BONITRON

Solutions for AC Drives

Model M3534-I3

Ride-Thru
Voltage Regulator

Customer Reference Manual

Bonitron, Inc.
Nashville, TN

An industry leader in providing solutions for AC drives.

ABOUT BONITRON

Bonitron designs and manufactures quality industrial electronics that improve the reliability of processes and variable frequency drives worldwide. With products in numerous industries, and an educated and experienced team of engineers, Bonitron has seen thousands of products engineered since 1962 and welcomes custom applications.

With engineering, production, and testing all in the same facility, Bonitron is able to ensure its products are of the utmost quality and ready to be applied to your application.

The Bonitron engineering team has the background and expertise necessary to design, develop, and manufacture the quality industrial electronic systems demanded in today's market. A strong academic background supported by continuing education is complemented by many years of hands-on field experience. A clear advantage Bonitron has over many competitors is combined on-site engineering labs and manufacturing facilities, which allows the engineering team to have immediate access to testing and manufacturing. This not only saves time during prototype development, but also is essential to providing only the highest quality products.

The sales and marketing teams work closely with engineering to provide up-to-date information and provide remarkable customer support to make sure you receive the best solution for your application. Thanks to this combination of quality products and superior customer support, Bonitron has products installed in critical applications worldwide.

AC Drive Options

In 1975, Bonitron began working with AC inverter drive specialists at synthetic fiber plants to develop speed control systems that could be interfaced with their plant process computers. Ever since, Bonitron has developed AC drive options that solve application issues associated with modern AC variable frequency drives and aid in reducing drive faults. Below is a sampling of Bonitron's current product offering.

World Class Products

Undervoltage Solutions

Uninterruptible Power for Drives
(DC Bus Ride-Thru)
Voltage Regulators
Chargers and Dischargers
Energy Storage

Overvoltage Solutions

Braking Transistors
Braking Resistors
Transistor/Resistor Combo
Line Regeneration
Dynamic Braking for Servo Drives

Common Bus Solutions

Single Phase Power Supplies
3-Phase Power Supplies
Common Bus Diodes

Portable Maintenance Solutions

Capacitor Formers
Capacitor Testers

Power Quality Solutions

12 and 18 Pulse Kits

Green Solutions

Line Regeneration

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1. INTRODUCTION

1.1. WHO SHOULD USE THIS MANUAL

This manual is intended for use by anyone who is responsible for integrating, installing, maintaining, troubleshooting, or using this equipment with any AC drive system.
Please keep this manual for future reference.

1.2. PURPOSE AND SCOPE

This manual is a user’s guide for the Model M3534 Ride-Thru Voltage Regulator. It will provide the user with the necessary information to successfully install, integrate, and use this in a variable frequency AC drive system.

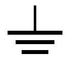
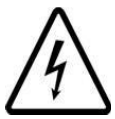
In the event of any conflict between this document and any publication and/or documentation related to the AC drive system, the latter shall have precedence.

1.3. MANUAL REVISION

Notations added to connectors in Figures 3-2, 3-3, 3-4, 3-5, and 3-6 in Rev 00b
The manual template was updated in Rev 00c.
Figures 3-4 and 3-5 were updated in Rev 00d.
Figure 6-5 was updated in Rev 00e.
Updates were made to Section 4.4 for the Enable Input in Rev 00f.
Update made to revision update of the Interface board in Section 2 in Rev 00g.
Updates to Table titles were made in Section 6 in Rev 00h.
Section 6.2 Derating was added in Rev 00i.
Figure 3-3 DP10 wiring was updated in Rev 00j.
Display options were updated in Rev 00k.
Update to include DD5 display in Rev 01a
Updated table 6-5 in Rev 01b.
Updated Section 3.5 in Rev 01c.

Figure 1-1: M3534R in the K7 Chassis

1.4. SYMBOL CONVENTIONS USED IN THIS MANUAL AND ON EQUIPMENT

	Earth Ground or Protective Earth
	AC Voltage
	DC Voltage
 **DANGER!**	DANGER: Electrical hazard - Identifies a statement that indicates a shock or electrocution hazard that must be avoided.
 **DANGER!**	DANGER: Identifies information about practices or circumstances that can lead to personal injury or death, property damage, or economic loss.
 **CAUTION!**	CAUTION: Identifies information about practices or circumstances that can lead to property damage, or economic loss. Attentions help you identify a potential hazard, avoid a hazard, and recognize the consequences.
 **CAUTION!**	CAUTION: Heat or burn hazard - Identifies a statement regarding heat production or a burn hazard that should be avoided.

2. PRODUCT DESCRIPTION

Bonitron's M3534 Ride-Thru Voltage Regulator provides protection from power quality events for variable frequency drives (VFDs) that use a fixed rectifier and DC bus. The M3534R provides sag protection for up to 2 seconds at 50% line sag on all 3 phases. It can also provide protection from short term full outages of up to 2 seconds with the addition of storage systems, such as capacitors. The M3534B, in conjunction with a battery bank, provides protection for up to 60 seconds during a full outage.

Industries with continuous processes can suffer huge losses from equipment downtime, loss of production, or damaged product when VFDs trip on under-voltage conditions. Traditional UPS solutions are connected in series, which decreases the overall drive system reliability. All Bonitron Ride-Thru products connect in parallel with the drive, thus increasing system availability and reliability.

The M3534 regulates incoming voltage to the DC bus of the variable frequency drive. This allows the drive to "ride through" these events while maintaining motor speed and torque without experiencing drive shutdown.

ADVANTAGES

- Reliability
- Parallel connection to AC system
- M3534 maintenance can be done while normal process is on-line
- Works with almost any fixed bus, variable frequency, PWM drive
- Only 2-3 parallel connections
- Can use existing AC feed wiring and breakers
- Instant response
- Bumpless transfer
- Easy commissioning

2.1. RELATED PRODUCTS AND DOCUMENTS

2.1.1. PRODUCTS

S3534CR SERIES RIDE-THRU SYSTEMS

Complete systems that use electrolytic capacitor storage for short term power outages.

S3534UR SERIES RIDE-THRU SYSTEMS

Complete systems that use ultracapacitor storage for short term power outages.

S3534BR SERIES RIDE-THRU SYSTEMS

Complete systems that use batteries for longer term power outages.

M3460 SERIES RIDE-THRU MODULES

Voltage regulators used for sag or outage protection of higher power systems.

M3528 BATTERY AND ULTRACAPACITOR CHARGERS

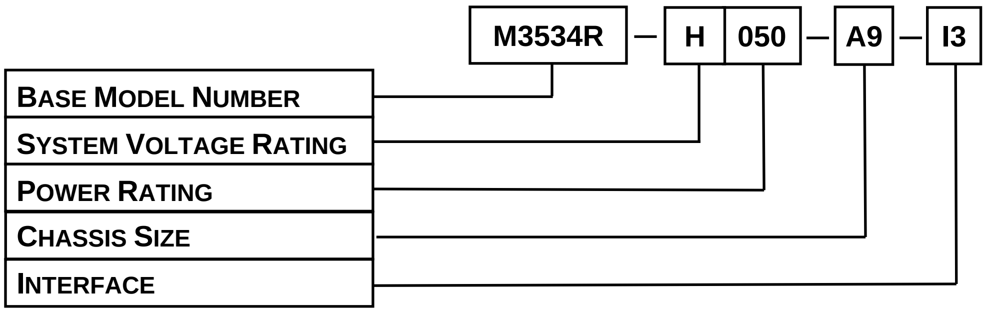
Chargers for high voltage storage strings.

2.1.2. Documents

Please refer to the KIT 3660DD5 manual when this unit is equipped with the DD5 Digital Display option. This manual is available at www.bonitron.com or by contacting Bonitron.

2.2. Part Number Breakdown

Figure 2-1: Example of Part Number Breakdown



Base Model Number

The base model number for all ride-thru modules in this series rated for 2 second operation is **M3534R.** The base model number for all ride-thru modules in this series rated for 60 second operation is **M3534B.**

System Voltage Rating

The M3534 is available in several input voltage ratings. This rating is indicated by a code as shown in Table 2-1.

Table 2-1: System Voltage Rating Codes

Rating Code	Nominal Voltage (AC Line / Drive Bus)
L	230VAC / 325VDC
E	380-415VAC / 540-585VDC
H	460VAC / 650VDC

Power Rating

The power rating indicates the maximum power in kilowatts that can safely be handled by the M3534 and is represented by a 3-digit value based on the nominal DC system voltage rating and the maximum output current rating of the M3534. For instance, the rating code for a 50kW M3534 is **050**.

Chassis Size

Four open type chassis sizes are indicated by a code as shown in Table 2-2. This chassis size is determined by the current rating of the unit.

Table 2-2: Chassis Size Codes

Chassis Size Code	Dimensions (H x W x D)	M3534R	M3534B
A5	18.6” x 5.1” x 9.4”	20A	-
K7	20.0” x 7.4” x 10.3”	40A	-
K9	20.0” x 9.1” x 10.3”	-	40A
A9	22.1” x 8.7” x 10.3”	85A	-

INTERFACE

The Interface selection indicates the M3534 is able to utilize the DP10 and DD5 display options. All current M3534 ride-thru modules have the **I3** interface option. For legacy M3534 modules go to www.bonitron.com or contact Bonitron for the legacy customer manual.

2.3. GENERAL SPECIFICATIONS

Table 2-3: General Specifications

PARAMETER	SPECIFICATION
Input AC Voltage	208 – 480 VAC
Input DC Voltage	200 – 585 VDC
Output DC Voltage	265 – 650 VDC
DC Bus Current Rating	20 – 85 ADC
Power Rating	6 –50 kW
Inactive Power Consumption	<40 W
Duty Cycle (Full Load)	1%
Sag/Outage Duration	2 seconds – 60 seconds
Enclosure Rating	Open
Operating Temperature	0 to +40ºC
Storage Temperature	-20 to +65 ºC
Humidity	Below 90% non-condensing
Atmosphere	Free of corrosive gas and conductive dust

2.4. GENERAL PRECAUTIONS AND SAFETY WARNINGS

DANGER!

- HIGH VOLTAGES MAY BE PRESENT!
- NEVER ATTEMPT TO OPERATE THIS PRODUCT WITH THE ENCLOSURE COVER REMOVED!
- NEVER ATTEMPT TO SERVICE THIS PRODUCT WITHOUT FIRST DISCONNECTING POWER TO AND FROM THE UNIT.
- ALWAYS ALLOW ADEQUATE TIME FOR RESIDUAL VOLTAGES TO DRAIN BEFORE OPENING THE ENCLOSURE.
- **FAILURE TO HEED THESE WARNINGS MAY RESULT IN SERIOUS INJURY OR DEATH!**

CAUTION!

- CERTAIN COMPONENTS WITHIN THIS PRODUCT MAY GET HOT DURING OPERATION.
- ALWAYS ALLOW AMPLE TIME FOR THE UNIT TO COOL BEFORE ATTEMPTING SERVICE ON THIS PRODUCT.
- INSTALLATION AND/OR REMOVAL OF THIS PRODUCT SHOULD ONLY BE ACCOMPLISHED BY A QUALIFIED ELECTRICIAN IN ACCORDANCE WITH NATIONAL ELECTRICAL CODE OR EQUIVALENT REGULATIONS.
- BEFORE ATTEMPTING INSTALLATION OR REMOVAL OF THIS PRODUCT, BE SURE TO REVIEW ALL SYSTEM DOCUMENTATION FOR PERTINENT SAFETY PRECAUTIONS.
- NO USER-SERVICEABLE PARTS ARE CONTAINED WITHIN THIS PRODUCT. INOPERABLE UNITS SHOULD BE REPLACED OR RETURNED FOR REPAIR.
- THIS PRODUCT DOES NOT PROVIDE MOTOR OVERLOAD PROTECTION.

ANY QUESTIONS AS TO APPLICATION, INSTALLATION, OR SERVICE SAFETY SHOULD BE DIRECTED TO THE EQUIPMENT SUPPLIER.

3. INSTALLATION INSTRUCTIONS

The M3534 has an open type chassis construction. It is intended to be part of a larger variable frequency drive system, and will require different hardware for interconnection based on the installation. An appropriate enclosure may need to be provided to protect personnel from contact and the system from damage. The enclosure may also need to protect the equipment from the installation environment.

Please read this manual completely before designing the drive system or enclosure layout to ensure all required elements are included.

3.1. ENVIRONMENT

The maximum ambient operating temperature of the M3534 should not exceed 40°C. Temperatures above this can cause overheating during operation.

The standby heat production of the M3534 is quite low, but can generate significant heat during boosting. This is only of concern with the M3534B models because the M3534R run time of 2 seconds will not allow the system to reach thermal equilibrium, and should not cause thermal issues.

Non-condensing, filtered air may be required to cool the system if other components cause excessive heat buildup in the enclosure.

3.2. UNPACKING

Inspect the shipping crate and M3534 for damage.

Notify the shipping carrier if damage is found.

3.3. MOUNTING

Mounting dimensions can be found in Section 6.

1. Remove the M3534 from the shipping crate and mount it in the desired location using the mounting slots and holes and ¼" diameter studs or bolts. Mounting hardware is 'not supplied with the M3534.
2. If supplied, install the display panel in an appropriate location.

3.4. WIRING AND USER CONNECTIONS

Review this entire section before attempting to wire the M3534.

3.4.1. POWER WIRING

DANGER!

THE M3534 CAN HAVE MULTIPLE POWER SOURCES, INCLUDING THE MAIN AC INPUT, ENERGY STORAGE SYSTEMS AND THE DC CONNECTION TO THE VFD.

ENSURE THAT ALL SOURCES ARE DISCONNECTED AND LOCKED OUT BEFORE ATTEMPTING SERVICE OR INSTALLATION.

FAILURE TO HEED THESE WARNINGS MAY RESULT IN SERIOUS INJURY OR DEATH!

This section provides information pertaining to the field wiring connections of the M3534. Actual connection points and terminal numbers of the AC drive system will be found in the documentation provided with the drive system.

Be sure to review all pertinent AC drive system documentation as well as the connection details listed below before proceeding.

Table 3-1: M3534 20A Power Wiring Connections

TERMINAL DESIGNATION	FUNCTION	WIRING SPECIFICATION	CONNECTION	TORQUE
AC LINE L1 L2 L3	AC Input	600 VAC	#10 lug ring or spade	20 lb-in
STORAGE BUS + -	DC Input	600 VAC	14-8 AWG Box Connection	15 lb-in
DRIVE BUS - +	DC Output	600 VAC	#10 lug ring or spade	20 lb-in
⏚	Ground	600 VAC	#10 lug ring or spade	15 lb-in

Table 3-2: M3534 40A Power Wiring Connections

TERMINAL DESIGNATION	FUNCTION	WIRING SPECIFICATION	CONNECTION	TORQUE
AC LINE L1 L2 L3	AC Input	600 VAC	#10 lug ring or spade	20 lb-in
STORAGE BUS + -	DC Input	600 VAC	12-4 AWG Box Connection	32 lb-in
DRIVE BUS - +	DC Output	600 VAC	#10 lug ring or spade	20 lb-in
⏚	Ground	600 VAC	#10 lug ring or spade	15 lb-in

Table 3-3: M3534 85A Power Wiring Connections

TERMINAL DESIGNATION	FUNCTION	WIRING SPECIFICATION	CONNECTION	TORQUE
AC LINE L1 L2 L3	AC Input	600 VAC	12-4 AWG Box Connection	32 lb-in
STORAGE BUS + -	DC Input	600 VAC	12-4 AWG Box Connection	32 lb-in
DRIVE BUS - +	DC Output	600 VAC	12-4 AWG Box Connection	32 lb-in
⏚	Ground	600 VAC	#10 lug ring or spade	15 lb-in

Main power connections should be made with copper wire; use compression fitting lugs. Wire sizing should be appropriate for the current being carried. System ratings are listed in Section 6.

