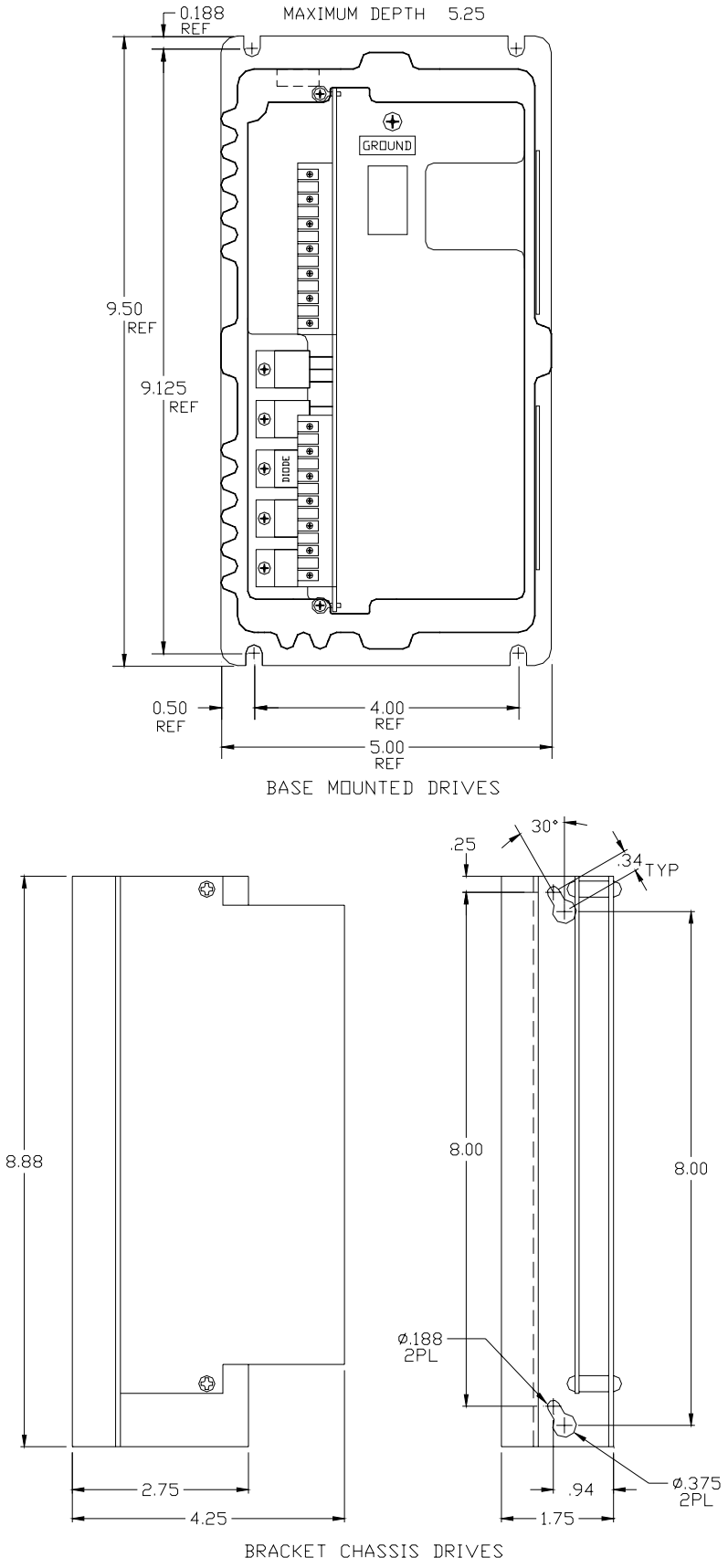


FIGURE 2. CONTROLLER MOUNTING DIMENSIONS

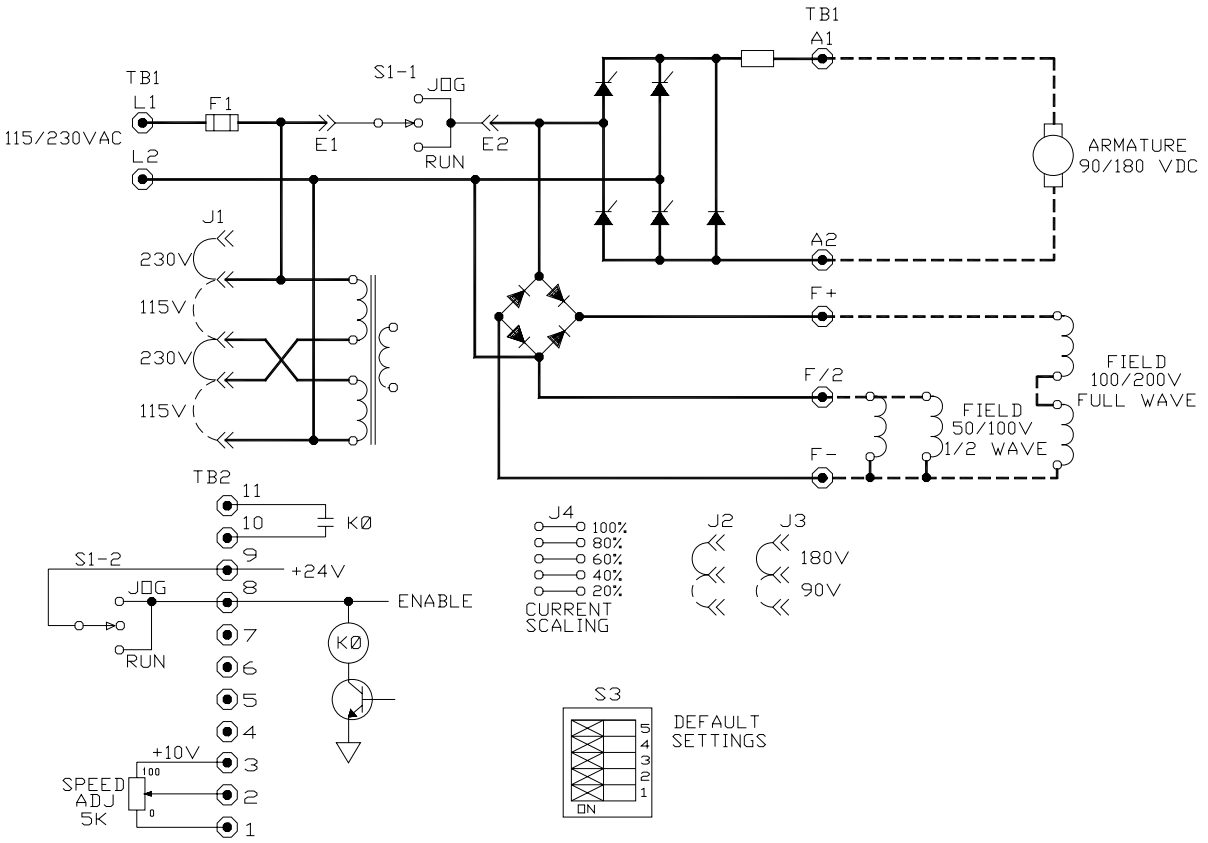


Figure 3. Logic connection diagram, Run-Stop-Jog Switch

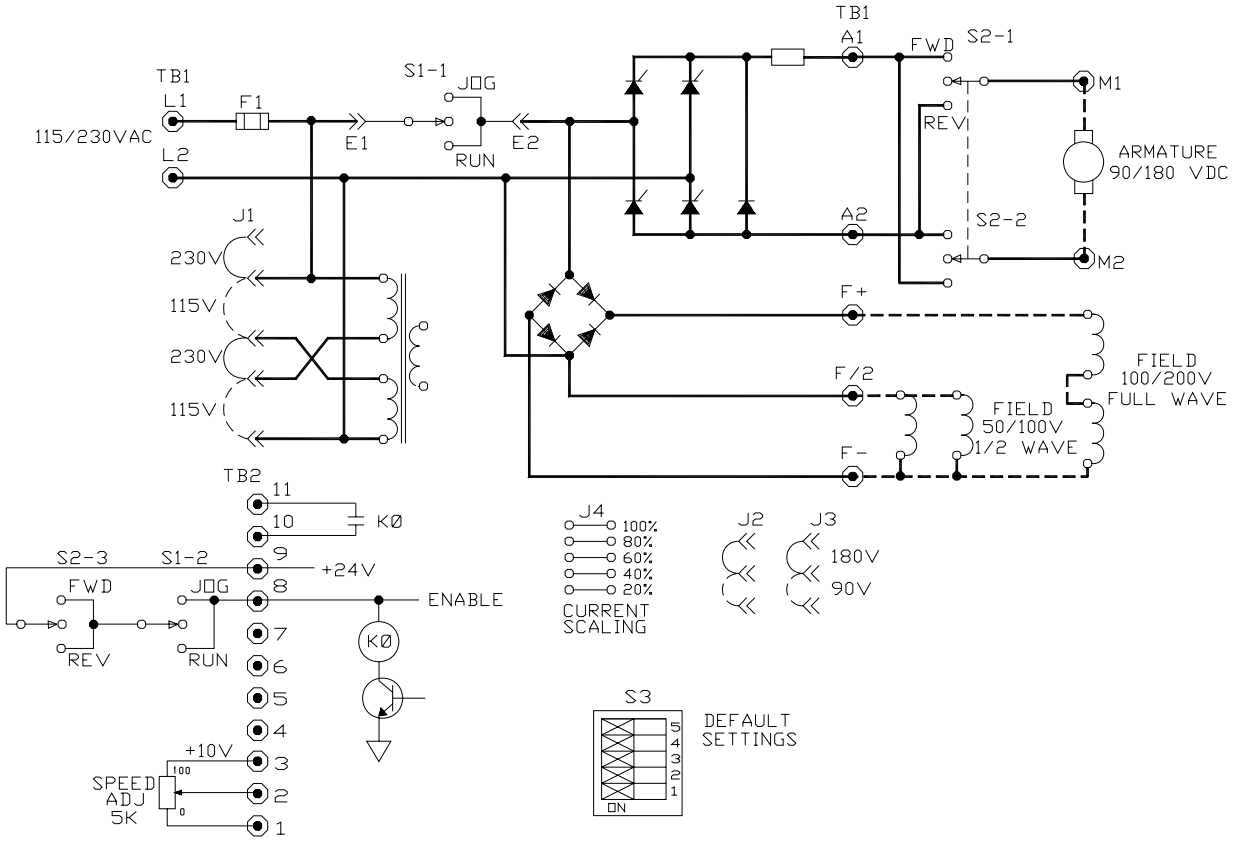


Figure 4. Logic connection diagram, Forward-Reverse Switch and Run-Stop-Jog Switch

