Model S3460SR
Ride-Thru System

Customer Reference Manual

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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.

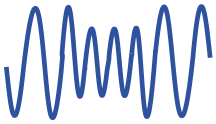
The Bonitron engineering team has the background and expertise necessary to design, develop, and manufacture the quality industrial electronic systems demanded in today's market. A strong academic background supported by continuing education is complemented by many years of hands-on field experience.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

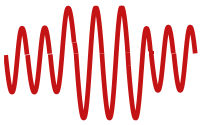
In 1975, Bonitron began working with AC inverter drive specialists at synthetic fiber plants to develop speed control systems that could be interfaced with their plant process computers. Ever since, Bonitron has developed AC drive options that solve application issues associated with modern AC variable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

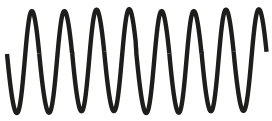
Braking Transistors
Braking Resistors
Transistor/Resistor Combo
Line Regeneration
Dynamic Braking for Servo Drives

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 S3460SR ride-thru systems. It will provide the user with the necessary information to successfully install, integrate, and use these 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

The initial release of this manual is Rev 00a.

Table 2-3 was updated and Figures 6-1, 6-2, 6-3, and 6-4 were added in Rev 00b.

Editing mistake fixed in Rev 00c.

Updated to add the DD5 digital display in Rev 01a.

Update to Figure 3-3 made in Rev 01b.

Updated Figures 1-1, 3-3, 6-1, and 6-2 in Rev 01c.

Figure 1-1: S3460SR Ride–Thru System

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 S3460SR sag ride-thru systems provide protection from short term line sag events for variable frequency drives (VFDs) that use a fixed rectifier and DC bus. The S3460SR provides sag protection for up to 2 seconds at 50% line sag on all 3 phases. Industries with continuous processes can suffer huge losses from equipment downtime, loss of production, or damaged product when VFDs trip on undervoltage 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 S3460SR 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
- 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

M3460 SERIES RIDE-THRU MODULES

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

M5628 BATTERY AND ULTRACAPACITOR CHARGERS

Chargers for high voltage storage strings.

S3460BR SERIES BATTERY RIDE-THRU SYSTEMS

An enclosed system for full outage up to 4 minutes.

S3460UR SERIES RIDE-THRU SYSTEMS

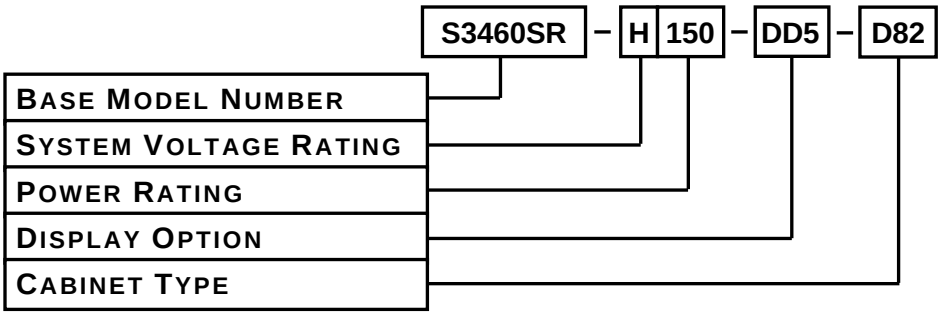
Complete systems that use ultracapacitor storage for short term power outages.

2.1.2. DOCUMENTS

Refer to M3460 manual.
Refer to the KIT 3660DD5 manual when the system is equipped with the DD5 Digital Display option.
These manuals are 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 enclosed ride-thru systems is S3460SR**.**

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 S3460SR and is represented by a 3-digit value based on the nominal DC system voltage and rating and the maximum output current rating of the S3460 SR. For instance, the code **150** indicates a 150kW S3460SR.

DISPLAY OPTION

The display option indicates which display is mounted on the front of the enclosure. The displays show the M3460 operating status and permit a system test to be performed. The DD5 digital display 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 features.

Table 2-2: Display Panel Configurations

DISPLAY MODEL	LOCAL INDICATORS	VOLTMETER	AMMETER	TOTAL COUNTER	RESETTABLE COUNTER	ACTIVITY LOGGING	LOCAL TEST INITIATION
DD5	✓	✓	✓	✓	✓	✓	✓
DP10	✓				✓		✓

CABINET TYPE

The S3460SR is available in several cabinet styles.

Enclosure type and size is indicated by a code as shown in Table 2-3. All cabinet dimensions are in inches, see Section 6.4 for complete dimensional outline.

