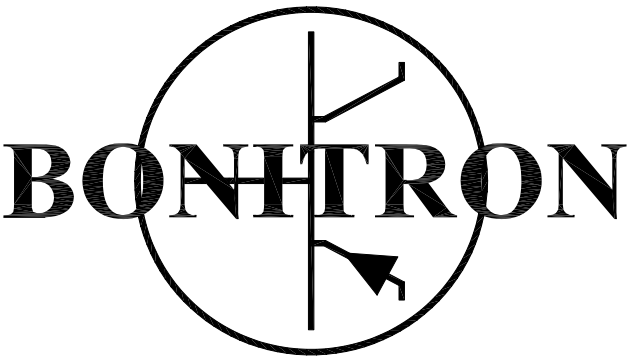


Model M3534UR

DC Bus Ultra-Cap Ride-Thru Cabinet Systems

Customer Reference Manual

TEL. (615) 244-2825 • www.bonitron.com • FAX (615) 244-2833

Bonitron, Inc.

An Industry Leader in AC Drive Systems and Industrial Electronics

OUR COMPANY

Bonitron Inc. is an industrial electronics and electrical systems design, engineering, and manufacturing company founded in 1962 and located in Nashville, Tennessee. Bonitron designs and manufactures custom and standard product modules and systems for industry with the highest possible degree of quality and reliability.

Bonitron has all the necessary resources in-house for complete electronic product development and manufacturing. Engineering facilities include a CAD lab for circuit board design and engineering labs for prototype testing and evaluation. Production facilities include production areas for circuit board assembly, a machine tool and sheet metal shop for chassis fabrication, and a systems assembly and checkout area. With these assets, Bonitron is positioned to be a leader into the future while maintaining first class support for their current customer base.

Worldwide sales of equipment are generated mainly by reputation and referrals. Our customer base includes all of the major drive manufacturers, their distributors, OEMs, end users, and many other satisfied companies. Equipment is installed throughout the United States as well as in Canada, Mexico, Costa Rica, Argentina, Brazil, Chile, Venezuela, Northern Ireland, the Netherlands, Spain, Hungary, Israel, Turkey, China, India, Indonesia, Singapore, Taiwan, and the Philippines.

TALENTED PEOPLE MAKING GREAT PRODUCTS

The engineering team at Bonitron has the background and expertise needed to design, develop, and manufacture the quality industrial systems demanded by today's client. A strong academic background supported by continuing education is complemented by many years of hands-on field experience. Expertise encompasses a broad range of applications and engineering solutions such as modern power conversion design techniques and microprocessor-based controls. This insures a solution tailored to the specific needs of the client.

A clear advantage that Bonitron has over many competitors is combined on-site engineering labs and manufacturing facilities. This allows the engineering team to have immediate access to and response from testing and manufacturing. This not only saves time during prototype development, but also is essential to providing only the best quality products.

AC DRIVE OPTIONS

In 1975, Bonitron began working with the AC inverter drive specialists at synthetic fiber plants to develop speed control systems that could be interfaced to their plant process computers. Since that time, Bonitron has developed AC drive option modules that help overcome many of the problems encountered in applications of modern AC variable frequency drives. Bonitron's Ride-Thru module provides protection from AC line voltage sags while the Line Regen and Resistive Braking modules provide DC Bus regulation for over-voltage due to regenerated voltage. Today, many drive system integrators use Bonitron AC drive option modules with their variable frequency drives.

WORLD CLASS PRODUCTS

Bonitron has developed over 3000 different modules and systems. Bonitron is willing and able to meet the unique specifications the client may request.

Some Bonitron products include:

- Power Sag Ride-Thru Modules
- Power Outage Ride-Thru Modules
- Line Regen Modules
- Resistive Braking Modules
- Modular High Speed Precision AC Inverter Systems
- Inverter Upgrade Modules
- Multi-motor, Multi-phase Current Sensors
- Battery Production Charging Systems
- Data Acquisition Systems
- Process Controllers
- Temperature Control Systems
- RMS True Reading Digital Voltmeters, Ammeters, and Frequency Meters

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 M3534UR Full Outage DC Bus Ultra-cap Ride-Thru System. It will provide the user with the necessary information to successfully install, integrate, and use the M3534UR 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 02 includes the E69 and D41 cabinet systems and the standardized formatting.

Figure 1-1: Typical M3534UR Cabinet

D41

E69

2. PRODUCT DESCRIPTION

This document describes a Ride-Thru System used to provide the DC bus power for AC PWM inverter drives during a power loss situation.

The Ride-Thru module is factory set to become active (begin supplying power) if the DC bus voltage drops to a preset level. The Ride-Thru module is designed to operate at its rated load for 2 seconds during a 100% loss of voltage.

The Ride-Thru module is designed to operate continuously, 24 hours per day, 365 days per year.