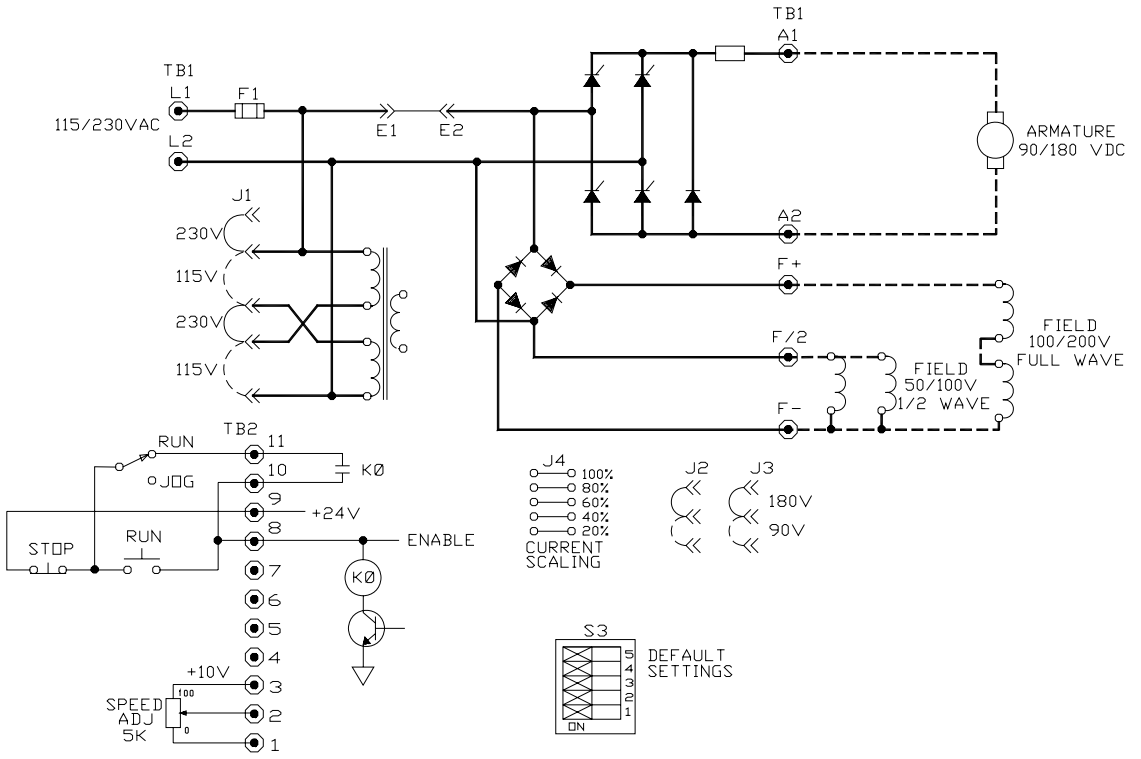


Figure 5. Logic connection diagram, Run-Stop Pushbuttons and Run-Jog Switch

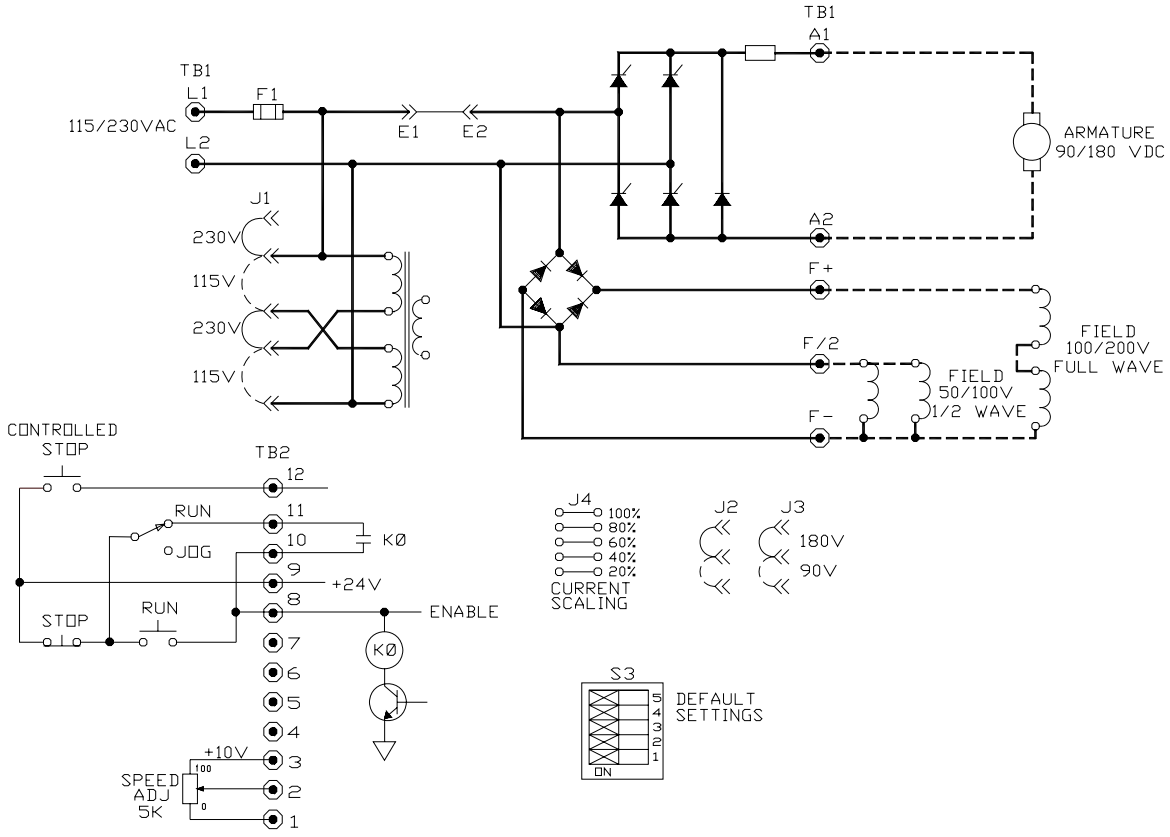


Figure 6. Logic connection diagram, Run-Stop-Controlled Stop Pushbuttons and Run-Jog Switch

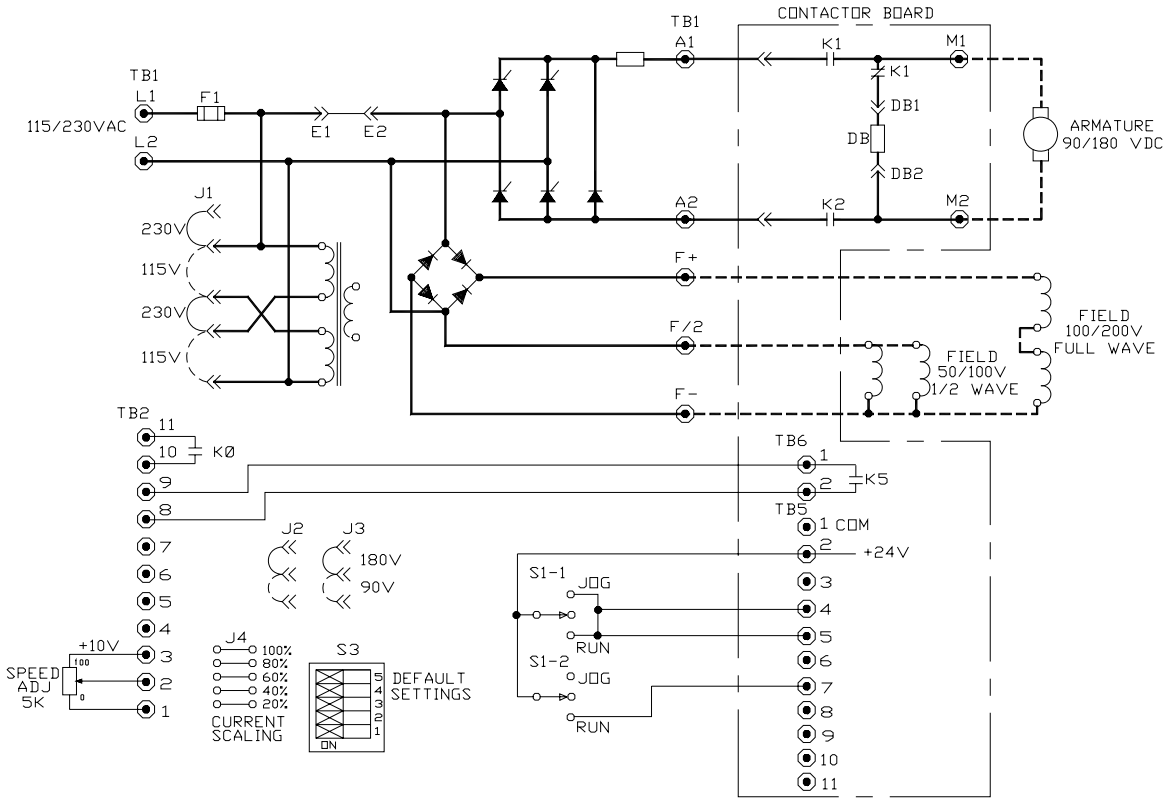


Figure 7. Logic connection diagram, Optional Unidirectional Contactor using Run-Jog Switch

