Medium Voltage

DBS

Digital Bypass
Solid State Starters

Operator's Guide and Instruction Manual

MVDBS / JAN 08 / REV 1
SUPERSEDES JAN 05

RAM INDUSTRIES LLC

Table of Contents

List of Tables

List of Figures

Conventions used in this manual

Symbols

The following list contains an explanation of the symbols used in this document.

NOTE: This symbol is used when there is information you might find especially useful. The information may also warn you about possible problems you could encounter.

CAUTION! This symbol is used when there is important information that can help you avoid potential injury.

DANGER! This symbol is used when there is important information that can help you avoid the risk of serious personal injury or death.

WARNING! This symbol is used when there is important information that can help you avoid the risk of serious personal injury or death.

DISCLAIMERS

NOTE:

The information contained herein is not intended as a training manual for unqualified personnel. It does not relieve the user of responsibility to use sound practices in application, installation, operation, and maintenance of the equipment purchased or in personnel safety precautions. Should a conflict arise between the general information contained in this publication and the contents of drawings or supplementary information supplied with this equipment, the latter shall take precedence.

RAM Industries reserves the right to make changes in specifications shown herein or add improvements at any time without notice or obligation.

WARNING

Disconnect all Sources of Power and Lockout
Before Servicing This Equipment

This equipment should be installed and maintained by qualified personnel only, in accordance with recognized safety standards and applicable electrical or building codes. The manufacturer is not responsible for damages or injuries resulting from improper installation or use.

For the purposes of this manual, a qualified person is one who is familiar with the installation, construction, or operation of the equipment and the hazards involved. In addition, he has the following qualifications:

a) Is trained and authorized to energize, de-energize, clear, ground, and tag medium voltage circuits and equipment in accordance with established safety practices.

b) Is trained in the proper care and use of protective equipment such as rubber gloves, hard hat, safety glasses or face shields, flash clothing, etc., in accordance with established safety practices.

c) Is trained and authorized to work near exposed parts that may be energized.

d) Is trained in rendering first aid.

Handling and Storage

Handling

- Strap or brace the MVDBS controller prior to moving it.
- Do not top-stack MVDBS controllers.
- Do not remove MVDBS controller from skid or unpack it until final installation, if possible.
- Packaged MVDBS controllers should be moved with a forklift and tethered with safety straps.
- Top-lifting should be done only with suitable lifting eyes attached to mounting brackets when provided.

Storage

If the MVDBS controller will be stored for an extended period before installation:

- Inspect for possible damage incurred in transit.
- Re-package after inspection.
- Store in clean, dry environment with a uniform temperature to prevent condensation inside the controller.
- Cover the controller to protect from dust, moisture, and falling objects.

Main Door and Main Disconnect Switch Operation

Disconnect Handle Positions

The main disconnect switch has three positions:

(1) The **ON** position means the main disconnect switch is closed and power can be applied to the unit.

(2) The **OFF** position means the main disconnect switch is open and power has been killed to the unit.

WARNING: The incoming power terminals will still be hot unless an upstream disconnecting means has been opened.

(3) The **OPEN/CLOSE** position is used to open or close the main door. In this position, the disconnect switch handle must be fully counterclockwise.

To Open the Main Door/Open Main Disconnect Switch

(1) Rotate all main door latches away from the main door.

(2) Rotate handle into OFF position.

NOTE: The main disconnect switch blades should now be in the open position. Verify via the disconnect switch viewing window.

(3) Move handle into fully counterclockwise position (OPEN/CLOSE) until mechanical interlock releases.

(4) Open door.

To Close the Main Door/Close Main Disconnect Switch

(1) Move handle into fully counterclockwise position (OPEN/CLOSE) to engage the mechanical interlock.

NOTE: This step is necessary in order to fully close the main door.

(2) Ensure the main door is in the fully seated against body of enclosure.

(3) Release handle.

(4) Rotate handle into clockwise position (ON) to close the disconnect switch.

NOTE: The main disconnect switch should now be in the closed position. Verify via the disconnect switch viewing window.

NOTE: The above 4 steps should be done before securing the main door latches (9 total).

1.0 Description

1.1 Overview

The MVDBS (medium voltage digital bypass solid state) reduced-voltage starter is a microprocessor controlled motor starting device which utilizes SCRs (silicon controlled rectifiers) to electronically reduce the applied voltage to an AC induction motor, allowing the motor to start at a reduced current. Because the MVDBS accelerates the motor in a smooth stepless manner, it reduces drop in the supply voltage as well as mechanical shock on the driven equipment, that is normally experienced with two-step, electromechanical, reduced-voltage starting methods.

The MVDBS can be programmed to provide a gradual build up of torque, from zero to almost full motor locked rotor torque, or to limit starting currents to a constant value, which prevents an excessive voltage drop during motor starting.

The MVDBS can also be programmed to provide a controlled deceleration of the motor when a normal coast stop time is too short for the intended application.

1.2 Standard Features

Universal Source Matching: The MVDBS automatically adjusts itself to any input frequency from 45 to 65 Hz.

Closed Loop Starting: The MVDBS starts a motor in a continuous controlled current mode, which eliminates mechanical shock to the motor.

Automatic Bypass: The MVDBS includes a bypass contactor that is automatically engaged after the motor has reached full speed, or when the bypass delay has expired. The bypass contactor reduces power losses and heat build-up so that the MVDBS controller, in an unventilated enclosure in a 50°C ambient, can continuously operate a fully-loaded motor.

Electronic Motor Overload Protection: The MVDBS has integral electronic motor protection. This micro-processor-based feature provides comprehensive motor overload protection as well as monitoring and annunciating system alarm and shutdown conditions. See Section 1.8 for full explanation of motor overload protection features.

LED Diagnostics: The MVDBS has four LEDs provided on the front of its control board to indicate the operating state of the MVDBS.

Motor Connection: No special induction motor is required. Any standard 3-phase motor can be connected to the MVDBS. See Figure 12 in the Appendix for typical 3-wire connection diagrams.

Starting Modes: Two starting modes provide optimum performance to match the MVDBS to the motor load characteristics:

a. **Constant Current Mode:** Starting current is limited to a maximum level, adjustable from 200-425% of FLA, until the motor attains full speed. This mode is recommended for light to moderate inertial-type loads. See Figure 6, Section 5.

b. **Step Ramp (Current Ramp) Mode:** After the starting current quickly reaches the current step limit, it can ramp up to 500% FLA. The ramp time allowed can be set from 3-30 seconds. This mode is recommended for heavy inertial and friction-type loads. See Figure 7, Section 5.

Stopping Modes: Two stop modes provide additional flexibility based on the required motor stop time:

a. **Coast Stop Mode:** When the motor stop time is not critical, this mode should be selected.

b. **Controlled Deceleration Mode:** When a longer deceleration time is required, this mode can be programmed to extend the deceleration time of the motor up to 60 seconds.

Test Mode: As a troubleshooting feature, this mode can be selected to ensure the starter basic functions are working properly.

Control Modes: Two control operating modes are available: Display and Network, which incorporates Modbus communication features. See Section 1.5 for a full explanation of each control mode.

UL and CUL Approved: All models have been tested and approved by Underwriters Laboratory per UL 347 Standard, and conform to Canadian National standards.

Isolating Disconnect Switch: A 400, 5kV load make/load break disconnect switch is provided. This disconnect switch has the following standard features:
- Mechanically interlocked with the medium voltage access door to prevent entry with the switch in the ON position
- Grounded in the OFF position
- Viewing window provided to determine status of the disconnect blades
- Provision for pad locks in the OFF position

Medium Voltage Section: Standard component in the medium voltage starting section include:
- Class R-rated motor fuses
- Vacuum starting contactor
- Control power transformer
- Current transformers for overload sensing

Motor Connecting Bus: Motor connection output bus is provided.

Low Voltage Section: The following is included in the low voltage section, which is built into the main access door:
- Motor overload protection relay
- Start/Stop control logic

Fiber Optics: For noise and voltage immunity, the SCRs are gated with fiber optics.

1.3 Optional Features

Incoming Power Horizontal Bus: Incoming power horizontal bus can be provided. Otherwise, incoming power connections are made directly to the top of the isolating disconnect switch.

1.4 System Parameters

The motor and load characteristics and the control method define system parameters. These are configured with switches on the control board of the MVDBS controller.

- Full Load Amps (FLA)
- Constant Current Level (% FLA)
- Ramp Bypass Time (Seconds)
- Control Mode (Display, Network)
- Network Address
- Test Mode (Enabled/Disabled)
- Controlled Deceleration / Coast Stop
- Overload Protection (Enabled / Disabled)
- Starting Mode (Constant Current / Step Ramp)

NOTE: System parameters can be changed only when motor is not running. Refer to Figure 9, Section 5, for switch configurations.

1.5 Control Modes

The MVDBS can be set up to operate in either the Display or Network control mode by means of DIP switches located on the MVDBS control board. - Refer to Figure 9, Section 5, for switch configurations.

Display Mode: The display module connects to the MVDBS via an RS-232 port. The display unit is mounted on the front of the enclosure door and permits access by service personnel to all monitoring and diagnostic information without opening the enclosure door. All aspects of motor operation and control are supported in this mode.

Trips Detected:
- Thermal Overload, Shorted SCR, Phase Loss, Phase Reversal, Jam, Ambient Overtemperature, and Short Circuit Trips.

Alarms Detected:
- Current Unbalance

Network Control Mode: Configuration in this mode is set by the user's external control system computer, which is connected to the MVDBS via the Network RS485 port. Monitoring and diagnostic information is also available. Full fault detection is enabled in this mode. Modbus communication is standard, refer to Appendix D.

Trips Detected:
- Thermal Overload, Shorted SCR, Phase Loss, Phase Reversal, Jam, Ambient Overtemperature, and Short Circuit Trips.

Alarms Detected:
- Current Unbalance

1.6 Operating States

The operating states, annunciated by means of status codes on the control/display unit, describe the MVDBS conditions seen by its microprocessor. - See Section 8.1 for Status Codes.

READY - The MVDBS is ready to start the motor. The MVDBS has passed all the preliminary system checks, including verifying there are no shorted SCRs, all internal system tests have passed, and no phase reversal or trip condition is present.

START - The MVDBS is in the process of starting the motor. Full speed has not been attained, and the bypass contactor has not been turned on.

RUN - The motor has reached full speed, or the end of the bypass time has been reached, and the bypass contactor has been turned on.

TRIP - The MVDBS has detected a trip condition and stopped the motor.

COOLDOWN - The motor has exceeded its thermal capacity and will not be allowed to start until enough time has elapsed to allow the motor to cool. The time until the motor can be re-started can be viewed in the Monitor Menu under “Time Till Start.”

1.7 LED Annunciation

CONTROL BOARDS:
LEDs, located on the front of the MVDBS control board, annunciate operating status and assist in troubleshooting.

READY LED (Green) indicates the MVDBS is in the READY state.

RUN LED (Green) indicates the MVDBS is in either the START or RUN state. The LED will blink when in the START state, then turn on steady once the RUN state is reached.

ALARM LED (Yellow) indicates the MVDBS has detected an ALARM condition. The LED will blink until the alarm is acknowledged (see Section 8.3). When the condition is no longer present, the LED will go out, and normal operation can resume. If the condition is acknowledged, but is still present, the LED will turn on steady and remain on until the alarm condition is removed. The control/display unit or remote controller will show the cause of the alarm.

TRIP LED (Red) indicates the MVDBS is in the TRIP state. The LED will blink until the trip is acknowledged (see Section 8.3). When the trip condition is no longer present, the LED will go out, and normal operation can resume. If the condition is acknowledged, but is still present, the LED will turn on steady and remain on until the trip condition is removed. The control/display unit or remote controller will show the cause of the trip.