These units can provide high surge currents for a limited amount of time; therefore wire heating is not as much a concern as mechanical strength.

3.4.1.1. AC LINE (L1 L2 L3) CONNECTIONS

The AC input to the M3534 can temporarily reach up to 200% of the normal input current during a power quality event. Size the upstream current protection devices accordingly, so that the incoming AC will not be interrupted by the temporary power draw.

During a power quality event, the AC input to the drive will not be drawing current. Sizing the incoming AC feed to supply both the drive and the M3534 simultaneously is not necessary. Even though the input current during a power quality event may be higher than the normal input current, this temporary overload is allowed by most codes without upsizing the normal AC feed bus.

Due to the increased currents in the AC feed during a power quality event, the total IR drop of the incoming AC feed should be considered to make sure the voltage doesn't dip too low.

If line chokes are to be used in the system, the M3534 must be installed on the load side of these chokes. This minimizes the possibility of circulating currents through the M3534 and converter section of the VFD.

There is no need to connect the AC line to the M3534 if an ultracapacitor or battery bank is being used. See Figure 3-5.

3.4.1.2. STORAGE BUS (+ -) CONNECTIONS

If a storage module is used, such as ultracapacitors or batteries, the input from this module is made at the Storage Bus terminals.

Make sure the polarity is correct for the connection, failure to do so can cause severe damage to the system.

DANGER!

FOR SYSTEMS THAT HAVE DC STORAGE, ALWAYS MEASURE DC VOLTAGES, AND FOLLOW PROPER PRECAUTIONS TO ENSURE THEY ARE AT SAFE LEVELS BEFORE MAKING CONNECTIONS.

3.4.1.3. DRIVE BUS (- +) CONNECTIONS

The M3534 must have a DC bus connection directly to the DC bus filter capacitors within the drives. Connections cannot be made through the braking terminals or with precharge resistors or DC link chokes between the output of the M3534 and the DC bus capacitors in the drive. Consult the manufacturers' documentation or contact Bonitron for further assistance.

Make sure the polarity is correct for the connection, failure to do so can cause severe damage to the system.

DANGER!

FOR SYSTEMS THAT HAVE DC STORAGE, ALWAYS MEASURE DC VOLTAGES, AND FOLLOW PROPER PRECAUTIONS TO ENSURE THEY ARE AT SAFE LEVELS BEFORE MAKING CONNECTIONS.

3.4.1.4. GROUNDING REQUIREMENTS

All units come equipped with a ground stud that is connected to the module chassis. Ground the chassis in accordance with local codes. Typically, the wire gauge will be the same as is used to ground the attached drive.

3.4.2. CONTROL INTERFACE AND I/O WIRING

Control wiring allows for remote enabling, testing, and monitoring of the M3534. Inputs can be a dry contact using an internally generated, isolated supply, or an external 15-24VDC signal.

Outputs are individual contacts with a jumper to choose the logic state desired.

3.4.2.1. CONNECTIONS FOR BASE CONFIGURATION

Table 3-4: User I/O Basic Connections with 3534I3 Board

3534I3 TERMINAL	FUNCTION	ELECTRICAL SPECIFICATIONS	WIRE AWG	TORQUE
TB4 – 5	Enable / Disable -	24 VDC, 15 mA	16 AWG	2.1 lb-in
TB4 – 6	Enable / Disable +			
TB4 – 3	Ride-Thru Ready (RTR)	24 VDC, 15 mA		
TB4 – 4				
TB4 – 1	Ride-Thru Active (RTA)			
TB4 – 2				

3.4.2.2. CONNECTIONS WITH DD5 DIGITAL DISPLAY

When the DD5 digital display is used, some user connections to the digital display interface are made on a different module than the M3534. They are made to the 3660I4 interface module.

Refer to the KIT 3660DD5 manual for operational and functional details.

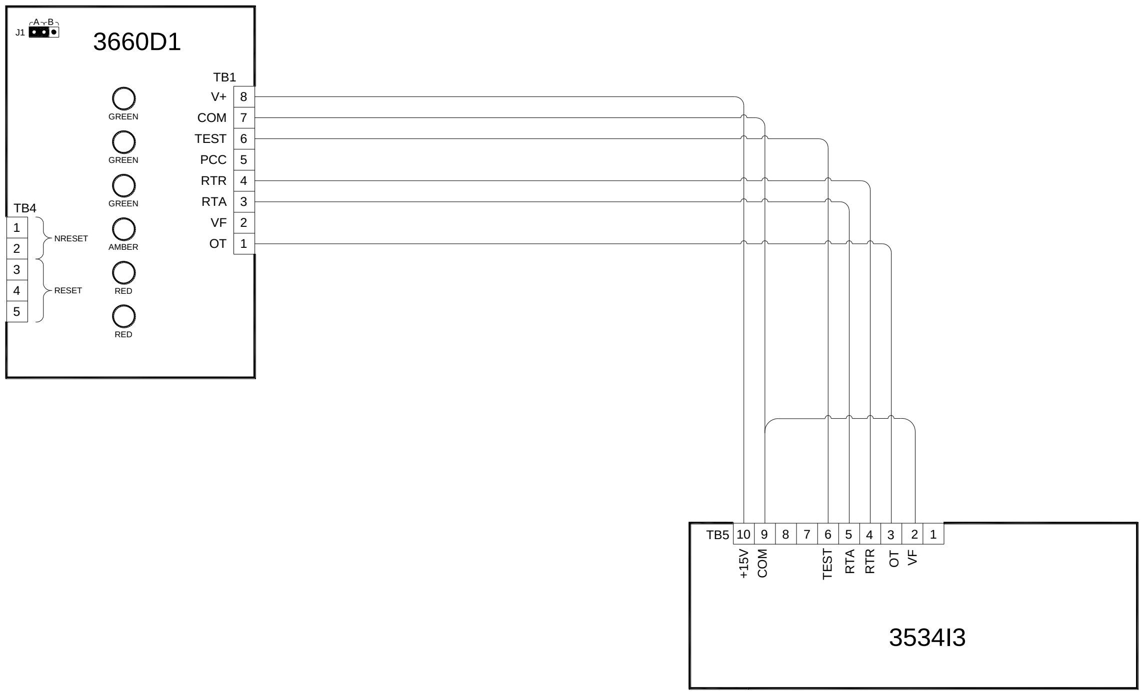
3.4.2.3. CONNECTIONS WITH DP10 ANALOG DISPLAY

When the M3534 is used with the DP10 analog display, the interconnections are made through TB5 on the 3534I3 board and TB1 on the 3660D1 board.

Table 3-5: User I/O Connections with DP10 Display

3660D1 TERMINAL	3534I3 TERMINAL	FUNCTION	ELECTRICAL SPECIFICATIONS	WIRE AWG	TORQUE
TB1 – 1	TB5-3	Overtemperature (OT)	15 VDC, 15 mA	16 AWG	2.1 lb-in
TB1 – 2	N/U	Voltage Fault (VF)			
TB1 – 3	TB5-5	Ride-Thru Active (RTA)			
TB1 – 4	TB5-4	Ride-Thru Ready (RTR)			
TB1 – 5	N/U	Pre-Charge Complete (PCC)			
TB1 – 6	TB5-6	Test			
TB1 – 7	TB5-9	Local I/O Supply -	15 VDC, 50 mA		
TB1 – 8	TB5-10	Local I/O Supply +			