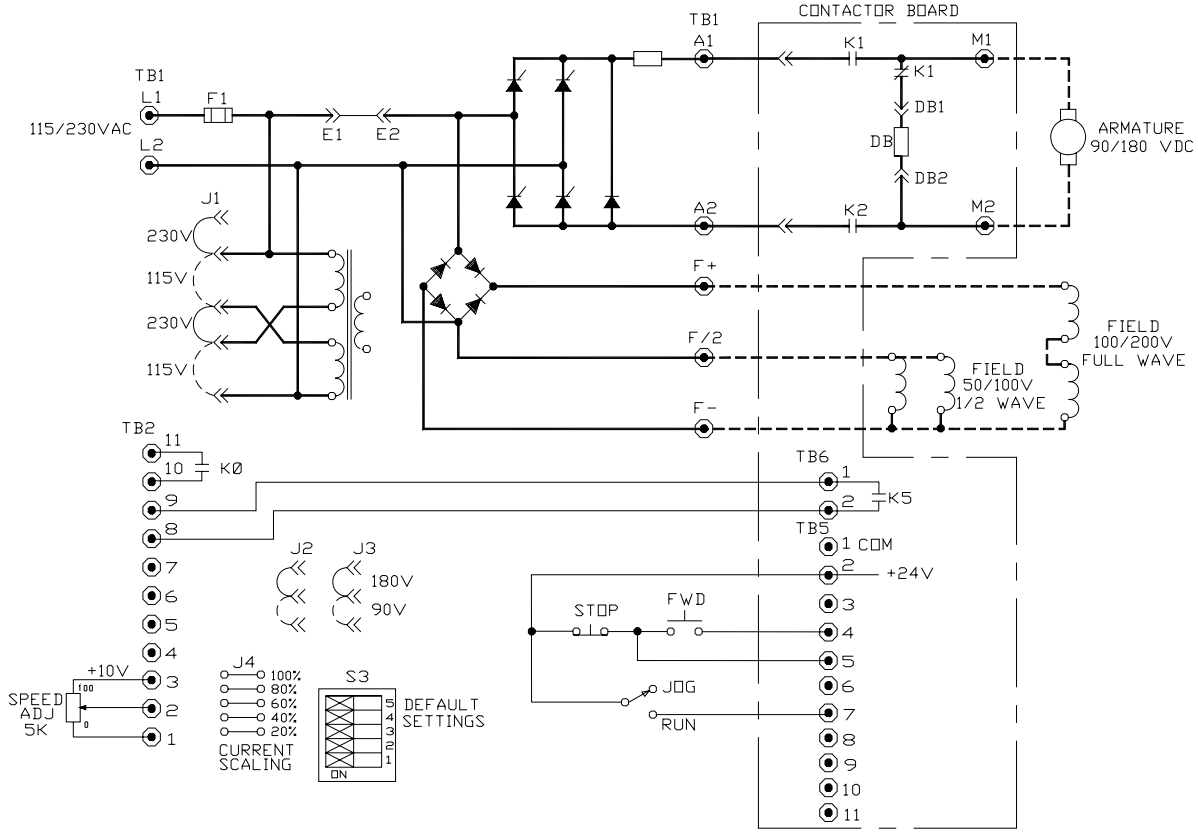


Figure 8. Logic connection diagram, Optional Unidirectional Contactor using Run-Stop Pushbuttons and Run-Jog Switch

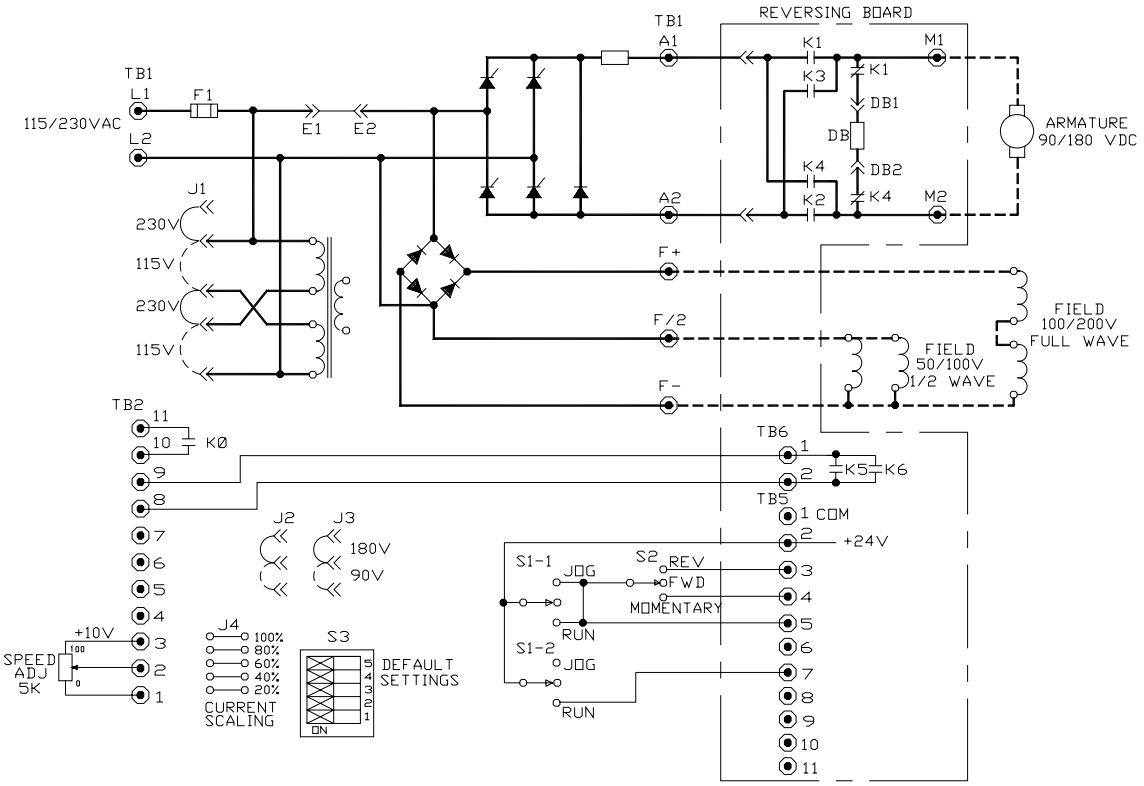


Figure 9. Logic connection diagram, Optional Armature Contactor Reversing using Switches

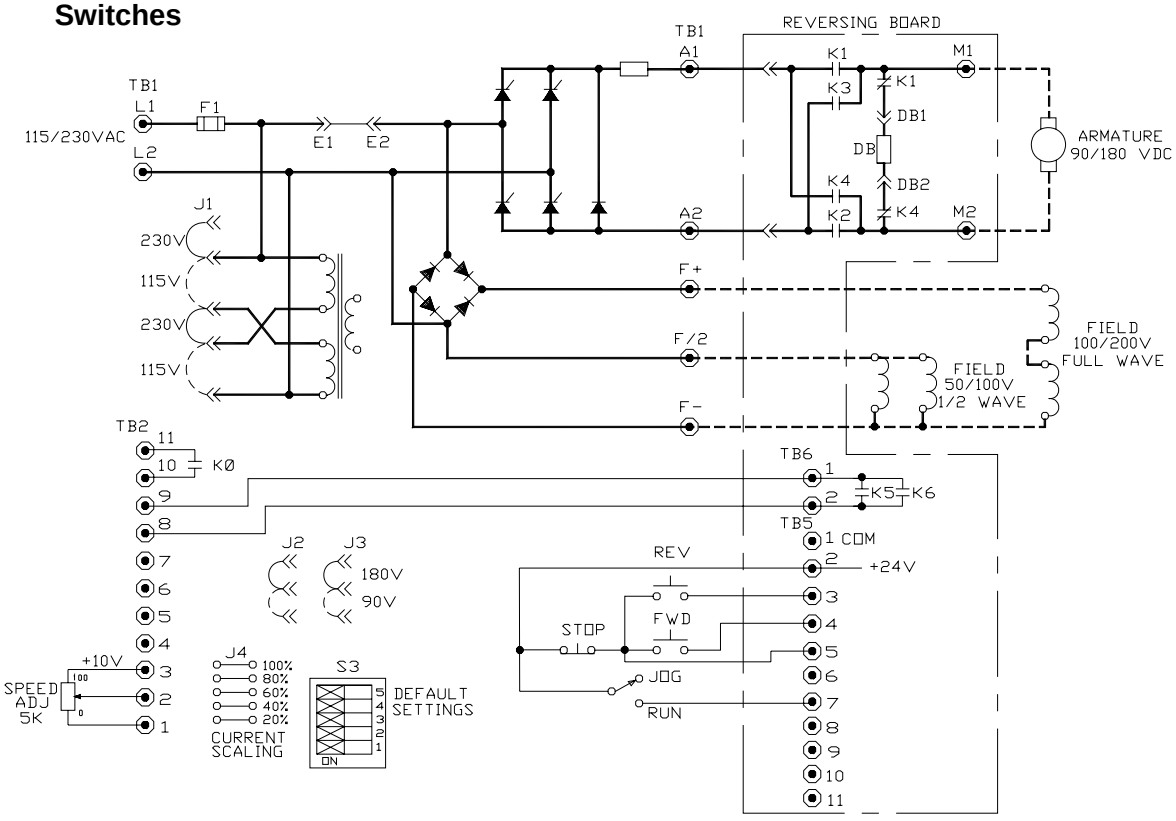


Figure 10. Logic connection diagram, Optional Armature Contactor Reversing using Pushbuttons and Run-Jog Switch