TRANSMIT LED (Green) indicates the MVDBS is transmitting data to a remote location.

RECEIVE LED (Yellow) indicates the MVDBS is receiving data from a remote location.

GATE DRIVER BOARD:
LEDs, located on the front of the MVDBS gate driver boards, annunciate operating status and assist in troubleshooting. The Gate Driver Boards are located on the SCR Assemblies, in the medium voltage compartment.

GATING LED (Red) indicates the SCRs are receiving a gating command from the Power Board. This signal is transmitted fiber optically from the Power Board to each of the three Gate Driver Boards.

CONTROL DISPLAY UNIT:
An LCD, located on the front of the Control Display Unit, annunciates operating status. The Control Display Unit is located on the front of the control cabinet.

ALARM LED (Red) indicates the MVDBS has detected an ALARM condition. The LED will blink until the alarm is acknowledged (see Section 8.3). When the condition is no longer present, the LED will go out, and normal operation can resume. If the condition is acknowledged, but is still present, the LED will turn on steady and remain on until the alarm condition is removed. The control/display unit or remote controller will show the cause of the alarm.

1.8 Electronic Motor Overload Protection and Monitoring

The MVDBS electronically monitors and protects the motor, during both start and run states, by using, in addition to user presets, a unique model of operating limits for the motor created from three-phase current and voltage input signals. It also records pertinent operating history for troubleshooting and maintenance purposes.

Fault conditions are annunciated and acknowledged through either the MVDBS door-mounted control/display unit or the remote controller.

The MVDBS electronic overload affords motor protection against the following conditions:
- Stalling
- Overheating
- Locked Rotor

Additionally the MVDBS microprocessor will detect the following conditions:
- Jam
- Short Circuit
- Phase Loss
- Current Unbalance
- Phase Reversal

1.8.1 Trip Conditions

Multiple trip conditions can be detected and displayed in either MVDBS control mode. The detection of a trip condition while the motor is running will cause it to stop. - Refer to the Set Point Menu (Section 9, Table 7) for trip set points and defaults. Refer to Table 5, Section 7.4 for LED and Relay status during a Trip condition.

SHORT CIRCUIT - This trip will occur if the current exceeds 800% FLA while the MVDBS is in the START state.

THERMAL OVERLOAD - This trip will occur when the calculated thermal energy stored in the motor exceeds 100% of the motor's thermal capacity. The motor will be allowed to start again when the motor has sufficiently cooled.

SHORTED SCR - This trip will occur if one or more of the SCRs is shorted. This check is performed only when the MVDBS is in the READY state.

PHASE REVERSAL - This trip will occur if two or more of the phases have been reversed. Start-up will not be allowed until the phases are connected in the correct sequence. Control power must be cycled to clear this fault.

PHASE LOSS - This trip will occur with the loss of one or more of the three voltage phases. Start-up will not be allowed until the phase loss is corrected.

AMBIENT OVERTEMPERATURE - This trip will occur when the MVDBS internal ambient of the enclosure has exceeded safe operating conditions.

PLL FAILURE - This failure is related to poor power quality. This trip will occur when the line voltage being monitored is too distorted for the control circuitry to lock onto a voltage zero crossing.

If the trip occurred when the motor was not running, the PLL will automatically reset when the condition is cleared.

If the trip occurred when the motor was running, control power must be cycled to clear this fault.

JAM - This trip will occur if the current is above the Jam Current Level and the Jam run delay has expired. This trip will occur only in the run state.

1.8.2. Alarm Condition

An alarm condition will be annunciated on the control/display unit or remote controller and cause the yellow Alarm LED on the MVDBS control board to light. - Refer to Set Point Menu, Section 9, Table 7, for alarm set points and defaults. Refer to Table 5, Section 7.4 for LED and Relay status during an Alarm condition.

CURRENT UNBALANCE - This alarm will be activated when the current unbalance % exceeds the Current Unbalance level and the Current Unbalance Delay has expired.

$$\text{Current Unbalance \%} = \frac{\text{MAX Current Deviation from Average Current}}{\text{Average Current}} \times 100$$

Example

a $\dfrac{33\ A_1 + 29A_2 + 34\ A_3 = 96\ A_{TOTAL}}{3} = 32\ A_{AVERAGE}$

b
$33\ A_1 - 32\ A_{AVERAGE} = 1\ A$
$29\ A_2 - 32\ A_{AVERAGE} = -3\ A$ Largest value: $3\ A_{DEVIATION}$
$34\ A^3 - 32\ A_{AVERAGE} = 2\ A$

c $\dfrac{3\ A_{DEVIATION}}{32\ A_{AVERAGE}} \times 100\% = 9.4\%$

2.0 Specifications

TABLE 1 MVDBS Specifications

AC POWER SUPPLY	2300V / 3300V / 4160V RMS (REFER TO SCHEMATICS SUPPLIED WITH JOB)
CURRENT CAPACITY	REFER TO SCHEMATICS SUPPLIED WITH JOB
CONTROL VOLTAGE	115 VAC, +/-15% NOTE: 115V CONTROL POWER MUST BE DERIVED FROM THE 3 PHASE POWER SOURCE.
LINE FREQUENCY	45 TO 65 HZ
STARTS / HOUR	4 COLD, 3 HOT MOTOR STARTS PER HOUR AT RATED THERMAL OVERLOAD CAPACITY
THERMAL OVERLOAD CAPACITY	300% FLA FOR 40 SECONDS 500% FLA FOR 30 SECONDS
OPERATING TEMPERATURE	0 TO 50 DEGREES C
STORAGE TEMPERATURE	-40 TO 65 DEGREES C
STANDARD STARTING MODES	CONSTANT CURRENT - 200% TO 425% FLA STEP RAMP - 200% TO 425% FLA, RAMP UP TO 500% FLA MAX
STANDARD USER ACCESSIBLE RELAYS	RUN RELAY: (2) SPST NORMALLY OPEN CONTACTS - 10 AMPS @ 25O VOLT AC, INDUCTIVE RATING ALARM RELAY: (1) SPDT 1-NORMALLY OPEN, 1-NORMALLY CLOSED CONTACT - 10 AMPS @ 250 VOLT AC, INDUCTIVE RATING
COMMUNICATION PORTS	DISPLAY PORT (J1) - RS232, 9600 BAUD NETWORK PORT - RS485, 19,200 BAUD; Receive (RX) LED (yellow) and Transmit (TX) LED (green) indicate network activity. Jumpers JP1 (+) and JP3 (-) select 10k bias resistors: 1-2 Enable, 2-3 Disable. Jumper JP2 selects 120ohm termination resistor: 1-2 Enable, 2-3 Disable (See Figure 5).
SHORT CIRCUIT INTERRUPTION LEVEL	50kA Tested per UL347 requirements.
IMPULSE WITHSTAND LEVEL (BIL)	45kV impulse withstand level. Tested per UL347 requirements.

3.0 Receiving and Installation

3.1 Receiving

- Upon receipt of the MVDBS controller, immediately unpack it and look for any shipping damages. If any shipping damages are encountered, file a claim with the freight carrier within 15 days of receipt.
- Verify that the ratings sticker on the MVDBS chassis matches the motor's HP, current, and voltage rating for the installation.
- Check for loose mechanical connections and assemblies, and wires which may have broken or loosened during shipping and installation.
- Manually exercise all electromechanical devices to make sure they work freely.

3.2 Mounting and Cleaning

- Make sure that the manner in which the controller is mounted meets the latest requirement of the National Electrical Code and any other local code requirements for working space (NEC Code Articles 110-13 and 110-16).
- Freestanding controllers should be securely mounted to a flat, level, base using mounting holes provided.
- Remove access plates prior to drilling or punching holes to prevent metal filings and debris from causing short circuits or reducing electrical clearances.

WARNING! Remove all sources of power before cleaning controller.

- After mounting and wiring is completed, thoroughly clean and vacuum the enclosure, and make sure that all filings, metal chips, and other materials are removed before start-up.

3.3 Environment

The MVDBS controller may be installed and operated at nameplate rating in an area where the following conditions exist:

- Ambient Temperature shall not exceed 50 degrees C (122 degrees F) with a 15 degree C rise inside the enclosure as maximum.
- Ambient Temperature shall not be less than 0 degrees C (32 degrees F).
- Altitude above sea level shall be 6000-ft. (2000 m.) or less.
- Ambient air is reasonably clean, dry, and free of flammable or combustible vapors, steam, or corrosive gases.

3.4 Derating Factor

WARNING! **When a MVDBS enclosure is in an environment not in accordance with Paragraph 3.3 as described above, it must be derated as follows:**

- Derate starter size 1.5% per degree C above 50 degrees C Ambient Temperature or 0.75% per degrees F above 122 degrees F Ambient Temperature.
- Derate starter size 1% for every 100m above 2000m or every 300 ft. above 6000 ft. elevation.

4.0 Wiring

The MVDBS controller shall be wired in accordance with the National Electrical Code and any local codes that may apply.

Copper conductors for 90 deg. C (min.) shall be used for power and control wiring unless specified otherwise.

Minimum recommended wire sizes are #14 AWG for control circuits

Tighten connections per torque values shown on devices. Otherwise, refer to torque values in Table 2.

4.1 Incoming Power

Connect properly sized power wires to the input terminals on the MVDBS chassis marked L1, L2, & L3.

CAUTION! **Incoming power wires must be connected in the correct order: L1, L2, L3. Because the MVDBS controller is phase sensitive, it will not operate unless the phase sequence is in this order. If not, a Phase Reversal trip will occur.**

Refer to the National Electrical Code for wire sizing.

TABLE 2 Recommended Tightening Torque

UNLESS OTHERWISE NOTED ON INDIVIDUAL DEVICE

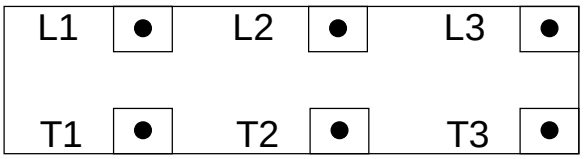
WIRE SIZE (AWG or kcmil)	TORQUE - IN/LB		
	SLOTTED HEAD NO. 10 AND LARGER		
	SLOT WIDTH ≤3/64 IN SLOT LENGTH ≤1/4 IN	SLOT WIDTH >3/64 IN SLOT LENGTH >1/4 IN	HEX HEAD OR SCREWS SOCKET HEAD
18 -10	20	35	75
8	25	40	75
6 -4	35	45	110
3	35	50	150
2	40	50	150
1		50	150
1/0 - 2/0		50	180
3/0 - 4/0		50	250
250 - 400		50	325
500 - 750		50	375

4.2 Motor Connection

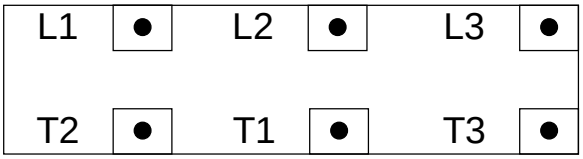
Connect properly sized motor leads to terminals T1, T2, and T3 as specified on the drawings. If motor rotation needs to be reversed, swap the position of any two motor leads. See Figure 1.

NOTE: Do not swap incoming wires to reverse the motor's rotation as this will cause a Phase Reversal trip.

FIGURE 1 Forward and Reverse Motor Connections



FORWARD



REVERSE

4.3 Control

Customer control wiring is to be connected to the controller's terminal block in accordance with RAM wiring diagram supplied.

4.4 Grounding

Connect properly sized ground cable to the starter ground terminal. Refer to the National Electrical Code for proper size, and make sure the ground conductor is connected to a solid earth ground.