Table 2-3: Cabinet Codes

CABINET CODE	VOLTAGE RATING	POWER RATING	DESCRIPTION
D81	L	25 kW, 38KW, 50KW	71" H x 32" W x 20" D NEMA 1 floor mount enclosure
	E	43 kW, 65KW, 87KW	
	H	50 kW, 75KW, 100KW	
D82	L	75 kW, 100 kW, 125KW	79" H x 40" W x 20" D NEMA 1 floor mount enclosure
	E	130 kW, 175 kW, 215KW	
	H	150 kW, 200 kW, 250KW	

2.3. GENERAL SPECIFICATIONS

Table 2-4: S3460SR 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	85 – 425 ADC
Power Rating	25 – 250kW
Inactive Power Consumption	< 200W
Duty Cycle (Full Load)	1%
Sag/Outage Duration	2 seconds
Enclosure Rating	NEMA 1
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 REMOVING THE ENCLOSURE COVER.
- **FAILURE TO HEED THESE WARNINGS MAY RESULT IN SERIOUS BODILY INJURY OR DEATH!**

CAUTION!

- CERTAIN COMPONENTS WITHIN THIS PRODUCT MAY GENERATE HIGH AMBIENT TEMPERATURES DURING OPERATION.
- ALWAYS ALLOW AMPLE TIME FOR THE UNIT TO COOL BEFORE ATTEMPTING SERVICE ON THIS PRODUCT.
- BEFORE ATTEMPTING INSTALLATION OR REMOVAL OF THIS PRODUCT, BE SURE TO REVIEW ALL DRIVE AND/OR RESISTIVE LOAD 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.
- 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

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 S3460SR 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 maximum operating temperature of the ride-thru system should not exceed 40°C.

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

1. Move the cabinet to the desired installation site.
2. Remove the hardware securing the cabinet to its pallet.
3. Using a crane or hoist connected to the cabinet's lifting eyes, remove the cabinet from the pallet, and set it in the desired location.
    - Secure the S3460SR cabinet in place. Cabinets may be anchored to the floor as necessary.

3.4. WIRING AND CUSTOMER CONNECTIONS

This section provides information pertaining to the field wiring connections of the S3460SR 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.

3.5. WIRING AND CUSTOMER CONNECTIONS

Review this entire section before attempting to wire the S3460SR.

3.5.1. POWER WIRING

DANGER!

THE M3460 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 S3460SR ride-thru cabinet system. Actual connection points and terminal numbers of the AC drive system will be found in the documentation provided with that drive system.

Be sure to review all pertinent AC drive system documentation before proceeding.

3.5.1.1. POWER CONNECTIONS

AC LINE (L1, L2, L3) CONNECTIONS

The AC input to the S3460SR 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 S3460SR 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 voltage 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 S3460SR must be installed on the load side of these chokes. This minimizes the possibility of circulating currents through the M3460R and converter section of the VFD.

DC BUS (+ -) CONNECTIONS

The S3460SR 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 S3460SR and the DC bus capacitors in the drive. Consult the manufacturer’s documentation or contact Bonitron for further assistance.

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

GROUNDING REQUIREMENTS

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

Table 3-1: Power Field Wiring Connections for Cabinets

TERMINAL TYPE	FUNCTION	ELECTRICAL SPECIFICATIONS	MIN WIRE AWG	MAX WIRE AWG	TORQUE LB-IN
Disconnect Switch (DSC)	AC Input L1, L2, L3	600 VAC	4 AWG	4 / 0	150 lb-in
Disconnect Switch (DSC)	DC Output + –	600 VAC	4 AWG	4 / 0	150 lb-in
Stud (Ring Lug)	Ground		Limited by Ring Lug	Limited by Ring Lug	75 lb-in

Use copper wiring rated at 75°C for all connections.

3.5.1.2. CONTROL INTERFACE AND I/O WIRING

The control interface and I/O wiring are from the M3460 ride-thru module. Please see the M3460 manual for further information on these outputs.
See Figure 3-1 for terminal locations.