Figure 3-1: M3534 Interconnections with DP10



3.5. TYPICAL CONFIGURATIONS

Figure 3-2: M3534R without Energy Storage

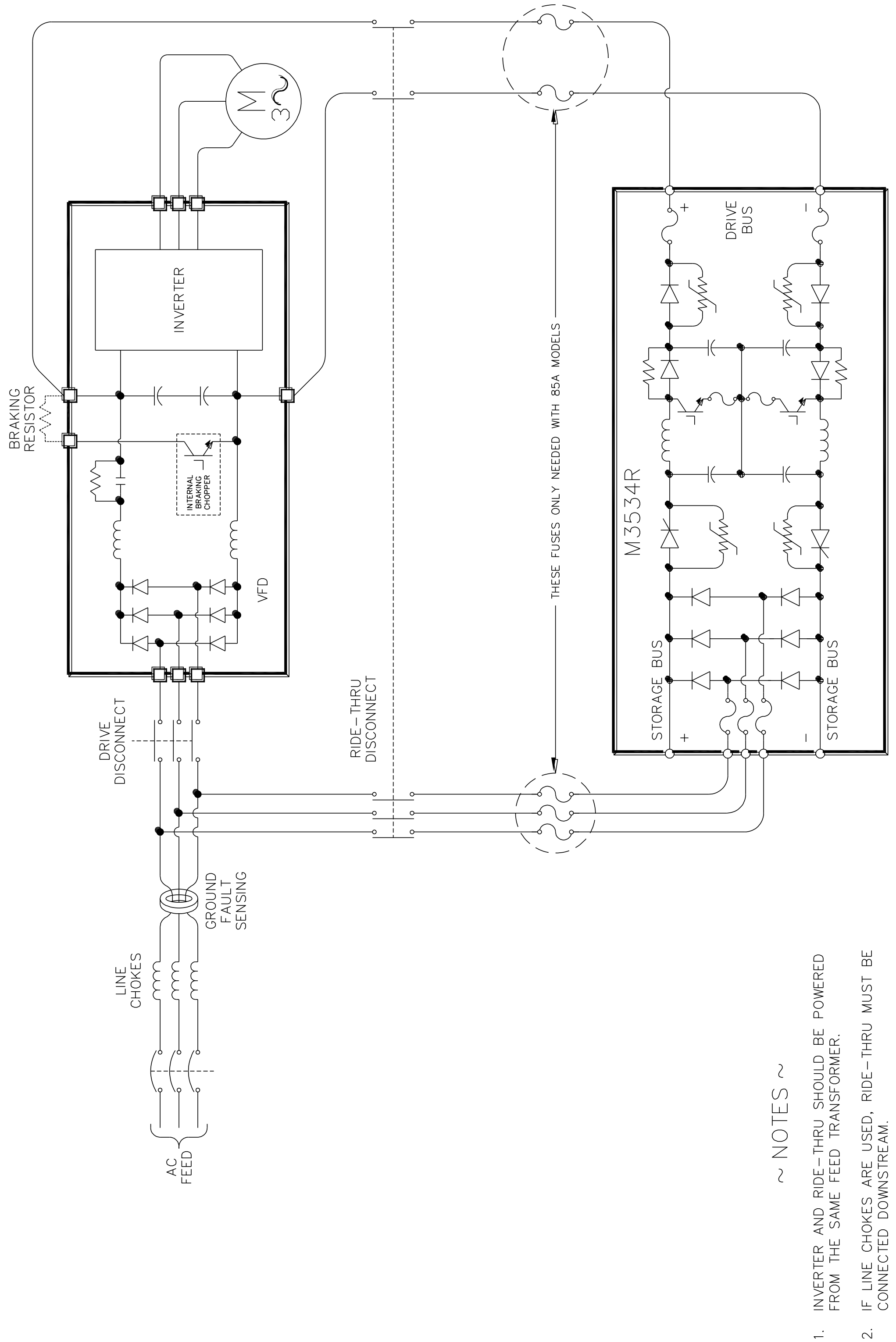


Figure 3-3: M3534R with Electrolytic Capacitor Storage Bank

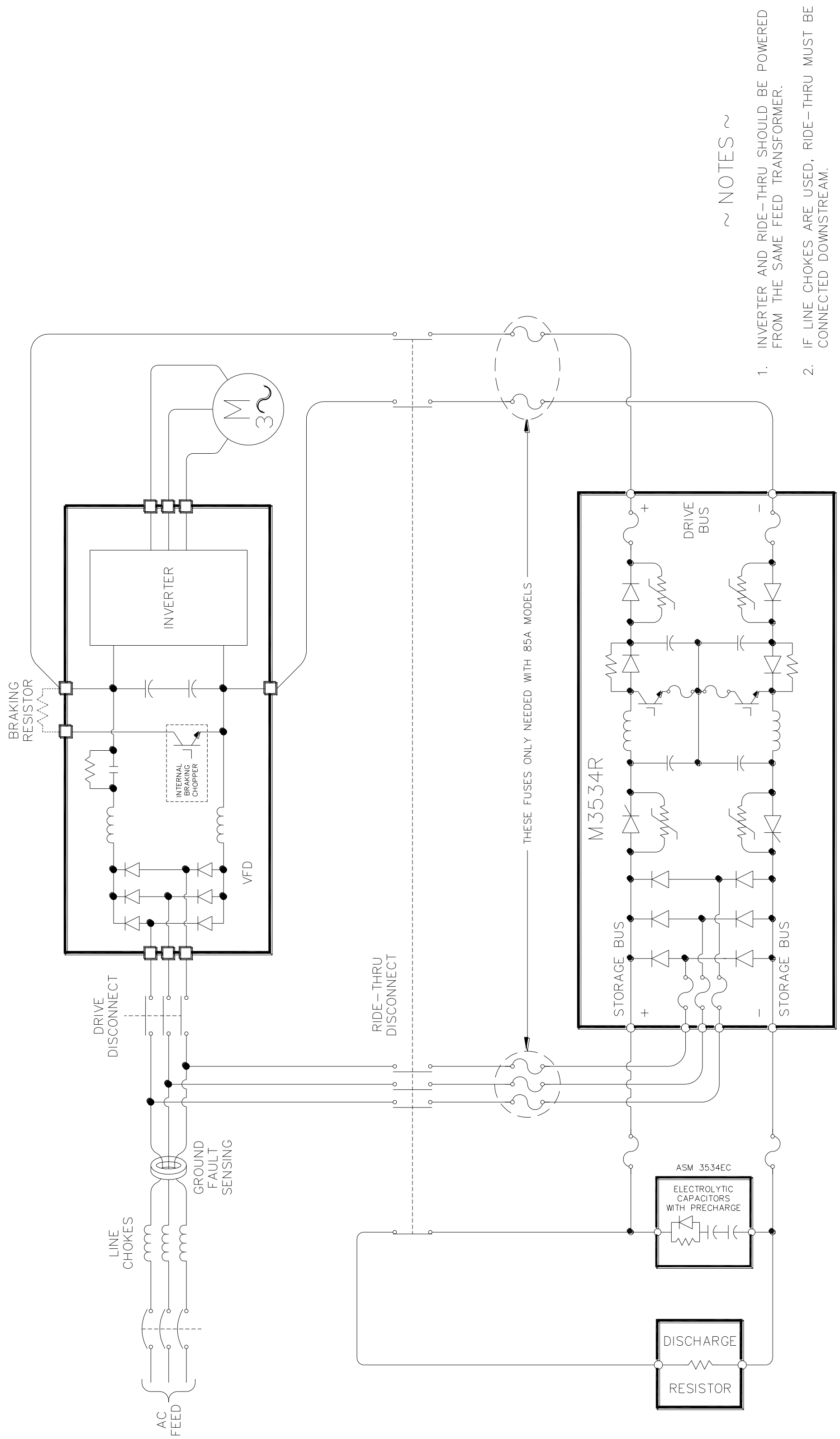


Figure 3-4: M3534R with Ultracapacitor Storage Bank and M3528 Charger

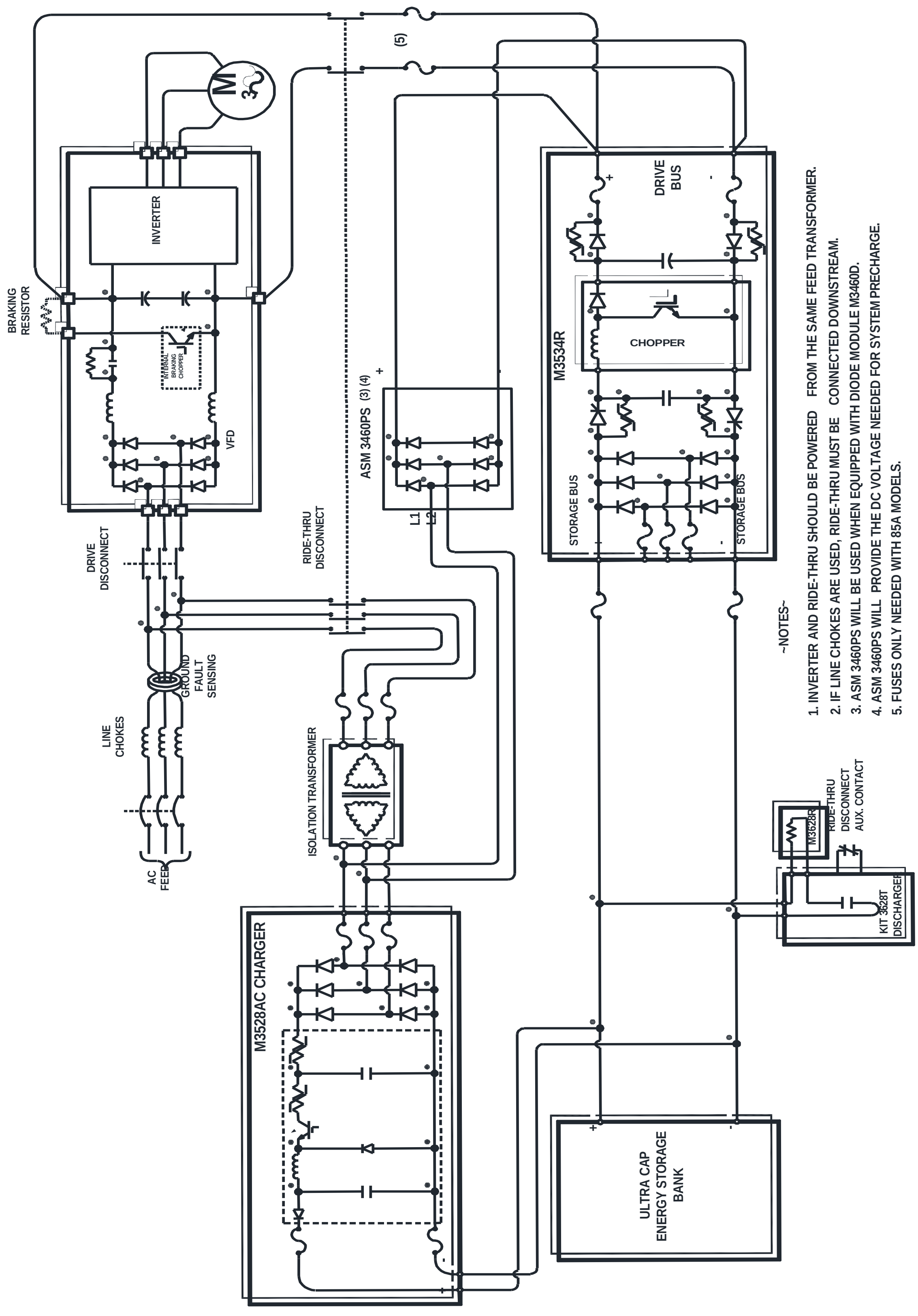


Figure 3-5: M3534R with Ultracapacitor Storage Bank and M5628 Charger

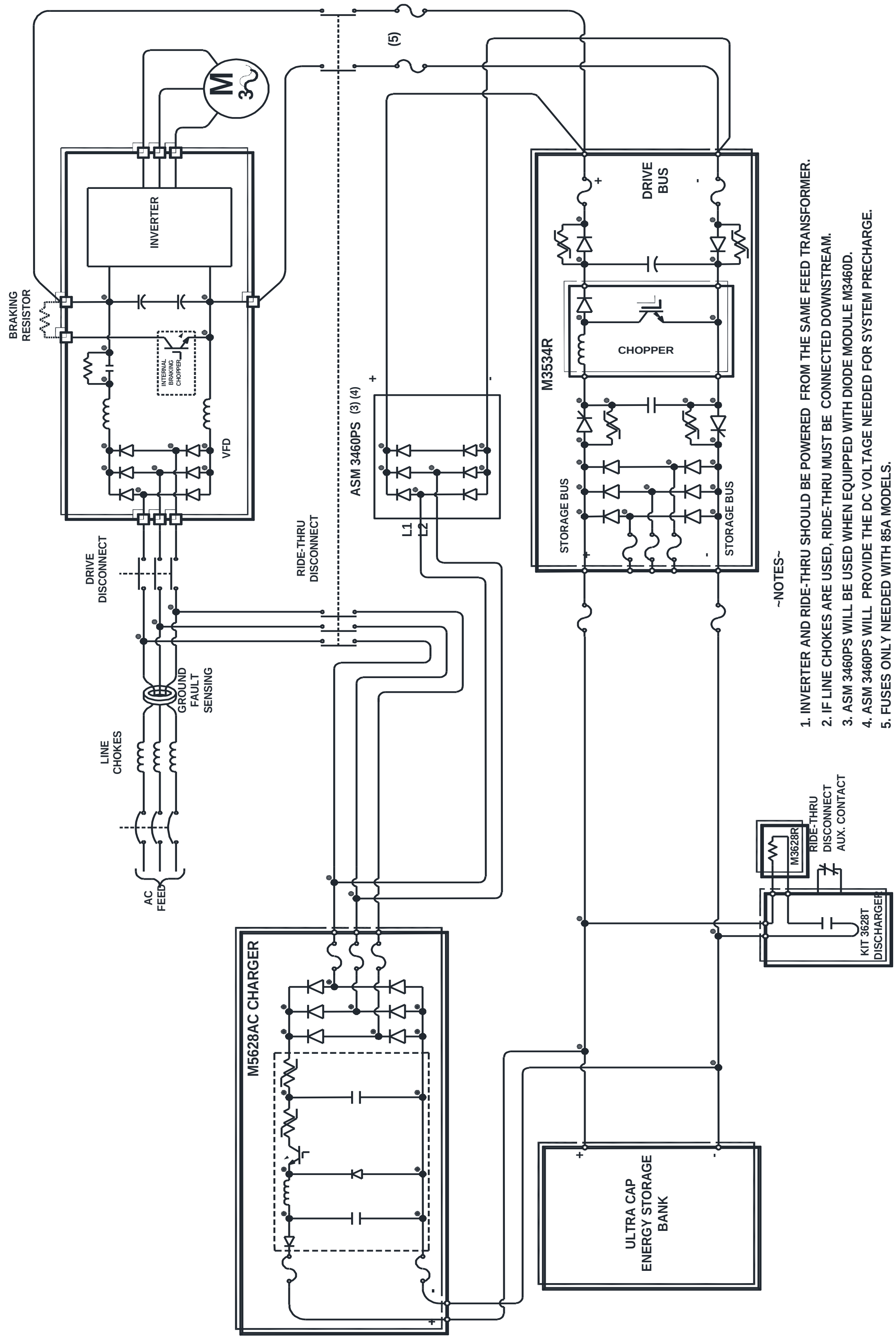
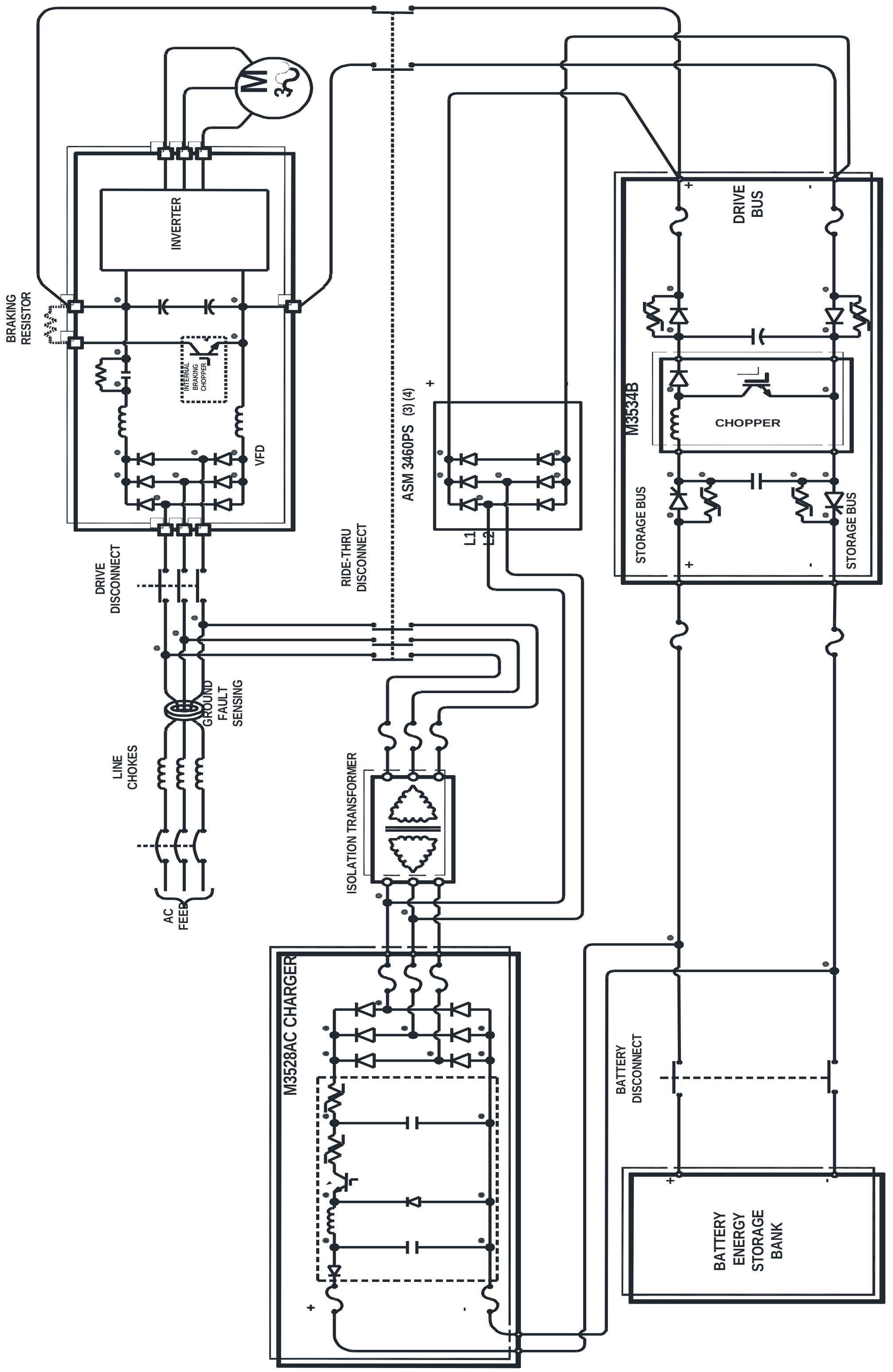


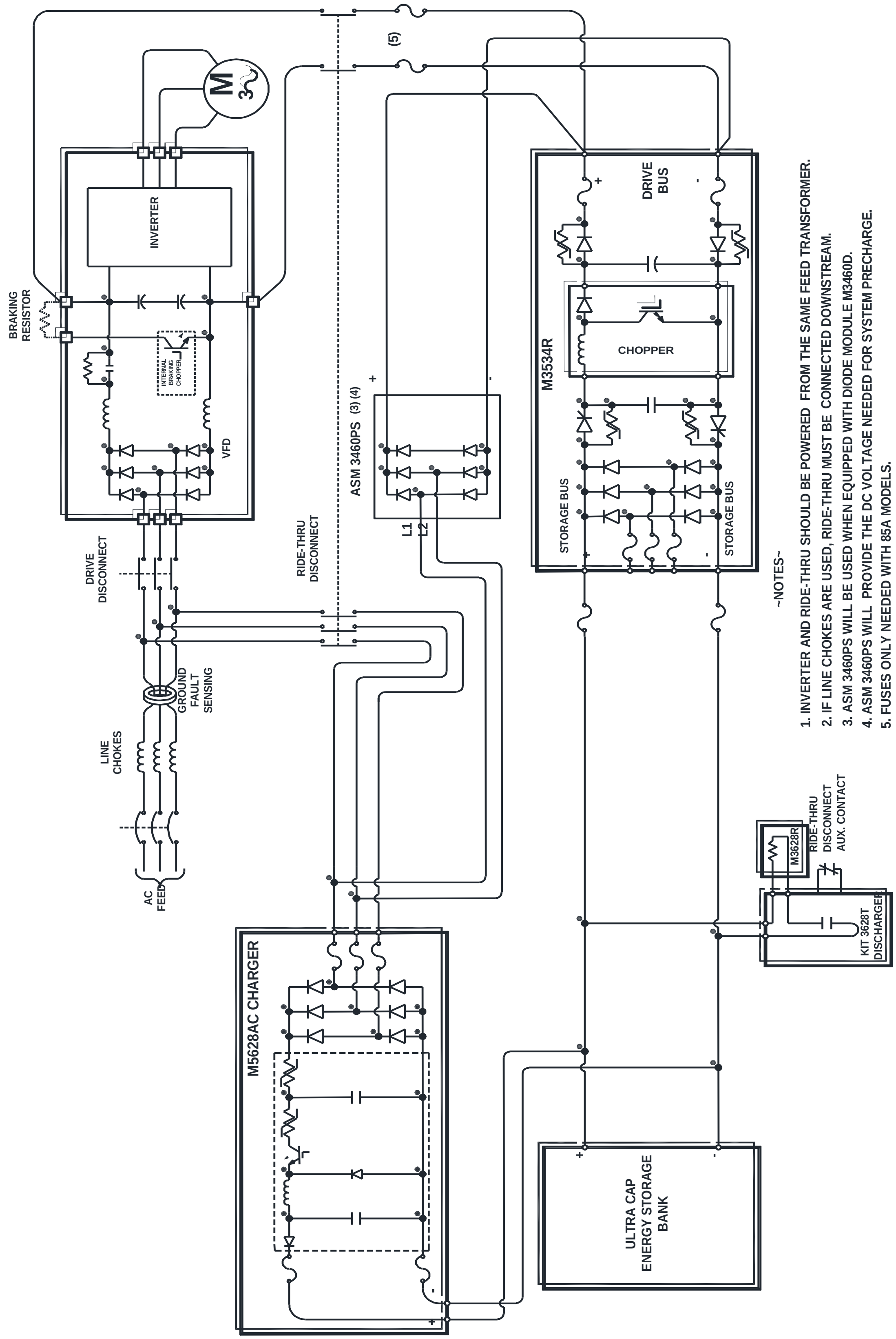
Figure 3-6: M3534B with Battery Storage Bank and M3528 Charger



~NOTES~

1. INVERTER AND RIDE-THRU SHOULD BE POWERED FROM THE SAME FEED TRANSFORMER.
2. IF LINE CHOKES ARE USED, RIDE-THRU MUST BE CONNECTED DOWNSTREAM.
3. ASM 3460PS WILL BE USED WHEN EQUIPPED WITH DIODE MODULE M3460D.
4. ASM 3460PS WILL PROVIDE THE DC VOLTAGE NEEDED FOR SYSTEM PRECHARGE.