4.5 Control and Power Boards

Every starter has a control and power board set located in the control enclosure (Figure 3). Important customer connections are explained below.

4.5.1 Status Relays

The contacts of two relays on the MVDBS power board are available for controlling external devices when not being utilized by the basic control starter circuit. These contacts are connected to TB1 on the MVDBS power board. - See Figure 3, Section 4, for illustration of contacts and Table 1, Section 2, for contact values.

Run Relay - Energized when a start sequence is initiated.
N.O. Contact connected to terminals 7 and 8 may be used as a dry contact.
N.O. Contact connected to terminals 5 and 6 should be used ONLY as part of the start circuit.

Alarm Relay - Energized when an alarm condition exists.
N.O. Contact connected to terminals 11 and 12, may be used as a dry contact.
N.C. Contact connected to terminals 12 and 13, may be used as a dry contact.

4.5.2 Communication Ports

Display Port - RJ-45 modular connector provides RS-232 communication for display. - Refer to Sections 8 and 9 for control/display unit operation.

Network Port - 3-position block provides RS-485 network communication.

4.6 SCR Assembly Boards

Each SCR Assembly has a Gate Driver Board (Figure 4) and a Voltage Divider Board (Figure 5). The SCR Assemblies are located in the Medium Voltage Section of the enclosure.

4.7 Snubber Circuit

Each SCR Assembly requires its own snubber circuit. The snubber circuit is mounted adjacent to the SCR Assembly and has 2 connections to the SCR heatsink plates - one for the top plate and one for the bottom plate.

4.8 MOV Board

Each SCR Assembly has its own MOV board. It is mounted underneath the Voltage Divider Board and has two connections to the SCR heatsink plates - one for the top plate and one for the bottom plate.

4.9 Power Factor Correction Capacitors

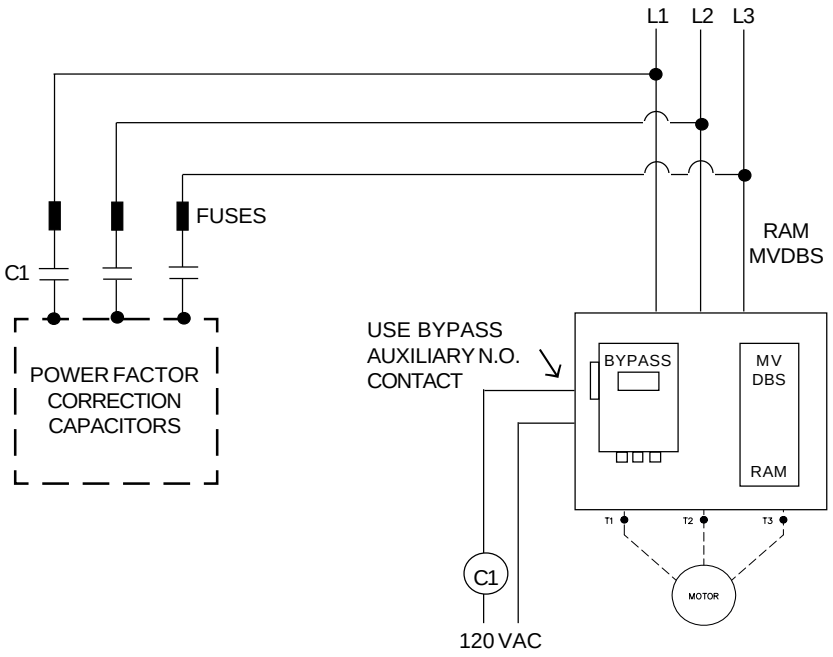
CAUTION! **Power factor correction capacitors, when utilized, must be connected to the line side of the starter and never to the load. Power factor capacitors should never be in the circuit during motor acceleration or deceleration.**

See Figure 2 for the correct connection method.

CAUTION! **For multiple starters, ensure each starter is up to speed before starting the next unit.**

FIGURE 2

Power Factor Correction Capacitor Connections



4.10 Lightning Arrestor

Lightening arrestors are recommended in areas where frequent lightning occurs. They should be installed on the line side of the starter. Lightning arrestors are factory installed as an option.

4.11 Line Reactor

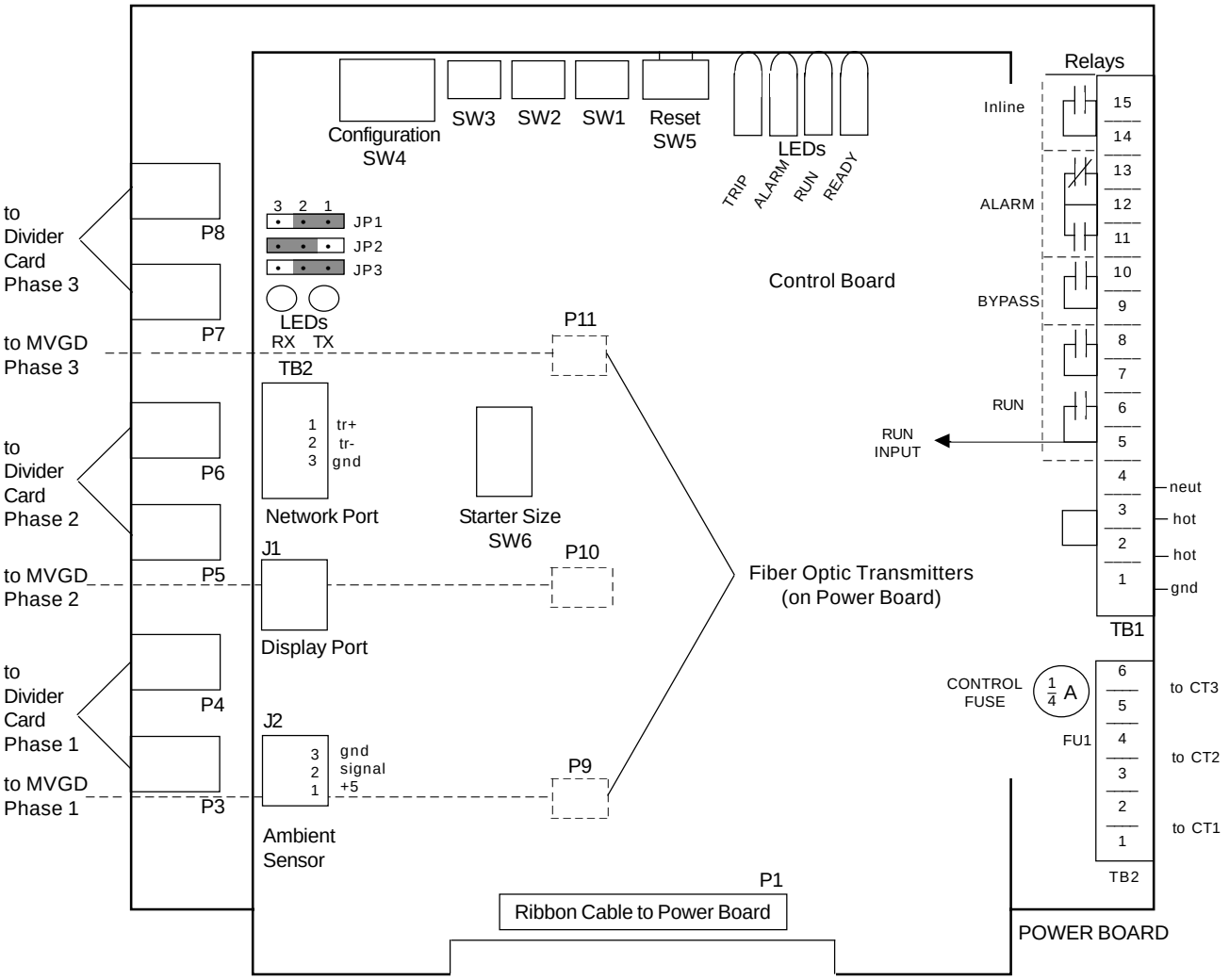
If the sum total of the power cable length:

a. from the supply transformer to the line side of the starter, plus

b. from the load side of the starter to the motor approximates 600 feet or more, consult the RAM factory, a line reactor may be needed to prevent di/dt failure of the SCRs.

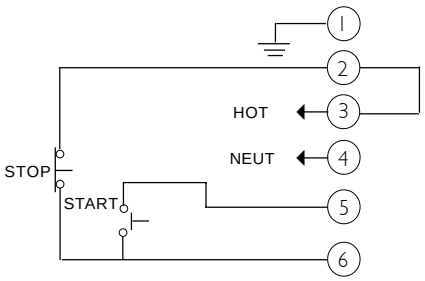
FIGURE 3

External Connections to Control and Power Boards



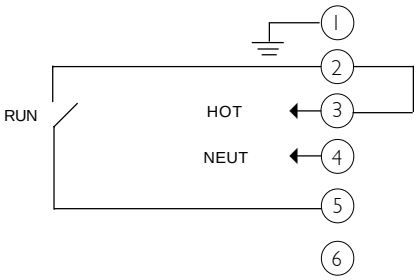
Three-Wire Connection

Connect a maintained N.C. (normally closed) stop button between HOT (pin 2 or 3) and pin 6 of TB1 on the power circuit board. Connect a momentary N.O. (normally open) start button between HOT (pin 2 or 3) and pin 5 of TB1 on the power board.



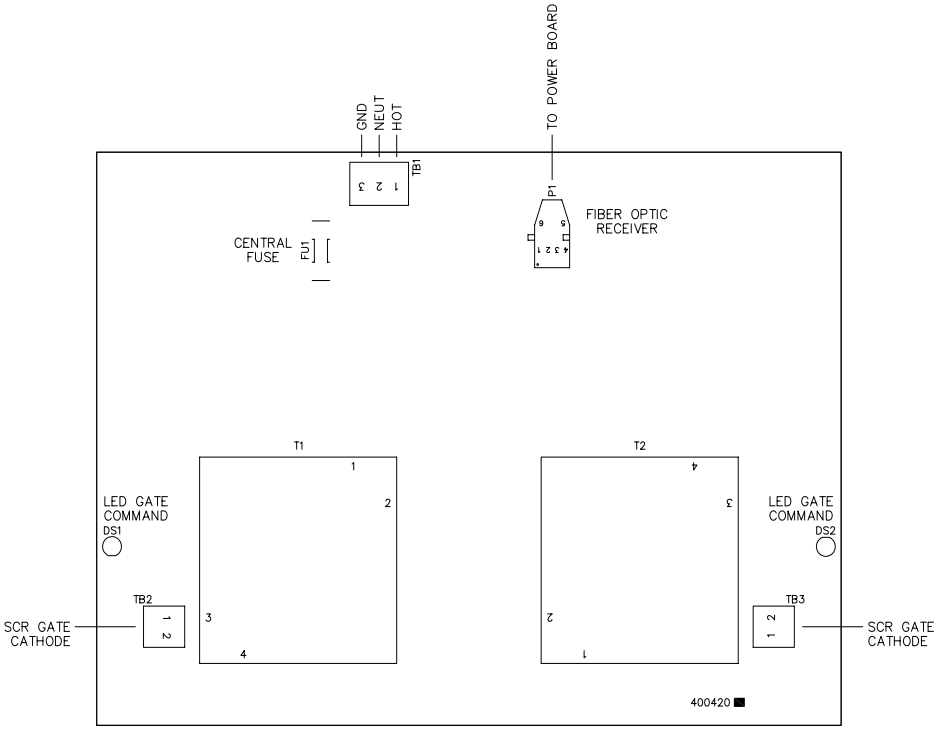
Two-Wire Connection

An alternate connection for unattended operation replaces start/stop buttons by connecting a maintained N.O. contact closure (run switch or jog pushbutton) between pins 2 and 5 of TB1 on the power circuit board.