Table 3-2: User I/O Terminal Connections for Cabinets

TERMINAL	FUNCTION
TB – 1	Courtesy + 24V
TB – 2	Ride-Thru ENABLE
TB – 3	Ride-ThrU TEST
TB – 4	Input COM
TB – 5	Courtesy COM
TB – 6	Fault 1
TB – 7	Fault 2
TB – 8	Ride-Thru Active (RTA)
TB – 9	Output COM

Figure 3-1: Power Connections

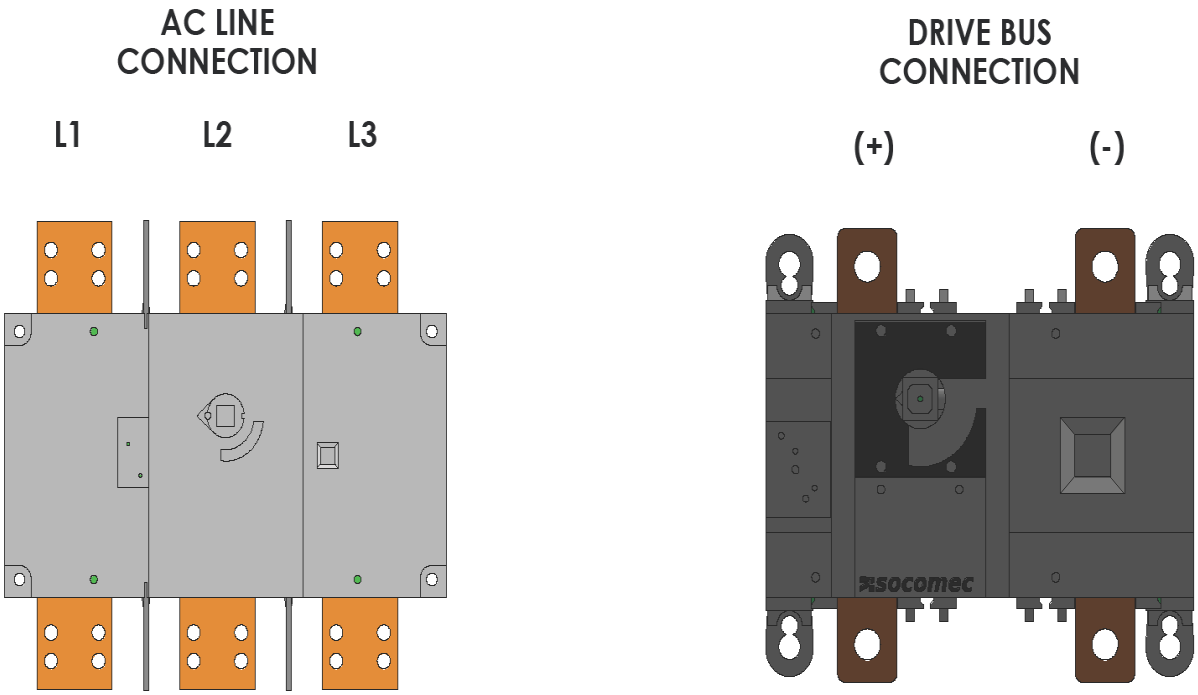