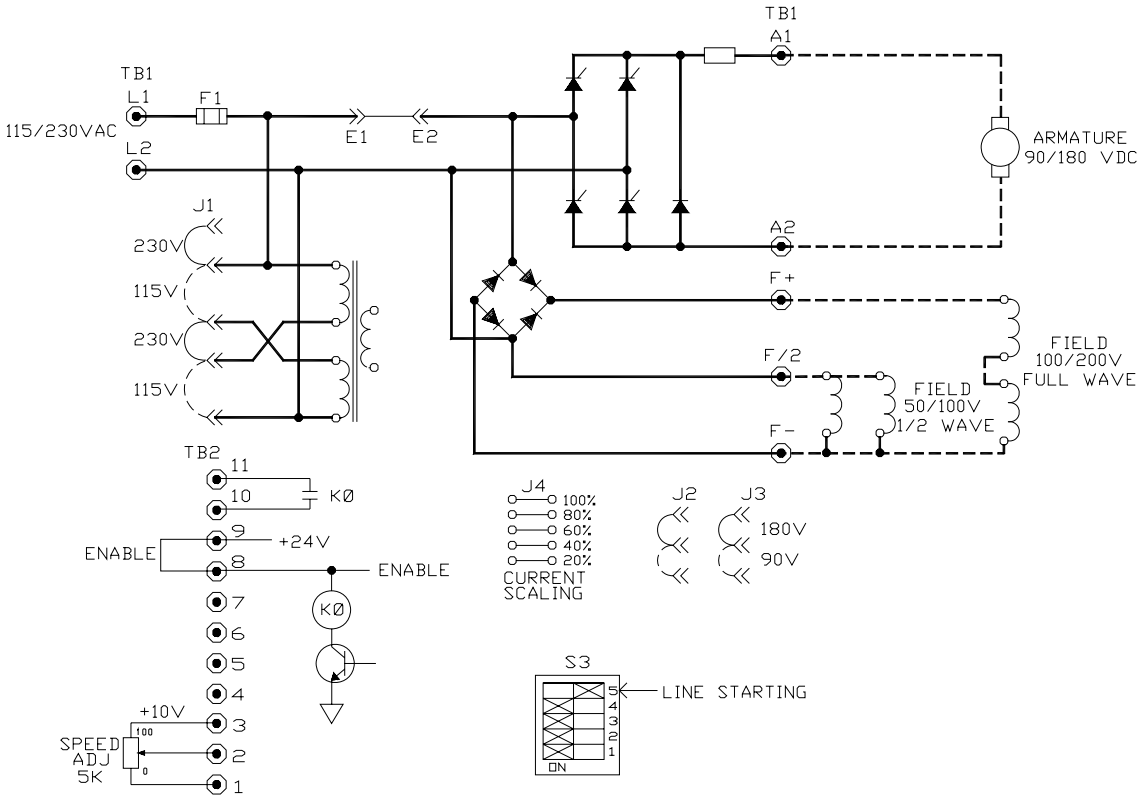


Figure 11. Logic connection diagram, Line Starting with Motor Speed Potentiometer

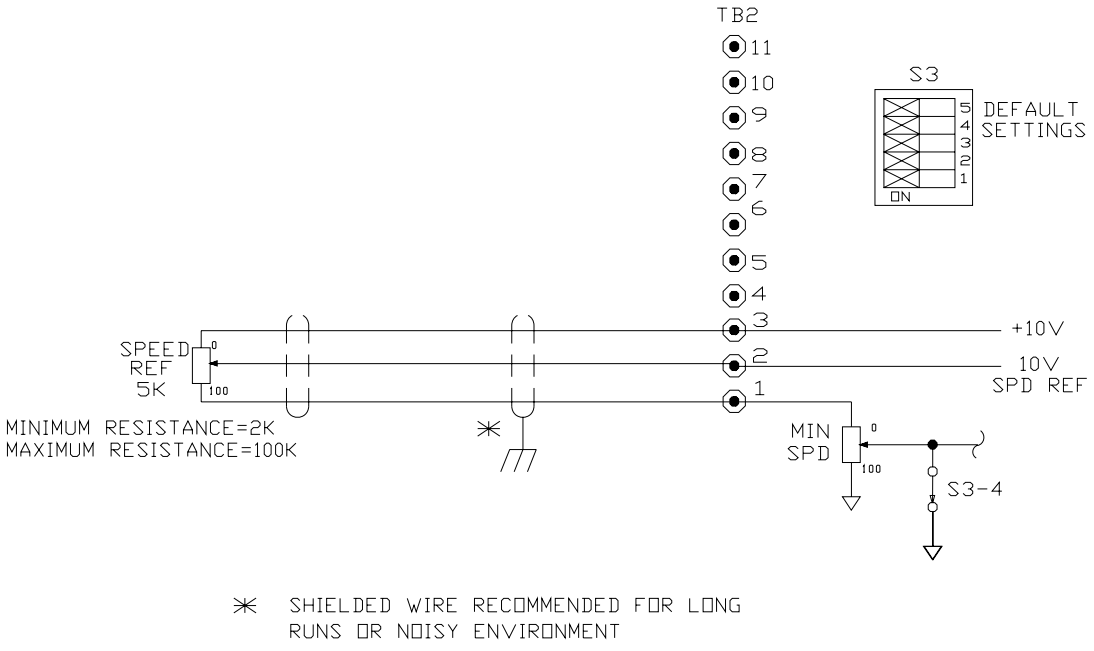


Figure 12. Signal Connection Diagram, Motor Speed Potentiometer

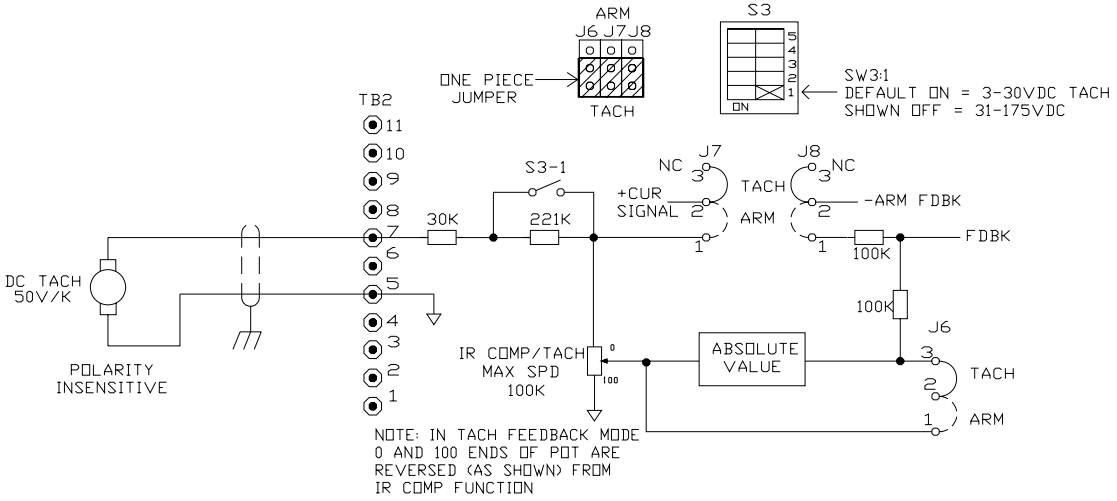


Figure 13. Signal Connection Diagram, Tachometer Feedback

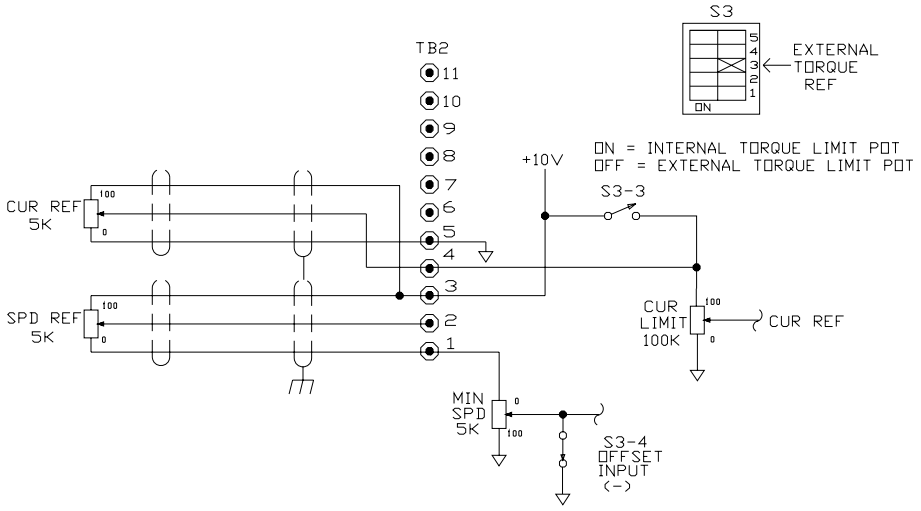


Figure 14. Signal Connection Diagram, Current (Torque) Reference Potentiometer

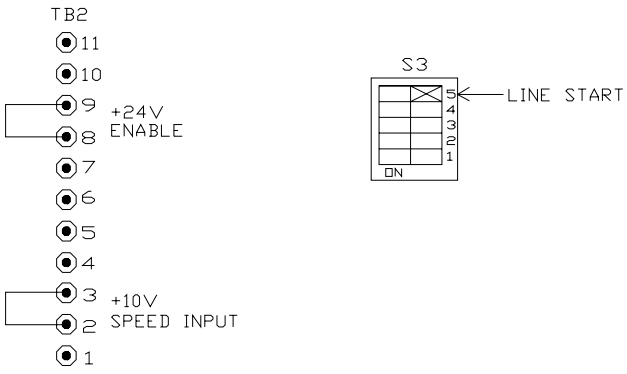


Figure 15. Signal Connection Diagram, Line Starting Without a Motor Speed Potentiometer