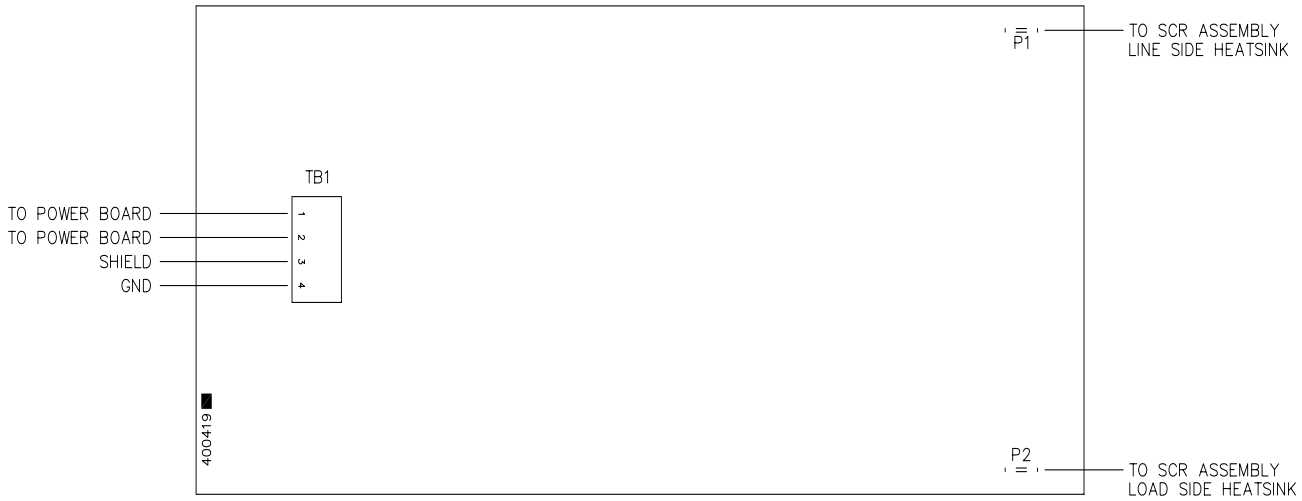
CAUTION! Two-wire connection must be opened (switched off) when a trip occurs in order to prevent the motor from restarting when the trip is cleared.

FIGURE 4 External Connections to Medium Voltage Gate Driver Board



DRAWING #207681
REV A

FIGURE 5 External Connections to Medium Voltage Divider Board



DRAWING #207680
REV A

5.0 Set-Up Instructions

CAUTION! **Equipment is at lethal AC line voltage when AC power is connected. All phases must be disconnected by shutting down main power feed to this unit before it is safe to touch motor terminals or control equipment parts.**

5.1 Inspection

- Ensure that the starter has been installed according to the preceding guidelines.
- Ensure that the controller has been wired according to the schematics and all electrical codes.
- Check that all connections are tight. Ensure that motor shaft rotates freely.

CAUTION! **Before power is applied to the starter, the following settings and adjustments should be reviewed and appropriate changes made as required.**

5.2 Set-Up Switches

The MVDBS chassis has been factory set for normal operation via switches SW1, SW2, SW3, SW4, and SW6, on its control board - See Figure 3, Section 4.

5.2.1 Motor FLA - SW1

This 16-position rotary switch setting is based on MVDBS chassis size and the FLA rating of the motor. Per Table 3, Section 5, select the value that most closely matches the Motor Full Load Current from the box that corresponds to the MVDBS size.

5.2.2 Constant Current Level Switch - SW2

This 10-position rotary switch sets the initial current step of the controller when in either **Constant Current** or Step Ramp mode. This switch is adjustable from 200-425% FLA in increments of 25%. - See Table 7, Section 9.

When the controller mode is set for Constant Current, the maximum current the motor can draw during starting is limited until the motor reaches full speed.

When the controller mode is set for **Step Ramp**, the initial current drawn during starting is limited. The Step Ramp mode then allows the motor to draw up to 500% FLA to attain full speed over a set time range.

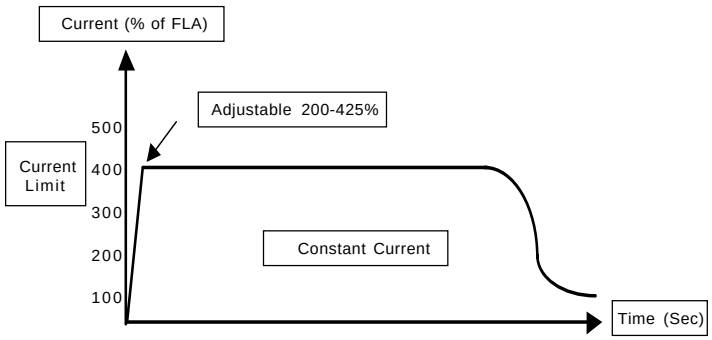
5.2.3 Ramp/Bypass Time Switch - SW3

In the **Step Ramp** mode this 10-position rotary switch sets the amount of time the current draw is allowed to increase from its initial Current Step level (set by SW2) to a maximum of 500% FLA. The maximum time until the bypass contactor is energized is 5 seconds, plus the programmed ramp time. - See Table 9, Section 9.

In the **Constant Current** mode, this switch sets the maximum time until the bypass contactor is energized.

SW3 is adjustable from 3-30 seconds, in 3-second increments.

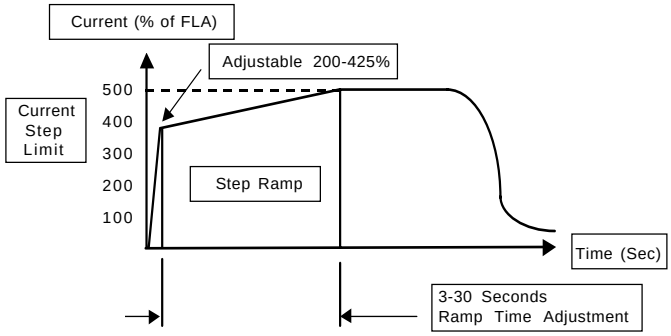
FIGURE 6 Constant Current Mode



Constant Current

This method limits the starting current to a value adjustable from 200-425% FLA. The Constant Current mode is recommended for light and moderate inertial type loads. At rated horsepower, the Constant Current mode is capable of smoothly starting most loads without making any adjustments.

FIGURE 7 Step Ramp Mode



Step Ramp

On heavy inertia and friction type loads, an optional method of operating this starter at its rated horsepower can be accomplished by changing from Constant Current mode to Step Ramp mode. This operating mode limits the initial step current to a value adjustable from 200-425% FLA and then ramps the current to a maximum of 500% FLA.

5.2.4 System Configuration Dip Switch - SW4

This 8-position DIP switch defines the operation of Control Mode, Network Address, Test Mode/Run, Controlled Decel/Coast Stop, Overload Protection, and Step Ramp/Constant Current Mode. The MVDBS system parameters are factory preset and require no changes for normal operation. - See Figure 9, Section 5 factory default settings.

Test Mode/Run: In normal and stopping conditions, switch SW4, position 4 is set to the right. Refer to Figure 9. For troubleshooting purposes, the Test Mode is enabled by setting SW4, position 4 to the left. Refer to Section 7.1 for details regarding use of the Test Mode.

Controlled Decel/Coast Stop

Coast Stop: Each RAM solid state starter is preset at the factory in Coast Stop mode, Switch SW4, position 5 set to the right. Refer to Figure 9. In this mode, the motor deceleration time is determined only by the motor inertia, and the inertia of the load attached to the motor.

Controlled Deceleration: In the Controlled Deceleration mode, the deceleration time of the motor can be extended beyond the normal motor Coast Stop time. Switch SW4, position 5 must be set left. Refer to figure 9. In addition, the three parameters below must be programmed in the Set Point Menu, and verified before this mode can work properly. Refer to Table 7, Section 9.

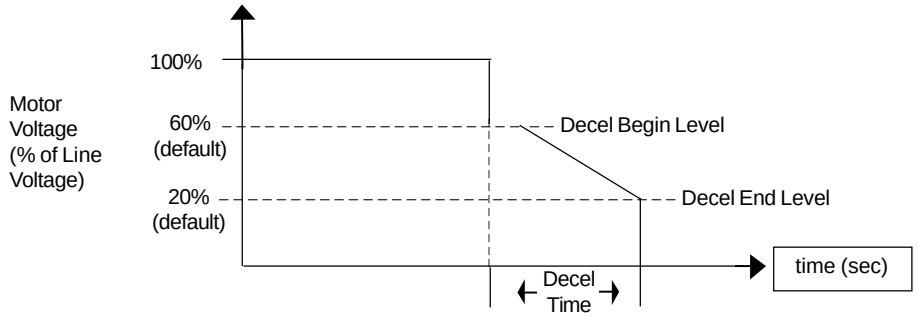
Decel Begin Level: This level should be set below 100% to allow a smooth deceleration. This parameter is adjustable from 0 to 100% of line voltage. Default recommendation is 60%.

Decel End Level: This is the voltage level where the motor is no longer responsive to a controlled deceleration. This parameter is adjustable from 0 to 100% of line voltage. Default recommendation is 20%.

Decel Time: This parameter sets the time between the Decel Start Voltage and the Decel Stop Voltage. Time is adjustable from 0 to 60 seconds.

WARNING: The recommended number of thirty (30) second motor starts per hour should not be exceeded – four (4) cold motor starts and three (3) hot motor starts. A controlled deceleration should be considered a motor start. For example, a 60 second controlled deceleration is equivalent to two (2) thirty (30) second motor starts.

FIGURE 8 Controlled Motor Deceleration



5.2.5 Reset Pushbutton - SW5

This pushbutton allows the operator to acknowledge a fault condition at the MVDBS control board when the low voltage compartment door is open. The MVDBS will not allow the motor to start until all trip conditions are cleared. See Section 1.7 for LED functions.

5.2.6 Starter Size Switch - SW6

This factory preset 8-position dipswitch configures the MVDBS software for the size of the chassis which is designated for the application according to either horsepower or current at a given voltage. If the MVDBS control board is being replaced, SW6 must be set on the new board per Figure 11 in the Appendix.