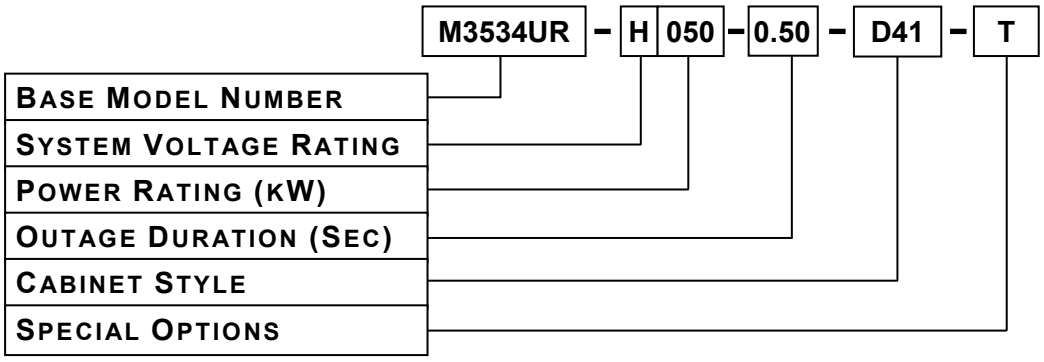
2.1. RELATED PRODUCTS

M3628T AND M3628R

Capacitor Discharge Switch and Load Resistor are used to drain voltage to safe levels in a reasonable time.

2.2. PART NUMBER BREAKDOWN

Figure 2-1: Example of Part Number Breakdown



BASE MODEL NUMBER

The Base Model Number for all Full Outage, AC Input, DC Bus Ultra-cap Ride-Thru Modules is **M3534UR.**

SYSTEM VOLTAGE RATING

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

Table 2-1: System Voltage Rating Codes

SYSTEM VOLTAGE RATING CODE	VOLTAGE (NOMINAL)
U	115VAC Line / 190VDC Bus
L	230VAC Line / 375VDC Bus
E	400VAC Line / 620VDC Bus
H	460VAC Line / 750VDC Bus

POWER RATING

The Power Rating indicates the maximum power in kilowatts that can safely be handled by the M3534UR System.

This rating is directly represented by a 3-digit value based on the nominal DC system voltage rating and the maximum output current rating of the RTM. For instance, the rating code for a 50kW BPS is **050**.

Units are currently available for each of the various system voltages listed above in Table 2-1 up to 85A maximum output current.

OUTAGE DURATION

The Outage Duration indicates the amount of time (in seconds) the M3534UR module is able to hold the DC bus at the threshold level while loaded to the rated current. This duration is directly represented by a 3-digit value. For example, **0.50** in this position represents .5 seconds of Outage Duration.

CABINET STYLE

The Cabinet Style is determined by the Power Rating. See Table 2-2.

Table 2-2: Chassis Information

CHX CODE	UNIT SIZE	TYPE	DIMENSIONS (H" x W" x D")
D41	50kW	NEMA-12	72" x 34 x 18"
E69	24kW	NEMA-12	42" x 36 x 12"

DISPLAY OPTIONS

All standard Model M3534UR DC Bus Ultra-cap Ride-Thru Systems are supplied with a basic set of status indicator lights on the ASB3534R Control Board as shown in its User's Manual. Full cabinet systems include both the DP17 and DP18 display panels on the front of the cabinet.

SPECIAL OPTIONS

Special Options are represented by an alpha code which can be appended after a comma at the end of the model number. Special Options can be used in conjunction with the Options listed above. (ex: ,DP10,K).

ADDED OPTIONS

The Model M3460UR Ride-Thru is available with several add-on options if desired.

The added options are indicated by codes as shown in Table 2-3 and 2-4.

Table 2-3: Option Codes

OPTION CODE	DESCRIPTION
M2	Under / Over voltage monitor
D	Dual Output
K	Kinetic Buffering
DC3	24VDC, 8A Supply

Table 2-4: Discharge Option Codes

OPTION CODE	DESCRIPTION
P	Provisions for portable cap discharger
T	Internal discharge switch
R	Internal discharge resistor

Option Codes are omitted if not required.

Contact Bonitron if other special options are required.

2.3. GENERAL SPECIFICATIONS

Table 2-5: General Specifications Chart

PARAMETER	SPECIFICATION
Input / Output Voltage	• Units available for various standard AC Input / DC Output voltages. • See Section 6.1 of this manual for available Input / Output voltage ratings.
Max. DC Output Current	• Units available with ratings of 20A, 40A, 85A max DC output current.
Max. Power Rating	• Units available for up to 50kW based on the nominal DC system voltage rating and the maximum output current rating of the RTM.
Outage Duration	• Ranges from .2 to 3 seconds @ full power
Minimum Cooling Time	• 30 minutes
Re-charge Time	• Ranges from 1 minute to 5 minutes @ full power
Indicators	• DP17 panel for Boost section • DP18 panel for Storage section • See Section 4
Counters and Meters	• DP17 and DP18 panels standard
Power Connections	• AC line input • DC bus output
Fault / Status Outputs	• Disconnect Status • Fault Contact (see Table 3-2)
Operating Temp	• 0°C to +40°C
Airflow	• None required
Fusing	• See various individual module specifications
Enclosure	• See Table 2-2
Operating Temperature	• 50° Celsius
Storage Temp	• -20 to + 65 deg C
Humidity	• Below 90 % Non Condensing
Atmosphere	• Free of Corrosive Gas and Dust

2.4. General Precautions and Safety Warnings

DANGER!

- HIGH VOLTAGES MAY BE PRESENT!
- NEVER ATTEMPT TO OPERATE THIS PRODUCT WITH THE CABINET 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 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.

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

3. INSTALLING THE M3534UR RIDE-THRU MODULE

WARNING!

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 Model M3534UR Ride-Thru Cabinet 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 start up of this product to the equipment supplier or system integrator.

Refer to the Installation Considerations in Section 7.