Figure 3-7: M3534B with Battery Storage Bank and M5628 Charger



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4. OPERATION

4.1. FUNCTIONAL DESCRIPTION

The M3534 ride-thru voltage regulator monitors the DC bus of the attached variable frequency drive (VFD) and provides power in a voltage controlled, current limited supply directly to the filter capacitor section of the drive above the inverter stage. During a power quality event the internal DC bus of the VFD drops. When this level meets the DC bus threshold voltage of the M3534, power is delivered through blocking diodes to hold up the voltage in the VFD bus. The M3534 regulates and boosts the input voltage to the drive at a constant voltage.

In standby mode, when the incoming AC power is normal, the M3534 power consumption is minimal.

4.2. M3534R OPERATION FOR FULL OUTAGE PROTECTION

The M3534R can be used with an energy storage system to allow for protection against full outages for up to 2 seconds. This storage is typically double layer capacitors or ultracapacitors, but can be any DC power source that needs regulation to attach to the DC input of a variable frequency drive.

In order to use an ultracapacitor storage bank for outage support, the capacitor bank must be charged with a separate charger, such as the Bonitron M5628, as the M3534 does not have charging capabilities.

Refer to Section 7 for general guidelines on sizing a capacitor bank for full outage protection.

4.3. OPERATION MODES AND CONFIGURATION

4.3.1. NORMAL OPERATION

During normal operation, the M3534 will monitor the output DC bus. When the output DC bus voltage goes below the DC bus threshold voltage, the M3534 will become active and regulate the output DC bus and attached drive to the DC bus threshold voltage. As the input voltage drops, more current is required to maintain the same output power. If the input voltage drops to the point where the required output power makes the input current higher than the input current limit, the M3534 will operate in current limit, and the output voltage will drop according to the actual output load required by the drive.

This mode is activated by the Enable input. Refer to Section 4.4.1.1 for details on configuring this input.

4.3.2. TEST MODE

The Test mode allows the M3534 to be tested during normal power conditions. In this mode, the M3534 adjusts the DC bus threshold above the normal DC bus threshold setpoint. This forces the M3534 to begin sourcing power and driving up the DC bus voltage of the attached drive. When properly adjusted, the test voltage will be approximately 17% higher than the DC bus threshold. This level should not be high enough to overvoltage the attached drives or cause braking systems to activate. If the drive is heavily loaded when the test is done, the DC bus may not reach 17% above the threshold voltage due to the current limiting feature.

This mode is activated by the Test input. Refer to Section 4.4.1.2 for details on configuring this input.

4.4. I/O, Features, and Displays

Status monitoring is available through discrete I/O points located on the 3534I3 board.

Figure 4-1: 3534I3 Interface Board Layout

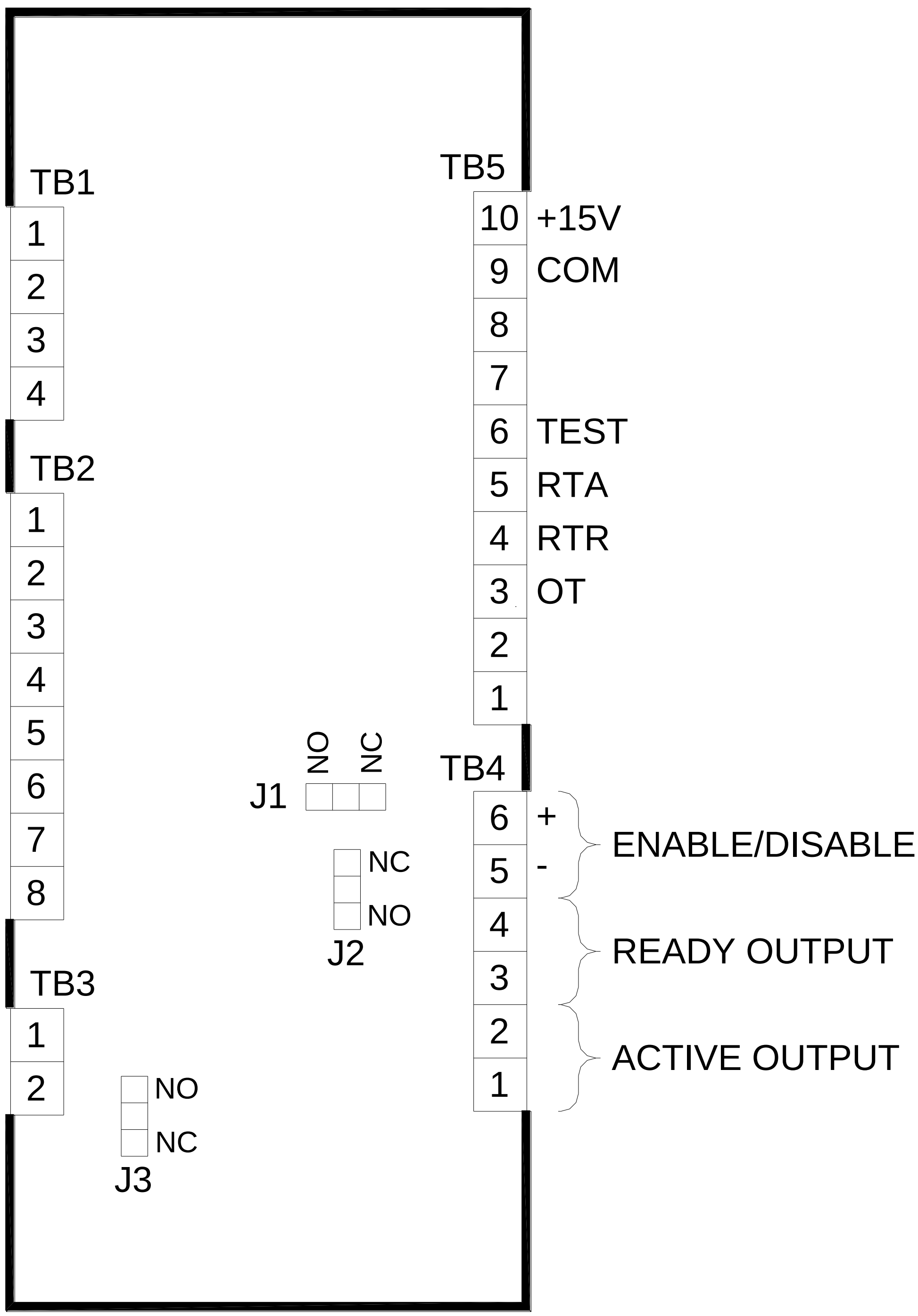


Figure 4-2: 3534I3 I/O Diagram

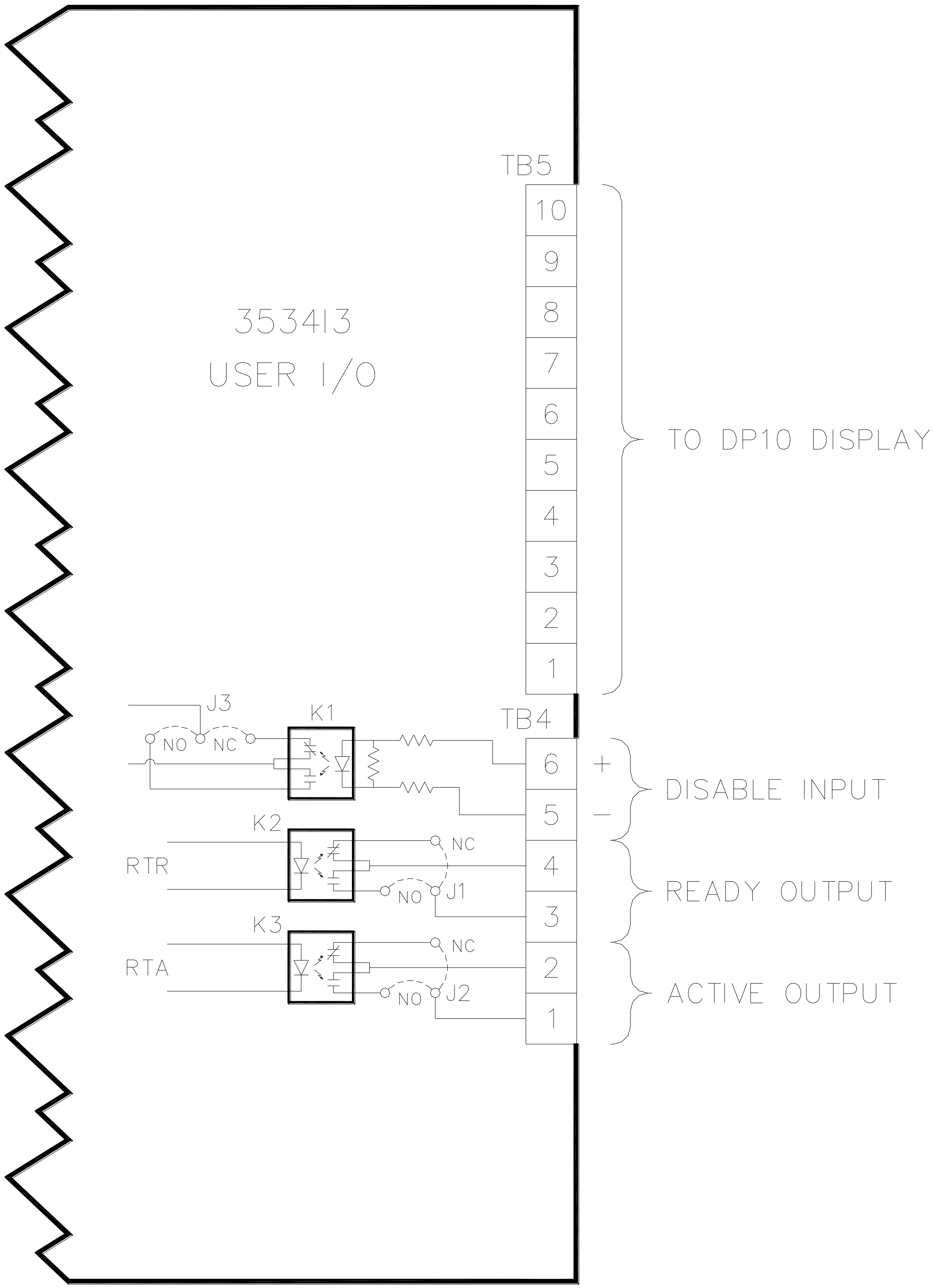


Figure 4-3: 3534R2 Control Board Layout

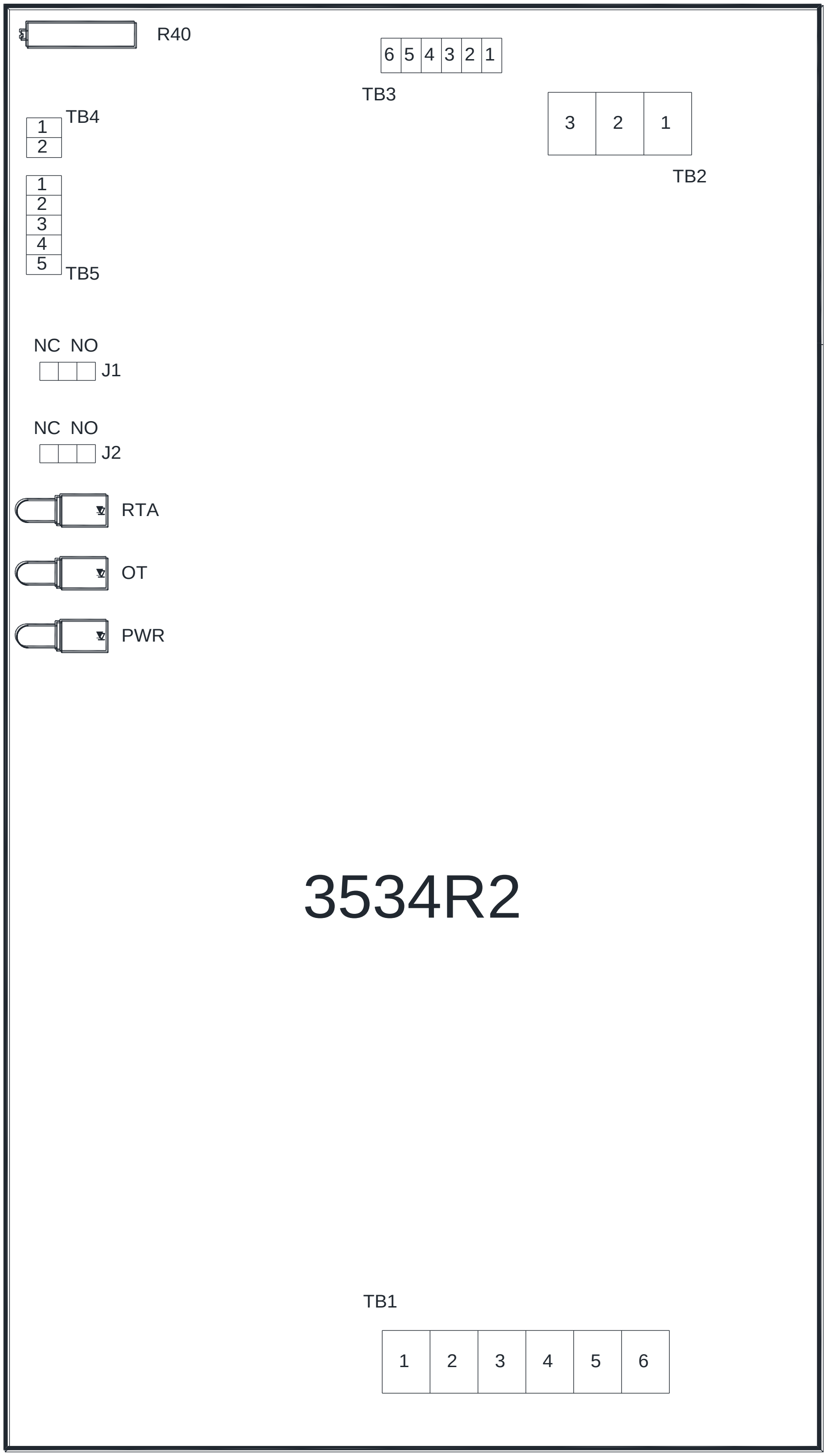
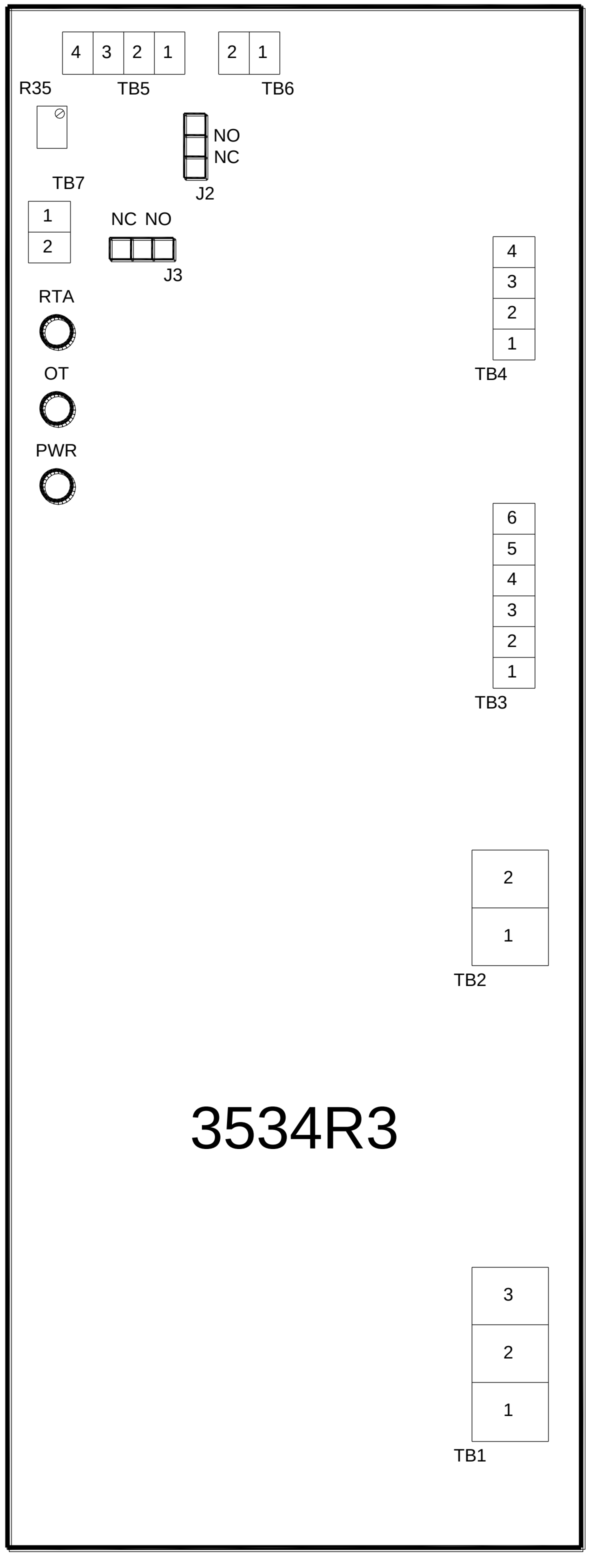