FIGURE 9

MVDBS Control Board

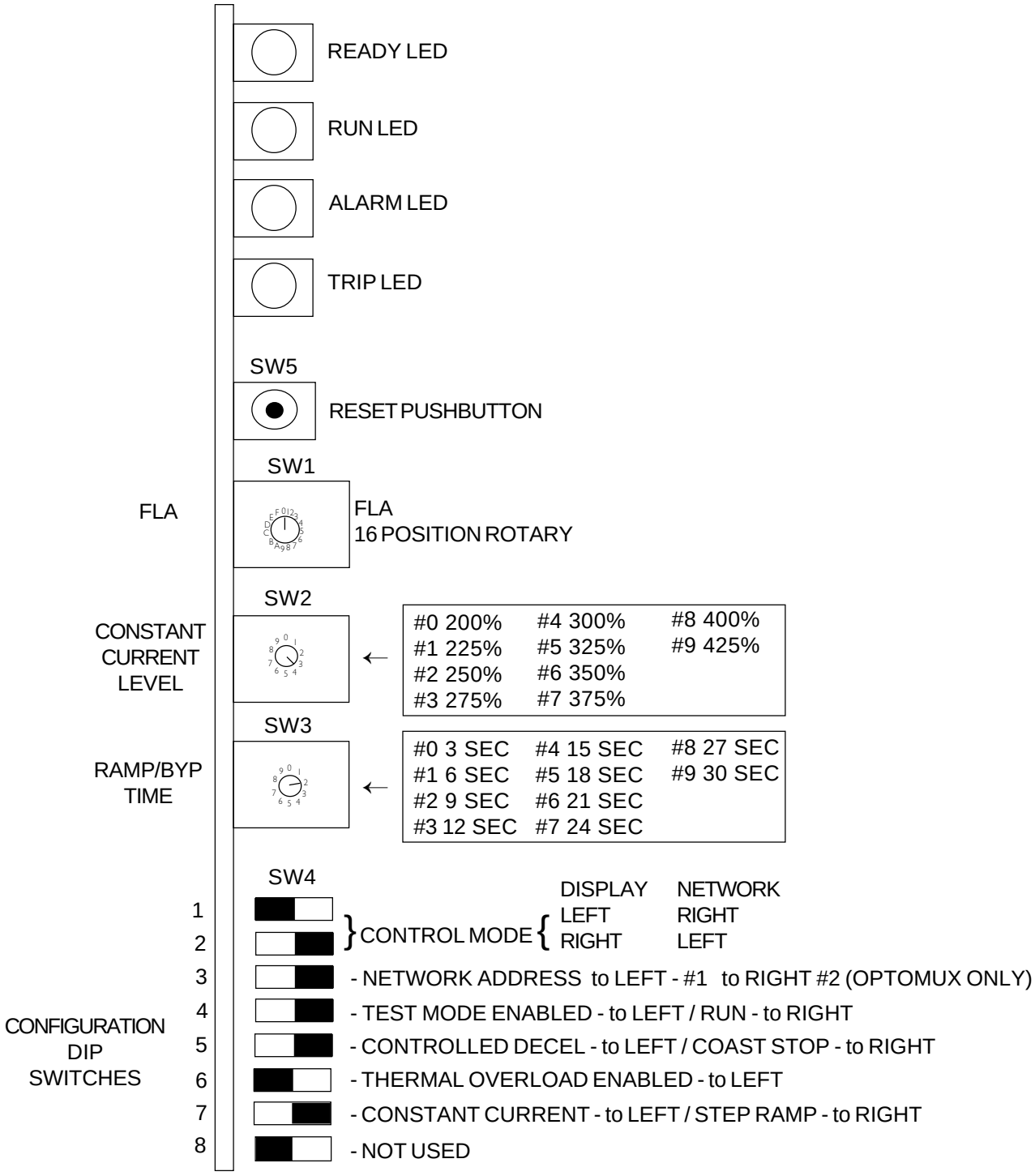


TABLE 3

FLA - Starter Size Tables

Values shown are 100% FLA. Use value which most closely matches the motor nameplate current.

	STARTER A
SWITCH #	F.L.A.
0	10
1	12
2	14
3	16
4	18
5	20
6	21
7	22
8	23
9	24
A	25
B	26
C	27
D	28
E	29
F	30

	STARTER D
SWITCH #	F.L.A
0	45
1	47
2	49
3	51
4	53
5	55
6	57
7	59
8	61
9	63
A	65
B	67
C	69
D	71
E	73
F	75

	STARTER G
SWITCH #	F.L.A.
0	121
1	124
2	127
3	130
4	133
5	136
6	139
7	142
8	145
9	148
A	151
B	154
C	157
D	160
E	163
F	166

	STARTER J
SWITCH #	F.L.A.
0	207
1	211
2	215
3	219
4	223
5	227
6	231
7	235
8	239
9	243
A	247
B	251
C	255
D	259
E	263
F	267

	STARTER B
SWITCH #	F.L.A.
0	24
1	25
2	26
3	27
4	28
5	29
6	30
7	31
8	32
9	33
A	34
B	35
C	36
D	37
E	38
F	39

	STARTER E
SWITCH #	F.L.A.
0	64
1	67
2	70
3	73
4	76
5	79
6	82
7	85
8	88
9	91
A	94
B	97
C	100
D	103
E	106
F	109

	STARTER H
SWITCH #	F.L.A.
0	146
1	149
2	152
3	155
4	158
5	161
6	164
7	167
8	170
9	173
A	176
B	179
C	182
D	185
E	188
F	191

	STARTER K
SWITCH #	F.L.A.
0	236
1	240
2	244
3	248
4	252
5	256
6	260
7	264
8	268
9	272
A	276
B	280
C	284
D	288
E	292
F	296

	STARTER C
SWITCH #	F.L.A.
0	33
1	34
2	35
3	36
4	37
5	38
6	39
7	40
8	41
9	42
A	43
B	44
C	45
D	46
E	47
F	48

	STARTER F
SWITCH #	F.L.A.
0	92
1	95
2	98
3	101
4	104
5	107
6	110
7	113
8	116
9	119
A	122
B	125
C	128
D	131
E	134
F	137

	STARTER I
SWITCH #	F.L.A.
0	172
1	176
2	180
3	184
4	188
5	192
6	196
7	200
8	204
9	208
A	212
B	216
C	220
D	224
E	228
F	232

	STARTER L
SWITCH #	F.L.A.
0	269
1	275
2	281
3	287
4	293
5	299
6	305
7	311
8	317
9	323
A	329
B	335
C	341
D	347
E	353
F	359

6.0 Start-up Instructions

6.1 Preliminary Instructions

CAUTION! **Equipment is at lethal AC line voltage when AC power is connected. All Phases must be disconnected by shutting down main power feed to this unit before it is safe to touch motor terminals or control equipment parts.**

1. Verify that incoming supply voltage matches the rated supply voltage of the MVDBS unit. Per NEMA MG1, for long motor life, voltage unbalance should not exceed 5%.

2. Verify that full-load amps (FLA) of motor does not exceed the FLA rating of the MVDBS being used, as shown in Section 5, Table 3.

3. Follow the Setup Instructions in Section 5.2 and verify that the 8-position dipswitch, located on the main control board, is set correctly for application. (See Factory Default Settings, Section 5, Figure 9)

4. Verify that the 16-position FLA switch (SW1) on the main control board is set in correct position for the starter size and FLA of motor being used. Starter current rating is shown on the nameplate.

5. Verify that Current Step switch (SW2), located on the main control board, is set in accordance with the RAM data sheet for this job. This switch is adjustable from 200-425% of FLA.

6. When MVDBS is set to operate in Step Ramp mode, the Ramp Switch (SW3) should be set to control the time in seconds in which the current rises from its initial current setting to 500% FLA. This switch designates the bypass time when starter is in Constant Current mode.

7. Verify that properly sized power leads are connected to MVDBS incoming terminals L1, L2, and L3.

8. Verify that properly sized ground cable is connected to Ground Terminal on MVDBS.

9. Check motor lead connections and verify that proper power leads are connected to MVDBS as shown in Section 4, Figure 1, depending on rotation of motor.

10. Verify that control wire connections are made per RAM wiring diagram.

11. Run the starter in the "Test Mode" per Section 7.1.

6.2 Start-Up

NOTE! **When starting the MVDBS controller, it is recommended that the display unit be used to continuously monitor current during the start-up procedure.**

DANGER! **Fuse barriers and removeable panels must be in place before applying power to the starter.**

1) Pre-start adjustments have been checked and confirmed.
2) Make certain all personnel, tools, and equipment are clear of controller and motor-driven moving parts.
3) If the motor is remotely located, it is essential to have another person stand by the motor to verify direction of motor rotation.
4) Apply power; close main disconnect switch on starter.
5) MVDBS control board performs preliminary system diagnostics.
6) Green "READY" LED illuminates confirming all internal system tests have passed and there are no shorted SCRs, phase reversal, or other faults.

WARNING! **Do not manually operate contactor to jog motor. SERIOUS PERSONAL INJURY OR EQUIPMENT DAMAGE MAY RESULT!**

7) Make sure the motor is ready to be started in an unloaded condition.
8) Energize the “Start” circuit; motor will begin to accelerate; green “RUN” LED will blink.
9) Motor reaches full speed; green “RUN” LED remains on steady.
10) Check all three line currents are balanced via the display unit.

CAUTION! **Do not allow motor to remain energized if it stalls. If the motor fails to accelerate, immediately de-energize the motor by local, remote, or manual stop control.**

11) If at any time during the starting cycle the motor does not accelerate or stops, disconnect power to the control circuit and open the line disconnect.
12) Make necessary adjustments and repeat starting procedure.
13) Should the motor still fail to start, consult Section 7.0, Troubleshooting.

6.3 Re-adjustments

After the motor has been started, fine adjustments may be required. The MVDBS settings should be adjusted so that the motor reaches full speed in the minimum amount of time without causing any appreciable power dip or excessive mechanical stress.

7.0 Troubleshooting

CAUTION! **Equipment is at lethal AC line voltage when AC power is connected. All Phases must be disconnected by shutting down main power feed to this unit before it is safe to touch motor terminals or control equipment parts.**

NOTE! **Ensure the main disconnect switch is open before using the Test Mode or servicing this equipment. Verify through the disconnect viewing window, that the main disconnect blades are fully seated against the switch grounding bar.**

WARNING! **When the main disconnect switch is open, the primary line terminals may be still be energized by circuits upstream.**

7.1 Test Mode

The Test Mode can assist in verifying the proper operation of the MVDBS. Enter and run the MVDBS Test Mode as follows:

Enter and Run the Test

- Open the main disconnect switch. The Test Mode cannot be enabled with the main disconnect closed.
- Insert a 120Vac supply into the receptacle in the low voltage control cabinet.
- Put the control panel Test/Run switch in “Test.”
- Set Switch SW4, position 4 on the control board to the left. Refer to Figure 9, in section 5.
- The display unit should read: “Test Mode Ready”.
- Press “Enter” on the keypad to begin the test.
- The line contactor will cycle 3 times. This ensures the line contactor is functional.
- Then, the Bypass contactor will cycle 3 times. This ensures the Bypass contactor is functional.

NOTE! **An ohmmeter can be used to verify closure of the contactor by monitoring the contactor auxiliary contacts. Refer to the schematics supplied with the job for terminal block points to monitor. When the contactor closes, the meter will read near zero ohms (short). When the contactor opens, the meter will read infinite impedance.**

- Lastly, two red LEDs on the gate driver boards will pulse on and off. Refer to Figure 4. These LED’s signify that the Gate Driver Boards are receiving a gate command from the Power Board located in the control cabinet. The Gate Driver Boards are located on the SCR Assemblies inside the main door.
- After the Test has fully cycled, the Test may be repeated by pressing “Enter” on the display unit.
- Note any problems encountered, and refer to Table 4 for Diagnostics and Troubleshooting suggestions.

Exit the Test

- Remove the 120Vac supply from the control panel.
- Put the control panel Test/Run switch in “Run.”
- Set Switch SW4, position 4 to the right. Refer to Figure 9, in section 5.

7.2. Start-Up Problems

TABLE 4 Diagnostics and Troubleshooting

PROBLEM	PROBABLE CAUSE	SOLUTION
1. Motor will not start.	1. Start circuit wired incorrectly. 2. No start input signal.	1. Remove power; correct wiring. 2. Confirm voltage exists between terminals 4 and 5 on MVDBS control board. 3. Restore start input signal from micro controller.
2. Display and LEDs not illuminated.	1. No control voltage on MVDBS control board.	1. Check FU1 fuse on MVDBS control board. 2. Check control power transformer fuse. 3. Check all fuses in control cabinet. 4. Check cable from J1 of MVDBS control board to J1 of door display. 5. Verify control harness plugs solidly connected at main door to enclosure junction. 6. Check for loose control wires.
3. Controller does not make transition to RUN.	1. Defective bypass contactor. 2. FLA setpoint (SW1) not programmed properly. 3. Motor incorrectly connected.	1. Check operation of contactor; connect remote source of control power to contactor. 2. Coordinate SW1 setting with FLA of motor. See Table 3. 3. Connect motor per motor nameplate.
4. Cannot enter EDIT mode to change setpoint values.	1. MVDBS controller is in "Start" or "Run" state.	1. Setpoint values cannot be changed while motor is running. 2. Status code "rdy", "trip", or "cool" must appear on display.
5. Inline or Bypass contactor does not cycle during the Test Mode.	1. Loose connection. 2. Defective contactor.	1. Check that the harness plug is fully seated in the contactor receptacle. 2. Use an ohmmeter to check that T1 and L1 terminals not shorted. Repeat with T2, L2, and T3, L3.
6. LEDs on MVGD board do not pulse during Test Mode.	1. Loose connection. 2. Defective board.	1. Check FU1 fuse on the MVGD board. 2. Check the fiber optic cable is plugged in PL1 on the MVGD board. 3. Check the fiber optic cables are plugged into P9, P10, and P11 on the Power Board. 4. Check harness plugs are fully seated in TB1, TB2, and TB3 receptacles.