Figure 3-2: User I/O Connections Detail

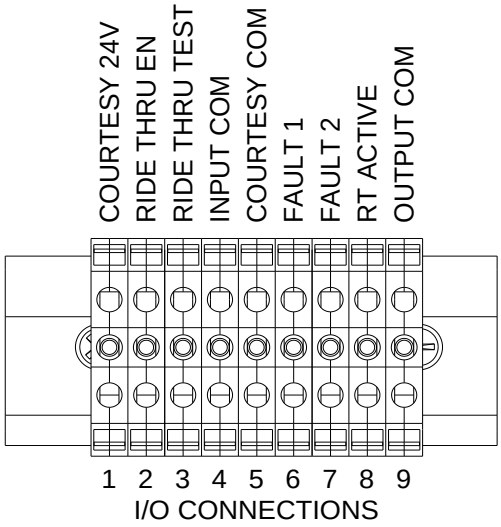


Figure 3-3: User I/O Jumper Placement for Internal Enable

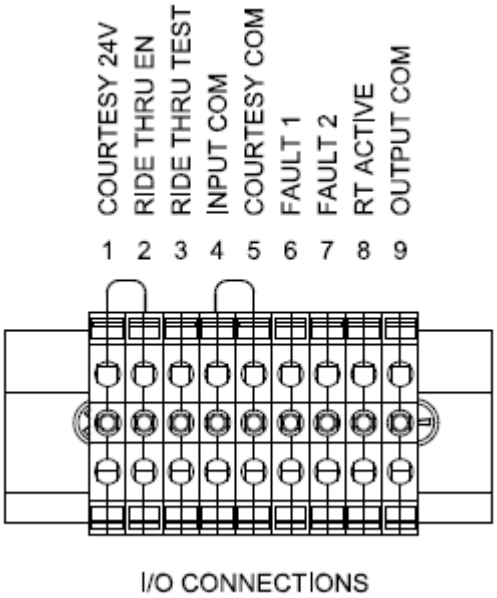


Figure 3-4: User I/O Connections with DD5 Interface Module

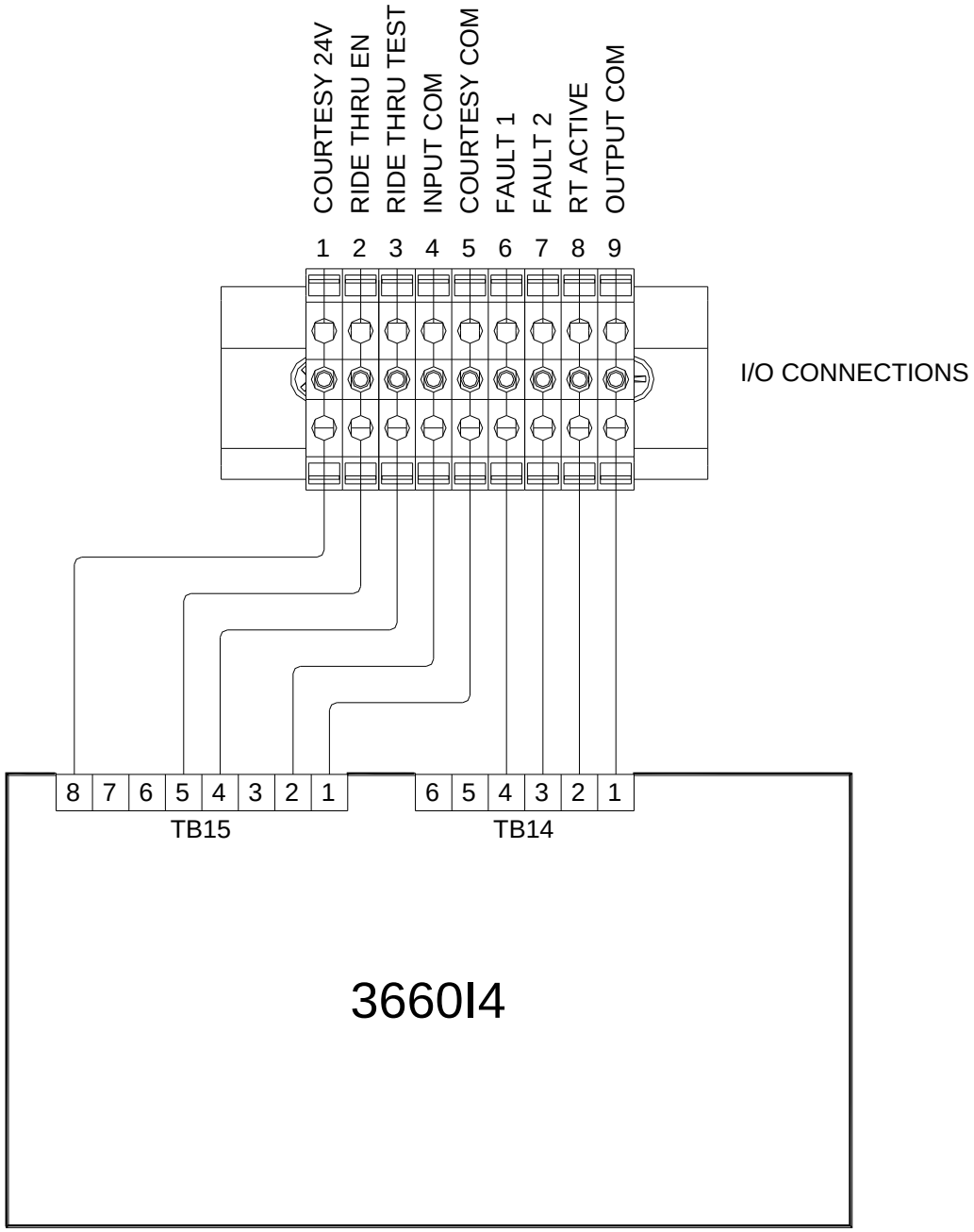
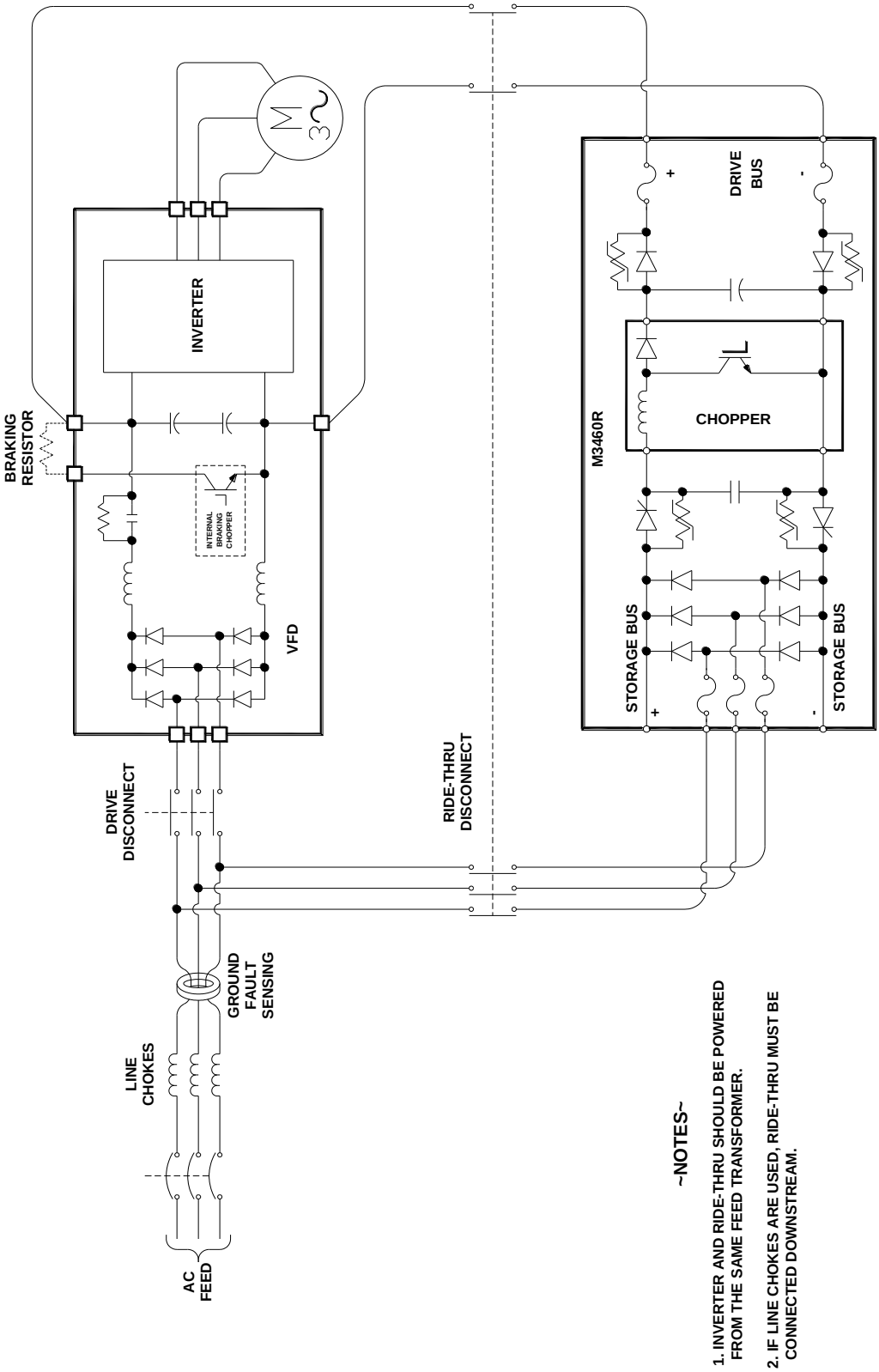


