Model S3534CR

Full Outage Drive Ride-Thru System For Variable Frequency AC Drives

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.

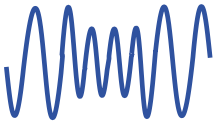
The Bonitron engineering team has the background and expertise necessary to design, develop, and manufacture the quality industrial electronic systems demanded in today's market. A strong academic background supported by continuing education is complemented by many years of hands-on field experience. 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

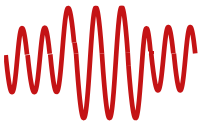
In 1975, Bonitron began working with AC inverter drive specialists at synthetic fiber plants to develop speed control systems that could be interfaced with their plant process computers. Ever since, Bonitron has developed AC drive options that solve application issues associated with modern AC variable 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

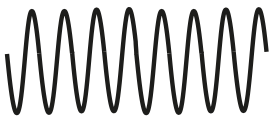
Braking Transistors
Braking Resistors
Transistor/Resistor Combo
Line Regeneration
Dynamic Braking for Servo Drives

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 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 S3534CR Full Outage Drive Ride-Thru System. It will provide the user with the necessary information to successfully install, integrate, and use the S3534CR System 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 VERSION AND CHANGE RECORD

Rev 01 incorporates the new part numbering format and data clarification.

Table 6-1 is updated in Rev 01a.

Ratings are updated in Rev 01b.

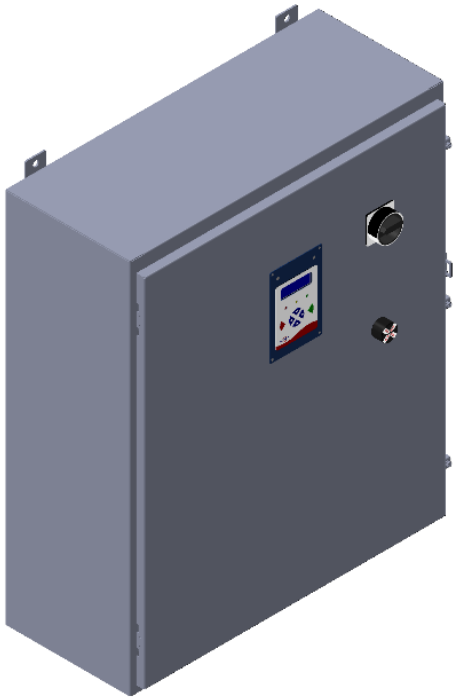
Ratings and product name are updated in Rev 01c.

Wiring drawings were updated in Rev 01d.

Update to manual format, and component ratings were made in Rev 02a

Updated Figures 1-1, 6-1, 6-2, 6-3, and 6-4 in Rev 02b.

Figure 1-1: Typical S3534CR Ride-Thru System



SYMBOL CONVENTIONS USED IN THIS MANUAL AND ON EQUIPMENT

	Earth Ground or Protective Earth
	AC Voltage
	DC Voltage
 **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!**	Heat or burn hazard - Identifies a statement regarding heat production or a burn hazard that should be avoided.

2. PRODUCT DESCRIPTION / FEATURES

Bonitron's Model S3534 series of Ride-Thru Systems provide protection from AC line voltage sags and outages for variable frequency drives (VFDs) that use a fixed rectifier and DC bus. The S3534 series of Ride-Thru Systems provides protection from line voltage sags or the momentary loss of one phase by temporarily storing energy internally and releasing it back into the DC bus when needed. This allows the drive to "ride through" these events, maintaining motor speed and torque, without experiencing drive shutdown.

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 Model M3534R Ride-Thru Control module provides sufficient ride through capability to handle these types of voltage sags. However, 100% power outages can still occur, and even one such instance can be costly. For this reason, the S3534CR incorporates additional capacitive energy reservoirs known as Storage Capacitors with the base M3534R Controller module. This allows the Ride-Thru to supply DC bus power to the drive during full outages of a predetermined duration in addition to its normal sag protection.

2.1. RELATED PRODUCTS AND DOCUMENTS

2.1.1. PRODUCTS

S3534SR SERIES RIDE-THRU SYSTEMS

Complete systems for 50% line sag for 2 seconds.

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.

M3534 SERIES RIDE-THRU MODULES

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

M5628 BATTERY AND ULTRACAPACITOR CHARGERS

Chargers for high voltage storage strings.

KIT 3628T AND M3628R ULTRACAPACITOR DISCHARGER AND RESISTOR

Automatic discharge for large Ultracapacitor storage banks for safety and quick maintenance entry.

2.1.2. DOCUMENTS

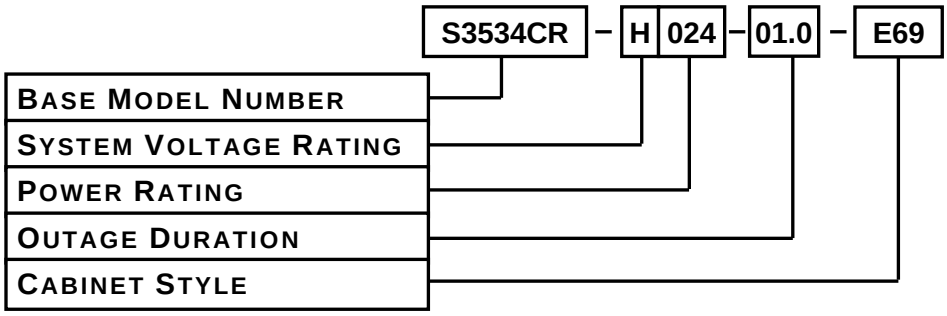
Please refer to the M3534 Ride-Thru Module manual.

Please refer to the KIT 3660DD5 manual when the unit is equipped with the DD5 Digital Display option.

These manuals are available at www.bonitron.com.

2.2. PART NUMBER BREAKDOWN

Figure 2-1: Example of Part Number Breakdown



BASE MODEL NUMBER

The base model number for a full outage AC Input Drive Ride-Thru System with a M3534R Module is **S3534CR.**

SYSTEM VOLTAGE RATING

The System Voltage rating indicates the nominal AC / DC voltage levels of the AC Drive system the Ride-Thru is intended to support. A code letter indicates the system voltage.

Table 2-1: System Voltage Rating Codes

RATING CODE	VOLTAGES (NOMINAL AC LINE / DC BUS)
L	230VAC / 320VDC
E	380 - 415VAC / 540 - 585VDC
H	460VAC / 640VDC

POWER RATING (KW)

The Power rating indicates the maximum power in kilowatts that can safely be handled by the S3534CR. This rating is directly represented by a 3-digit value. For instance, the code **024** indicates that it is a 24kW system.

OUTAGE DURATION

The Outage Duration indicates the maximum time (in seconds) the S3534CR will support the DC bus at the minimum bus voltage setpoint for the specified system voltage. The time is directly represented by a 3-digit value. For example, **01.0** in this position represents 1.0 seconds of Outage Duration.