TABLE 4 (CONTINUED)

7.3. Trip Conditions

TRIP CONDITION	PROBABLE CAUSE	SOLUTION
1. Jam	1. Current exceeded Jam Trip level set point longer than time delay set point while in RUN state.	1. Acknowledge trip. 2. Confirm Jam trip and delay setpoints. 3. Resolve mechanical problems of driven equipment.
2. Short Circuit	1. Current exceeded 800% of FLA set point while motor was starting.	1. Acknowledge trip. 2. Confirm correct motor wiring. 3. Check for shorts in starter and motor junction box: phase-to-phase, phase-to-ground.
3. Thermal Overload	1. Calculated thermal capacity of motor exceeded 100% of limit. 2. Motor is "short-cycling".	1. Acknowledge trip. 2. Allow motor to cool then re-start. 3. Check current of fully loaded motor to verify whether it exceeded its temperature limit, with readout on display unit. 4. Confirm setpoints: • FLA (SW1) • Locked rotor current • Stall time • Service factor
4. Shorted SCR	1. Defective SCR. 2. Defective bypass contactor. 3. Motor disconnected.	1. Acknowledge trip. 2. Check SCRs per test procedure. (See Appendix C) Call RAM if defective. Do not replace in field. 3. Inspect main contacts of bypass contactor.

TABLE 4 (CONTINUED)

7.3. Trip Conditions

TRIP CONDITION	PROBABLE CAUSE	SOLUTION
5. Phase Loss	1. Loss of at least one phase of supply voltage. 2. Loss of at least one phase of current feedback. 3. Loose CT (current transformer wires). 4. Starter size dip switches not correctly set.	1. Acknowledge trip. 2. Restore power. 3. Check CT connector TB2 on MVDBS power board. 4. Check CT wires on TB2 (left wall) inside main enclosure. 5. Check gate lead connections P3-P8 on MVDBS power board. 6. Check fiber optic cable connections. 7. Verify starter size is set per customer label (see Appendix A). 8. Replace MVDBS control/power board set.
6. Phase Reversal Trip (Trip occurs in READY state)	1. Incorrect phase order at MVDBS chassis input terminals. 2. Control power applied before 3 phase power.	1. Acknowledge trip. 2. Reverse L1 and L2 power wires at MVDBS input. 3. If control power is derived from separate source, it must be in phase with the power supply to MVDBS.
7. Ambient Overtemperature	1. Internal temperature of enclosure has exceeded maximum safe operating temperature of 70 deg. C. 2. Temperature sensing cable connection P2 is loose.	1. Acknowledge trip. 2. Allow starter to cool, then re-start motor. 3. Assure ambient temperature does not exceed 50 deg. C. 4. Controller load capacity must be derated when ambient temperature exceeds 50 deg. C. 5. Replace defective temperature sensing cable.

TABLE 4 (CONTINUED)

7.4 Alarm Conditions

ALARM CONDITION	PROBABLE CAUSE	SOLUTION
1. Current Unbalance	1. Current between two phases exceeds the setpoint value longer than the time delay setpoint. 2. Voltage unbalance. 3. Abnormal SCR operation.	1. Acknowledge alarm. 2. Check for voltage balance between phases. Customer must consult power supplier if balance is abnormal. 3. Load balance on customer's system must be re-distributed. 4. Current unbalance and current run delay setpoints may need adjustment. See Table 7, Section 9.

TABLE 5

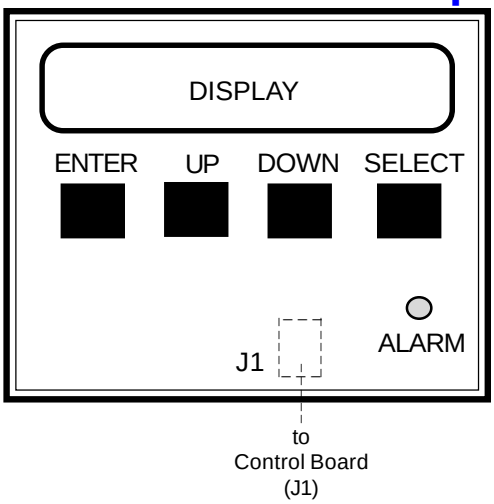
LED and Relay Status for Alarm and Trip Conditions

CONDITION	LED STATUS				RELAY STATUS		
TRIP	**READY** (Green)	**RUN** (Green)	**ALARM** (Yellow)	**FAULT** (Red)	**RUN**	**BYPASS**	**ALARM**
SHORT CIRCUIT	OFF	OFF	OFF	**ON**	OFF	OFF	**ON**
THERMAL OVERLOAD	OFF	OFF	OFF	**ON**	OFF	OFF	**ON**
SHORTED SCR	OFF	OFF	OFF	**ON**	OFF	OFF	**ON**
PHASE REVERSAL	OFF	OFF	OFF	**ON**	OFF	OFF	**ON**
PHASE LOSS	OFF	OFF	OFF	**ON**	OFF	OFF	**ON**
JAM PROTECTION	OFF	OFF	OFF	**ON**	OFF	OFF	**ON**
AMBIENT OVERTEMPERATURE	OFF	OFF	OFF	**ON**	OFF	OFF	**ON**
PLL FAILURE	OFF	OFF	OFF	OFF	OFF	OFF	OFF
ALARM							
CURRENT UNBALANCE	N/A	N/A	**ON**	OFF	N/A	N/A	**ON**

8.0 MVDBS Control Display Unit

Refer to Figure 10 for an illustration of the MVDBS Control Display Unit, which is located on the Control Section door.

FIGURE 10
MVDBS Control Display Unit



8.1 Description

The MVDBS Control/Display Unit is mounted in the door of the controller's enclosure. All aspects of motor operation and control can be performed via this interface. The Control/Display unit is connected to the MVDBS control board by cable to its RS-232 port.

DISPLAY - The backlit liquid crystal display screen has 2 lines of 20-characters. The display screen shows the current menu selection, operating mode, associated values, and units of measurements.

MENUS - Four menus enable the operator to view motor, operating, and historical data for the application, as well as edit the operating parameters. The menus are MONITOR, SET POINT, SYSTEM SETUP, and FAULT HISTORY.

NAVIGATION - Four keypad buttons are used to move through the menus, to edit set point values, and to acknowledge alarm and trip conditions.

ALARM - An LED on the face of the Control/Display unit alerts the operator to an alarm or trip condition. The LED will blink until the alarm or trip condition is acknowledged.

STATUS CODES - A status code denoting the operating state of the MVDBS controller is displayed continually in the lower left of the display screen. These codes are:

1. **run** = RUN
2. **rdy** = READY
3. **strt** = START
4. **trip** = TRIP
5. **cool** = COOL-DOWN
6. **edit** = EDIT MODE

8.2 Operation

- When power is applied, the display screen will read “RAM Industries.” After the MVDBS chassis performs preliminary system diagnostics, “MONITOR MENU” will appear on the display screen.
- During normal operation the MONITOR menu should be selected. From this menu the operator can acknowledge alarm or trip conditions, monitor the current operating status of the system, and view the motor operating conditions.
- Press SELECT key to choose an alternate menu.
- Pressing the SELECT key while in any one of a menu’s parameters will cause the display screen to revert to the title of that menu.
- To view the contents of a menu, press the UP/DOWN keys.
- Pressing the ENTER key while in the any of the main menus, or while viewing parameters in the MONITOR or FAULT HISTORY menus will have no effect.

8.3 Acknowledging Trips and Alarms

- If an alarm or trip condition occurs, it will be displayed regardless of the menu selected at the time it occurs.
- The display screen will read “Alarm - Enter = Ack” or “Trip - Enter = Ack”.
- To acknowledge a trip or alarm condition, press the ENTER key.
- A message on the display screen will confirm the TRIP/ALARM has been acknowledged.

8.4 Editing Set Points

- Set points cannot be edited while in the START or RUN operating states.
- Select the SET POINT menu.
- Press the UP/DOWN keys to go to the desired parameter, then press the ENTER key to enter the “Edit” mode. The edit code (8.1.5.6.) will flash on the display screen.
- Press the UP/DOWN keys to increase or decrease the set point value. If a subsequent key is not pressed within 30 seconds, the previously stored value will be retained.
- To abort the edit and return to the stored value, press the SELECT key.
- To save the new value as the set point, press the ENTER key.

8.5 Confirming System Setup

- Select SYSTEM SETUP menu.
- To view the values of the settings on the MVDBS control board, press the UP/DOWN keys.

8.6 System Override Functions

- In the SYSTEM SETUP menu there are three functions that can be reset by an authorized operator or technician: CLEAR THERMAL CAPACITY, CLEAR FAULT HISTORY, and LOAD FACTORY SETUP.
- To clear the memory of a function, select the function via the UP/DOWN keys, then press ENTER.
- Press the SELECT key to go to confirm selection.

9.0 MVDBS Control / Display Unit Menu Tables

TABLE 6 Monitor Menu

This menu is used to display the current system conditions of the MVDBS controller.

SELECTION	UNITS	DESCRIPTION
Average Current	Amps	Current measured by the three current inputs averaged together and displayed as an rms value.
Current Phase A	Amps	"Live" current reading for phase A.
Current Phase B	Amps	"Live" current reading for phase B.
Current Phase C	Amps	"Live" current reading for phase C.
Elapsed Run Time	Hr:Min	Time since last start.
Thermal Capacity Used	%Cap	Calculated thermal capacity used by the motor.
Ambient Temperature	DegC	Enclosure internal ambient temperature.
Time Till Start	Minutes	Time remaining before the thermal capacity drops low enough for the motor to be allowed to start.
Alarm - Enter = Ack		Prompt to acknowledge alarm.
Trip - Enter = Ack		Prompt to acknowledge trip.

TABLE 7 Set Point Menu

This menu displays the set point values programmed into the MVDBS controller. Changes to system set points in this menu must be made from the "edit" mode.

SELECTION	RANGE	DEFAULT	UNITS	DESCRIPTION
Locked Rotor Current	300 - 800	600	%FLA	Motor manufacturer's specified current draw for a stalled motor.
Stall Time	1 - 60	10	Seconds	Length of time the motor can draw lock rotor current and not experience damage.
Jam Current Level	100 - 600	300	%FLA	Current limit allowed for an abnormally sudden increase in motor load.
Jam Run Delay	0 - 60	10	Seconds	Length of time the jam current level can be exceeded before an alarm.
Service Factor	75 - 125	115	%FLA	Service factor shown on the motor nameplate
Current Unbalance Level	2 - 25	25	%FLA	Amount of current one phase is allowed to exceed the average current of all three phases.
Current Unbalance Delay	0 - 240	5	Seconds	Length of time the current unbalance level can be exceeded before an alarm.
Decel Time	1-60	5	Seconds	Time to decelerate the motor in a controlled deceleration.
Decel Begin Level	0-100	60	% Volts	Percentage of the line voltage applied to the motor at the start of the controlled deceleration.
Decel End Level	0-100	20	% Volts	Percentage of the line voltage applied to the motor at which the motor is no longer responsive to a controlled deceleration.