Figure 3-5: M3460R Typical Configuration without Energy Storage



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4. OPERATION

4.1. FUNCTIONAL DESCRIPTION

The S3460SR ride-thru system 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 M3460, power is delivered through blocking diodes to hold up the voltage in the VFD bus. The M3460 regulates and boosts the input voltage to the drive at a constant voltage.

In standby mode, when the incoming AC power is normal, the S3460SR ride-thru system power consumption is minimal.

NORMAL OPERATION

During normal operation, the M3460 will monitor the output DC bus. When the output DC bus voltage goes below the DC bus threshold voltage, the M3460 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 M3460 will operate in current limit, and the output voltage will drop according to the actual output load required by the drive.

4.2. STARTUP PROCEDURE

4.2.1. PRE-POWER CHECKS

1. Ensure the Bonitron ride-thru has been properly installed as per the instructions in Section 3 of this manual.
2. The ride-thru DC bus threshold must be coordinated with the undervoltage trip setting of the VFD. If the threshold is too close to the nominal bus, the ride-thru may supply power to the drive continuously and overheat. If the threshold is too close to the undervoltage trip level of the VFD, the system may not "ride-thru", and under voltage trips will still occur. Most VFDs have an undervoltage trip point of -15% of nominal. Some VFDs can be reprogrammed to change this trip level. Bonitron typically would like the DC bus threshold to be about -10% of the nominal bus. For example, Bonitron sets all 460VAC systems to hold the DC bus to 585VDC.
3. Ensure that the associated VFD is working properly.
    - Confirm the under-voltage trip point if possible.