3.1. ENVIRONMENT / SITE SELECTION

The installation site for the cabinet should be chosen with several considerations in mind:

- The cabinets have a NEMA-12 rating and will therefore require some protection from the elements.
- The unit will require a minimum clearance of two (2) inches above and below it to allow for proper airflow for cooling.
- The mounting surface should be clean and dry.

3.2. PRODUCT INSPECTION / 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

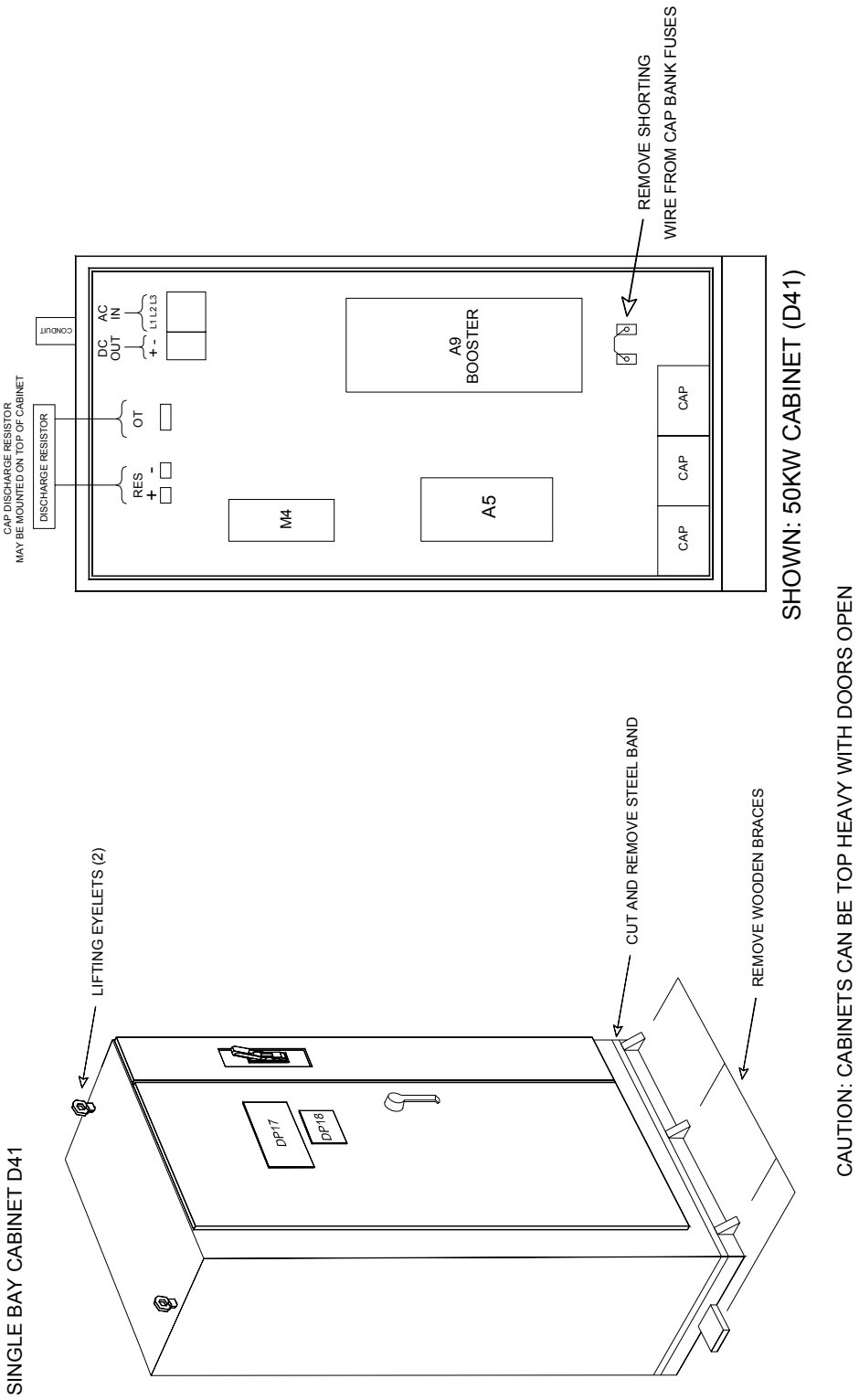
Once the installation site has been selected as outlined above, the unit should be mounted in place. The cabinet is provided with eye hooks for lifting. Required mounting hardware is not supplied with the cabinet.

Cabinets can be bolted to the floor from inside, or by using angle brackets on the outside.

Do not remove capacitors from the bottom of the cabinet unless absolutely necessary.

To determine the correct mounting dimensions and provisions for the unit being mounted, please refer to the appropriate Dimensional Outline in Section 6.5 of this manual:

Figure 6-1: Mounting Instructions for D4x Series Cabinets



3.4. WIRING THE M3534UR RIDE-THRU CABINET

This section provides information pertaining to the field wiring connections of the M3534UR Ride-Thru Cabinet. 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 the RTM to Drive Interconnection details listed below before proceeding.

WARNING!