Figure 4-4: 3534R3 Control Board Layout



4.4.1. INPUT TERMINALS – 3534I3 TB4 & TB5

The input terminals are located on TB4 & TB5 of the 3534I3 board. They can use an internal supply with a dry contact or an external 24VDC.

4.4.1.1. ENABLE INPUT – TB4 - 5 & 6

The Enable input is used to allow the M3534 to operate. This signal can be configured for either enable or disable operation.

This input operation is configured with jumper J3 on the 3534I3 board.

The input operation is set to “Enable” with J3 set to "NC", and the M3534 will operate when 24VDC is applied to the input.

The input operation is set to “Disable” with J3 set to "NO", and the M3534 will be inhibited and not operate when 24VDC is applied to the input.

Connect the 24V positive to TB4-6 and the 24V common to TB4-5 to enable or disable the M3534.

The isolated 15V available at TB5-9 & 10 may be used to drive this input.

The factory default setting is to have the operation set to "Enable".

Table 4-1: 3534I3 Enable Input Logic Jumper Details

JUMPER	POSITION	FUNCTION	3534I3 FIELD TERMINALS	FACTORY SETTING
J3	NC	Enable	TB4 - 5 & 6	NC (Enable)
	NO	Disable		

CAUTION!

THE M3534 MAY NOT OPERATE CORRECTLY IF THE UNIT IS NOT PROPERLY CONFIGURED. PAY SPECIAL ATTENTION TO THIS CONFIGURATION, AS THIS CAN CAUSE THE UNIT TO NOT PROTECT THE DRIVE IN THE CASE OF A POWER SAG OR OUTAGE.

4.4.1.2. TEST INPUT – TB5 – 6 & 10

The Test input is used to make the M3534 go into Test mode.

Connect the internal supply 15V positive at TB5–10 to the test input at TB 5–6 to go into Test mode.

When the DP10 display is used, pressing the test button on the display will put the M3534 into Test mode.

4.4.2. OUTPUT TERMINALS – 3534I3 TB5 & TB4

The status of the M3534 can be monitored from TB5 and TB4 on the 3534I3 board. The Overtemperature and Ride-Thru Active status outputs can be configured with jumpers to be normally open (NO) or normally closed (NC). The Ride-Thru Ready status output is hard-wired and is not jumper selectable at TB5-4. The Ride-Thru ready status output can be configured with jumper to normally open (NO) or normally closed (NC) at TB4-3 & 4. In the descriptions below, the operation is described for the jumpers to be set in the normally open position.

4.4.2.1. OVERTEMPERATURE - TB5 - 3

This output is pulled to the internal supply common when the temperature of the heatsink remains at a safe level. The contact will open when the temperature rises to an unsafe level. This overtemperature condition will internally prevent the M3534 from functioning as long as the condition exists.

The output configuration can be set to normally open or normally closed with Jumper J1 on the 3534R2 board or J2 on the 3534R3 board.

4.4.2.2. RIDE-THRU READY - TB5 - 4 (DP10 DISPLAY)

This output can be used as a general status indication. On the 40A and 85A models, it is pulled to the internal supply common when the M3534 is operating properly and is ready to protect against a power quality event. The contact will open when the M3534 precharge is not complete, the internal power supply is not functioning properly, an internal IGBT stage fuse is blown, or when the power board has an unbalance fault. On the 20A models, this output is pulled to the internal supply common permanently.

4.4.2.3. RIDE-THRU READY – TB4 - 3 & 4 (NO DISPLAY)

This output can be used as a general status indication. On the 40A and 80 A models, this output is dry contact that can be configured with jumper (J1) to be normally open (NO) or normally closed (NC). The Ready output will change status when precharge is not complete, there is an overtemperature condition, the internal power supply is not functioning properly or an internal IGBT stage fuse is blown. The Ride-Thru Ready output has 3700 V_{rms} Input / Output isolation.

4.4.2.4. RIDE-THRU ACTIVE – TB5 – 5 (DP10 DISPLAY)

This output is pulled to the internal supply common when the M3534 is currently regulating the output DC bus of the system. This indicates a power sag or outage on the main AC input power of the attached drive or that a drive input fuse has opened. This output will also be pulled to the internal supply common when the unit is put into Test mode with the Test input, assuming the attached drive is loaded.

The output configuration can be set to normally open or normally closed with Jumper J2 on the 3534R2 board, J3 on the 3534R3 board and J2 on the 3534I3 board.

4.4.2.5. RIDE- THRU ACTIVE – TB4- 1&2 (NO DISPLAY)

This output indicates a power sag or outage on the main AC input power of the attached drive, this output is dry contact that can be configured with jumper (J2) to be normally open (NO) or normally closed (NC). The Ride Thru Active will change the status when the M3534 is regulating the output DC bus of the system or when the unit is put into test mode. The Ride Thru Active output has 3700 Vrms Input / Output isolation.

Table 4-2: 3534I3 Status Output Signal Logic Jumper Details

OUTPUT	ABBREVIATION	3534I3 FIELD TERMINALS		3534R2 JUMPER	3534R3 JUMPER	3534I3 JUMPER	FACTORY SETTING
Over Temperature	OT	TB5 – 3		J1	J2	None	Normally Open (NO)
Ride-Thru Ready	RTR	TB5–3,4	TB5-4	None	None	J1	
Ride-Thru Active	RTA	TB4-1,2	TB5-5	J2	J3	J2	

4.4.3. Local I/O Power Supply – 3534I3 TB5

The control inputs and status outputs for the M3534 can use the internal supply as described in Sections 4.4.1 and 4.4.2.

The isolated supply is available at TB5. The 15V positive is at TB5-10 and the 15V common is at TB5-9.

When the DP10 analog display is installed with the M3534, this internal power supply is used to drive the I/O on the display panel.

4.4.4. Indicators

There are three light-emitting diodes (LEDs) visible at the front panel used to indicate the status of the M3534

4.4.4.1. Power

The Power light will illuminate green when the M3534 internal power supply is operating.

4.4.4.2. Active

The Active light will illuminate yellow while the M3534 is regulating the DC bus to the attached equipment or when the M3534 is put into Test mode. If the M3534 is unloaded or lightly loaded, this light may not illuminate.

4.4.4.3. Overtemp

The Overtemperature light will illuminate red when the temperature of the heatsink or the inductor has risen to an unsafe level. This light will remain illuminated until the temperature returns to a safe level. The M3534 will be inhibited and will not function while in an overtemperature condition.

4.4.5. Display Options

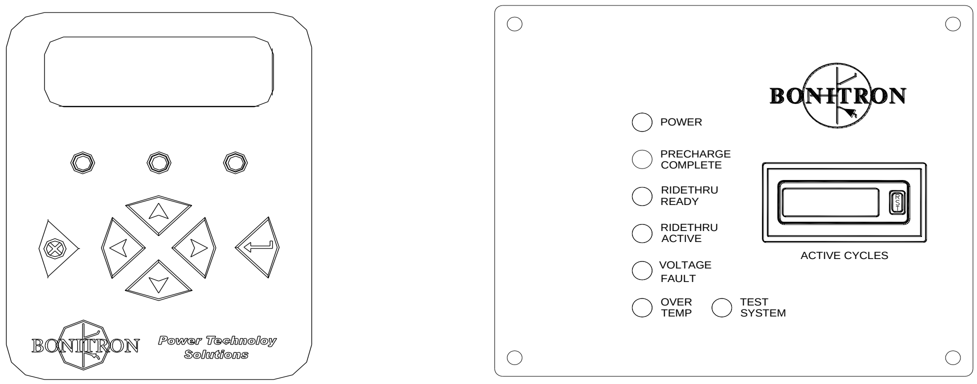
There are two display options available for local indication. They are designed to be mounted to the door or deadfront of a drive cabinet or system. The displays show the M3534 operating status and also permit a system test to be performed. The DD5 digital display system has many more features than the DP10 analog display, including outage and fault logging. Please refer to the KIT 3660DD5 manual for a full description of the features.

Table 4-3: Display Panel Configurations

Display Model	Local Indicators	Voltmeter	Ammeter	Total Counter	Resettable Counter	Activity Logging	Local Test Initiation
DP10	✓				✓		✓
DD5	✓	✓	✓	✓	✓	✓	✓

Figure 4-5: Display Panels

DD5 **DP10**



4.4.5.1. DD5 DIGITAL DISPLAY

The KIT 3660DD5 digital display system has many features and control modes that can be used to monitor, test and log information about the M3534 and its activity.

Below are very basic operation instructions. Please refer to the KIT 3660DD5 manual for detailed instructions and configuration information.

The KIT 3660DD5 power supply should not be connected to earth ground.

The digital display can also be used to monitor charging and storage modules for Ride-Thru systems.

DIGITAL DISPLAY INPUTS

There are two remote inputs to control the activity of the M3534: Enable and Test. They allow remote initiation of these inputs, but the digital display system allows the M3534 to be tested locally.

DIGITAL DISPLAY OUTPUTS

There are two outputs that can be configured for various indications on the digital display.

DEFAULT OPERATION

When the M3534 is ordered with the KIT 3660DD5 digital display, the factory settings are for Automatic Control mode.

The M3534R will be disabled locally under the following conditions:

- Overtemperature
- Runtime Exceeded

The M3534B will be disabled locally under the following conditions:

- Input Undervoltage
- Overtemperature
- Runtime Exceeded

This allows for the most protection for the M3534. This can be reconfigured if these warnings should be ignored.

CAUTION!

DISABLING THESE FAULTS CAN DAMAGE THE M3534 BY FORCING IT TO OPERATE OUTSIDE OF DESIGN PARAMETERS!

4.4.5.2. DP10 ANALOG DISPLAY

The DP10 has LED indicators for the following status outputs:

- Power
- Precharge Complete
- Ride-Thru Ready
- Ride-Thru Active
- Voltage Fault
- Overtemperature

Please note that the Precharge Complete and Voltage Fault indicators on the DP10 display serve no function on M3534 models.

In addition, there is a total cycle counter that can be reset. It indicates the number of times the M3534 has been active since the last reset. This number will increase when there is a power quality event, or when the system is tested.

There is also a local Test button that can be used to initiate a system test.

4.5. DC BUS THRESHOLD VOLTAGE SETTING

The DC bus threshold voltage is the voltage at which the M3534 maintains the DC bus at during a power quality event. Whenever the output DC bus voltage drops below the DC bus threshold voltage setting, the M3534 becomes active to regulate the DC bus to the setpoint voltage.

The DC bus threshold voltage is important to the installation in that if it is set too low, the attached drive may trip on an undervoltage fault. If it is set too high, then minor power disturbances, such as line notching or high harmonics, that would not normally cause the drive to have problems, may cause the M3534 to become active when there is no need. If this is a constant or frequent occurrence, the M3534 may overheat and not be available in the event of an actual sag or outage.

The M3534 DC bus threshold voltage setting is determined by the drive installation. Consult the manufacturers' specifications on the attached drive, and make sure that the DC bus threshold voltage is above this value. For instance, many 460-480VAC input drives have an undervoltage trip point of 400VDC. This may allow the drive to keep operating, but the DC bus voltage may not be enough to allow the drive to operate at full power. Therefore it's useful to set the DC bus threshold voltage setting above this value.

Generally, the DC bus threshold voltage should be set at 10% below the nominal DC bus level. Use the following formula to calculate this value:

$$\mathrm{VDC} = \mathrm{VAC} * \sqrt{2} * 0.9$$

An actual on-site check may performed to determine the loaded DC bus level as well as the amount of ripple present on the DC bus.

If you find that your incoming AC power is susceptible to long term sags or conditions below 10%, the M3534 may become active when not needed. In this case, the DC bus threshold voltage setting should be lowered to allow the M3534 to only be active during a true power quality event. The M3534 should not become active during normal everyday operation.