CABINET STYLE

The model S3534CR outage system is available in various cabinet sizes. The size is dependent on the boost module's KW rating. The cabinet size is indicated by a code as shown in table 2-3. See section 6.4 for complete dimensional outline.

Table 2-3: Cabinet Codes and Sizes

CHASSIS CODE	CHASSIS DESCRIPTION
E61	24" (H) x 20" (W) x 12" (D) Type 12 Wall Mount Enclosure
E63	30" (H) x 24" (W) x 12" (D) Type 12 Wall Mount Enclosure
E66	36" (H) x 30" (W) x 12" (D) Type 12 Wall Mount Enclosure
E69	42" (H) x 36" (W) x 12" (D) Type 12 Wall Mount Enclosure

2.3. GENERAL SPECIFICATIONS

Table 2-4: General Specifications Table

PARAMETER	SPECIFICATION	
AC Input Voltage	3-Phase, 230 – 480 VAC	
DC Output Voltage	320 – 650 VDC	
DC Output Current	Up to 85 A	
Power Rating	Up to 50 kW	
Maximum Outage Duration	2.0 seconds	
Pre-charge Time	Approximately 8 seconds	
Pre-charge Current	Approximately 8A peak per capacitor assembly	
Discharge Resistance	390 Ohms	
Discharge Times with a Discharge Resistor	≈ 60 - 90 seconds	
Inactive Power Usage	Less than 35 watts	
Display	3660 DD5 digital display interface	
Field Connections	AC Line Input DC Bus Output Ground	
User Outputs	Ride-Thru Active (RT Active) Fault 1 (Normally Open) Fault 2 (Normally Open) Output Common	250VDC 120mA
User Inputs	Courtesy 24V 24V Common Input Common Ride-Thru Enable (RT EN) Ride-Thru Test (RT Test)	24VDC, 25mA
Operating Temperature	0 to +40°C	
Storage Temperature	-20ºC to +65ºC	
Humidity	Below 90% non-condensing	
Atmosphere	Free of corrosive gas and conductive dust	
Enclosure	Type-12	

2.4. General Precautions and Safety Warnings

DANGER!

- High voltages may be present!
- Never attempt to operate this product with the enclosure door open!
- 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 door.
- **FAILURE TO HEED THESE WARNINGS MAY RESULT IN SERIOUS BODILY INJURY OR DEATH!**

CAUTION!

- This product will generate high ambient temperatures during operation.
- This product should be installed accordingly on non-flammable surfaces with clearances of at least two inches in all directions.
- Always allow adequate time for the unit to cool before attempting service on this product.
- Before attempting installation or removal of this product, always review all AC drive documentation for pertinent safety precautions.
- Installation and/or removal of this product should only be accomplished by a qualified electrician in accordance with National Electrical Code or equivalent regulations.

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

3. INSTALLATION INSTRUCTIONS

DANGER!

Installation and/or removal of this product should only be performed by a qualified electrician in accordance with National Electrical Code or local codes and regulations.

Proper installation of the S3534CR Ride-Thru should be accomplished following the steps outlined below. Be sure to refer to the AC Drive instruction manual as these steps are performed. Please direct all installation inquiries that may arise during the installation and startup of this product to the equipment supplier or system integrator.

3.1. ENVIRONMENT

The installation site for the module should be chosen with several considerations in mind.

- The enclosure has a NEMA-12 rating and will therefore require some protection from the elements.
- Conduit access for field wiring may be provided on the top-right surface of the enclosure, if desired.
- The unit will require a minimum clearance of two (2) inches in all directions around it when mounted near a non-heat source.
- The mounting surface should be clean and dry.

3.2. UNPACKING

Upon receipt of this product, please verify that the product received matches the product that was ordered and that there is no obvious physical damage to the unit. If the wrong product was received or the product is damaged in any way, please contact the supplier from which the product was purchased.

3.3. MOUNTING

Once the installation site has been selected as outlined above, the unit should be mounted in place. The enclosure is provided with (4) mounting holes.

Mounting holes should be drilled and mounting studs or anchors installed before positioning the enclosure. Mounting hardware is not supplied.

Refer to Section 6.4 of this manual to determine the correct mounting dimensions for the unit.

DANGER!

A minimum of two people should be used to position the unit!

3.4. WIRING AND CUSTOMER CONNECTIONS

This section provides information pertaining to the field wiring connections of the S3534CR Drive Ride-Thru. Actual connection points and terminal numbers of the AC Drive system will be found in the documentation provided with that system.

Be sure to review all pertinent AC Drive System documentation as well as this entire Section before proceeding.

3.4.1. POWER WIRING

DANGER!

THE S3534 CAN HAVE MULTIPLE POWER SOURCES, INCLUDING THE MAIN AC INPUT, CAPACITOR 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!

Table 3-1: Power Wiring Connections

ENCLOSURE (KW)	TERMINAL	FUNCTION	ELECTRICAL RATINGS	WIRE SIZE MIN.	WIRE SIZE MAX.	TORQUE
(Up To 12kW)	DC BUS (+)	DC Power Output +	650VDC, 20A	14 AWG	8 AWG	9 - 11 lb-in
	DC BUS (-)	DC Power Output -	650VDC, 20A			9 - 11 lb-in
	L1, L2, L3	AC Line Input	480VAC, 30A			9 – 11 lb-in
	GND	System Ground	Limited by Ring Lug 3/8"			40 - 50 lb-in
(Up To 24kW)	DC BUS (+)	DC Power Output +	650VDC, 40A	12 AWG	8 AWG	18 - 21 lb-in
	DC BUS (-)	DC Power Output -	650VDC, 40A			18 - 21 lb-in
	L1, L2, L3	AC Line Input	460VAC, 60A			18-21 lb-in
	GND	System Ground	Limited by Ring Lug 3/8"			40 - 50 lb-in
(Up To 50kW)	DC BUS (+)	DC Power Output +	650VDC, 85A	8 AWG	4 AWG	22 – 26 lb-in
	DC BUS (-)	DC Power Output -	650VDC, 85A			22 - 26 lb-in
	L1, L2, L3	AC Line Input	460VAC, 90A			22 - 26 lb-in
	GND	System Ground	Limited by Ring Lug 3/8"			40 - 50 lb-in

All terminals connections are located in the upper right hand section of the enclosure.

DC BUS OUTPUT

Make the DC bus output interconnections at DC BUS (+) and DC BUS (-). See Table 3-1 for wire size.

3-PHASE AC LINE INPUT

Make the 3-phase AC Line input interconnections at L1, L2, L3 terminals. See Table 3-1 for wire size.

GROUND

The cabinet should be earth grounded to the stud in upper right corner of the backplate. See Table 3-1 for wire size.