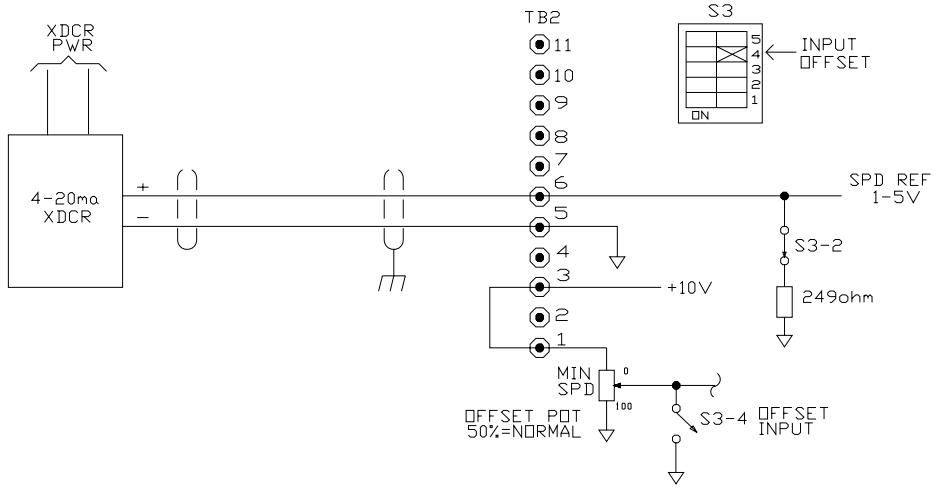


Figure 16. Signal Connection Diagram, 4-20mA Interface

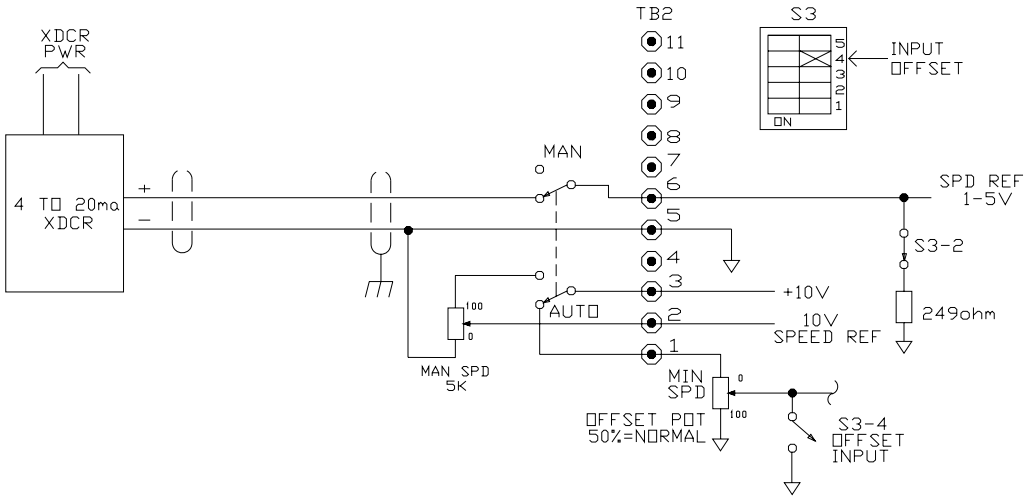
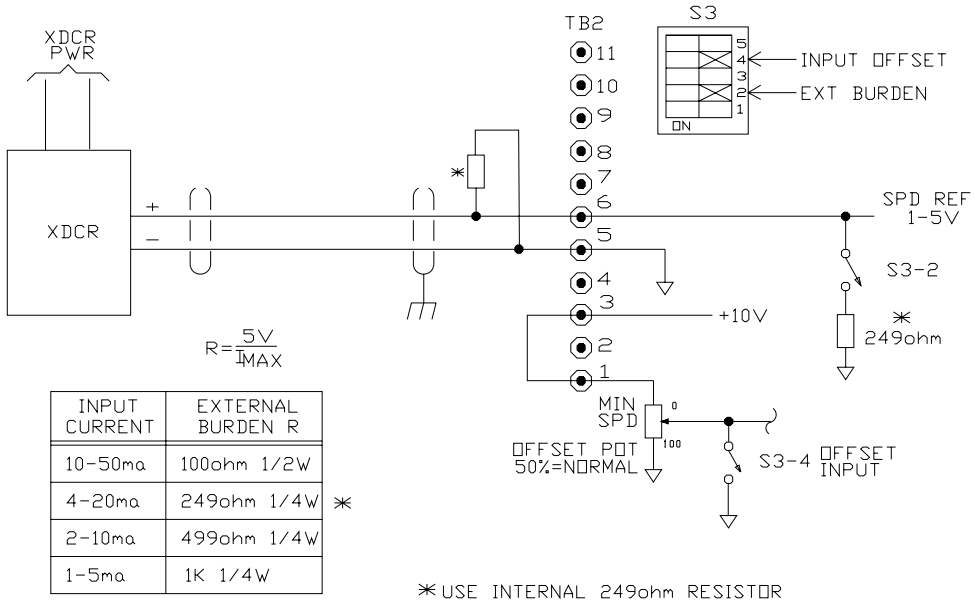


Figure 17. Signal Connection Diagram, 4-20mA Transducer with Manual/Auto Switch



INPUT CURRENT	EXTERNAL BURDEN R
10-50ma	100ohm 1/2W
4-20ma	249ohm 1/4W *
2-10ma	499ohm 1/4W
1-5ma	1K 1/4W

Figure 18. Signal Connection Diagram, Transducer with External Burden Resistor

INITIAL STARTUP

1. Open the controller cover (if used) by removing the four cover screws.

2. Be familiar with all options installed in the controller by reviewing the instruction sheets supplied with the options.

3. Be sure all wiring is correct and all wiring terminations are tightened securely.

4. Be sure the controller is calibrated correctly. See steps 4 and 5 under "Installing The Controller" on page 5.

5. Be sure the AC supply voltage to the controller agrees with the controller data label.

6. The potentiometers in the controller are factory adjusted as shown in Table 4. These settings will provide satisfactory operation for most applications. If different settings are required, refer to "Adjustment Instructions" starting on page 23 .

TABLE 4. INITIAL POTENTIOMETER SETTINGS

POTENTIOMETER	SETTING	DESCRIPTION
ACCEL	1/3 Turn Clockwise	10 Seconds
CUR LMT	Fully Clockwise (100%)	150% Load
DECEL	1/3 Turn Clockwise	10 Seconds
IR/TACH	Fully Counterclockwise (0%)	0% Boost
MAX SPD	3/4 Turn Clockwise	100% Speed
MIN SPD	Fully Counterclockwise (0%)	0% Speed

7. If the controller has a cover, place it on the controller and secure it with the four cover screws.

8. Turn-on the AC supply to the controller.

9. Check motor rotation, as follows:

   a. If a MOTOR SPEED potentiometer is used, turn it fully counterclockwise. If an external signal is used for the speed reference, set it at minimum.

   b. If a RUN-STOP-JOG switch is used, place it in RUN position. Otherwise, initiate a Run command.

   c. Turn the MOTOR SPEED potentiometer clockwise or increase the speed reference signal, as applicable. To stop the motor, place the switch in STOP position or initiate a Stop command, as applicable.

If the motor rotates in the wrong direction, turn-off the AC supply to the controller, and then interchange the motor armature leads at the motor connection box or at the controller terminal board.

10. Refer to Section III, "Operation" for operating instructions.

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SECTION III

OPERATION

POWER ON/OFF

To energize the drive, turn-on the AC supply voltage to the controller. When this occurs, the motor shunt field energizes with rated field voltage, and potentially hazardous voltage is present at the motor armature terminals. **These voltages can cause electric shock resulting in personal injury or loss of life.**

If the AC supply is interrupted, and the controller is not set up for line starting, the motor will not restart when the AC supply is restored until the controller is reset by initiating a Stop command and then a Start command. If the controller is set up for line starting, and the AC supply is interrupted, the motor will restart when the AC supply is restored, provided the external AC line contactor is pulled in.

RUN

If a RUN-STOP-JOG switch is used, place the switch in RUN position. Otherwise, initiate a Run command. A Run command will accelerate the motor to the setting of the MOTOR SPEED potentiometer or external speed reference signal, as applicable. The rate of acceleration is preset by the ACCEL potentiometer on the controller control board.

STOP

If a RUN-STOP-JOG switch is used, place the switch in STOP position. Otherwise, initiate a Stop command. A Stop command will stop the motor at a rate proportional to the stopping rate of the motor load.

If the controller has dynamic braking, the motor stopping time will be reduced. Dynamic braking provides exponential rate braking of the motor armature, which occurs when the circuit is opened between the controller and the motor armature, and one or more resistors connect across the motor armature.

The dynamic braking resistors provide initial braking torque and stops per minute as shown in Table 5.

TABLE 5. DYNAMIC BRAKING CHARACTERISTICS[a]

COMPONENT	MODEL	RATED VOLTAGE	RATED HORSEPOWER								
			1/6	1/4	1/3	1/2	3/4	1	1-1/2	2	3
BRAKING TORQUE (%)	2331 2335	115V	180	129	103	66	44	34	NA	NA	NA
		230V	NA	NA	400	278	190	130	88	62	NA
	2332 2336	115V	300	215	170	110	75	60	NA	NA	NA
		230V	NA	NA	NA	400	320	220	145	105	85
STOPS PER MINUTE	2331 2335	115V	15	12	11	8	6	2	NA	NA	NA
		230V	NA	NA	12	8	6	1	1	1	NA
	2332 2336	115V	9	6	5	5	4	4	NA	NA	NA
		230V	NA	NA	NA	5	4	4	3	3	2

a. HIGH INERTIA LOADS MAY EXTEND BRAKING TIME AND CAUSE THE WATTAGE RATING OF THE DYNAMIC BRAKING RESISTORS TO BE EXCEEDED.

An antiplug feature is included with optional Armature Contactor Reversing With Dynamic Braking (Option 1004). This feature prevents restarting the motor before the motor has braked to a stop.

SPEED CONTROL

Motor speed is directly proportional to the setting of the MOTOR SPEED potentiometer or the magnitude of an external speed reference signal, as applicable. This potentiometer or the speed reference signal may be adjusted while the motor is running or may be preset before the motor is started.

The rates of acceleration and deceleration are preset by the ACCEL and DECEL potentiometers, respectively, located on the controller control board.

Maximum speed and minimum speed are preset by the MAX SPD and MIN SPD potentiometers, respectively, located on the control board.