The DC bus threshold voltage is factory preset on all M3534 modules according to Table 6-2 of this manual. However, field adjustment of this setting may be required to achieve the optimum setpoint level for any given system. There are two ways to determine the DC bus threshold voltage described below. Be sure to read through both methods completely before attempting any adjustment of the DC bus threshold voltage setting.

DANGER!

- **HIGH VOLTAGES WITH RESPECT TO THE CHASSIS ARE PRESENT!**
- **NEVER USE AN UNINSULATED TOOL OF ANY KIND!**
- **FAILURE TO HEED THESE WARNINGS MAY RESULT IN SERIOUS INJURY OR DEATH!**

4.5.1. DETERMINING THE DC BUS THRESHOLD VOLTAGE SETTING DIRECTLY

Checking the DC bus threshold voltage setting directly requires the input power to be removed from the M3534. If the M3534 DC bus is not connected to the output of the drive, this can be done without powering down the drive. Otherwise, the drive must have the AC power removed from it as well. It may be difficult to get an accurate reading using a digital voltmeter due to the time it takes to calculate and average the reading. Use an analog meter if possible.

1. Monitor the output DC bus of the M3534, or the input DC bus to the drive, if connected.
2. Remove input voltage supply from system. This includes the AC input and battery bank input.
3. As the DC bus voltage drops to the DC bus threshold voltage setting, the M3534 will become active and maintain the DC bus voltage at the threshold voltage setpoint for approximately one second while the M3534 input filter capacitor discharges. The DC bus will then continue to drop.
4. Read the DC bus voltage as it is being maintained. This is the DC bus threshold voltage setting.

4.5.2. DETERMINING THE DC BUS THRESHOLD VOLTAGE SETTING USING THE TEST MODE

The DC bus threshold voltage setting may be checked with the drive connected using the test input to put the M3534 in Test mode. This raises the DC bus voltage approximately 17% above the actual DC bus threshold voltage setting, and is a fair indication of how the system is set. This has the advantage of not having to remove the input power, and can actually be done while the system is loaded.

Please note:

- If heavily loaded, the M3534 may run in current limit and the DC bus voltage may not rise as much as if it were unloaded.
- If the DC bus threshold voltage is set too high, the DC bus test voltage may be limited by the overvoltage setting of the M3534, thus providing an inaccurate result.

The M3534 may shutdown from the timeout feature, depending on the load.

1. Monitor the output DC bus of the M3534, or the input DC bus to the drive, if connected.
2. Enable the Test input, or initiate a test with the display.
3. Monitor the DC bus voltage while the M3534 is in Test mode. This is the DC bus test voltage setting.

The DC bus test voltage setting is approximately 17% higher than the DC bus threshold voltage setting.

For example, for an M3534 with an input voltage of 460VAC, the DC bus threshold voltage setting is preset to be 585VDC and the DC bus test voltage setting is preset for an increase of 17%, or 100VDC. Initiating the test described above would cause the DC bus voltage to rise to 685VDC (585VDC + 17% or 100VDC). Subtracting the DC bus test voltage (100VDC) from this reading shows that the actual DC bus threshold voltage setting is 585VDC.

4.5.3. ADJUSTING THE DC BUS THRESHOLD VOLTAGE SETTING

Adjustment of R40 on the 3534R2 control board or R35 on the 3534R3 control board (see Figures 4-2 & 4-3) is used to adjust the DC bus threshold voltage setting. Adjusting the pot in a clockwise direction will raise the setting. Alternately, a counter-clockwise adjustment of the pot will lower the setting.

After making the adjustments, repeat the test to verify the new setpoint. Fine tune the adjustment and retest as necessary.

5. START-UP, MAINTENANCE, AND TROUBLESHOOTING

5.1. START-UP / FIELD TEST PROCEDURE

1. Ensure the M3534 has been properly installed and is disabled.
2. Ensure the M3534 DC bus is disconnected from the drive DC bus.
3. Ensure the drive is operating properly with the M3534 disconnected.
4. Apply power to the input of the M3534 and observe the following conditions:
   - DC bus voltage should rise
   - Power light should be ON
   - Overtemperature light should be OFF
   - Ride-Thru Active light should be OFF
   - All status outputs are in the expected state. If there are faults on the system, check the configuration of the status output jumpers.
5. Enable the M3534 with either the enable input or the digital display.
6. Initiate the test mode with the Test input or display panel.
   - The DC bus should rise for as long as the test is performed.
7. Turn off the power to the M3534 and watch the DC bus voltage fall. The M3534 will become active.
   - The Ride-Thru Active light should turn ON when the M3534 starts to operate.
   - The DC bus will hold at the DC bus threshold voltage setting momentarily while the filter capacitors drain.
8. With the M3534 and drive power off, connect the DC bus of the M3534 to the DC bus of the drive.
9. Turn on power to the drive and ensure it is running properly without faults, then apply power to M3534 booster, **the drive must be ON before applying power to the Ride-Thru**.
10. Monitor the DC bus voltage and current with the display or with separate meters. Also, monitor the AC input current to the attached drive.
11. Load the drive as much as practical and put the M3534 into Test mode by activating the Test input or using the display panel.
    - DC bus voltage should rise to the test boost level.
    - Motor should not lose speed or torque.
    - DC bus current should flow from M3534 to drive.
    - Drive input current should decrease.

The M3534 and drive system should now be ready to be put into service.

CAUTION!

IF THE OUTPUT DC BUS DROPS BELOW 70% THE M3534 WILL HAVE TO GO THROUGH PRE-CHARGE AGAIN.

5.2. MAINTENANCE ITEMS

The M3534 is designed to require no maintenance. However, Bonitron recommends a yearly test of the system in order to ensure the system is functioning properly. If the system is equipped with displays, then the cycle counters should indicate the number of events since the last reset. If there are more than 10 events per month, the DC bus threshold voltage setting should be checked and/or adjusted.

5.3. TROUBLESHOOTING

Below are suggestions on how to check some common issues.
If you continue to have problems after going over this list, please contact Bonitron.

Table 5-1: Troubleshooting Guide

SYMPTOM	ACTION
No LEDs	▪ Check incoming power.
No RTR Output	▪ Check Enable input.
Test Mode Does Not Raise Output Voltage	▪ Check Enable input. ▪ Check Test input ▪ Check incoming and outgoing fuses ▪ Check normal DC bus voltage. If the DC bus is normally too high, the DC bus test setpoint may not raise the output voltage.
RTA Always On	▪ Check DC bus threshold voltage setting.
Ride-Thru Active Output Never Comes On or Attached Drive Trips On Outages	▪ Check Enable input ▪ Check DC link to attached drive. ▪ Initiate Test Mode. If the test does not raise the DC bus and / or the Ride-Thru Active output does not activate, there could be internal damage ▪ Check power quality data to confirm sag events should have caused activity to occur
Overtemp	▪ Check for constant current on the negative and positive DC bus links to the drive. Circulating currents may be overheating the unit in standby. ▪ Check activity record – too much activity causes overtemp
Voltage Fluctuates During Test Mode	▪ Check DC bus threshold voltage setting and test boost level. Overvoltage shutdown can occur if settings are too high, causing an oscillation effect. Lower threshold level and retry.
Stays in Test Mode	▪ Check to make sure test input is properly configured and not active.
Precharge Overheated	▪ Not enough time between power up / power down during testing. Pre-charge can only be done 3 consecutive times before overheating can occur ▪ Check DC bus ripple voltage. Too much ripple can cause the precharge circuit to overheat.

CAUTION!

REPAIRS OR MODIFICATIONS TO THIS EQUIPMENT ARE TO BE PERFORMED BY BONITRON APPROVED PERSONNEL ONLY. ANY REPAIR OR MODIFICATION TO THIS EQUIPMENT BY PERSONNEL NOT APPROVED BY BONITRON WILL VOID ANY WARRANTY REMAINING.

5.4. TECHNICAL HELP – BEFORE YOU CALL

If possible, please have the following information when calling for technical help:

- Exact model number of affected units
- Serial number of unit
- Name and model number of attached drives
- Name of original equipment supplier
- Brief description of the application
- The AC line to line voltage on all 3 phases
- The battery bank voltage
- The DC Bus voltage
- KVA rating of power source
- Source configuration Wye/Delta and grounding

This information will help us support you much more quickly. Please contact us at (615) 244-2825 or through www.bonitron.com

6. ENGINEERING DATA

6.1. RATINGS

Table 6-1: M3534 kW Ratings

DC BUS CURRENT (AMPS)	230VAC SYSTEM VOLTAGE	380-415VAC SYSTEM VOLTAGE	460VAC SYSTEM VOLTAGE
20 A	6 kW	10 kW	12 kW
40 A	12 kW	20 kW	24 kW
85 A	25 kW	43 kW	50 kW

Table 6-2: Factory Setpoints for DC Bus Threshold and Test Boost Voltages

SYSTEM VOLTAGE	DC BUS THRESHOLD	TEST BOOST (+ 17%)
230 VAC	285 VDC	333 VDC
380-415 VAC	485 VDC	567 VDC
460 VAC	585 VDC	684 VDC

Table 6-3: M3534R Minimum Input Voltages

SYSTEM VOLTAGE	MINIMUM AC INPUT VOLTAGE①	MINIMUM DC INPUT VOLTAGE② (IUV LEVEL)
230 VAC	115 VAC	160 VDC
380-415 VAC	190 VAC	265 VDC
460 VAC	230 VAC	320 VDC

① Minimum AC input for full power output operation without energy storage
② Minimum DC input for full power output operation with energy storage

Table 6-4: M3534B Battery Bank Typical Values

SYSTEM VOLTAGE	MINIMUM BATTERY VOLTAGE (IUV LEVEL)	NOMINAL BATTERY VOLTAGE	FULL / FLOAT BATTERY VOLTAGE	EQUALIZE BATTERY VOLTAGE
230 VAC	200 VDC	240 VDC	270 VDC	277 VDC
380-415 VAC	340 VDC	408 VDC	459 VDC	470 VDC
460 VAC	400 VDC	480 VDC	540 VDC	554 VDC

Table 6-5: Model Specifications

DC Bus Current ①	M3534R Chassis Size	M3534B Chassis Size	Recommended Fuse Rating ②		SCCR Rating
			DC Bus (F1 F2)	AC Line (F3 F4 F5)	
20 A	A5	-	20 A, 700 V	30 A, 600 V	100 kA ③
40 A	K7	K9	40 A, 700 V	40 A, 600 V	
85 A	A9	-	80 A, 700 V	100 A, 600 V	

① The input power source must be capable of handling a current surge of up to 200% of the M3534 nominal rating for the time specification of the M3534. Maximum duty cycle is 1% at full rated load.
② Fuses recommended for use with the M3534 are Gould-Shawmut A60QS series, A70QS series, Buss FWP series, or equivalent semiconductor fuses.
③ Suitable for use on a circuit capable of delivering not more than 100,000 rms symmetrical amperes with10ms time constant, 700 volts maximum when protected by recommended fuses.

6.2. Derating

Table 6-6: M3534R 20A Derating Values

Percent Sag	Percent Load	Current (Amperes)	Sag Duration (seconds)
60%	100%	20 A	2 s
60%	50%	10 A	20 s

Table 6-7: M3534R 40A Derating Values

Percent Sag	Percent Load	Current (Amperes)	Sag Duration (seconds)
50%	100%	40 A	6 s
50%	50%	20 A	20 s
50%	25%	10 A	30 s
60%	50%	20 A	10 s

6.3. EFFICIENCY / POWER CONSUMPTION

All M3534 models are 93% efficient or better at full load. Power consumption in standby mode is less than 25W for 20A models and less than 40W for the 40A and 85A models.

6.4. BRANCH CIRCUIT PROTECTION AND WIRE SIZING

The following information is supplied for assistance in selecting the appropriate field wiring sizes and power source fuse ratings for the M3534:

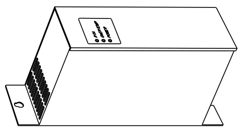
- Wire size must be coordinated with circuit protection devices and IR drop of wire. It is NOT necessary to size wire for continuous duty. Maximum allowed duty cycle for the M3534 is 1%.
- For branch circuit protection, steady state Class J Time Delay or equivalent fusing should be used to support the requirement for 2x surge capability. The recommended minimum current rating for the power source fusing is listed in Table 6-6 based on the DC bus current rating of the M3534. The maximum rating of the steady state power source fusing should be 225A for cabinets with disconnects.
- The field wiring sizes listed in Table 6-6 ensure a ≤10V drop for wire lengths of ≤100 feet and are compatible with the recommended steady state circuit branch protection fusing listed. The wire gauge selected for field wiring to the M3534 should be equal to or greater than that listed in Table 6-6.
- Use copper wiring rated 75°C or equivalent for field wiring terminals.
- These devices do not provide motor overload protection.

Table 6-6: Minimum Input Power Wiring Sizes and Fusing

M3534 DC BUS CURRENT RATING	MINIMUM CIRCUT BRANCH PROTECTION FUSING (CLASS J TIME DELAY)	RECOMMENDED FIELD WIRING SIZES
20 A	15 A	12 AWG
40 A	30 A	10 AWG
85 A	70 A	6 AWG