3.4.1.1. AC INPUT SOURCE CONSIDERATIONS

The AC input source should be able to supply charge current of 8 amps peak per capacitor module.

There are about five capacitor modules for the 10kW and 12kW Ride-Thru systems.

There are about nine capacitor modules for the 20kW and 24kW Ride-Thru Systems.

Figure 3-1: S3534CR Field Connection Terminal Layout

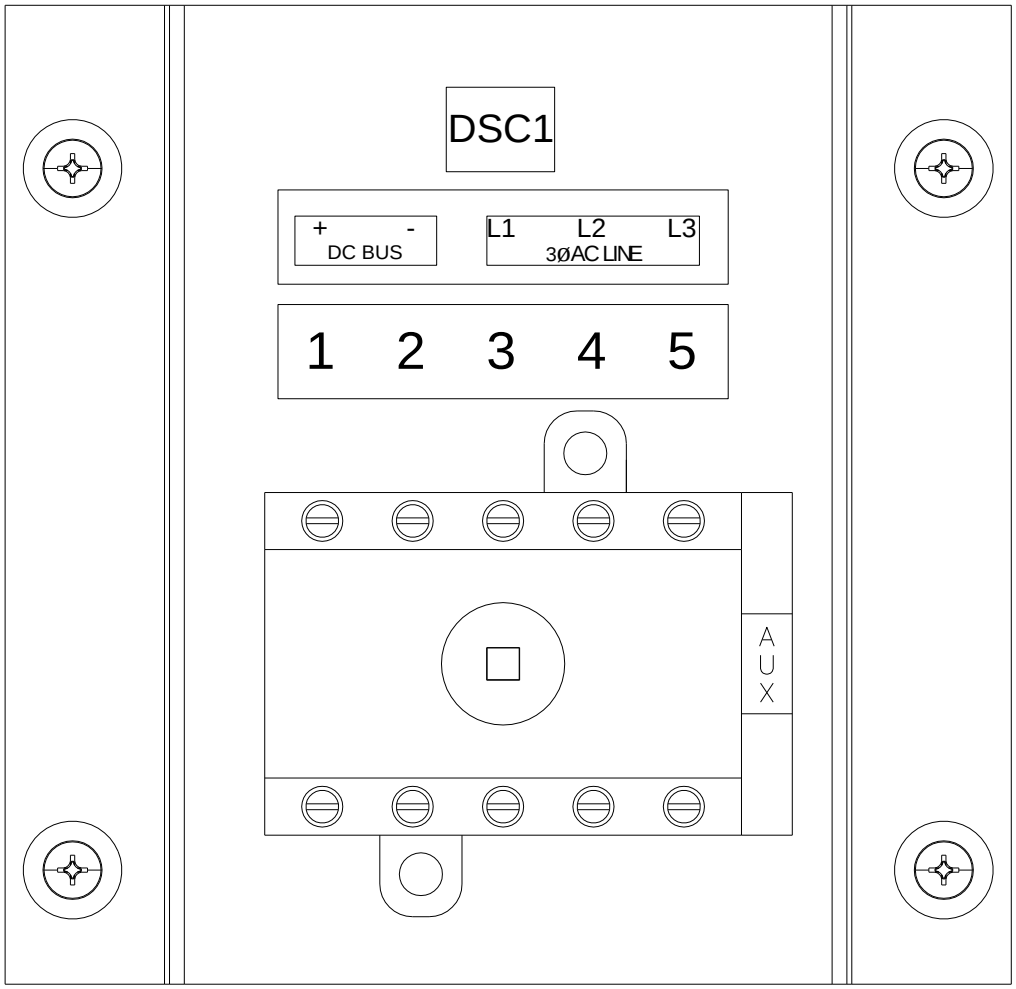


Figure 3-2: Typical S3534CR Power Wiring

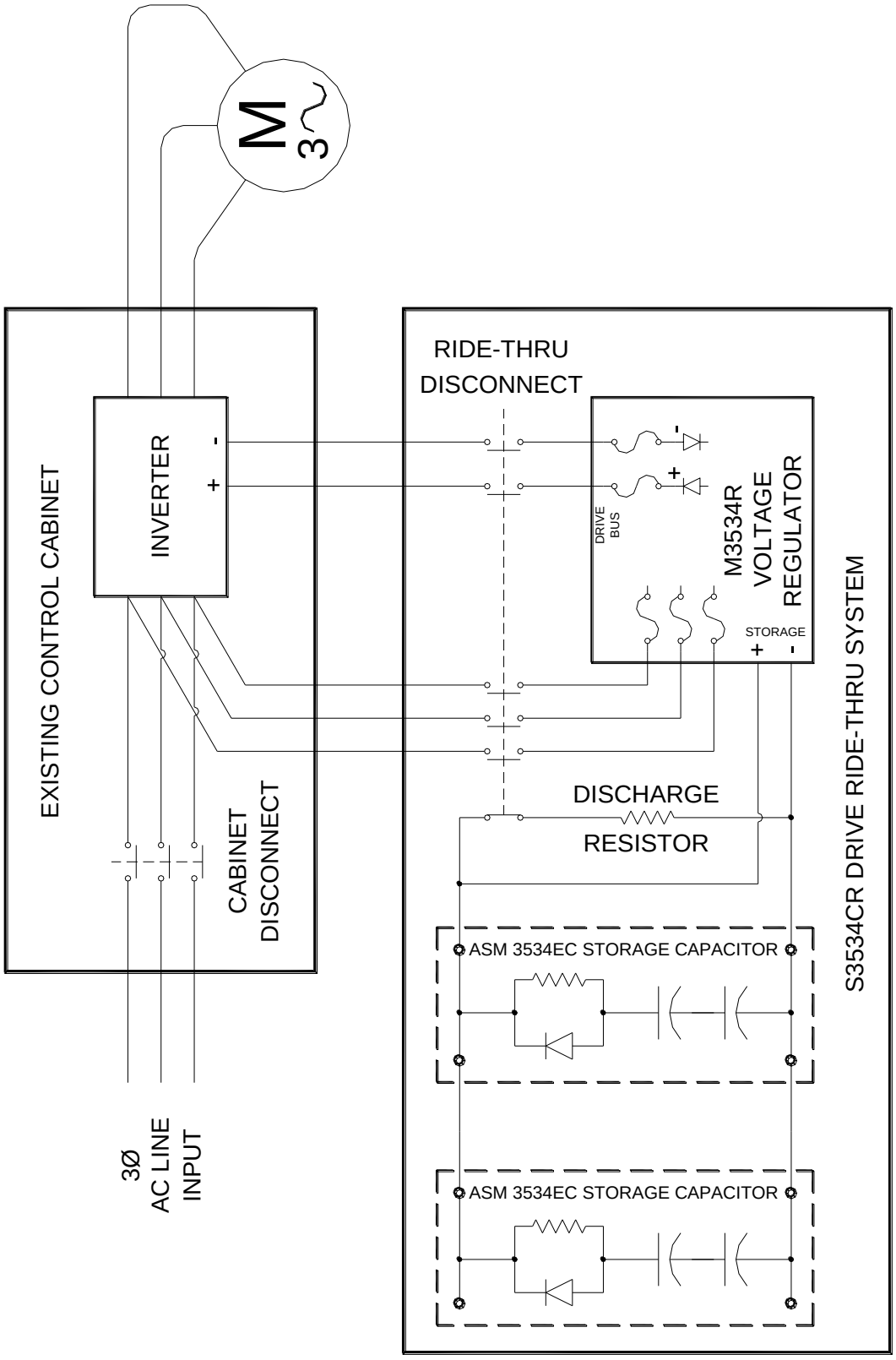


Figure 3-3: S3534CR Drive Ride-Thru System in E66 Cabinet Internal Layout

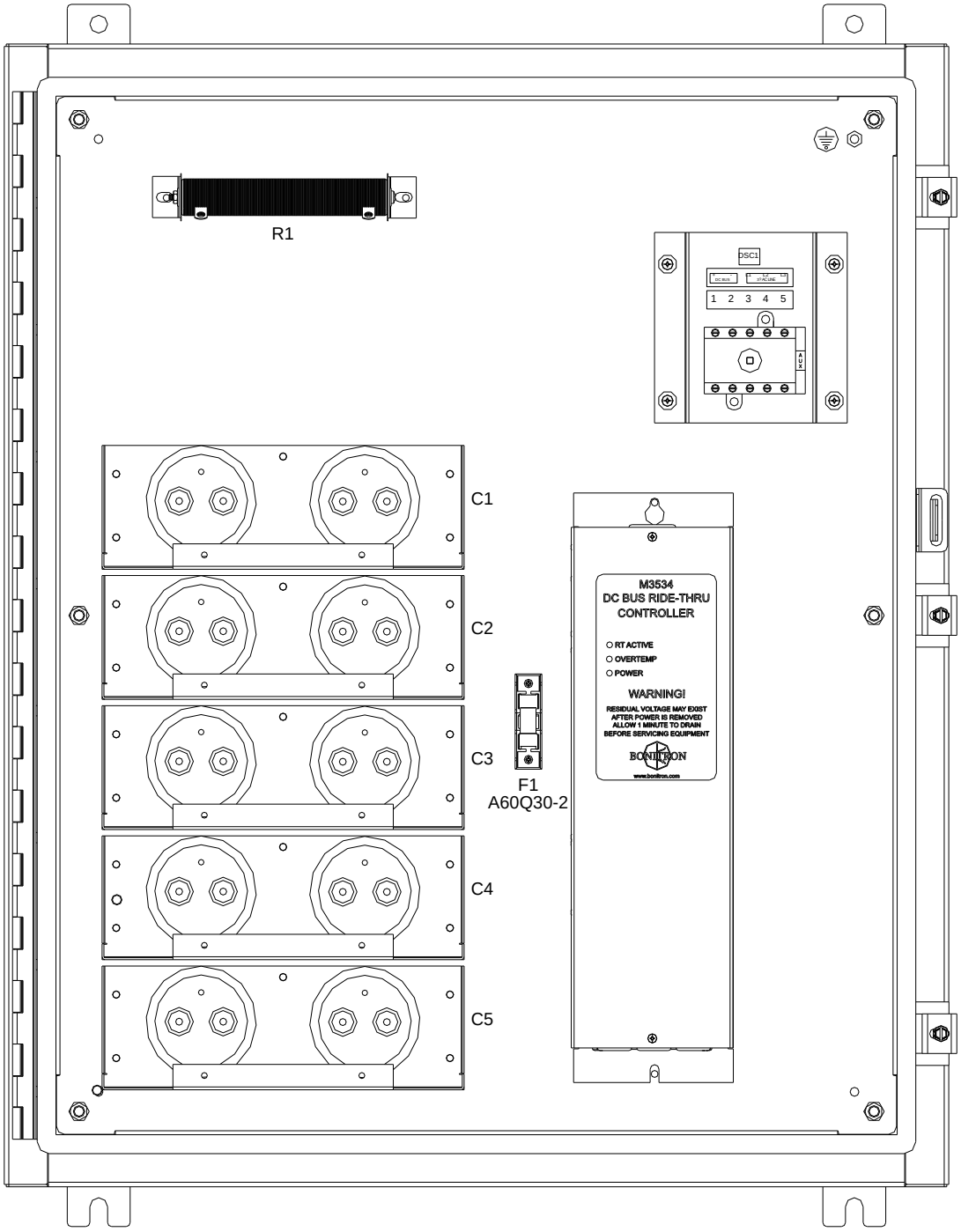
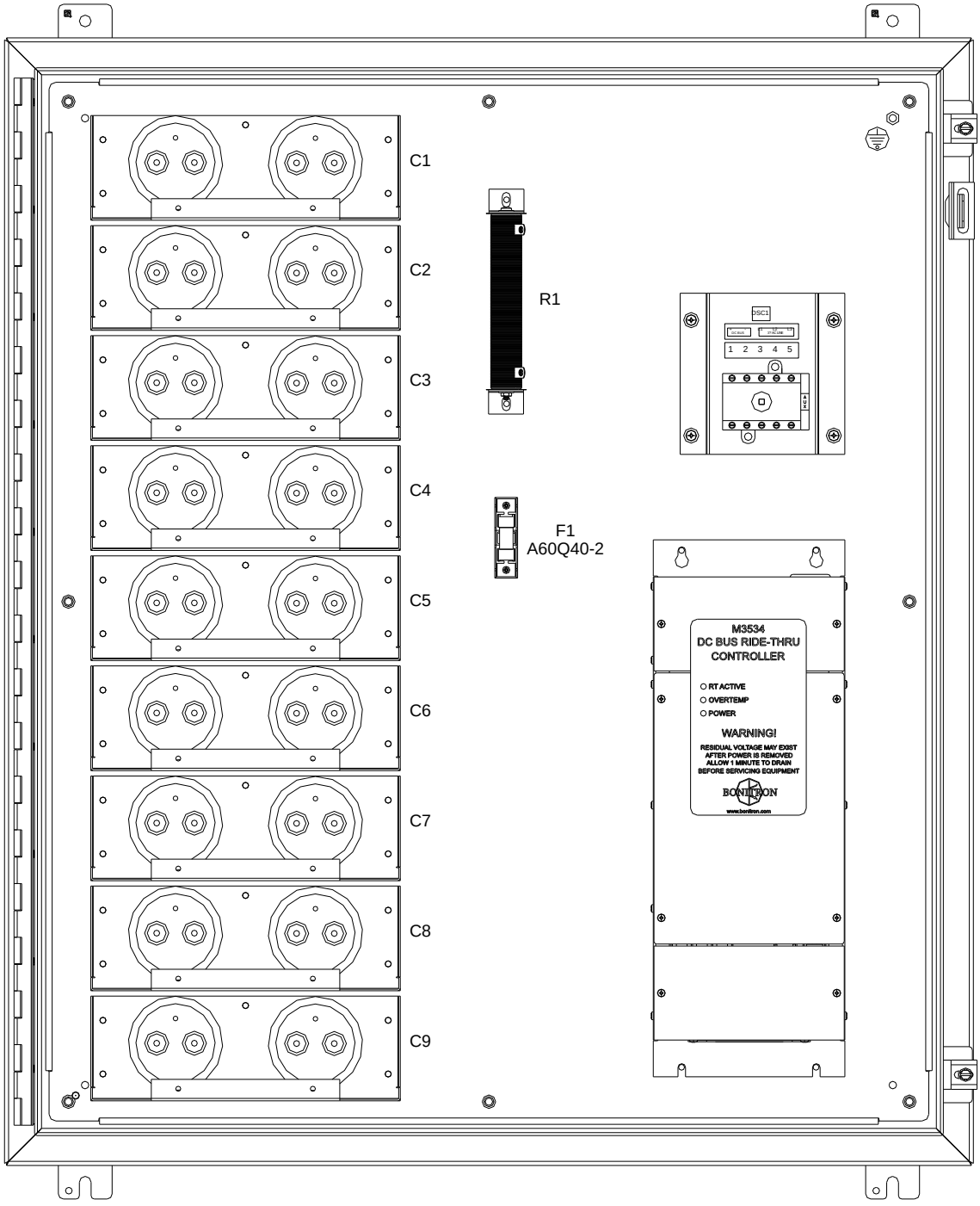