TORQUE CONTROL

Motor torque is directly proportional to the setting of the CURRENT LIMIT potentiometer or the magnitude of an external torque reference signal, as selected by dip switch SW3, position 3. This potentiometer or the current reference signal may be adjusted while the motor is running or may be preset before the motor is started. Note that if the process demands less torque then the torque reference is commanding, motor speed will continue to increase up to maximum speed.

JOG

If a RUN-STOP-JOG switch is used, place the switch in JOG position. Otherwise initiate a Jog command. Jog is momentary, causing motor rotation only while the switch is held in JOG position or while a Jog command is active. Release the switch to stop the motor.

Normally, jog speed is directly proportional to the setting of the MOTOR SPEED potentiometer. If a separate JOG SPEED potentiometer is used, jog speed will be directly proportional to the setting of the JOG SPEED potentiometer.

REVERSE

To reverse motor rotation on controllers with reversing capabilities, initiate a Stop function and then initiate a reversing command. The motor will then accelerate to the setting of the MOTOR SPEED potentiometer or external speed reference signal, as applicable. Forward and reverse speed ranges are identical.

If a FWD-REV switch is used, it must have a center position interlock, which requires a momentary relaxation of pressure before the opposite position can be engaged. The center position causes a Stop command and allows time for the motor to stop before a Reverse command is initiated. If a Reverse command is initiated while the motor is rotating, motor and controller damage may occur.

If Option 1004 (Armature Contactor Reversing With Dynamic Braking) is installed, an antiplug feature prevents reversing the motor before the motor has stopped.

LOAD MONITOR

UL approved as a motor protection device. The threshold for inverse timed overload will not exceed 120% of rated current and will shut down the drive (drop out K0) in about 60 seconds at 150% load current. The drive may be reset by cycling the enable line, or cycling input line power. Note that the timing capacitor is not reset by this, and that if the drive is immediately restarted into an overload, it will not take the full time to trip.

CURRENT LOOP TRANSDUCERS

Several onboard features allow easy interfacing to 4-20mA type transducers as well as other current ranges with appropriate external burden resistors. When SW3 position 2 is closed, an internal 249Ω resistor converts 4-20mA to a 1-5V input, and SW3 position 4 in the closed position converts the Min Speed Potentiometer to an Input Offset Potentiometer that allows precise nulling of the zero speed point.

INOPERATIVE MOTOR

If the motor stops and/or won't start, turn-off the AC supply to the controller, remove the controller cover (if used), and check the AC line fuse on the controller control board. For the location of the fuse, see Figure 23, page 37. If the fuse is blown, refer to the Troubleshooting Table (Table 6).

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SECTION IV

MAINTENANCE AND REPAIR

GENERAL

1. Keep the controller dry and free of dust, dirt, and debris. No parts require periodic replacement.

2. Periodically turn-off the AC line supply to the controller and check all wire terminations to be sure they are tight.

3. Visually check components for damage due to overheating or breakage. All damaged and/or faulty components must be replaced for satisfactory operation.

4. Maintain the motor according to maintenance instructions supplied by the motor manufacturer.

ADJUSTMENT INSTRUCTIONS

ACCELERATION

1. Set the MOTOR SPEED potentiometer at 100% or the external speed reference signal at maximum, as applicable.

2. Initiate a Run command and observe the time required for the motor to reach maximum speed.

3. Adjust the ACCEL potentiometer for the desired rate. Full counter clockwise rotation is the fastest acceleration (0.1 second), and full clockwise rotation is the slowest acceleration (30 seconds).

DECELERATION

1. With the motor running at maximum speed, quickly reset the MOTOR SPEED potentiometer to zero, or quickly decrease the speed reference signal to minimum, as applicable, and observe the time required for the motor to reach minimum speed.

2. Adjust the DECEL potentiometer for the desired rate. Full counter clockwise rotation is the fastest deceleration (0.1 second), and full clockwise rotation is the slowest deceleration (30 seconds).

IR COMPENSATION

IR compensation is used only for armature feedback. The IR/COMP potentiometer is factory set at zero (full counterclockwise rotation) for satisfactory operation with most motors. If improved speed regulation is desired, readjust IR compensation as follows:

1. If the motor is shunt-wound, run it at rated base speed. If the motor is a permanent-magnet type, run it at about 1/3 speed.

2. Turn the IR/COMP potentiometer clockwise *slowly* until motor speed becomes unstable.
Then turn the potentiometer counterclockwise until motor speed stabilizes.

MAXIMUM SPEED

The MAX SPD potentiometer is factory set to provide 90 VDC armature voltage with a 115 VAC line, or 180 VDC armature voltage with a 230 VAC line.

To readjust maximum speed, run the motor at maximum speed and adjust the MAX SPD potentiometer for the desired maximum speed.

NOTE: If the MAX SPD potentiometer is turned too far counterclockwise, speed instability may occur.

MINIMUM SPEED

1. Turn the MIN SPD potentiometer fully counterclockwise (0%) for zero speed.

2. Set the MOTOR SPEED potentiometer at 0% or the external speed reference signal at minimum, as applicable.

3. Initiate a Run command and adjust the MIN SPD potentiometer for the desired minimum speed (adjustable from 0 to 40% of motor base speed).

CURRENT LIMIT

1. Turn the CUR LMT potentiometer fully clockwise (100%) to limit motor armature current at 150% of rated.

2. Turn the CUR LMT potentiometer counterclockwise to reduce maximum motor armature current.

NOTE:An external 5K ohm Current (Torque) Limit potentiometer can be used as shown in Figure 14 on page 14. Dip switch SW3 position 3 must be in the OFF position if an external Current (Torque) Limit potentiometer is desired.

3. The GREEN power on LED indicator will change to RED whenever the controller is limiting (or regulating) current to the motor.

TACHOMETER FEEDBACK SETUP

1. Before connecting or configuring tachometer feedback, follow the instructions to install and perform initial startup, then run drive with maximum input speed reference and adjust the MAX SPEED potentiometer (R8b) for the desired maximum motor speed. Note that for best performance, this should be within +/-20% of the motor nameplate maximum speed or stability problems may occur.

2. Connect the tachometer wires to TB2:7 and 5 (polarity insensitive) and move the one piece jumper on J6, J7 and J8 from the ARM position to the TACH position. (Figure 20 on page 37)

3. Select the tachometer voltage scaling at max speed by dip switch SW3:1 as follows:

TACH VOLTAGE	SW3:1
8Vdc - 30Vdc	ON
31Vdc - 175 Vdc	OFF

4. Adjust the IR/TACH MAX SPEED potentiometer fully clockwise, this will provide minimum speed with tach feedback.

5. Run the motor with maximum speed reference and start adjusting the IR/TACH MAX SPEED potentiometer counterclockwise until motor speed increases to the desired maximum speed with tach feedback. Note that if the tachometer signal is lost, the drive will automatically revert back to armature feedback.

TROUBLESHOOTING

TABLE 6. TROUBLESHOOTING

INDICATION	POSSIBLE CAUSE	CORRECTIVE ACTION
1. Motor won't start (See "Inoperative Motor," page 21)	AC line open	Be sure rated AC line voltage is applied to the controller.
	Operator controls inoperative or connected incorrectly	Repair accordingly.
	Open circuit between Connectors E1 and E2	A wire jumper **or** switch must connect E1 to E2.
	Controller not reset	Initiate a Stop command and then a Start command.
	Line Voltage Selection Jumper J1 in wrong position	See Step 5 on page 5 under, "Installing The Controller."
	Controller not enabled	Be sure +24 VDC is applied to Terminal TB2 8.
	Loss of speed reference signal	Check for 0 - 10 VDC speed reference signal.
	Controller not adjusted correctly	Turn the ACCEL and CUR LMT potentiometers fully counterclockwise (100%).
	Open shunt field winding or wiring to the motor shunt field, causing loss of torque[a]	Check the motor shunt field and associated circuitry for a loose connection or a broken wire. Repair accordingly.
	Motor failure	Repair or replace the motor.
	Control board failure	Replace the control board.
2. Controller line fuse blows when AC line power is applied to the controller	Wiring faulty or incorrect	Check all external wiring terminating in the controller. Correct accordingly.
	Circuit, component, or wiring grounded	Remove ground fault.
	SCR1, SCR2, SCR3 or SCR4 shorted	Replace shorted SCR's or the control board.
	Bridge Diode D1b shorted	Replace shorted diode or the control board.
	Varistor RV1 shorted	Replace RV1 or the control board.
	Shunt Field Diode D39, D40, D41, or D42 shorted [a]	Replace shorted diode or the control board.
	Motor shunt field shorted or grounded[a]	Repair or replace the motor.
	Control board failure	Replace the control board.
Cont'd on next page		

TABLE 6. TROUBLESHOOTING

INDICATION	POSSIBLE CAUSE	CORRECTIVE ACTION
3. Controller line fuse blows when a Start command is initiated	One or more SCR's or Diode D1b shorted	Replace shorted devices or the control board.
	Motor shorted or grounded	Repair or replace the motor.
	Control board failure causing SCR's to turn-on fully	Replace the control board.
4. Controller line fuse blows while the motor is running	Motor overloaded	Check shunt field current.[a] Low shunt field current causes excessive armature current. If field current is adequate, check for a mechani cal overload. If the unloaded motor shaft does not rotate freely, check motor bearings. Also check for a shorted motor armature. Motor overload can also be caused by incorrect gear ratio. Correct accordingly.
	Loose or corroded connection. Wiring faulty, incorrect, or grounded	Check all terminals, connections, and wiring between the line, controller, and motor.
	Motor shorted or grounded	Repair or replace the motor.
	One or more SCR's or Diode D1b breaking down (shorting intermittently)	Replace faulty devices or the control board.
	Control board failure causing SCR false firing or misfiring	Replace the control board.
5. Minimum speed excessive	Minimum speed not adjusted correctly	Turn the MIN SPD potentiometer counter clockwise.
	Motor armature grounded	Correct ground fault.
	Control board failure	Replace the control board.
6. Maximum speed excessive	Maximum speed set too high	Turn the MAX SPD potentiometer counter clockwise.
	Controller not calibrated correctly	Refer to Steps 4 and 5 on page 5.
	Open shunt field winding or wiring to the motor shunt field[a]	Check the motor shunt field and associated circuitry for a loose connection or a broken wire. Repair accordingly.
	Motor field demagnetized[b]	Replace the motor.
Cont'd on next page		