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

Table 3-1: Power Field Wiring Connections

TERMINAL TYPE	FUNCTION	ELECTRICAL SPECIFICATIONS	MIN WIRE AWG	MAX WIRE AWG	TORQUE LB-IN
Disconnect Switch	AC Input L1, L2, L3	600VAC / 85 Amps	10	3 / 0	150 lb-in
Disconnect Switch	DC Output + —	600VAC / 85 Amps	10	3 / 0	150 lb-in
Stud (Ring Lug)	Gnd		18	2	45 lb-in

Table 3-2: Discharge Wire and Fuse Size

IGBT SWITCH MODULES FOR 1 MINUTE DISCHARGE					
IGBT MODEL #	SYSTEM AC VOLTAGE	MAX DC VOLTAGE	PK CURRENT	RES WIRE SIZE	FWP TYPE FUSE
3628T-EH075 (A,B)	400-460V	750	75	10 AWG	50
3628T-EH150 (A,B)	400-460V	750	150	6 AWG	100
3628T-EH200 (A,B)	400-460V	750	200	4 AWG	150
3628T-EH300 (A,B)	400-460V	750	300	2 AWG	200
3628T-EH600 (A,B)	400-460V	750	600	3 / 0	400

Table 3-3: Status and Control Field Wiring Connections

TERMINAL TYPE	FUNCTION	ELECTRICAL SPECIFICATIONS	MIN WIRE AWG	MAX WIRE AWG	TORQUE LB-IN
Sak 2.5	DISABLE	24VDC / 100ma	22	14	4.4 lb-in
Sak 2.5	FAULT	24VDC @ 1A 115VAC @ .5A	22	14	4.4 lb-in
Sak 2.5	DISC	24VDC @ 2A 115VAC @ 2A	22	14	4.4 lb-in

3.4.1. POWER WIRING

Several illustrations are provided to assist with the field connection of the M3534UR Ride-Thru cabinet to an existing AC drive system. Also, be sure to refer to the documentation supplied with the drive system for field connection points within that system. The DC bus must always be directly connected to the drive output cap bank. Connecting upstream of the DC bus inductors may damage both the Drive and the Ride-Thru unit.
A typical field connection terminal layout for the M3534UR Cabinet is shown in Figure 3-2. Figure 3-5 shows a typical power interconnection of the M3534UR Ride-Thru Cabinet with an existing AC drive system.

GROUND

Make ground connection to ground stud located at top of backplate.

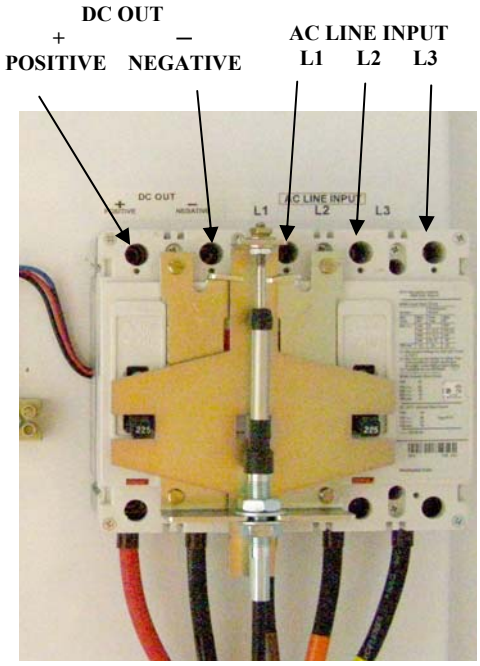
AC LINE INPUT CONNECTIONS

Make AC line feed connections to main disconnect switch at upper right side of cabinet.

DC BUS OUTPUT CONNECTIONS

Make drive DC bus connections to main disconnect switch at upper right side of cabinet.

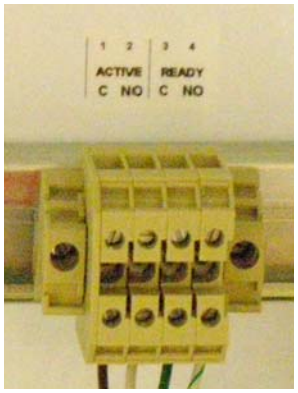
Figure 3-1: Field Connections at Main Disconnect Switch



3.4.2. CONTROL INTERFACE WIRING

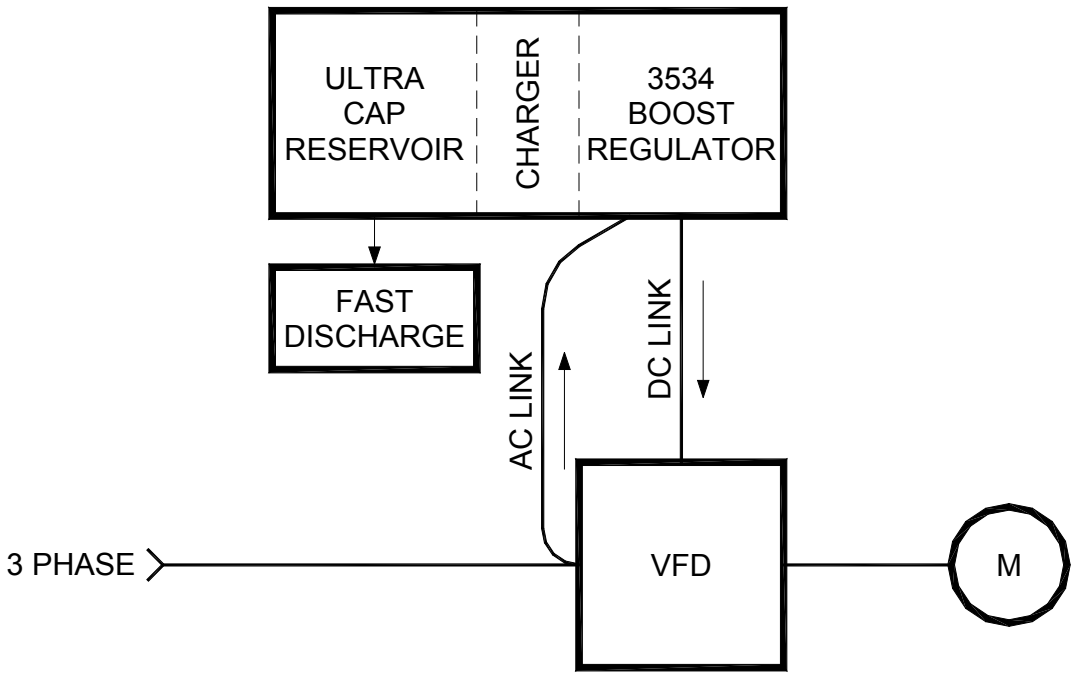
- Make status monitoring connections to TS1 at the upper middle of backplate. See Figure 3-3.
- Make control connections to TS1 at the upper middle of backplate. See Figure 3-3.