Figure 3-4: S3534CR Drive Ride-Thru System in E69 Cabinet Internal Layout



4. OPERATION

4.1. FUNCTIONAL DESCRIPTION

The S3534CR Ride-Thru System monitors the DC bus of the attached variable frequency drive and provides power directly to the filter capacitor section of the drive above the inverter stage. During a power quality event, such as a sag or outage, the internal DC bus of the VFD drops. When this level meets the threshold of the S3534CR, power is delivered through blocking diodes to hold up the VFD. Energy is stored in a capacitor bank and the M3534 boost module regulates and boosts the output voltage to the drive at a constant voltage.

4.2. FEATURES

4.2.1. VOLTAGE REGULATOR DETAILS

All S3534CR systems use the M3534R Voltage Regulator module. The Voltage Regulator modules are equipped with basic fault and status outputs. For connection details and features see the manual for M3534R Voltage Regulator.

4.2.2. MONITORING SYSTEM DETAILS

All S3534CR systems use KIT 3660DD5 monitoring system. For more details see the manual for KIT 3660DD5 monitoring system.

- The KIT 3660DD5 gives the users real time information about ride-thru system functions and can be used to monitor and present power quality issues that can cause process disturbances and production loss. A history of power quality events is stored in persistent memory for later analysis, showing the effectiveness of the ride-thru system.

  The KIT 3660DD5 ride-thru monitoring system is designed to monitor and display information about the Bonitron ride-thru system, such as the present values of the system voltages and currents, or any fault conditions that may exist. The KIT 3660DD5 also provides the ability to easily test the ride-thru system to ensure full protection from any power quality events. The monitoring system saves the thirty most recent power quality events, recording information such as the time of the event, the duration of the event, and the voltage levels during the event
- A Grace voltage indicator is mounted on the door of S3534CR Systems. This indicator flashes Red if there is any AC line voltage or DC voltage present in the cabinet. The door should not be opened while the grace voltage indicator is illuminated.

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5. MAINTENANCE AND TROUBLESHOOTING

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 on this unit.

5.1.1. PRE-POWER CHECKS

1. Ensure power connections have proper torque. See Table 3-1.
2. Ensure DC bus connections between the driver and the S3534CR are the proper polarity.
3. Ensure the unit has an ENABLE signal, the system should be enabled by the internal 24V or an external PLC control signal.

5.1.2. STARTUP PROCEDURE AND CHECKS

The associated drive should be powered up and proven operational before adding the unit on-line.

With power already applied to the associated drive, turn on the main disconnect switch.

a. Pre-charge of capacitor bank should last approximately 8 seconds.
b. Capacitor bank DC voltage should read 1.4 times the AC line RMS voltage.
c. The GREEN power LED on the DD5 display should turn ON.
d. The RED fault LED on the DD5 display should be OFF.
e. Press RIDE THRU test function on the DD5 display, the DC bus voltage should increase about 70-100V above nominal. And the display shows BOOSTING, and yellow LED is ON.

The S3534CR is now ready for operation. Full power operational testing is recommended during commissioning.

5.2. TROUBLESHOOTING

SYMPTOM	ACTION

No Ride-Thru capability	• Check for Power LED on Voltage Regulator module.
	• Check for voltage reading on capacitor bank.
	  • If OK, check DC output fuses in Voltage Regulator module.
	  • If OK, do capacity test, checking for activity on Voltage Regulator module.

No voltage on display	• Check for 3-phase AC voltage at input to box. • Check for 3-phase AC downstream of disconnect. • Check AC line fuses inside Voltage Regulator module. • Check capacitor bank fuse on backplate.

Low voltage on display	• Check each individual capacitor pack, measuring on capacitor terminals.
	  • Each capacitor pack supplies some voltage to meter. If one out of two capacitor packs are at zero volts, the meter will read half voltage.
	  • Bonitron's design will allow a capacitor pack to fail short and not affect the remaining capacitor packs, with the Capacitor Voltage Meter reading proportionally low.

No POWER LED on Voltage Regulator module	• Check for 3-phase AC downstream of disconnect. • Check AC line fuses inside Voltage Regulator module.
No RTA LED on Voltage Regulator module	• Ensure voltage regulator threshold is set properly. • If DC bus drops below threshold setting, and no activity occurs, contact Bonitron for repair.

OT FAULT is ON	• Check temperature of Voltage Regulator module.
	  • Warmth indicates excessive activity or current flow.
	  • Check threshold setting and lower if nominal DC bus level is within 10V of threshold.
	  • Measure static current flow. Presence of line chokes in series with the drive may allow excessive current flow through voltage regulator's parallel rectifier bridge.

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.

5.3. 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 CHARTS

To provide full outage protection, 3534EC storage capacitors are required. See section 7.3 for basic calculation for the energy storage capacitors needed for a full outage Ride-Thru system.

6.2. WATT LOSS

S3534CR Models use less than 35W in stand-by mode and are 93% (or better) efficient at full load.

6.3. FUSE SIZING AND RATING

Fuses are located inside the M3534R Voltage Regulator enclosures.