TABLE 6. TROUBLESHOOTING

INDICATION	POSSIBLE CAUSE	CORRECTIVE ACTION
7. Motor won't reach top speed	Low line voltage	Check for rated line voltage, ±10%, on the controller line terminals.
	Motor overloaded	Check shunt field current.[a] Low shunt field current causes excessive armature current. If field current is adequate, check for a mechani cal overload. If the unloaded motor shaft does not rotate freely, check motor bearings. Also check for a shorted motor armature. Motor overload can also be caused by incorrect gear ratio. Correct accordingly.
	Maximum speed set too low	Turn the MAX SPD potentiometer clockwise.
	Current limit set too low	Turn the CUR LMT potentiometer clockwise.
	Current scaling jumper J4 in wrong position	See Step 4 and Table 2 on page 5.
	Motor field demagnetized[b]	Replace the motor.
	Control board failure	Replace the control board.
8. Unstable speed	AC line voltage fluctuating	Observe line voltage with a voltmeter or oscil loscope. If fluctuations occur, correct condi tion accordingly.
	Loose or corroded connection. Wiring faulty, incorrect, or grounded	Check all terminals, connections, and wiring between the line, operator controls, controller, and motor.
	Oscillating load connected to the motor	Stabilize the load. Turning the IR/TACH potentiometer counterclockwise may mini mize oscillations.
	Voltage Selection Jumpers J1, J2 or J3 in wrong position	See Step 5 on page 5 under, "Installing The Controller."
	IR compensation not adjusted cor-rectly	See the IR Compensation adjustment instruc tions on page 23.
	Maximum speed not adjusted correctly	See the Maximum Speed adjustment instruc tions on page 23.
	Motor faulty	Check motor brushes. Replace if needed. Repair or replace the motor.
	Tachometer generator or coupling faulty (if used)	Repair accordingly.
Cont'd on next page		

TABLE 6. TROUBLESHOOTING

INDICATION	POSSIBLE CAUSE	CORRECTIVE ACTION
9. Line and motor arma ture current excessive	Motor overloaded	Check shunt field current.[a] Low shunt field current causes excessive armature current. If field current is adequate, check for a mechani cal overload. If the unloaded motor shaft does not rotate freely, check motor bearings. Also check for a shorted motor armature. Motor overload can also be caused by incorrect gear ratio. Correct accordingly.
10. Shunt field current [a] too low	Open shunt field winding or wiring to the motor shunt field	Check the motor shunt field and associated circuitry for a loose connection or a broken wire. Repair accordingly.
	Shunt field connected for incorrect voltage	Check motor rating and refer to Table 12 on page 34.
	Diode D39, D40, D41, or D42 failure	Replace faulty diode or the control board.
11. Shunt field current [a] too high	Shunt field connected for incorrect voltage	Check motor rating and refer to Table 12 on page 34.
	Shunt field windings shorted	Measure the shunt field resistance and com pare with the motor rating. Repair or replace the motor.
12. Motor thermal guard tripped (if used)	Ventilation insufficient	Remove dirt, dust, and debris from the motor intake and exhaust screens.
	Excessive motor load at low speed	Reduce the load or increase the speed.
	Line and motor armature current excessive	See Indication 9.
	Motor overheating from friction	Check for misalignment. Realign the motor.
	Shorted motor windings or faulty bear-ings	Repair or replace the motor.

a. Does not apply to permanent-magnet motors.
b. Does not apply to shunt-wound motors.

SECTION V

PARTS LIST

TABLE 7. PARTS LIST, SERIES 2330 MKII CONTROLLERS

PART	RATING	FINCOR PART NUMBER	
		MODEL 2331 2335	MODEL 2332 2336
Control Board	NA	106703903	106703904
Diode D1b	15A, 600V	3303207	NA
	24A, 600V	NA	3303292
Fuse, Line, F1	30A, 600V (ATM-30)	3002396	3002396
SCR1, SCR2, SCR3, SCR4	15A, 600V	3302201	NA
	55A, 800V	NA	3302231

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SECTION VI

RATINGS AND SPECIFICATIONS

RATINGS

1. Duty ..... Continuous
2. Horsepower Range ..... 1/6 - 3 HP (See Table 1, Page 2)
3. Line Fuse Interrupting Capacity ..... 100,000 Amperes
4. Line Power ..... 115V or 230V, Single-Phase, 50 Or 60 Hz
5. Motor Speed Potentiometer ..... 5K Ohms, 1/2W
6. Overload Capacity, Armature Circuit ..... 150% For 1 Minute
7. Timed Overload Threshold 120%
8. Service Factor 1.0

TABLE 8. TYPICAL APPLICATION DATA

COMPONENT			RATINGS								
RATED HORSEPOWER (HP)			**1/6**	**1/4**	**1/3**	**1/2**	**3/4**	**1**	**1-1/2**	**2**	**3**
RATED KILOWATTS (kW)			**0.124**	**0.187**	**0.249**	**0.373**	**0.560**	**0.746**	**1.120**	**1.492**	**2.238**
1-PHASE AC INPUT (FULL-LOAD)	Line Amps	115V Unit	3.9	5.0	6.0	8.7	12.4	15.8	NA	NA	NA
		230V Unit	NA	NA	NA	4.2	5.9	8.8	12.6	15.8	22.0
	KVA		0.48	0.58	0.71	1.00	1.40	2.00	3.00	4.00	5.00
DC OUTPUT (FULL-LOAD)	Motor Armature Amps	90V	2.0	2.8	3.5	5.4	8.1	10.5	NA	NA	NA
		180V	NA	NA	NA	2.6	3.8	5.5	8.2	11.6	15.1
	Motor Field Amps (Maximum)	Model 2331 2335	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	NA
		Model 2332 2336	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
FULL-LOAD TORQUE (lb-ft) with 1750 RPM Base Speed Motors			0.5	0.75	1.0	1.5	2.2	3.0	4.5	6.0	9.0
MINIMUM TRANSFORMER KVA FOR VOLTAGE MATCHING OR ISOLATION			0.5	0.75	0.75	1.0	1.5	2.0	3.0	5.0	7.5

TABLE 9. OPERATING VOLTAGES AND SIGNALS

POWER SOURCE (Single-phase)	OUTPUT VDC		SPEED REFERENCE SIGNAL	MAGNETIC CONTROL VOLTAGE
	Armature	Field		
115V, 50 or 60 Hz	0 - 90	50/100	0 -5 Vdc 0 - 10 Vdc 4 - 20Ma	24 VDC
230V, 50 or 60 Hz	0 - 180	100/200		

TABLE 10. CONTROLLER WEIGHTS

CONTROLLER MODEL	WEIGHT - LBS (KG)	
Rated Horsepower (HP)	1/6 - 2	3
2331, 2332, 2336	3.25 (1.48)	
2331A, 2332A, 2336A	3.80 (1.75)	
2331P0, 2331P1, 2331P2	5.50 (2.50)	NA
2331AP0, 2331AP3	6.05 (2.75)	NA
2335	0.90 (0.42)	
2335A,	1.70 (0.77)	

OPERATING CONDITIONS

1. Altitude, Standard ..... 1000 Meters (3300 Feet) Maximum[1]
2. Ambient Temperature ..... 0 - 40°C (32°F - 104°F)[2]
3. Line Frequency Variation ..... ± 2 Hz Of Rated
4. Line Voltage Variation ..... ±10% Of Rated
5. Relative Humidity ..... 95% Noncondensing

PERFORMANCE CHARACTERISTICS

1. Controlled Speed Range ..... 0 To Motor Base Speed
2. Displacement Power Factor (Rated Speed/Rated Load) 87%
3. Efficiency (Rated Speed/Rated Load)
   a. Controller Only 98%
   b. Controller With Motor, Typical 85%
4. Speed Regulation ..... See Table 11

1. Controller can be derated by 1% per 100 meters to operate at higher altitudes.
2. 55°C (131°F) maximum in enclosed areas where open-chassis controllers are mounted.

Regulation percentages are of motor base speed under steady-state conditions

TABLE 11. SPEED REGULATION CHARACTERISTICS

REGULATION METHOD	VARIABLE				
	Load Change (95%)	Line Voltage (±10%)	Field Heating (Cold/Normal)	Temperature (±10°C)	Speed Range
Standard Voltage Feedback with IR Compensation	2%	±1 %	5 - 12%	±2%	50:1
Optional Speed (Tach) Feedback[a]	0.5%	±1 %	0.2%	±2%	200:1

a. Unidirectional models only.

ADJUSTMENTS

1. Acceleration, Linear ..... 0.1 - 30 Seconds
2. Deceleration, Linear ..... 0.1 - 30 Seconds
3. IR (Load) Compensation ..... 0 - 10% Boost
4. Jog Speed ..... 0 - 100% of Motor Base Speed
5. Maximum Speed ..... 50% - 100% of Motor Base Speed
6. Minimum Speed ..... 0 - 40% of Motor Base Speed
7. Torque (Current) Limit ..... 0 - 150% of Full-Load Torque

SPECIFICATIONS

1. AC LINE PROTECTION - A 100,000 ampere interrupting capacity AC line fuse provides instantaneous protection from peak loads and fault currents. This line fuse is located inside the controller.

2. AUXILIARY CONTACT - A normally-open Form A relay contact, rated .5 ampere @115 VAC and 2A at 30 VDC, is available for external use. The relay energizes when a Run command is initiated, and de-energizes when a Normal Stop command is initiated, the overload monitor trips, or the anti-restart circuit is activated.