Figure 3-2: Control Connections at TS1



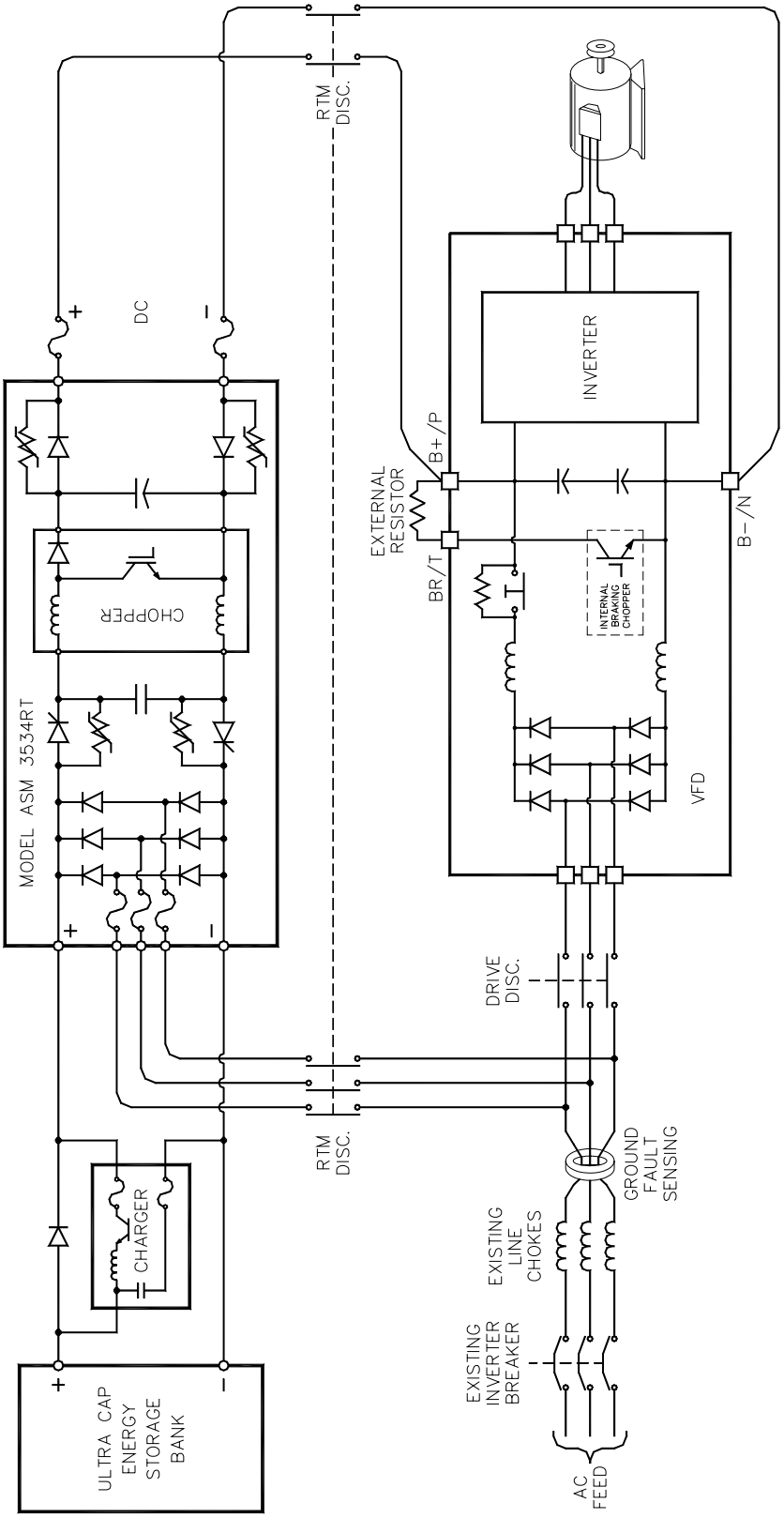
3.5. TYPICAL CONFIGURATIONS

Figure 3-3: BPS Ride-Thru System Configuration #3



50KW & BELOW, 0.5 - 2 SECOND, 100% OUTAGE PROTECTION
USING DC BOOSTER WITH ULTRA CAP RESERVOIR
SINGLE CABINET POWERED FROM AC LINE

Figure 3-4: Typical M3534UR Power Interconnection with Existing Drive System



4. OPERATION

4.1. FUNCTIONAL DESCRIPTION

The M3534UR series of Bonitron Power Sources (BPS) employs IGBT switching technology and energy storage banks to regulate the inverter DC bus to a preset minimum voltage level. As the incoming AC voltage disappears, the RTM "activates", boosting the battery DC voltage up to the minimum DC bus voltage level specified for the inverter allowing it to "ride through" the sag or outage event. An external RUN command inhibits boosting.