9.0 MVDBS Display Unit (continued)

TABLE 8

Fault History Menu

This menu displays the fault history of the system. Refer to this menu when troubleshooting.

SELECTION	UNITS	DESCRIPTION
Last Trip Condition		Type of trip last recorded.
Last Trip Current	Amps	Average RMS current measured at time of trip.
Last Trip Ambient Temperature	DegC	Temperature of enclosure internal ambient at time of trip
Last Trip Thermal Capacity	%Cap	Amount of motor's thermal capacity remaining at time of trip
Last Trip FLA	Amps	FLA setpoint at time of trip.
Last Trip Current Step	%FLA	Current step - setpoint at time of trip.
Last Trip Ramp Time	Seconds	Ramp time - setpoint at time of trip.
Last Trip Bypass Time	Seconds	Bypass time - setpoint at time of trip.
Last Trip Run Time	Hr:Min	Amount of time motor ran before trip.
Total No. of Starts		Number of times motor was started.
Total Run Time	Hr:Min	total motor run time unit has measured.
Total No. of Jam Trips		Number of jam trips.
Total No. of Short Circuit Trips		Number of short circuit trips.
Total No. of Phase Loss Trips		Number of phase loss trips.
Total No. of Phase Reversal Trips		Number of phase reversal trips.
Total No. of Current Unbalance Alarms		Number of current unbalance alarms.
Total No. of Ambient Overtemperature Trips		Number of enclosure internal ambient temperature trips.
Total No. of Thermal Overload Trips		Number of overload trips

TABLE 9

System Setup Menu

This menu displays the current system setup in the MVDBS controller.

SELECTION	PARAMETERS	DEFAULT
*Full Load Amps	Motor nameplate full load current (SW1)	See FLA - Starter Size Table 9
*Starting Mode	Constant Current/Step Ramp (SW4)	Factory set for Step Ramp - See Section 5.2.4.
*Constant Current Level	200 - 425% in 25% increments (SW2)	Factory set for 250% - See Section 5.2.2.
*Ramp Time	3 - 30 Sec. in 3 sec. increments (SW3)	Factory set for 6 Sec. - See Section 5.2.3.
*Bypass Time	3 - 30 Sec. in 3 sec. increments (SW3)	Factory set for 11 Sec. - See Section 5.2.3.
*Starter Size	A to L (SW6)	Factory set.
*Thermal Overload Protection	Enable - Disable (SW4)	Factory set for Enable.
*Decel	Controlled Decel / Coast Stop (SW4)	Factor set for Coast Stop.
*Control Mode	Display/Network (SW4)	Factory set for application.
Network Protocol	Modbus ASCII / Optomux / Modbus RTU	Valid when control mode selected is network.
Network Parity	Odd / None / Even	Valid when network protocol is Modbus.
Network Baud Rate	19200 / 9600 / 4800 / 2400	Valid when network protocol is Modbus.
Network Address	1 to 247	Valid when network protocol is Modbus.
Software Version		
Clear Fault History	Yes - No	Deletes fault history.
Clear Thermal Capacity	Yes - No	Resets calculated motor temperature to zero.
Load Factory Setup	Yes - No	Restores default set points. (See Table 14)

*Indicates setting is controlled by circuit board switches on main control board.

10.0 MVDBS Log

Serial Number_____

MVDBS Log

Switch Settings

(Copy settings as currently set on main control board)

	(Sw Pos)
Switch 1 - FLA	_____
Switch 2 - Current Step	_____
Switch 3 - Ramp Time	_____

Switch 4 - Configuration Dip Switch

	(Circle Switch Position)
Pos 1	LEFT/RIGHT
Pos 2	LEFT/RIGHT
Pos 3	LEFT/RIGHT
Pos 4	LEFT/RIGHT
Pos 5	LEFT/RIGHT
Pos 6	LEFT/RIGHT
Pos 7	LEFT/RIGHT
Pos 8	LEFT/RIGHT

Fault History Menu

	Setting	
Last Trip Condition	_____	
Last Trip Current	_____	Amps
Last Trip Ambient Temperature	_____	Deg C
Last Trip Thermal Capacity	_____	% Cap
Last Trip FLA	_____	Amps
Last Trip Current Step	_____	% FLA
Last Trip Ramp Time	_____	Seconds
Last Trip Bypass Time	_____	Seconds
Last Run Time	_____	Minutes
Total No. of Starts	_____	
Total Run Time	_____	Hours
Total No. of Jam Trips	_____	
Total No. of Short Circuit Trips	_____	
Total No. of Phase Loss Trips	_____	
Total No. of Phase Reversal Trips	_____	
Total No. of Current Unbalance Alarms	_____	
Total No. of Ambient Temperature Trips	_____	
Total No. of Thermal Overload Trips	_____	

Set Point Menu

	Setting	
Locked Rotor Current	_____	% FLA
Stall Time	_____	Seconds
Jam Current Level	_____	% FLA
Jam Run Delay	_____	Seconds
Service Factor	_____	% FLA
Current Unbalance Level	_____	% FLA
Current Unbalance Run Delay	_____	Seconds
Decel Time	_____	Seconds
Decel Begin Level	_____	% Volts
Decel End Level	_____	% Volts

System Setup Menu

	Setting	
FLA	_____	Amps
Start Mode	_____	
Constant Current Level	_____	% FLA
Ramp Time	_____	Seconds
Bypass Time	_____	Seconds
Starter Size	_____	
Thermal Overload	_____	
Decel	_____	
Control Mode	_____	
Protocol	_____	
Parity	_____	
Baud Rate	_____	
Address	_____	
Software Version	_____	

11.0 Maintenance

WARNING: **Disconnect all incoming power to this equipment and lock-out and tag circuits prior to performing preventive maintenance. Snubber capacitors require 2 minutes to discharge. Discharge other capacitors, if present. Positively ascertain that the equipment is totally de-energized, including possible foreign sources by using appropriate metering.**

NOTE: **Ensure the main disconnect switch is open. Verify through the disconnect viewing window, that the main disconnect switch blades are fully seated against the switch grounding bar.**

WARNING: **When the main disconnect switch is open, the primary line terminals may still be energized by circuits upstream.**

- For equipment to operate properly, and to reduce unscheduled down-time, a periodic maintenance program should be established.
- It is recommended that at least once each year the following steps be taken.

Enclosures

- Carefully inspect all enclosure surfaces for signs of excessive heat. As a general rule of thumb, any temperature which the palm of the hand cannot stand for about 3 seconds may indicate a problem.
- Check all cabinet doors to assure proper operation and that all door latching and/or locking devices are in proper working order.
- Look inside cabinets for any signs of moisture, dripping, or condensation. Seal off any conduits which may have dripped condensate or provide an alternate means for drainage. Seal off any cracks or openings which may have allowed moisture to enter the enclosure and eliminate the source of moisture on the outside of the enclosure.
- Thoroughly dry all cabinet surfaces which may be damp or wet. If accumulated deposits are apparent, conduct an electrical insulation test to assure proper insulation integrity.
- If there is an accumulation of dust, remove with a vacuum cleaner or clean with lint-free rags. Do not attempt to use compressed air as it may contaminate other internal components.

Wiring

- Inspect all accessible wiring for signs of looseness or overheating. Re-tighten to proper torque values as required. If major discoloration of wire insulation or cable damage is apparent, replace the affected cable.
- Identify and re-mark all cables in accordance with equipment drawings where required.

Disconnecting Means

- Operate main disconnect to assure proper operation of disconnect and mechanical interlock.

Fuses

- Examine all fuse clips and fuse blocks for signs of overheating or looseness. If there is any indication of reduced spring tension or overheating, replace the fuse clips or fuse block assembly.
- Assure that all fuses are the correct type and the proper size as listed on devices and applicable drawings.

Contactors

- If there is an accumulation of dust, remove with a vacuum cleaner or clean with lint-free rags. Do not attempt to use compressed air as it may contaminate other internal components.
- Operate both contactors via the Test Mode (Section 7.1) to ensure proper operation.

General

- List all component part numbers which may be showing signs of wear, and order replacements for installation at next scheduled shut-down period.
- Note any equipment additions and/or wiring modifications on the appropriate drawings, for maintenance use and troubleshooting.

Maintenance After a Fault Has Occurred

CAUTION! **After a fault has occurred, all equipment must be de-energized, disconnected, and isolated to prevent accidental contact with live parts. Check voltage on all terminals before touching or working on equipment. Only qualified individuals should be involved in the inspection and repair procedures and all safety precautions must be observed.**

- The excessive currents occurring during a fault may result in enclosure, component, and/or conductor damage due to mechanical distortion, thermal damage, metal deposits, or smoke. After a fault, determine the cause, inspect, and make any necessary repairs or replacements prior to re-commissioning this equipment. The following procedure is recommended for this inspection.

Enclosure

- Check cabinet exterior for any signs of deformation or heat damage. Assure that all hinges and cabinet latching and/or locking mechanisms are in working order. Replace affected parts if required.

Disconnecting Means

- Operate main disconnect to assure proper operation of disconnect and mechanical interlock.

Fuses

- Always replace all three fuses in a three phase circuit, even though only one or two are open. Possible heat damage in the remaining fuse(s) could result in a subsequent shutdown.

Terminals and Internal Conductors

- Replace all damaged parts which show signs of discoloration, melting, or arcing damage.

Contactors

- Operate both contactors via the Test Mode (Section 7.1) to ensure proper operation.

Restoring to Service

- Before restoring the equipment to service, it is recommended that the steps outlined in procedures for START-UP are followed.

DANGER! **Fuse barriers and removable panels must be in place before applying power to the starter.**