3. FIELD SUPPLY - A half-wave or full-wave shunt field supply is available as shown in Table 12;

TABLE 12. SHUNT FIELD DATA

CONTROLLER RATING (VAC)	SHUNT FIELD VOLTAGE (VDC)		MOTOR SHUNT FIELD LEAD CONNECTIONS	
	Half-Wave	Full-Wave[a]	F1	F2
115	50		F/2	F□
		100	F+	F□
230	100		F/2	F□
		200	F+	F□

a. Low inductance motors require a full-wave field to prevent speed instability.

4. MOTOR CONTACTOR - Controller model numbers with an 'A' or 'B' suffix, e.g., 2331A, 2331AP0, have a DC magnetic armature contactor, which disconnects both motor armature leads from the controller. An antiplug circuit ensures that the contactor does not make or break DC.

5. POWER CONVERSION - The DC power bridge consists of four SCR's, one freewheeling diode. Each device is rated at least 600 PIV. The controller base forms an integral heat sink, with the power devices electrically isolated from the base.

6. SELECTABLE CAPABILITIES - Switches allow the user to select various modes of operation, as follows:

a. **LINE STARTING -** By placing SW3:5 in the OFF position, the anti-restart feature will be disabled, and the controller may be started and stopped with an external AC line contactor. However, a wire jumper must be connected between TB2-8 and TB2-9. If full speed operation is desired, connect another wire jumper between TB2-2 and TB2-3.

b. **TACHOMETER FEEDBACK -** To use tachometer feedback with armature feedback backup, connect the tachometer generator signal to TB2-7 and TB2-5, (polarity insensitive) and select the tachometer generator voltage at maximum speed by using SW3:1 as follows:

TABLE 13. TACHOMETER FEEDBACK VOLTAGE SELECTION

TACH VOLTAGE	SW3:1
8Vdc - 30Vdc	ON
31Vdc - 175 Vdc	OFF

c. **TORQUE REGULATOR -** The controller will function as a torque regulator when SW3:3 is OFF. This allows an external potentiometer to set maximum motor torque (0 - 150% of rated).

7. VOLTAGE TRANSIENT PROTECTION - A metal oxide suppressor (varistor) across the AC line is combined with RC snubbers across the power bridge to limit potentially damaging high voltage spikes from the AC power source.

SECTION VII

DRAWINGS

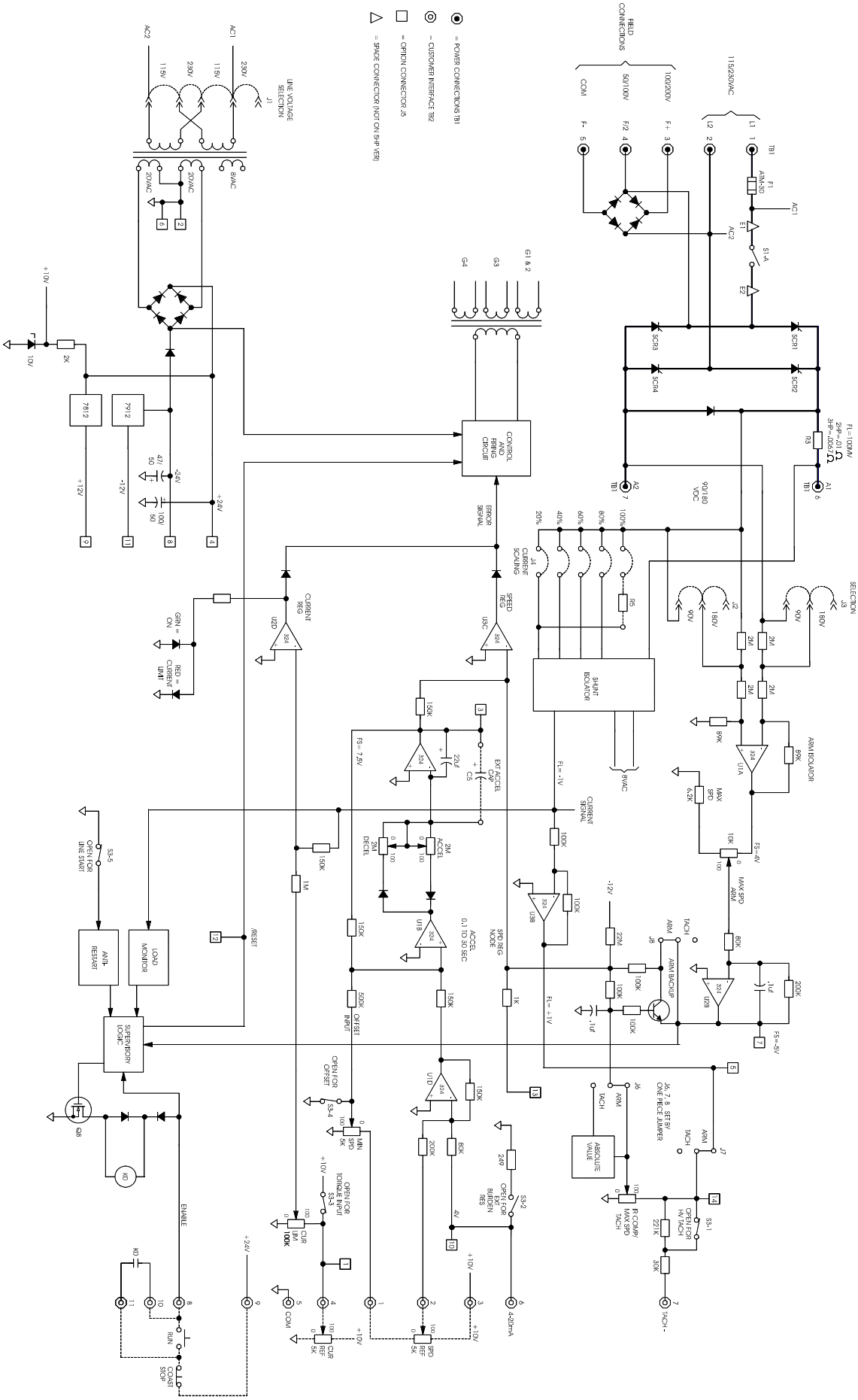

Figure 19. Functional Schematic, Series 2330MKII 1

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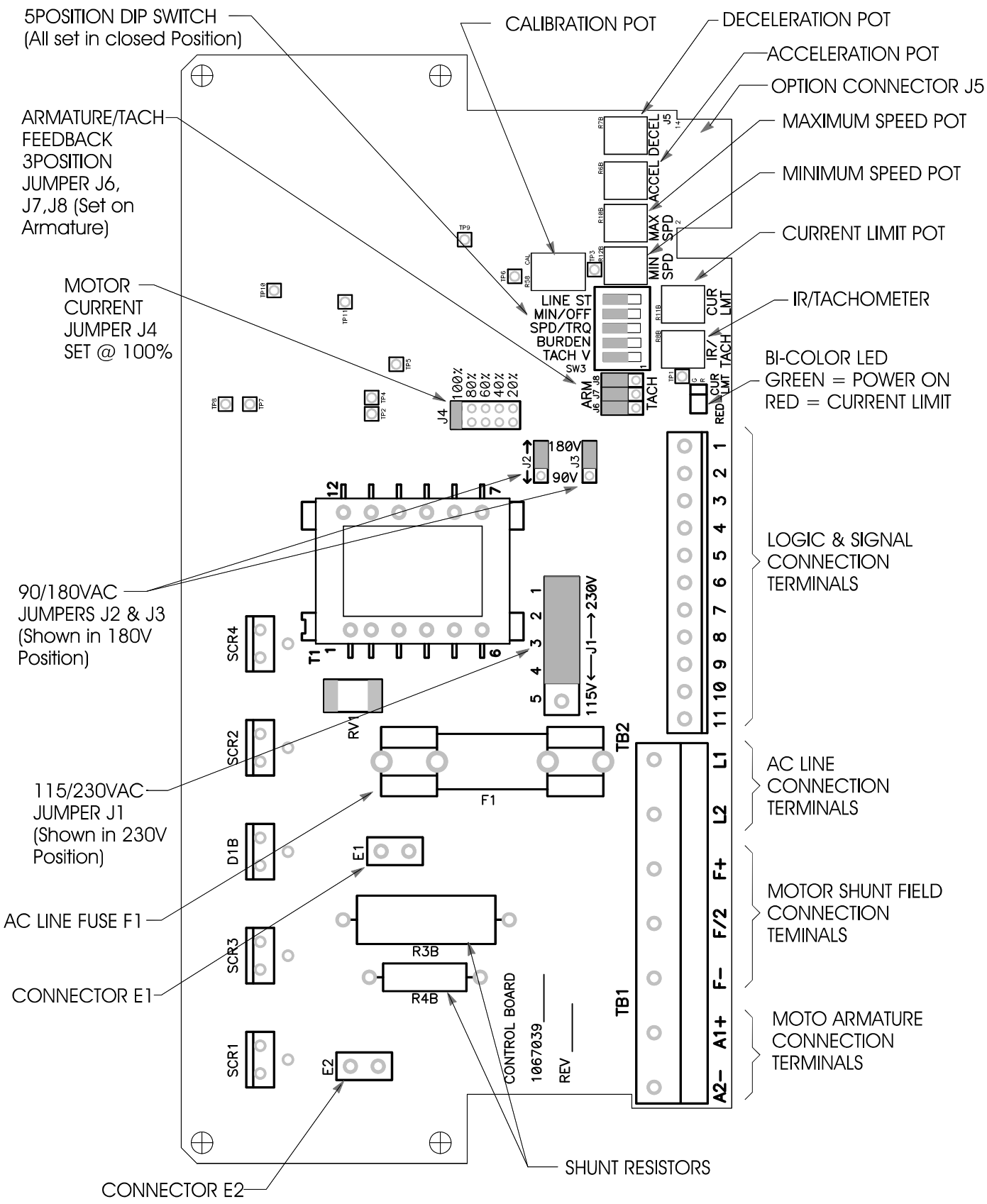

Figure 20. Series 2330MKII Control Board, 1/6 – 3HP

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