4.1.1. OPERATION DURING OUTAGE EVENT

During a voltage sag or outage, the inverter DC bus level will decrease, pulling the BPS bus down with it. Once the DC bus drops below a preset low limit "threshold" the RTM will become "active". When this occurs, the **RT ACTIVE** front panel LED will illuminate, the internal **RTA** relay contact will change states, the cooling fan will begin running in order to cool the internal IGBT heatsink, and the DC bus level will be supported by the RTM. The **RT ACTIVE** LED and internal relay will be **ON** only while the RTM is active (real time). The cooling fan will continue running after activity stops.
As energy is drained, the capacitor voltage will drop and the RTM will regulate the bank voltage up to the threshold level.

4.1.2. CONTINUOUS OPERATION

If the RTM begins supplying power continuously, possibly due to a low line level, overheated PTC devices, incorrect threshold adjustment, or inverter failure, an overtemp condition may occur. If this happens, the **OVERTEMP** front panel LED will turn **ON** and the internal **OT** relay will energize, shutting down the switching circuits and allowing the DC bus to drop to the nominal level. At this point, the RTM continues supplying power, but will not boost. Continuous currents can cause permanent damage. The **RTA** signal should not be active unless there is a power loss condition.
If the capacitor voltage drops too low while the RTM is fully loaded, the output DC bus level will begin to drop. If the inverter's **LOW BUS** trip level is reached, the inverter will shut down. When the DC bus drops to 100V, the RTM's internal logic supply will shut down.

4.2. FEATURES

4.2.1. TERMINAL STRIP I/O

4.2.1.1. M3534UR CABINET SYSTEMS

RIDE-THRU READY (RTR)

- RTR contact will close upon power up when the booster power stages are intact. An unbalance in the DC bus, a blown stage fuse, or a loss of power will cause RTR contact to open.

RIDE-THRU ACTIVE (RTA)

- RTA contact will close when the booster becomes active with at least .25 amps load.
- Cabinets equipped with a counter will see an increment each time activity occurs.

4.2.1.2. FAULT LOGIC DETAILS

The M3534UR Systems are equipped with a Fault output contact. This output is accessible via the terminal strip at the top of the BPS cabinet. The output is a dry contact and the Normally Open contact is made under a normal running condition. The Normally Closed contact is made in the Inactive, or fault state.

The following conditions will cause the fault relay to drop out.

- No 15V power to pcb
- An OVER TEMP condition in the battery bank
- An UNDER VOLTAGE condition on the battery bank
  - Factory set up to latch
- An OVER VOLTAGE condition on the battery bank
  - Factory set up to latch

Refer to Figure 3-2 for the location of field terminal TS1

Table 4-1: Fault Logic Table

BPS STATUS	FAULT CONTACT	
	NO	NC
Power off or P.S. failure	O	X
Power on and battery bank OK	X	O
Power on and Ride-Thru Active	X	O
Over temp condition	O	X
Under voltage condition	O	X
Over voltage condition	O	X

DP17 System Status Display for Booster Section

The DP17 display module provides visual indication of various system functions. The monitored functions include POWER, RIDETHRU ACTIVE, and OVERTEMP. In addition, this module provides the system TEST switch required for threshold voltage adjustments and system calibration.

The functions of each of these indicators are described below.

POWER LED

The **GREEN** POWER LED is **ON** if power is applied to the system.

(RTA) RIDE-THRU ACTIVE LED

The **AMBER** RIDE-THRU ACTIVE LED is **ON** if the module is regulating the DC bus voltage under an input line dip condition.

OVER TEMPERATURE LED

The **RED** OVERTEMP LED is **ON** if the heatsink temperature exceeds 70°C.

TEST SYSTEM SWITCH

The Test System push-button switch will cause the Ride-Thru section to raise the DC bus dip setpoint by 17%. The inverter input current will drop and the Ride-Thru current will start. This test will run and the DC bus dip setpoint will remain raised for as long as the switch is pressed.

4.2.1.3. DP18 SYSTEM DISPLAY FOR STORAGE SECTION

The DP18 display module provides visual indication of various system functions, including:

- POWER
- CHARGING
- OVERTEMP
- UNDERVOLTAGE
- OVERVOLTAGE

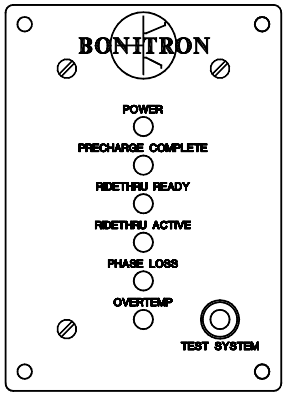
A RESET switch is included for use with the 3528M2 Battery Monitor option.