Table 6-1: M3534R Ratings and Fuses

MODEL	AC INPUT	POWER	FUSE		OUTPUT CURRENT	CHASSIS
			AC	DC		
M3534R-E010-A5	380 - 415VAC	10kW	A60Q30	A60Q25	20A	A5
M3534R-H012-A5	460 - 480VAC	12kW	A60Q30	A60Q25	20A	A5
M3534R-E020-K7	380 - 415VAC	20kW	A60Q40	FWP-50A	40A	K7
M3534R-H024-K7	460 - 480VAC	24kW	A60Q40	FWP-50A	40A	K7
M3534R-E043-A9	380 - 415VAC	43kW	A70QS125	A70QS90	85A	A9
M3534R-H050-A9	460 - 480VAC	50kW	A70QS125	A70QS90	85A	A9

6.4. DIMENSIONS AND MECHANICAL DRAWINGS

Figure 6-1: S3534CR E61 Enclosure Dimensional Outline

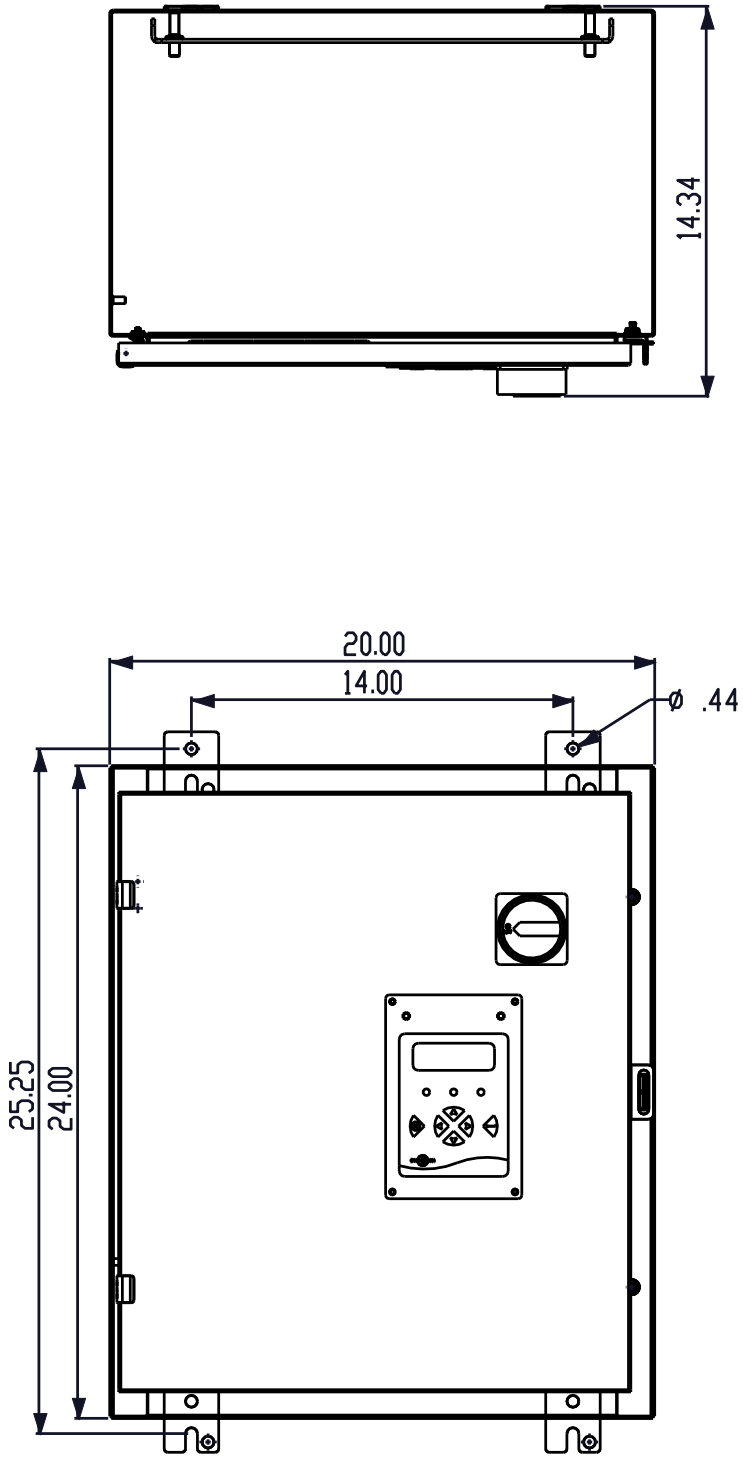


Figure 6-2: S3534CR E63 Enclosure Dimensional Outline

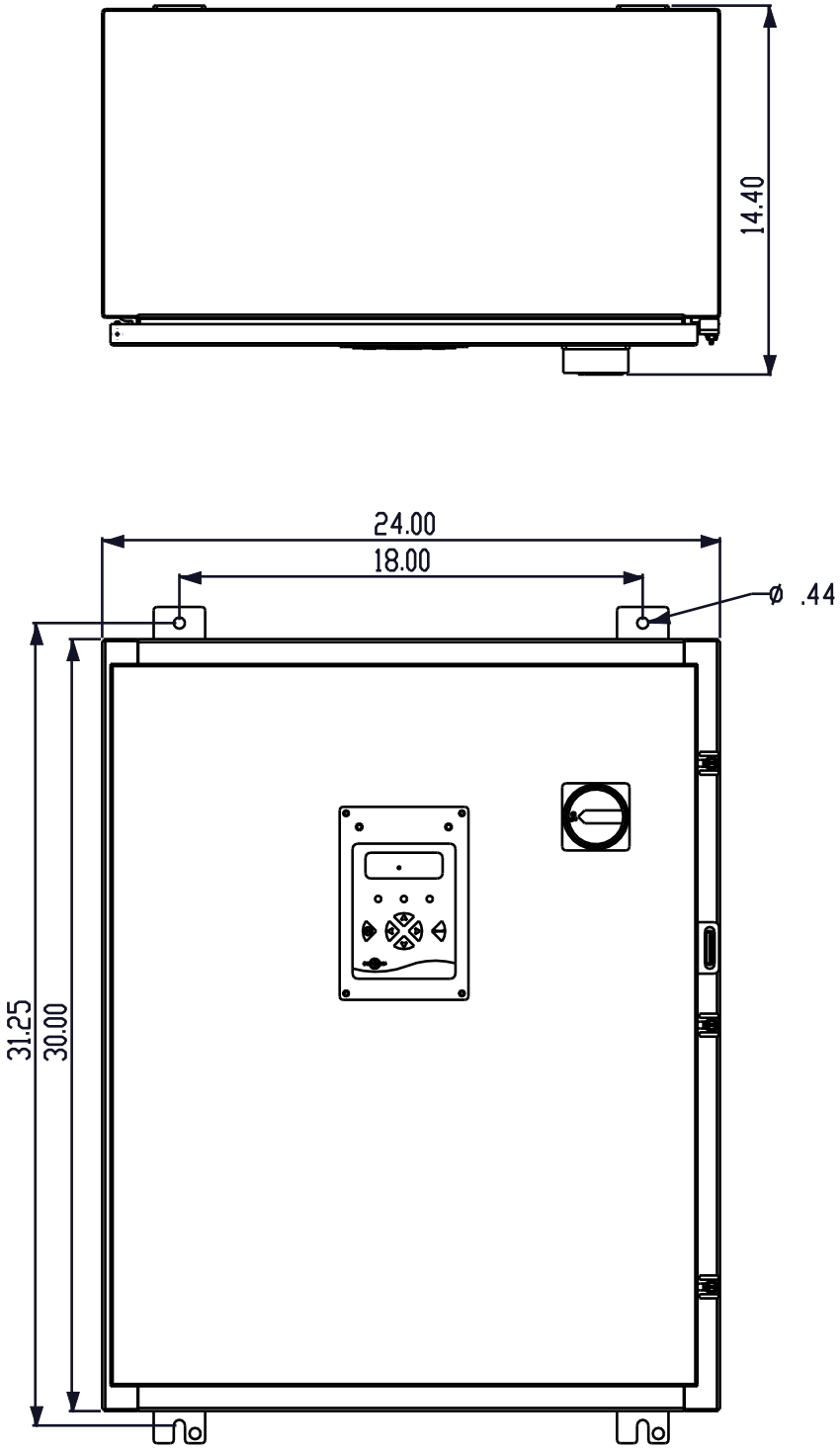


Figure 6-3: S3534CR E66 Enclosure Dimensional Outline

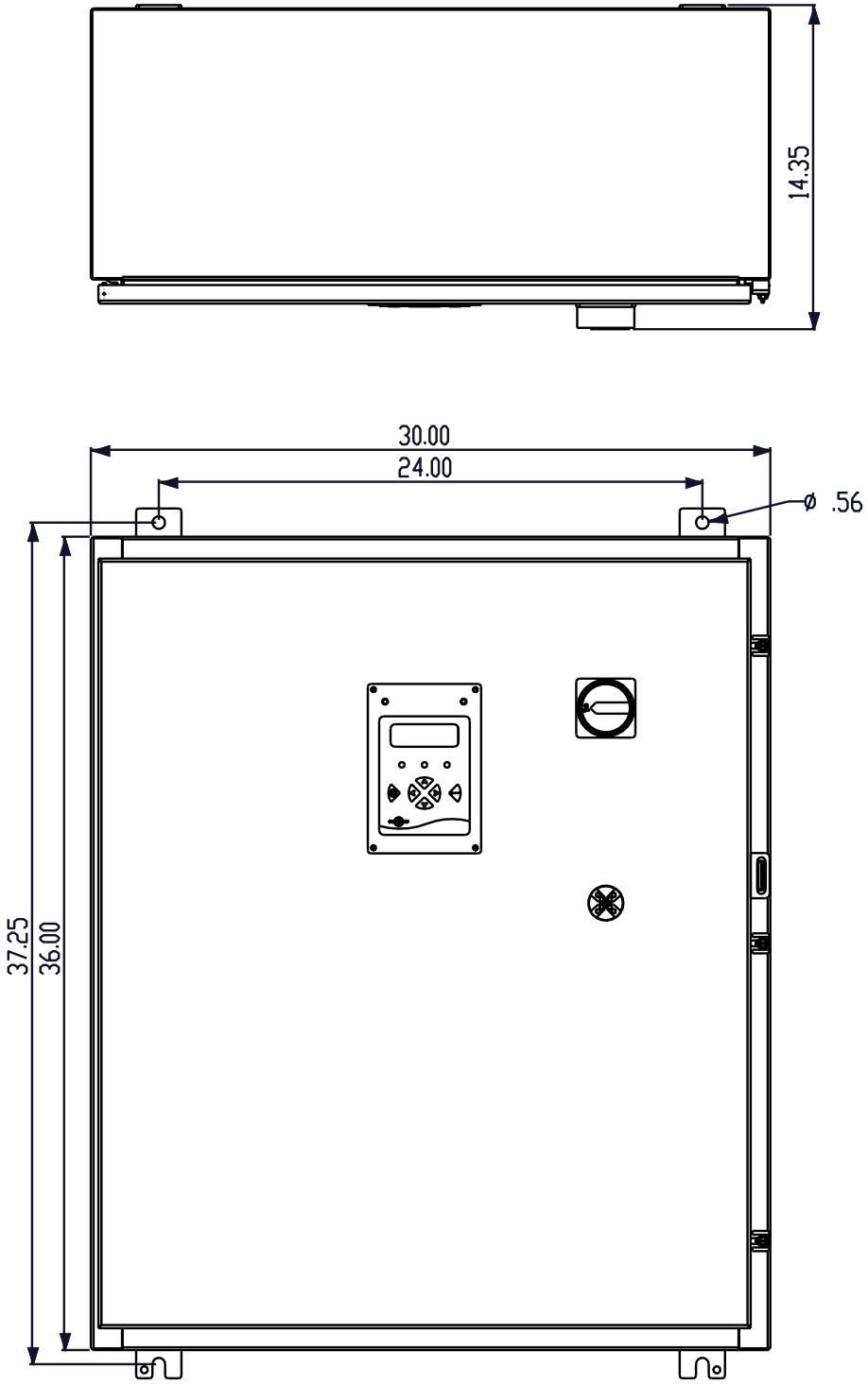
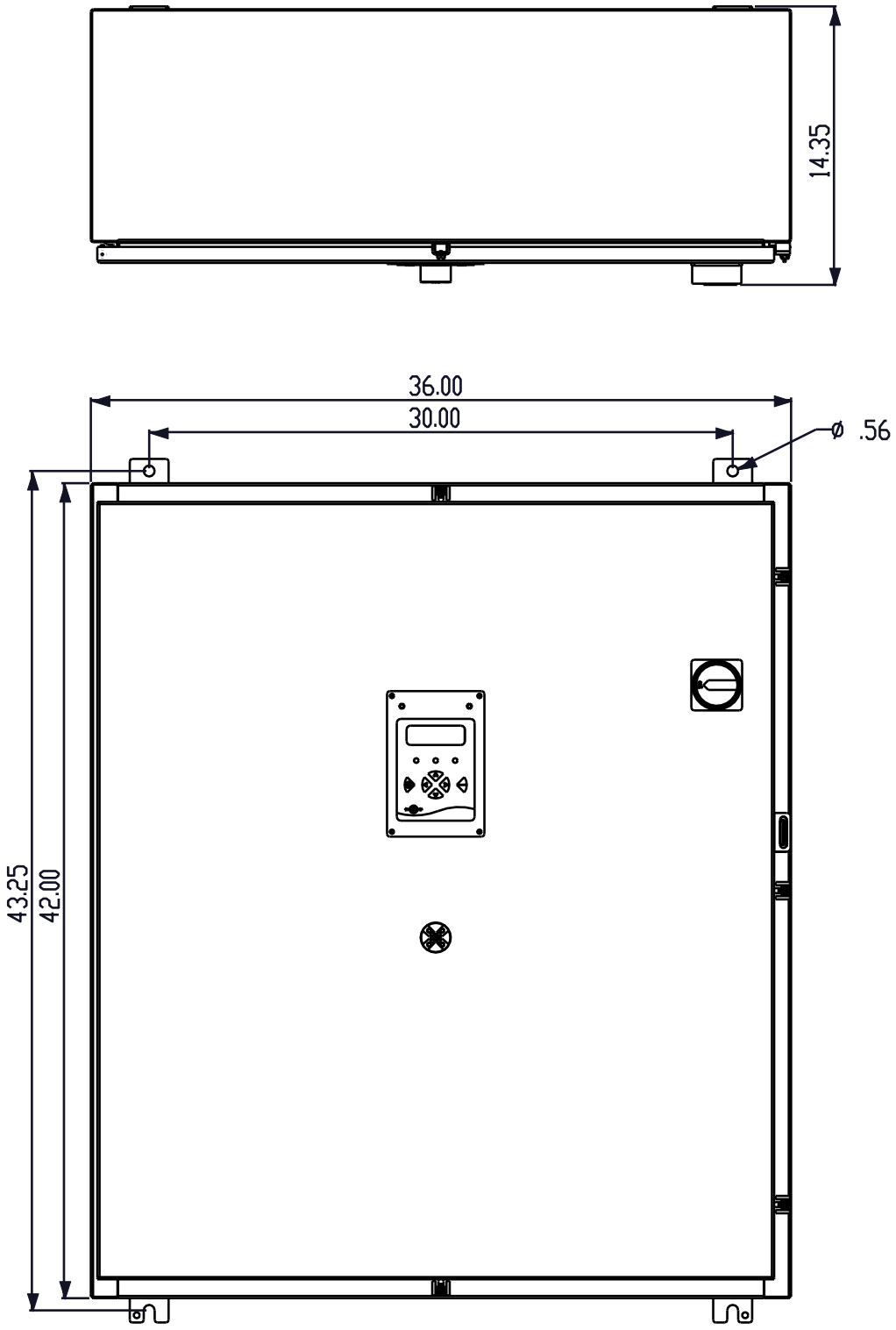
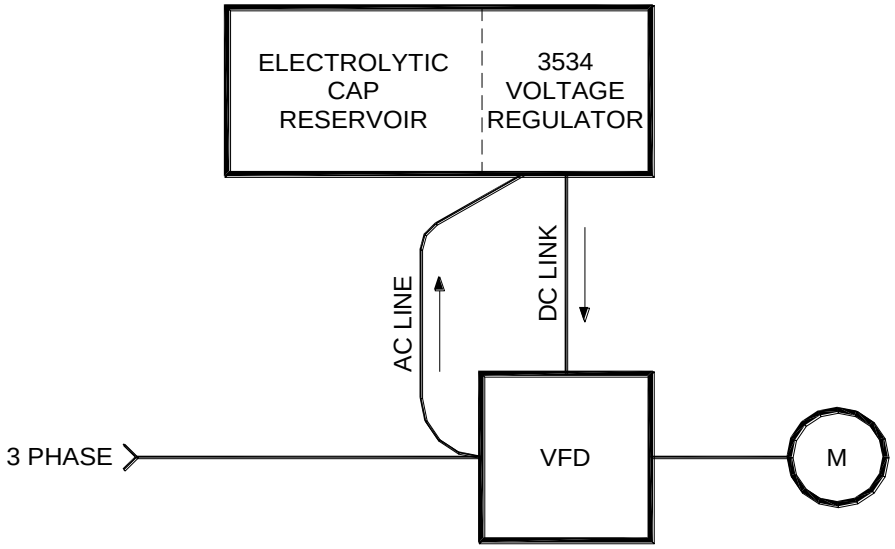