6.5. DIMENSIONS AND MECHANICAL DRAWINGS

Figure 6-1: M3534 A5 Chassis Dimensional Outline



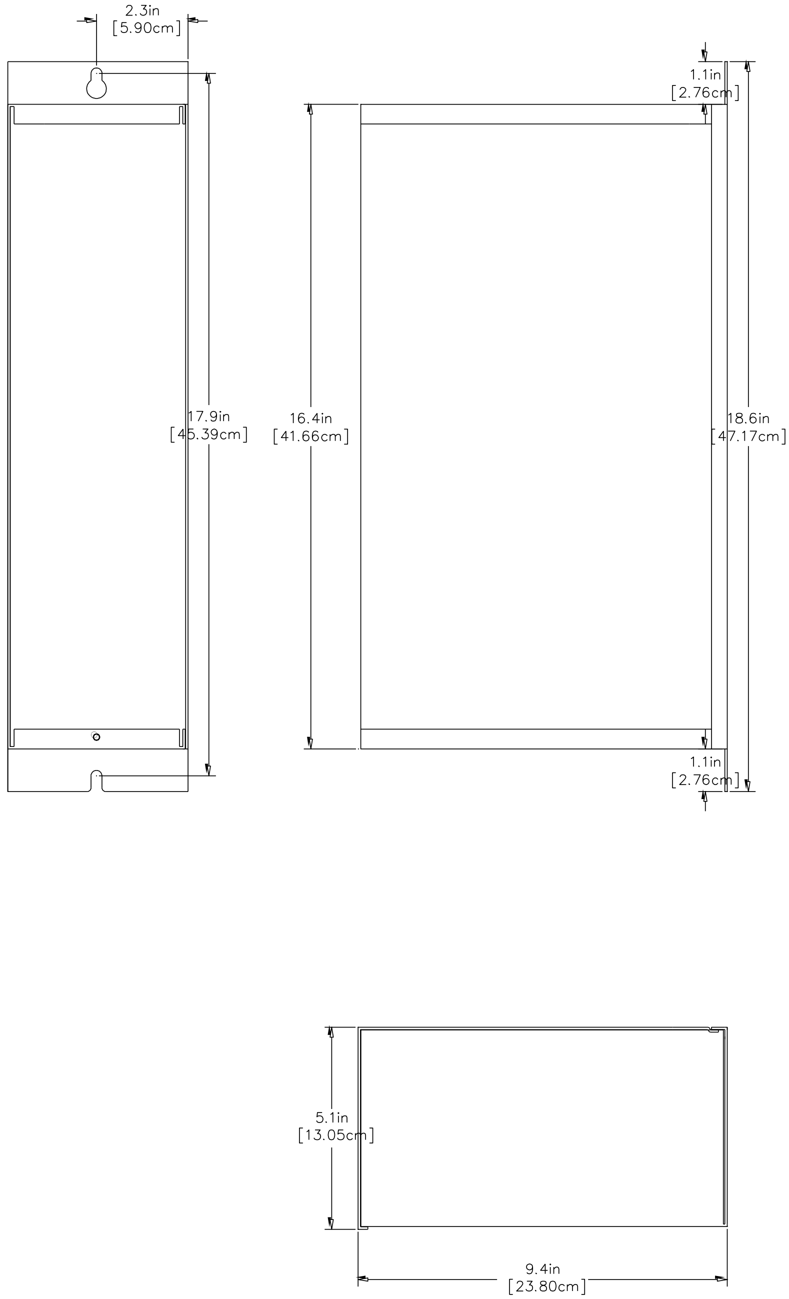


Figure 6-2: M3534 K7 Chassis Dimensional Outline

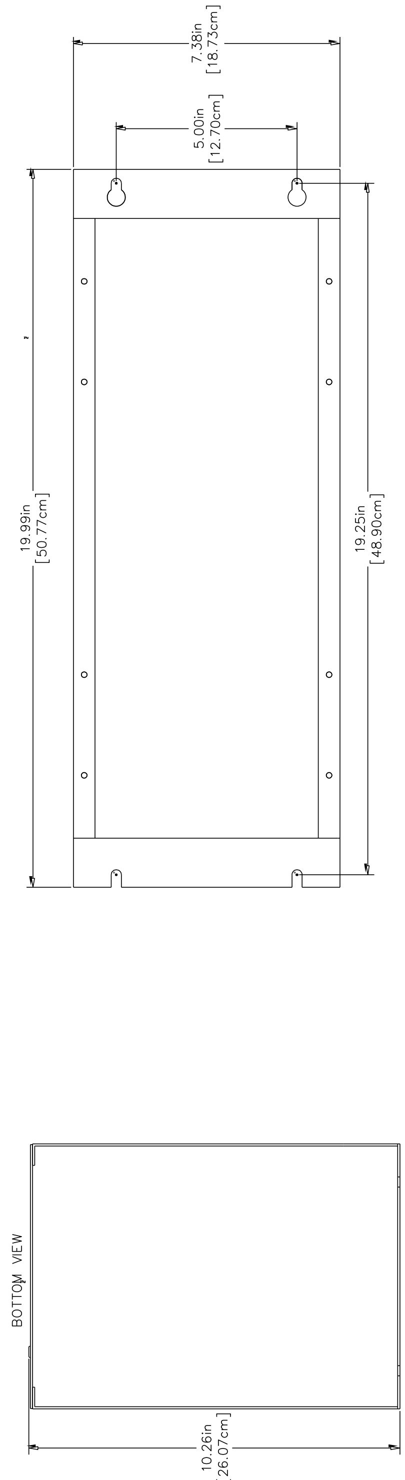


Figure 6-3: M3534 K9 Chassis Dimensional Outline

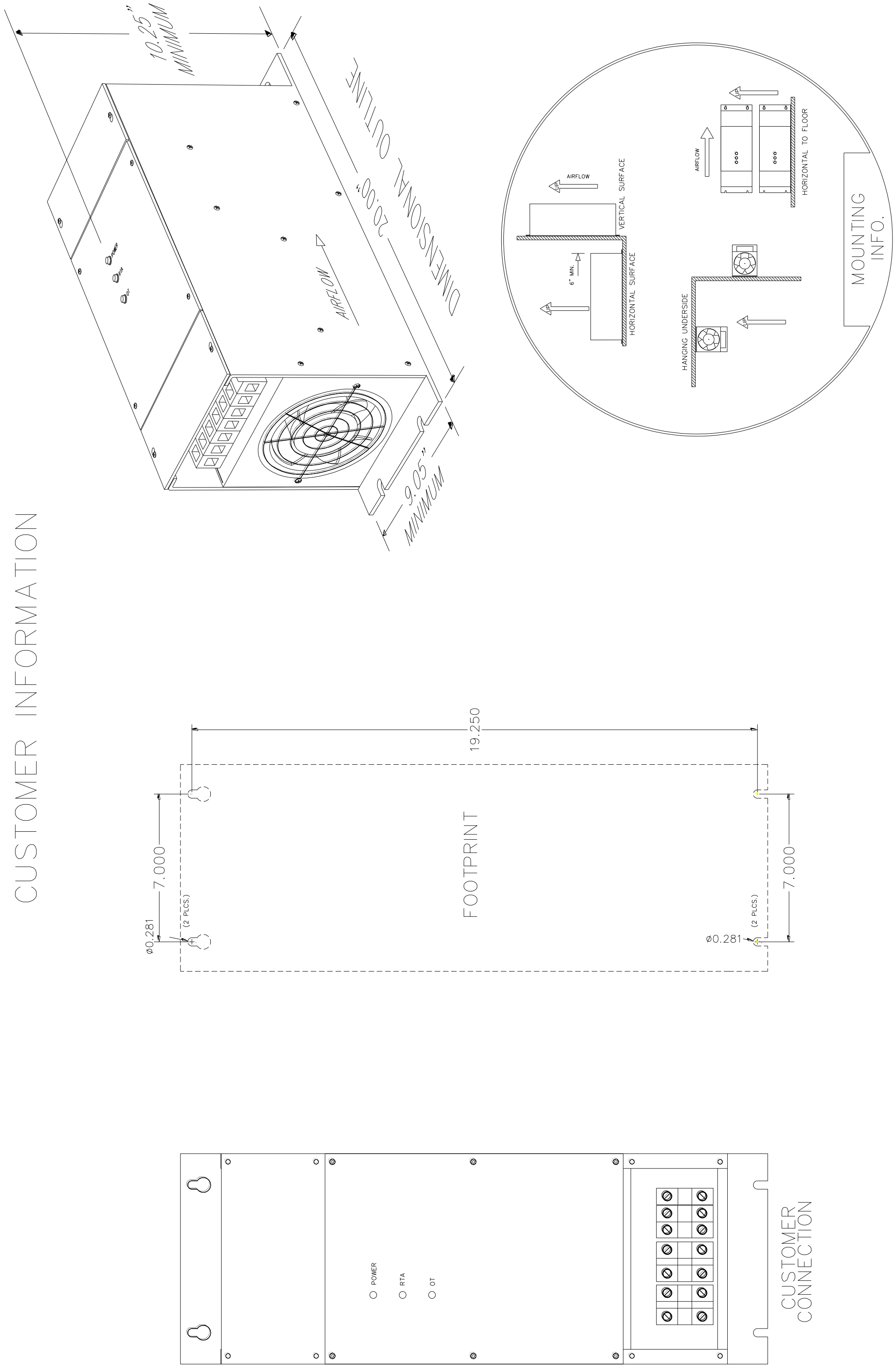


Figure 6-4: M3534 A9 Chassis Dimensional Outline

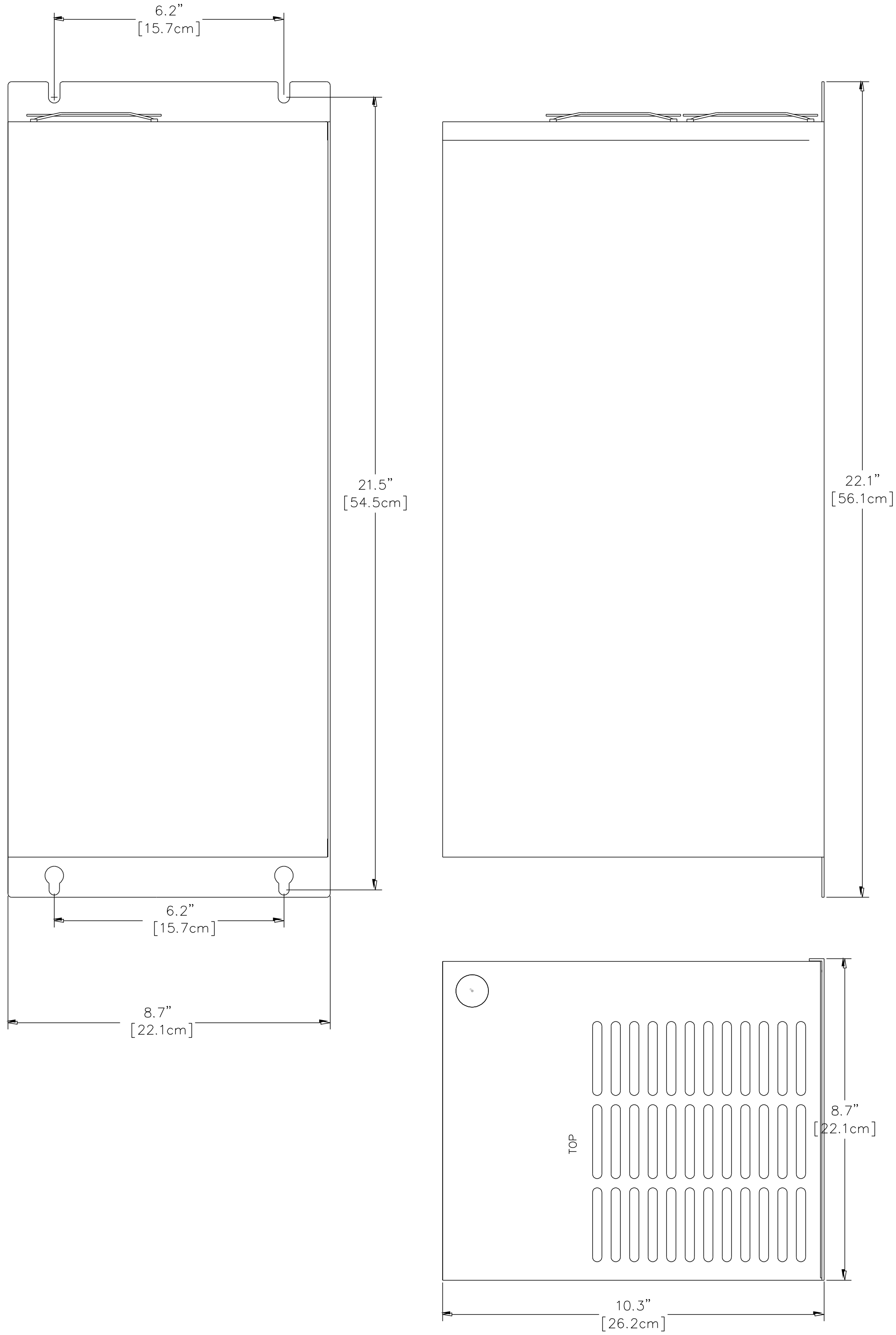


Figure 6-5: DD5 Display Cutout and Mounting Dimensions

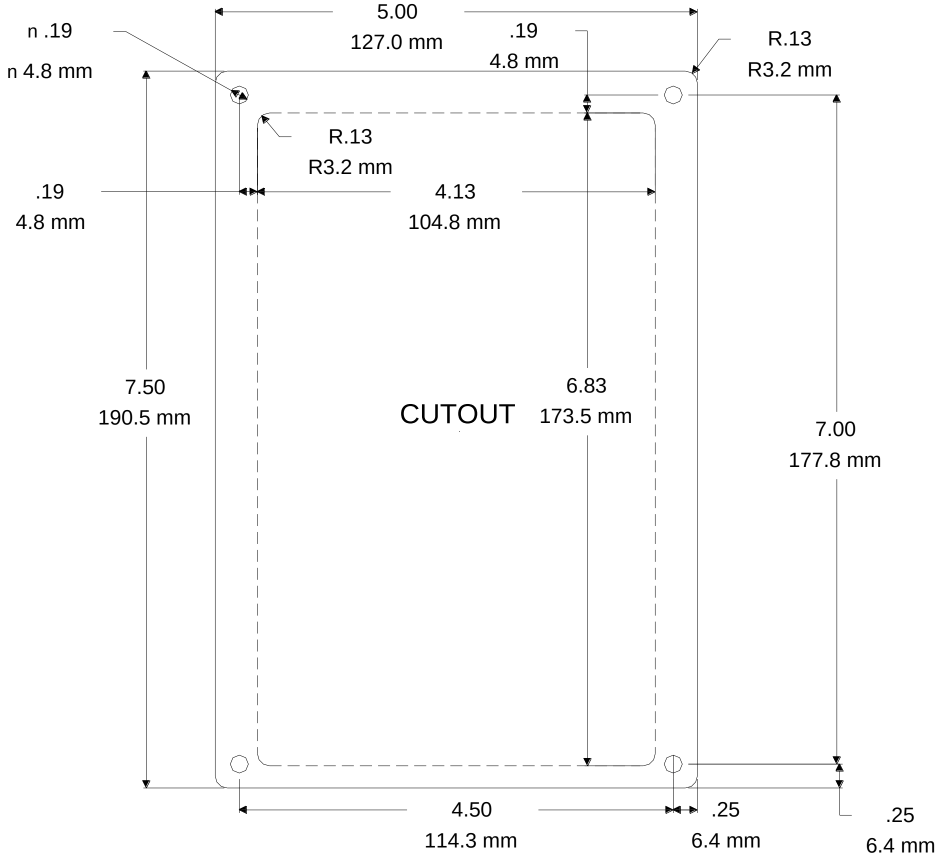
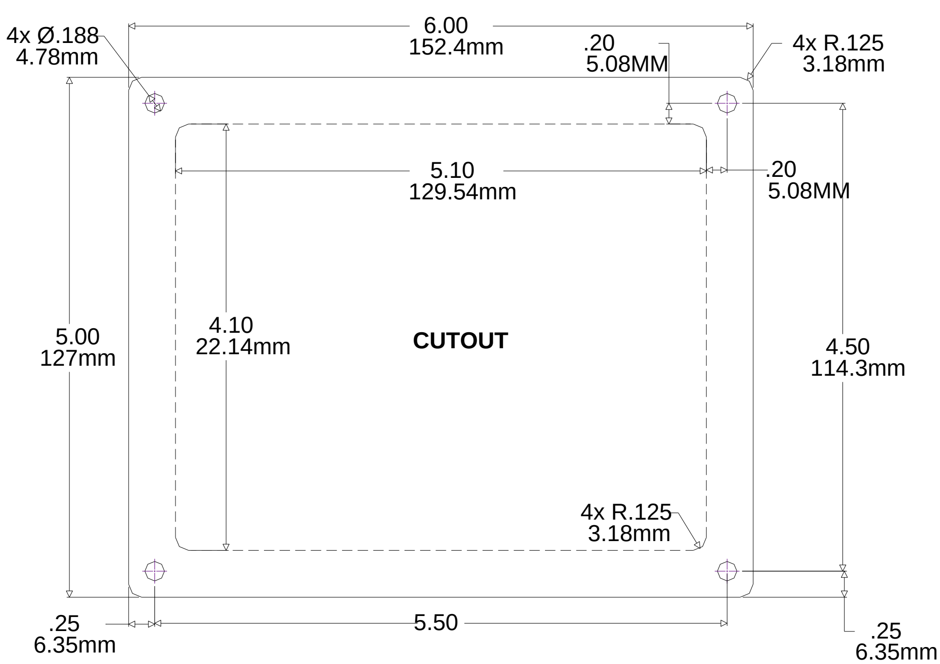


Figure 6-6: DP10 Display Cutout and Mounting Dimensions



7. APPENDICES

7.1. M3534 INSTALLATION CONSIDERATIONS

There are several things to take into account when backing up a drive system. The M3534 is designed to back up the power section of an AC drive, and does so within the DC link of the drive.