Table 4-2: Diagnostic Display Panel Configurations

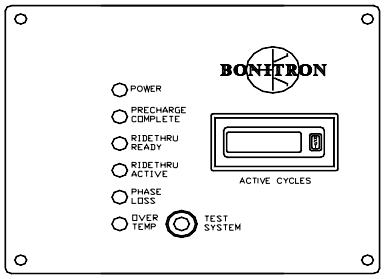
PANEL NUMBER	LEDS & TEST SWITCH	METERS		COUNTERS		PANEL DIMS.
		VOLTMETER	AMMETER	TOTAL CYCLES	ACTIVE CYCLES	
DP2	✓					5" x 3.6"
DP10	✓				✓	5" x 6"
DP11	✓	✓			✓	5" x 9"
DP17	✓	✓	✓	✓	✓	5" x 12"
DP18	✓	✓				5" x 7"

Figure 4-1: DP Series Remote Display Panel Layouts**

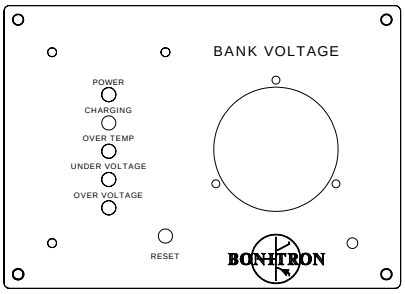
DP02



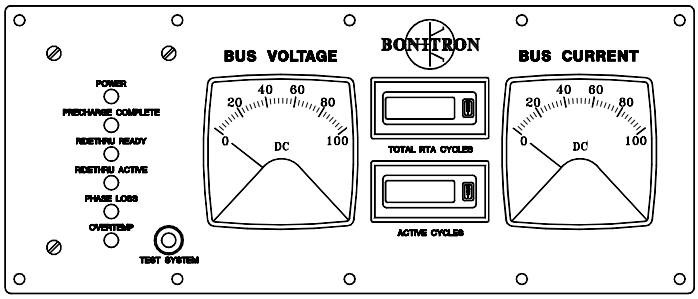
DP10



DP18



DP17



4.3. M3534UR SYSTEM START-UP PROCEDURE

4.3.1. 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 under voltage trip setting of the inverter. 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 under voltage trip level of the inverter, the system may not "Ride-Thru", and under voltage trips will still occur. Most inverters have an under voltage trip point of -15% of nominal. Some inverters 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.
   - Refer to your inverter's documentation for details on adjustment of the under voltage trip setting.
   - Refer to Section 4.4 for details on how the Ride-Thru DC bus threshold can be changed.
3. If equipped with the Ride-Thru disconnect, turn off, and apply power to the system. Otherwise, go to the Startup Procedure Section 4.3.2.2.
4. Ensure that the associated inverter is working properly.
   - Confirm the under voltage trip point if possible.

4.3.2. STARTUP PROCEDURE AND CHECKS

Refer to Table 4-4 for indications during different operating circumstances.

1. Apply power to the Ride-Thru and observe the following conditions on the DP17 and DP18 Display panels:
   - DP17 POWER led should be **ON**.
   - DP17 RIDE-THRU READY led should be **ON**.
   - DP17 RIDE-THRU ACTIVE led should be **OFF**.
   - DP17 OVERTEMP led should be **OFF**.
   - DP17 The BUS CURRENT meter should read **0** amps.
   - DP17 The BUS VOLTAGE meter should read **NOMINAL DC Bus voltage.**
   - DP18 POWER LED should be **ON.**
   - DP18 CHARGING LED should be **ON** during full charge time.
   - DP18 OVER TEMP LED should be **OFF.**
   - For systems with "M2" monitoring option:
     - DP18 UNDER VOLTAGE LED will be **ON** until the cap bank voltage gets above the minimum required to maintain the load.
     - DP18 OVER VOLTAGE LED should remain **OFF**.
     - DP18 Bank Voltage meter reading will **increase** as cap bank charges.
2. Verify DCS connections (if used). DCS should read the Ride-Thru fault signal as found in the Section 4.2.
   - See Figure 3-2 and Table 3-3 for DCS connection details.

3. Verify threshold setpoint.
   - Turn off BPS cabinet power and watch the DC bus voltage fall. Refer to the Threshold Adjustment procedure in Section 4.4.
   - RIDE-THRU ACTIVE LED will come **ON** when the bus drops to the threshold.
     - The DC bus will hold at the threshold as long as the storage bank has adequate voltage, or 2 seconds, whichever comes first.
     - DP18 CHARGE LED turns **OFF.**
   - Reapply system power.
4. Verify system capability.
   - With drive running, remove system power to drive and BPS cabinet for the specified time. Monitor DC bus voltage and current.
     - RTA LED should turn ON.
     - CHARGING LED should turn **OFF**.
     - Capacitor voltage should drop.
     - DC bus should drop to the threshold level.
     - Drive bus should drop to the threshold level.
     - Drive should continue to run full speed and torque.
     - DC bus current should flow from BPS to VFD.
5. Verify system TEST function. Monitor DC bus voltage and DC bus current, or inverter AC line current.
   - Initiate the TEST sequence. (See Threshold Adjustment Procedure in Section 4.4).
     - RIDE-THRU ACTIVE led on DP17 Display should come ON during test (RTA will flash if the load is light, stay on if the load is heavy).
     - Bonitron DC bus voltage should rise to the test boost level.
     - Inverter DC bus should rise to the test boost level.
     - Motor should not lose speed or torque.
     - DC bus current should flow from Ride-Thru to inverter.
     - Inverter input current should decrease.