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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. S3460SR START-UP / FIELD TEST PROCEDURE

1. Ensure the S3460SR has been properly installed and is disabled.
2. Ensure AC line input and drive bus installed properly to the cabinet disconnect.
3. Apply AC power to the drive and ensure it is working properly without faults, **the drive must be ON before applying power to the ride thru**.
4. Turn on the cabinet disconnect and observe the display status. The status should display Ride-Thru Ready. If there are faults on the system, turn off power and check the following:
    - Check configuration of the status output jumpers on M3460M6 board.
    - Check the DD5 interface module. Make sure all wires and connectors have been installed correctly. See KIT 3660DD5 manual for further details.
5. Enable the S3460SR with either the Enable input or the digital display.
6. Load the VFD as much as is practical for testing.
7. Initiate the test mode with the display panel to confirm that the booster is working properly.
   The DC bus should rise for about 100 VDC above the normal DC bus level.
8. Monitor the DC bus voltage and current with the display or with separate meters. Also, monitor the AC input current to the attached drive. You should observe the following if the S3460SR is operating correctly:
    - DC bus voltage should rise to the test boost level. For more information on the test boost level see the M3460 manual.
    - The motor should not lose speed or torque.
    - DC bus current should flow from the S3460SR to the drive.
    - The VFD input current should not decrease.

The S3460SR and drive system should now be ready to be put into service.

5.2. TROUBLESHOOTING

Table 5-1: Troubleshooting Guide

SYMPTOM	ACTION
No LEDs	▪ Check incoming power ▪ Check power supply 3460D5 for all voltages – replace if incorrect ▪ Check 24V RUN command
No +15 or -15 LEDs	▪ Check power supply 3460D5 for all voltages – replace if incorrect ▪ If OK, then replace 3460C1 control PCB
No RTR	▪ Check for RUN command ▪ Check stage fuses – look for blown fuse LED on 3460C1 ▪ Check 3460M6 interface ▪ IF OK replace 3460C1 control PCB
No PCC	▪ Check DC bus level – if not OK check pre-charge circuits or bus caps ▪ Check for RUN command ▪ Check stage fuses – look for blown fuse LED on 3460C1 ▪ Check 3460M6 interface ▪ IF OK replace 3460C1 control PCB
Voltage Fault	▪ Check input fuses ▪ Check 3460X4 phase loss monitor ▪ Check 3460M6 interface
RTA always ON	▪ Check DC bus levels on both sides of diodes ▪ Check for overheated pre-charge circuit ▪ Too much activity can cause stage fuse failures, overheating and draining of the battery ▪ Check threshold level, if changed over time adjust level or replace 3460C1
RTA never ON	▪ Check RUN command ▪ Initiate test cycle or remove power ▪ Watch and listen for signs of activity • Check RTA contact and LEDs • Ticking sound when active ▪ Check power quality data to confirm sag events should have caused activity to occur ▪ If no activity ever replace 3460C1

SYMPTOM	ACTION
Overtemp	▪ Check for constant current on the negative and positive DC bus links ▪ Check temp sensors ▪ On SCR heatsink ▪ On diode heatsinks ▪ On IGBT heatsinks ▪ On chokes (if used) ▪ Check pre-charge network for overheating – (cause of constant activity) ▪ If all OK replace 3460M6 interface PCB ▪ Check activity record–Too much activity causes overtemp
Blown Fuse LED ON	▪ Check stage fuses – LED on 3460F fuse PCB will be ON or Fuse Indicator will indicate blown fuse ▪ If all stage fuses are OK replace 3460C control PCB
Blown stage fuses	▪ Check for shorted IGBT ▪ Replace 3438C2 gate driver if IGBT is bad ▪ Check or replace stage choke current sensor ▪ Check or replace 3438S stage IGBT snubber ▪ Check activity record ▪ Too much activity causes fuse fatigue
TEST won't work	▪ Check DC bus level – too high causes no test ▪ Check blown fuse LED during test – if on check stage fuses ▪ Check test input to 3460C1 ▪ If OK replace 3460C1
Voltage fluctuates during TEST mode	▪ Check threshold and test boost level settings. Over-voltage shutdown can occur if settings are too high on 460V systems, causing an oscillation affect. ▪ Lower threshold level and retry ▪ Check for loss of feedback from DC bus to 3460C1
Stays in TEST mode	▪ Replace 3460C1
Precharge overheated	▪ Check DC bus ripple voltage. Too much ripple can cause PTCRs to overheat. ▪ Add parallel pre-charge PTCRs ▪ Change series pre-charge resistance ▪ Add fan to cool PTCRs ▪ Add isolated bias supply ▪ Precharge can only be done 3 consecutive times before overheating can occur

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

See M3460 manual for ratings for ride-thru module.