Figure 6-4: S3534CR E69 Enclosure Dimensional Outline



6.5. BLOCK DIAGRAMS

Figure 6-3: Ride-Thru System Configuration



24KW & BELOW, 0.5 - 1 SECOND, 100% OUTAGE PROTECTION
USING DC VOLTAGE REGULATOR WITH ELECTROLYTIC CAP
RESERVOIR SINGLE CABINET POWERED FROM AC LINE

7. APPENDICES

7.1. INSTALLATION CONSIDERATIONS FOR DRIVE RIDE-THRU SYSTEMS

The following items should be considered when installing a Bonitron Ride-Thru module.

1. Drive logic voltage must be "backed up"
   - Most new Drives derive logic supply from DC bus
   - Install small UPS on circuits with AC feed
2. Any control or Interlock relays must be "backed up"
   - Test Relays at half voltage for dropout
   - Use DC relays on logic supply
   - Install small UPS on circuits with AC feed
3. Determine the maximum motor voltage needed
   - To ensure "Threshold" level is sufficient to supply motor
   - Most drives automatically compensate RMS to motor with 10% low DC bus level
4. Verify actual AC line voltage and DC bus level
   - To ensure "Threshold" level is set – 10% of actual DC bus level
   - To ensure valleys of ripple do not cause unwanted activity
5. Determine Drive low bus trip point
   - To ensure "Threshold" level is above drive dropout
6. Drive ground fault circuits
   - Ride-Thru currents on 20-amp model may use Drive bridge negative diodes during operation
   - Circuits can be de-sensitized
   - External "upstream" ground fault circuits may be added
7. Electrical safety
   - Ride-Thru should not have AC power when drive does not
   - RT and Drive should feed from same point
   - Use shunt trip interlock between Drive and Ride-Thru if RT power is not fed downstream of drive power switch
   - Label Drive as having two power sources
8. Monitoring of status signals
   - Fault contacts available for remote control room monitoring
9. Input feed should be capable of 2x rated current during the 2 sec 50% dip
   - RT RMS rating is 1 percent of system KW
   - Most Drive feeds have been sized for a 150-200% surge for motor starting

7.2. APPLICATION NOTES FOR S3534CR SYSTEMS

A time limit fault will be generated on the DD5 display if the sag activity extends beyond the 2 seconds specified ride through time.

7.3. SPECIFYING A CAPACITOR STORAGE BANK FOR FULL OUTAGE PROTECTION WITH THE M3534R

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 considered.

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

7.3.1. 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

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

The total number of joules required is:

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

7.3.2. 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.

7.3.3. 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,

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

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