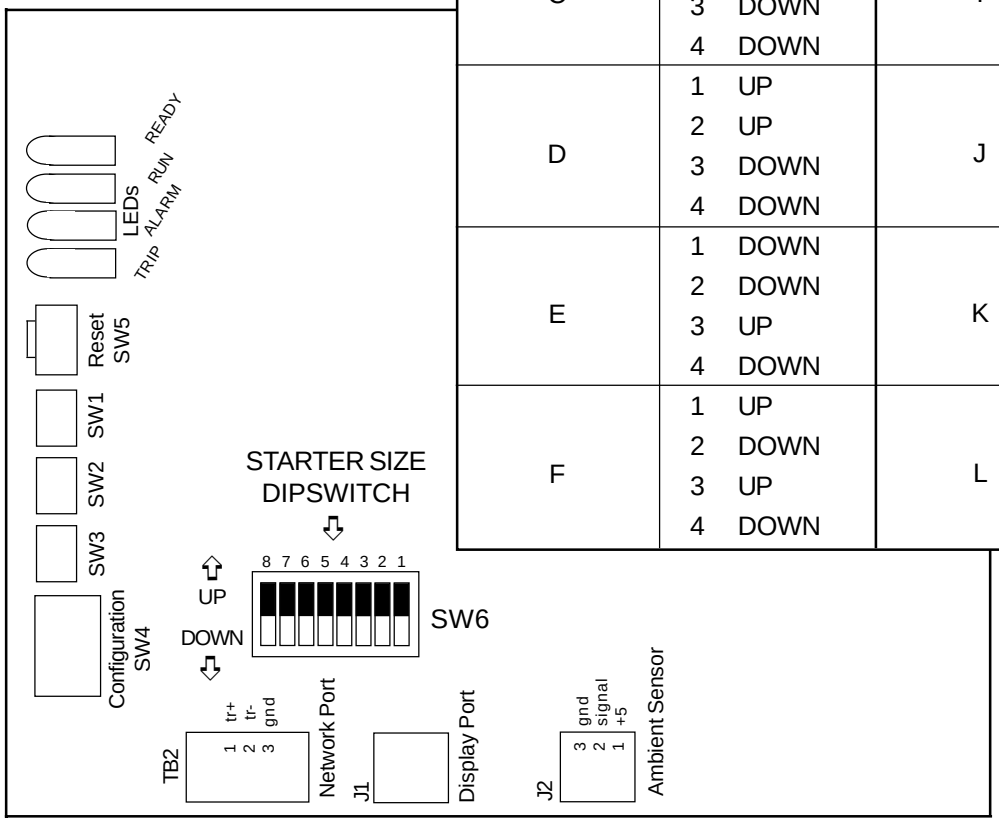
Appendix A

FIGURE 11 Starter Size DIP Switch Positions

TO DETERMINE STARTER SIZE

Revised 01/06

STARTER SIZE	SWITCH	STARTER SIZE	SWITCH
A	1 DOWN 2 DOWN 3 DOWN 4 DOWN	G	1 DOWN 2 UP 3 UP 4 DOWN
B	1 UP 2 DOWN 3 DOWN 4 DOWN	H	1 UP 2 UP 3 UP 4 DOWN
C	1 DOWN 2 UP 3 DOWN 4 DOWN	I	1 DOWN 2 DOWN 3 DOWN 4 UP
D	1 UP 2 UP 3 DOWN 4 DOWN	J	1 UP 2 DOWN 3 DOWN 4 UP
E	1 DOWN 2 DOWN 3 UP 4 DOWN	K	1 DOWN 2 UP 3 DOWN 4 UP
F	1 UP 2 DOWN 3 UP 4 DOWN	L	1 UP 2 UP 3 DOWN 4 UP



Starter size DIP switch is located on the interior of the board (SW6). SW6 is positioned horizontally toward the bottom of the board. Switch position #1 is farthest from the front edge of the board.

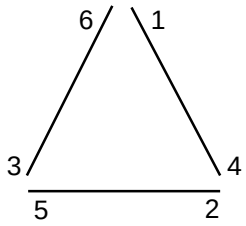
This switch is factory preset and shouldn't be changed without factory approval.

Appendix B

FIGURE 12 Typical Motor Connections Dual Voltage Six-Lead Delta/Wye Connected Motors

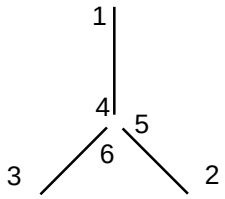
Lower Voltage
Delta Connection

L1	L2	L3
1, 6	2, 4	3, 5



Higher Voltage
Wye Connection

L1	L2	L3	JOIN
1	2	3	4 & 5 & 6



Appendix C

SCR Assembly Test Procedure

DANGER! **Hazard of Burn or Electrical Shock. Make certain that all incoming sources of power have been disconnected, locked out, and tagged prior to working on this equipment.**

NOTE! **Ensure the main disconnect switch is open. Verify through the disconnect viewing window, that the main disconnect switch blades are fully seated against the switch ground bar.**

WARNING! **When the main disconnect switch is open, the primary line terminals may still be energized by circuits upstream.**

1. Make sure that all power sources are turned off and properly locked out.

2. Remove the motor leads.

3. Measure with an ohmmeter L1, L2, L3 (top heatsink of SCR Assemblies), T1, T1, and T3 (bottom plate of SCR Assemblies) individually to ground. There should be an open circuit or an infinite reading on the meter.

4. Remove the Gate-Cathode leads on each SCR Assembly. This would be terminals TB2, and TB3 on the Gate Driver Card (refer to Figure 4, Section 4.) With an ohmmeter, measure between pins 1 and 2 on the TB2 and TB3 terminals. About 8 to 20 ohms should be measured in both directions.

5. Use an ohmmeter to measure L1 (top SCR heatsink plate) to T1 (bottom heatsink plate.) The resistance measurement should be greater than 50kohms. Reverse the polarity of the meter leads and measure again. The readings should be about the same. Repeat the measurements from L2 to T2 and L3 to T3.

NOTE! **Resistance measurements on the SCR Assemblies may vary depending upon the type of ohmmeter used.**

NOTE! **A steadily increasing resistance measurement may result with the R-C snubber circuit still tied across the SCR Assembly. This is simply a result of the capacitors charging up.**

Appendix D

Modbus Communication

Modbus Setup: In order to enable Modbus, it is necessary to do the following:

- Select the "Network" Control Mode via Switch SW4, switch positions 1 and 2.
- Configure the "Network Protocol" in the "System Setup Menu" by selecting "Modbus ASCII" or "Modbus RTU."
- If "Modbus ASCII" is selected, then you must select the Network Parity (Odd, None, Even), Network Baud Rate (19200, 9600, 4800, 2400), and Network Address (1 to 247).

Modbus Capability:

- RS-485 Half Duplex
- ASCII / RTU Mode
- 2400 / 4800 / 9600 / 19200 Mb/sec
- Even / Odd / None Parity

TABLE 10 Modbus Registers

REGISTER	DESCRIPTION	CAPABILITY
40020	Start/Stop Control	Read/Write
40021	Future	Read/Write
40022	Future	Read/Write

Set Point Menu (refer to Table 7)

REGISTER	DESCRIPTION	RANGE	DEFAULT	UNITS	CAPABILITY
40023	Locked Rotor Current	300-800	600	%FLA	Read/Write
40024	Stall Time	1-60	10	Sec.	Read/Write
40025	Jam Current Level	100-600	300	%FLA	Read/Write
40026	Jam Run Delay	0-60	10	Sec.	Read/Write
40027	Service Factor	75-125	115	%FLA	Read/Write
40028	Current Unbalance Level	2-25	25	%FLA	Read/Write
40029	Current Unbalance Delay	0-240	5	Sec.	Read/Write
40030	Deceleration Time	1-60	5	Sec.	Read/Write
40031	Deceleration Begin Level	0-100	60	%Volts	Read/Write
40032	Deceleration End Level	0-100	20	%Volts	Read/Write

System Setup Menu (refer to Table 9)

REGISTER	DESCRIPTION	UNITS	CAPABILITY
40034	Bypass Time	Sec.	Read
40035	Constant Current Level	%FLA	Read
40036	Ramp Time	Sec.	Read
40037	Starter Size		Read
40038	Future		Read
40039	Software Version		Read
40040	Full Load Amps	Amps	Read

Monitor Menu (refer to Table 6)

REGISTER	DESCRIPTION	UNITS	CAPABILITY
40041	Average Current	Amps	Read
40042	Elapsed Run Time (since last start)	Hours	Read
40043	Elapsed Run Time (minutes beyond hours)	Min.	Read
40044	Phase A Current	Amps	Read
40045	Phase B Current	Amps	Read
40046	Phase C Current	Amps	Read
40047	Ambient Temperature	DegC	Read
40050	Thermal Capacity Used	%Cap	Read
40051	Time Till Start	Min.	Read

Fault History (refer to Table 8)

REGISTER	DESCRIPTION	UNITS	CAPABILITY
40052	Last Trip Condition		Read
40053	Last Trip Current	Amps	Read
40054	Last Trip Internal Ambient Temperature	DegC	Read
40055	Future		Read
40056	Future		Read
40057	Last Trip Thermal Capacity	%Cap	Read
40058	Last Trip FLA	Amps	Read
40059	Last Trip Current Step	%FLA	Read
40060	Last Trip Ramp Time	Sec.	Read
40061	Last Trip Bypass Time	Sec.	Read
40062	Last Trip Run Time	Hours	Read
40063	Last Trip Run Time (minutes beyond hours)	Min.	Read
40064	Total Run Time	Hr:Min	Read
40065	Future		Read
40066	Total No. Starts		Read
40067	Total No. Short Circuit Trips		Read
40068	Total No. Jam Trips		Read
40069	Total No. Phase Loss Trips		Read
40070	Total No. Phase Reversal Trips		Read
40071	Total No. Current Unbalance Alarms		Read
40072	Total No. Ambient Overtemp.Trips		Read
40075	Total No. Thermal Overload Trips		Read

Glossary

Alarm - A warning signal that an undesirable condition has been detected. The alarm LED will blink when an alarm condition is detected. See Section 1.6 for more alarm LED information.

Ambient Temperature - The temperature surrounding a device.

Average Current - The current measured at each of the three current inputs, averaged together, and displayed as an rms value.

Bypass Time - The length of time that must expire after the motor is started to cause the bypass contactor to engage.

Constant Current Mode - In this mode, the starting motor current is maintained at a constant level. When the motor is at full speed, the current is determined by the motor load.

Current Phase A - The "live" current reading for Phase A.

Current Step - The initial current limit value of the controller when the MVDBS is in either the Constant Current or Step Ramp mode. When in Constant Current mode, this current limit is maintained until the motor reaches full speed. In Step Ramp mode, this value sets the initial ramp level limit and then allows the controller to continue the ramp to 500%.

Current Unbalance - When any one of the three current phases exceeds the average of the three current phases by more than a predetermined percentage.

CT - Current Transformer

Elapsed Run Time - The time that has expired since the unit has entered the Start state (Section 9, Table 6).

Fault - An undesirable condition that will cause an Alarm or a Trip to occur.

FLA (Full Load Amps) - The amount of current normally drawn by a motor when at rated load and voltage.

Heatsink - Metal used to dissipate the heat of solid-state components mounted on it.

Jam - An increase in motor load which causes the current to rise significantly.

Jam Current Level - The percentage of FLA that the average of the three current phases is allowed to reach during the Run state.

Jam Run Delay - The length of time during the Run state that the current must be above the Jam Current Level to cause a fault.

Glossary

LCD (Liquid Crystal Display) - A readout device in which each digit is formed by strips of liquid-crystal material.

LRC (Locked Rotor Current) - The steady-state current taken from the line with the rotor locked (stopped) and with the rated voltage and frequency applied to the motor. This is the motor manufacturer's specified current draw for a stalled motor.

MVGD - Medium Voltage Gate Driver.

NEMA - National Electrical Manufacturers Association.

Phase Loss - A condition when a loss of current or voltage has been detected in a polyphase circuit.

Phase Reversal - A condition when incorrect phase rotation has been detected in a polyphase circuit.

PLL - A phase-locked loop (PLL) is an electronic circuit that is constantly adjusted to match the frequency of an input signal.

SCR (Silicon Controlled Rectifiers) - A semiconductor device that must be triggered by a pulse applied to the gate before it will conduct.

Service Factor - An allowable overload; the amount of allowable overload is indicated by a multiplier which, when applied to a normal FLA rating, indicates the permissible loading.

Stall Time - The maximum time at which the motor can be at locked rotor current without damage.

Step Ramp Mode - In this mode, the starter provides an initial current that is a percent of FLA. The current is then ramped from its initial current setting to 500% over an adjustable time period. When the motor is at full speed, the current is then determined by the motor load.

Thermal Capacity - The allowable amount of thermal energy that can be absorbed before damage may occur to the motor.

Thermal Capacity Used - The calculated thermal capacity used by the motor.

Thermal Overload Level - The percentage of thermal capacity that has been consumed. This level is calculated using the average of the 3-phase currents and the time that the current level exists. It is also dependent on the Locked Rotor Current, Stall Time, and the FLA settings. NOTE: Heating from motor starting current normally consumes a large percentage of the thermal capacity. Repetitive starts in a short time span can exhaust the thermal capacity.

Trip - An undesirable condition that could result in damage to the motor. A trip condition will stop the motor if it is running and not allow the motor to start until the cause of the trip condition is cleared.

Notes

Notes

Notes

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