6.2. WATT LOSS (INACTIVE POWER CONSUMPTION)

See M3460 manual for Watt Loss information.

6.3. FUSE/CIRCUIT BREAKER SIZING AND RATING

Fuses are installed by Bonitron on the M3460 ride-thru module. Fusing information is available in M3460 manual.

Table 6-1: Input Power Wiring Sizes and Fusing

SYSTEM kW	RIDE-THRU DC BUS CURRENT RATING	MIN. SOURCE FUSING (CLASS J TIME DELAY)	RECOMMENDED FIELD WIRING SIZES	MCM EQUIVALENT WIRING SIZES
40 - 62	85 Amps	70 Amps	2 AWG	67 MCM
62 - 93	130 Amps	100 Amps	2 AWG	67 MCM
80 - 125	170 Amps	125 Amps	1 AWG	84 MCM
135 - 187	255 Amps	175 Amps	2/0 AWG	133 MCM
165 - 250	340 Amps	225 Amps	3/0 AWG	168 MCM
165 - 250	425 Amps	225 Amps	4/0 AWG	250 MCM

6.4. DIMENSIONS AND MECHANICAL DRAWINGS

Figure 6-1: D81 Cabinet Dimensional Outline

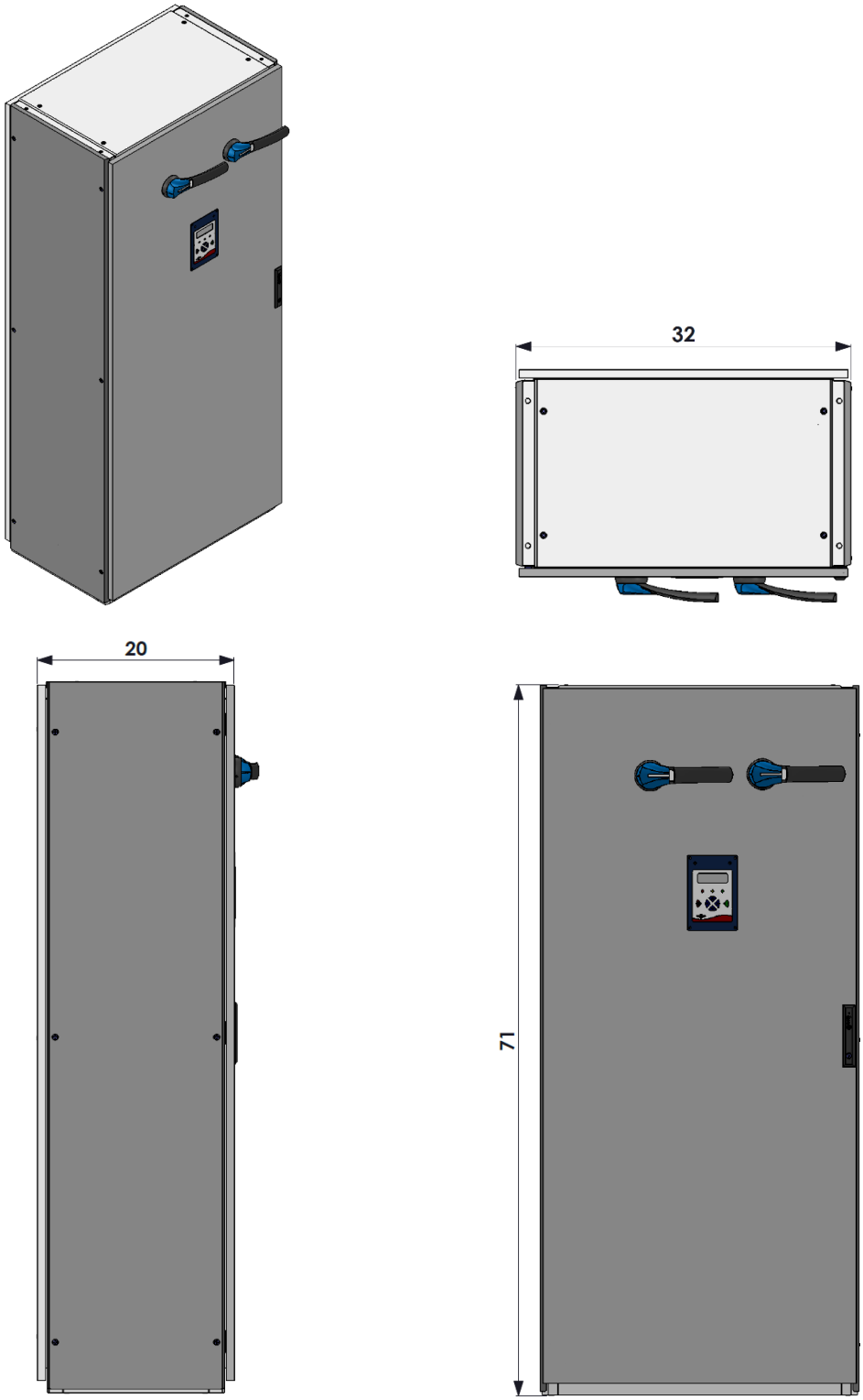
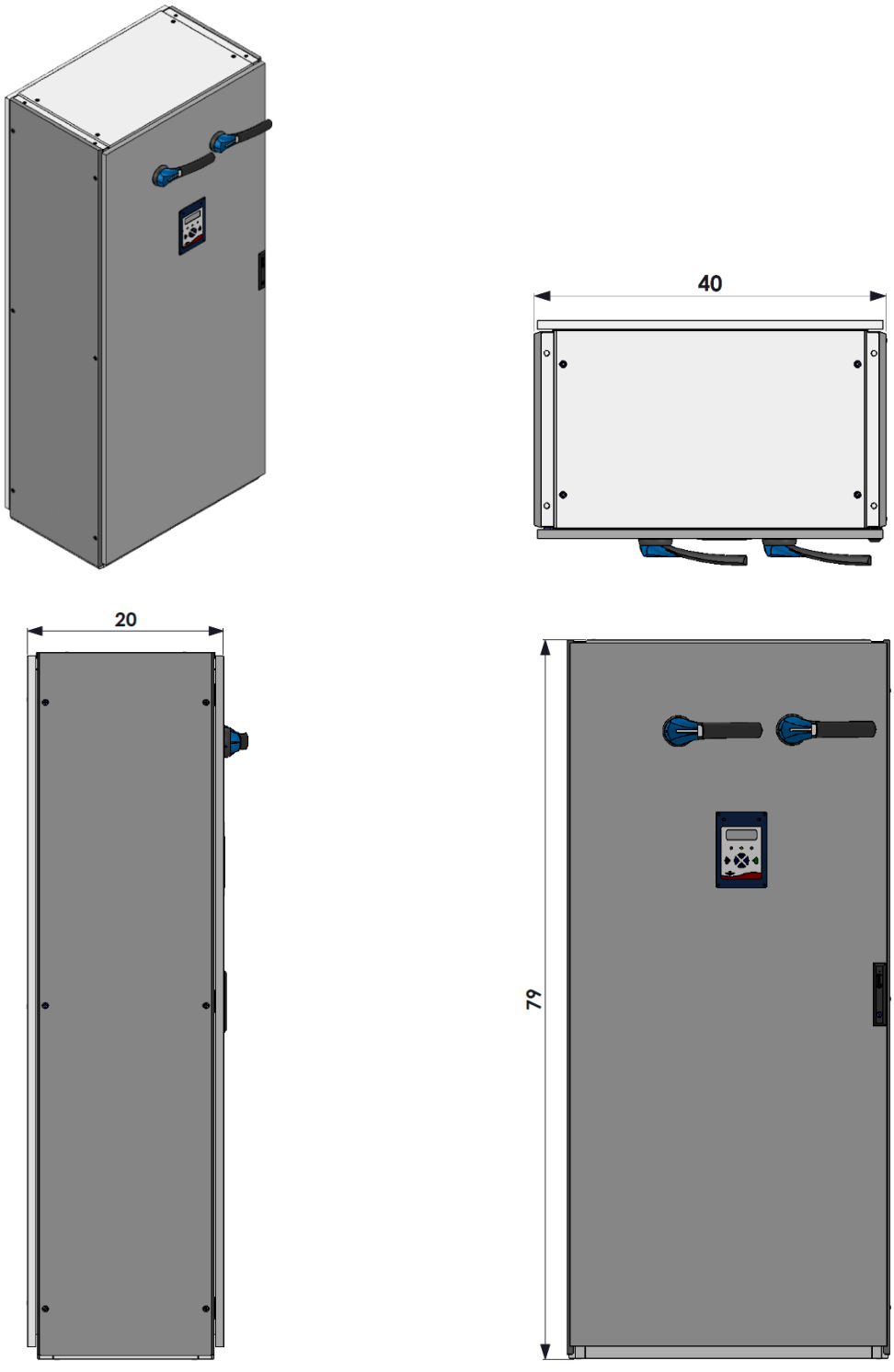


Figure 6-2: D82 Cabinet Dimensional Outline



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