DANGER!	*MAKE SURE THE M3534 AND DRIVE HAVE THE SAME AC FEED, AS THE M3534 WILL CONTINUE TO SUPPLY THE DRIVE WITH POWER IF BOTH SYSTEMS ARE NOT TURNED OFF AT THE SAME TIME. LETHAL VOLTAGES EXIST IN THE M3534.*
DANGER!	*FOR SYSTEMS THAT HAVE BACKUP STORAGE SYSTEMS, SUCH AS ELECTROLYTIC CAPACITORS, ULTRACAPACITORS, OR BATTERIES, THE M3534 WILL CONTINUE TO SUPPLY POWER EVEN THOUGH THE AC VOLTAGE IS REMOVED! TAKE SPECIAL PRECAUTIONS WITH THESE SYSTEMS TO ENSURE THAT THE POWER CAN BE REMOVED FROM THE SYSTEM AND LETHAL VOLTAGES DRAINED OR DISCONNECTED FOR SERVICE!*

1. The M3534 must have a DC bus connection directly to the DC bus filter capacitors within the drives. Connections cannot be made through the braking terminals or with precharge resistors or DC link chokes between the output of the M3534 and the DC bus capacitors in the drive. Consult the manufacturers' documentation or contact Bonitron for further assistance.
2. The drive system may depend on other parts of a larger control system that requires backup to allow the drive to keep operating, like sensors or external commands from PLC or relay logic. These systems will need to be backed up separately with AC UPS systems or logic power backup systems like 24VDC buffers.
3. Most drives have control and cooling power supplies that are connected to the DC bus of the drive. These will be backed up by the M3534. Some larger frame AC drives require consistent AC power to keep operating as they have fans that get power directly from the AC line. In this case, there may be special requirements to keep the drive operating.
4. Any AC line outage sensing must be disabled in the drive to keep the drive from automatically shutting down on a phase loss.
5. Any kinetic buffering option needs to be disabled in the drive. This can cause interference with the operation of the M3534.
6. If there is ground fault sensing within the drive, this may need to be disabled, as uneven currents can flow through the AC drive's input bridge causing a trip.

7.2. SPECIFYING AN ULTRACAPACITOR STORAGE BANK FOR FULL OUTAGE PROTECTION WITH THE M3534R

Bonitron M3534R models can have energy storage devices added to cover complete outages. This involves adding a capacitor bank with an appropriate charging and discharging system. Bonitron can source complete capacitor cabinets or individual capacitors. This section gives some instruction for sizing and specifying these storage devices.

The process described below is a good way to estimate the capacitor bank required. Since the discharge characteristic of a capacitor bank with a constant power load is a nonlinear differential equation, optimizing the capacitor bank selection is an iterative process. A general estimate of needs must be used to build a capacitor bank and then the actual values must be cross checked to make sure they are suitable.

There are several steps in the process. The capacitor bank will be comprised of capacitors connected in series for voltage support, with one or more strings in parallel to support the energy requirements. Since the extraction losses due to the electrostatic resistance (Esr) of the capacitor can be significant, they must be taken into account. If the Esr losses get too high, parallel capacitor strings can be used to reduce the current in each series string.

The steps to specify the string will include:

1. Determine the energy required for the outage.
2. Determine the minimum voltage acceptable for full power backup.
3. Determine the maximum current required to support the load at minimum voltage.
4. Specify the capacitor to be evaluated.
5. Estimate the losses for each capacitor.
6. Determine the minimum number of capacitors per series string required for the minimum voltage.
7. Add capacitors in series for outage energy.
8. Determine if parallel strings are required to provide outage energy.

These are the definitions of the variables we will use in the following equations:

C_{eol} - Capacitance at end of life
C_{tot} - Total capacitance of the entire cap bank
Esr_{tot} - Total equivalent ESR for the entire cap bank
Esr - Internal resistance at end of life
I_{peak} - Peak current into the M3534 during the discharge cycle
$J_{Available}$ - Total energy in charged capacitor bank prior to discharge
$J_{LossTot}$ - Total losses during discharge
J_{out} - Energy required to hold up the system during the outage
n_{series} - Number of capacitors in each series string
P_{sys} - System power in kilowatts
T_{out} - Time outage in seconds
V_{Charge} - Charge voltage at beginning of discharge
V_{CapEnd} - The capacitor string voltage at the end of the discharge
V_{CapMax} - Maximum charge voltage for the capacitor
V_{end} - Lowest voltage the capacitor bank can reach
$V_{TermEnd}$ - Terminal voltage of an individual capacitor during discharge

7.2.1. ENERGY REQUIRED FOR OUTAGE

The total energy required for the event must be calculated first.
Using the following equation, the total number of joules required for the outage can be calculated:

$$J_{Out} = P_{sys} * T_{out}$$

We will use a specification of 100 hp. for a 2 second outage for this example. For instance, a 100 hp drive outage for 2 seconds would be

$$P_{sys} = 100hp * .746 \ {}^{kwatts}/_{horsepower} = 75kW$$

The total number of joules required is:

$$J_{Out} = 75kW * 2s = 150kJ$$

7.2.2. MINIMUM CAPACITOR BANK VOLTAGE

There is a minimum voltage level that must be maintained at the end of the discharge during backup. An M3534R for a 460VAC nominal system has a minimum input voltage of 320VDC. Therefore, the final discharge voltage of the capacitor bank (V_{end}) should be 320 VDC.
These data are available in the specifications for the specific M3534R by nominal system voltage.

7.2.3. PEAK CURRENT

The peak current from the capacitor bank will occur at the minimum voltage. This can be estimated from the equation

$$I_{peak} = \frac{P_{sys}}{V_{end}}$$

For our example,

$$I_{peak} = \frac{75kW}{320Vdc} = 235A$$

7.2.4. CAPACITOR SPECIFICATIONS

At this point, a specific capacitor's characteristics can be used. It is best to use the values that are listed at end of life for the capacitor to make sure that the storage system is sized for the eventual degradation of performance over time. The critical points to use are

$Esr =$ *Internal resistance at end of life, typically 150-200% of the initial value.*

$C_{eol} =$ *Capacitance at end of life*

$V_{CapMax} =$ *Maximum charge voltage for the capacitor. (A general rule is to* use 95% of the value listed on the datasheet for a reasonable margin)

For our example, we will use the following values:

$Esr =$ *.01Ω*

$C_{eol} =$ *132F*

$V_{CapMax} =$ *46V*

7.2.5. MINIMUM SERIES STRING

From V_{capMax}, we can calculate the minimum series string of capacitors that will be required by the voltage rating. Below this voltage, there is an amount of stored energy that cannot be used, and will remain in the capacitor bank. Since there can be significant terminal voltage drop at the end of the discharge cycle due to Esr, it is best to use the terminal voltage of the capacitors ($V_{TermEnd}$) for this calculation.

$$\mathrm{V_{TermEnd} = V_{CapMax} - (I_{peak} * Esr)}$$

$$\mathrm{V_{TermEnd} = 46V - (235A * 0.01\Omega) = 43.7V}$$

For our example, the minimum number of caps in a series string would be:

$$\mathrm{n_{series} = \frac{V_{end}}{V_{TermEnd}} = \frac{320V}{43.7V} = 8}$$

7.2.6. AVAILABLE JOULES

At this point, the available maximum joules for the string can be calculated.

$$\mathrm{V_{Charge} = n_{series} * V_{CapMax}}$$

$$V_{Charge} = 8 * 46V = 368V$$

The capacitor voltage at the end of the discharge V_{CapEnd} will be given by:

$$\mathrm{V_{CapEnd} = V_{end} - n_{string} * I_{peak} * Esr}$$

$$\mathrm{V_{CapEnd} = 320V + 8 * 235A * 0.01\Omega = 338V}$$

The total capacitance of the series string is given by:

$$\mathrm{C_{tot} = \frac{C_{eol}}{n_{series}} * n_{parallel}}$$

$$\mathrm{C_{tot} = \frac{132F}{8} * 1 = 16.5F}$$

Now, the total energy that can be delivered to the load is given by:

$$\mathrm{J_{Available}} = \frac{1}{2} * \mathrm{C_{tot}} * \left(V_{Charge}^2 - V_{CapEnd}^2\right)$$

$$\mathrm{J_{Available} = \frac{1}{2} * 16.5F * (368V^2 - 338V^2) = 175kJ}$$

The equivalent Esr of the string is given by

$$\mathrm{Esr_{tot} = \frac{n_{string} * Esr}{n_{parallel}}}$$

$$\text{Esr}_{\text{tot}} = \frac{8 * 0.01\Omega}{1} = 0.08\Omega$$

The total extraction losses of the string is given by

$$\text{J}_{\text{LossTot}} = \text{Esr}_{\text{tot}} * \text{I}_{\text{Peak}}^2 * \text{T}_{\text{out}}$$

$$\text{J}_{\text{LossTot}} = 0.08\Omega * 235\text{A}^2 * 2\text{s} = \ 9\text{kJ}$$

Now the total required energy can be compared.

$$\text{J}_{\text{Out}} + \text{J}_{\text{LossTot}} < \text{J}_{\text{Available}}$$

$$150\text{kJ} + 9\text{kJ} < 175kJ$$

This combination of capacitors will be adequate for our example application. If the application required more energy, then capacitors can be added in series, and the calculations redone. If the charge voltage exceeds the maximum input voltage for the M3534R, then the minimum series string combination should be used in parallel and the process repeated.

7.3. DIODE SHARING WITH A BONITRON M3534 RIDE-THRU

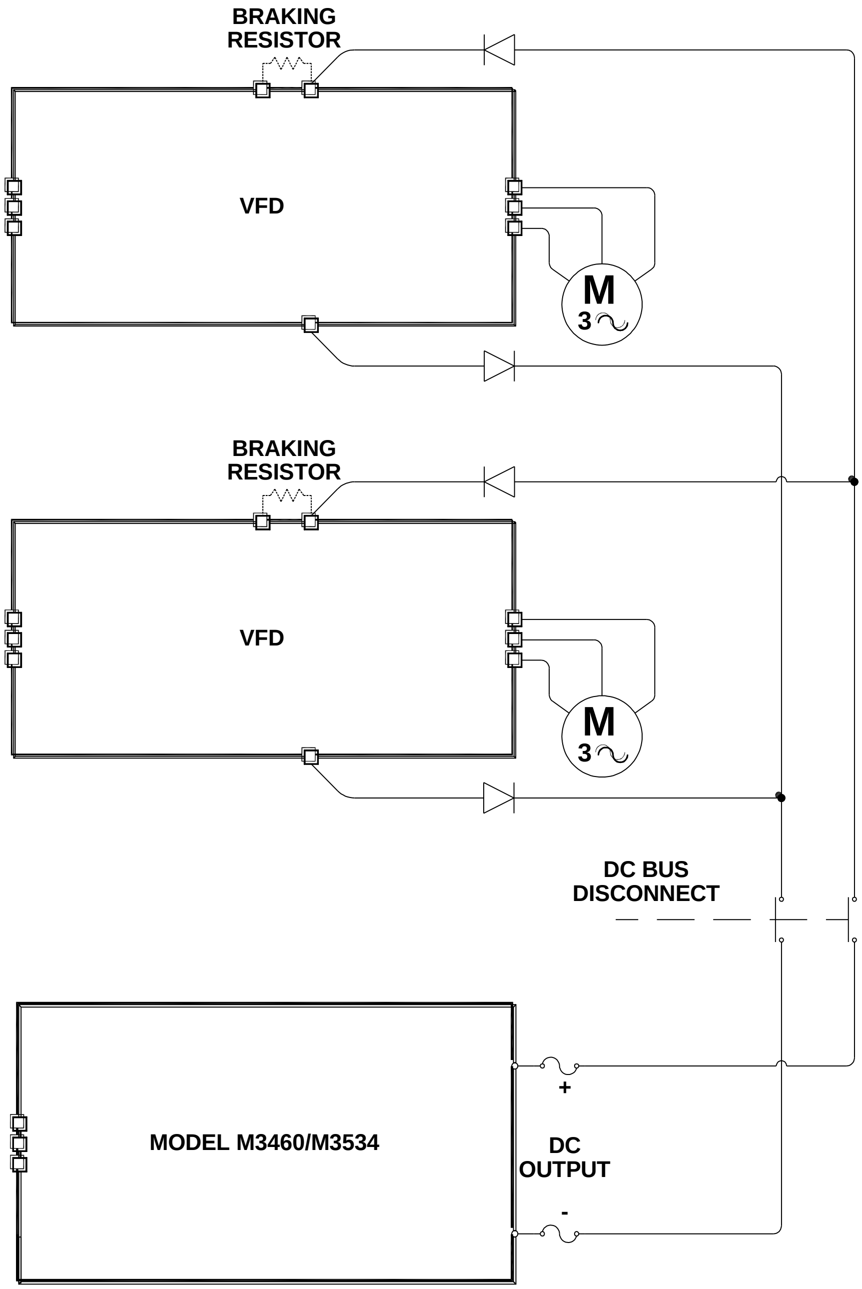
Diode sharing is used to decrease the cost of implementing M3534 modules to existing drive systems that are not common bussed. The use of diodes will prevent drive busses from "back feeding" each other, by allowing energy to pass one way only.

For Ride-Thru applications, the energy is allowed to pass from the M3534 to the drives, but is blocked from the drives to the M3534. Figure 7-1 is a block diagram of a diode sharing example.

Below are some basic guidelines for using diodes in this manner for M3534 applications.

1. Drives should have equivalent DC bus levels as would be found on equal size drives of a common manufacturer.
2. Drives should be on same AC feed and grounding. There must be no isolation transformers between the drives and or M3534 modules. Different feeds may have different potentials and may cause circulating currents or ground faults.
3. If line chokes or harmonic filters are used, all the drives should be connected to the output of a single choke or filter. Individual input harmonic filters or line chokes can cause unequal potentials with respect to earth.
4. The 3534 connection should be downstream of any input line filter. Input line filters cause lower DC bus levels. If a M3534 is placed upstream, the Ride-Thru DC bus can be higher than the drive bus, and current can flow through the M3534. This can cause constant activity and overheating. It may be necessary to lower the threshold for these applications.
5. Ground Fault sensing should be done upstream at common point of line connection, upstream of line filter, if used.

Figure 7-1: Diode Sharing Example



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