This completes the startup procedure for M3534UR with Diagnostic Display Panel.

Table 4-3: System Status Display Reference Tables

POWER UP	**DP1 - DP17**	**SITUATION**	**PWR**	**PCC**	**RTR**	**RTA**	**ØL**	**OT**
		Power up, fully charging, cap bank below minimum voltage	X	n/a	X	O	n/a	O
		Power up, fully charging, cap bank above minimum voltage	X	n/a	X	O	n/a	O
		Power up, fully charged & Ready	X	n/a	X	O	n/a	O
	DP18	**SITUATION**	**PWR**	**CH**	**OT**	**UV**	**OV**	
		Power up, fully charging, cap bank below minimum voltage	X	X	O	X	O	
		Power up, fully charging, cap bank above minimum voltage	X	X	O	O	O	
		Power up, fully charged & ready	X	O	O	O	O	
TEST	**DP1 - DP17**	**SITUATION**	**PWR**	**PCC**	**RTR**	**RTA**	**ØL**	**OT**
		Test, Unloaded	X	n/a	X	X	n/a	O
	DP18	**SITUATION**	**PWR**	**CH**	**OT**	**UV**	**OV**	
		Test, Unloaded	X	O	O	O	O	
POWER OFF	**DP1 - DP17**	**SITUATION**	**PWR**	**PCC**	**RTR**	**RTA**	**ØL**	**OT**
		Power up, fully Charged & Ready	X	n/a	X	O	n/a	O
		Power off, unloaded, initial change	X	n/a	X	O	n/a	O
		Power off, unloaded, after a couple of seconds **until** cap bank drops below minimum voltage	X	n/a	X	O	n/a	O
		Power off, unloaded, after a couple of seconds **after** cap bank drops below minimum voltage	X	n/a	X	X	n/a	O
	DP18	**SITUATION**	**PWR**	**CH**	**OT**	**UV**	**OV**	
		Power up, fully Charged & Ready	X	O	O	O	O	
		Power off, unloaded, initial change	X	O	O	O	O	
		Power off, unloaded, after a couple of seconds **until** cap bank drops below minimum voltage	X	O	O	O	O	
		Power off, unloaded, after a couple of seconds **after** cap bank drops below minimum voltage	X	O	O	X	O	
CHARGING	**DP1 - DP17**	**SITUATION**	**PWR**	**PCC**	**RTR**	**RTA**	**ØL**	**OT**
		Initial Charge	X	n/a	X	O	n/a	O
		Charging after cap voltage rises above minimum usable level.	X	n/a	X	O	n/a	O
		Full Charge	X	n/a	X	O	n/a	O
	DP18	**SITUATION**	**PWR**	**CH**	**OT**	**UV**	**OV**	
		Initial Charge	X	X	O	X	O	
		Charging after cap voltage rises above minimum usable level.	X	X	O	O	O	
		Full Charge	X	O	O	O	O	

4.4. OPERATIONAL ADJUSTMENTS

4.4.1. THRESHOLD VOLTAGE ADJUSTMENT PROCEDURE FOR MODEL M3534 RIDE-THRU MODULES

The THRESHOLD voltage level is the voltage at which the Bonitron Model M3534 Ride-Thru Module maintains the DC bus during a power sag. Whenever the DC bus level drops to the THRESHOLD setpoint, the Ride-Thru module becomes active to regulate the DC bus voltage to the THRESHOLD setpoint voltage.

Generally, the THRESHOLD level should be set at 10-15% below the nominal DC bus level. An actual on-site level setting must be determined by the loaded DC bus level as well as the amount of ripple present on the DC bus. The Ride-Thru module should not become active during normal everyday operation.

During a test cycle the TEST Boost level is typically elevated 17% above THRESHOLD on all Bonitron Model M3534 Ride-Thru Modules. Table 4-4 below lists the typical factory setpoints for the THRESHOLD, OVER-VOLTAGE, and TEST Boost levels for the Model M3534 Ride-Thru modules based on the system AC or DC input voltage requirements. Be sure to check the Customer Reference manual for each Ride-Thru module for specific setpoint levels.

Table 4-4: Factory Setpoints for Threshold and Test Boost Voltages

SYSTEM AC VOLTAGE	BATTERY INPUT VOLTAGE RANGE	THRESHOLD	TEST BOOST	OVER-VOLTAGE
440 - 480VAC	400 - 585VDC	585VDC	+100VDC	710VDC
380 - 415VAC	350 - 485VDC	485VDC	+82VDC	630VDC

4.4.2. DETERMINING THRESHOLD VOLTAGE SETPOINT

Testing and adjustment of the THRESHOLD voltage setpoint can be performed on systems on the test bench, while unloaded and offline, or under on-line and loaded condition as described in Methods 1, 2, and 3 below. Each of the 3 methods described require that you monitor the DC bus voltage during the testing and adjustment procedures.

Note that threshold level drops by approximately 7V-10V from no-load to full-load. See Figure 4-2 for approximate volts-per-turn.

See the M3534RT manual for details.

4.5. CALIBRATION

If DP17 and DP18 analog meters require calibration, consult Bonitron for instructions.

Figure 4-2: Volts-per-Turn Chart

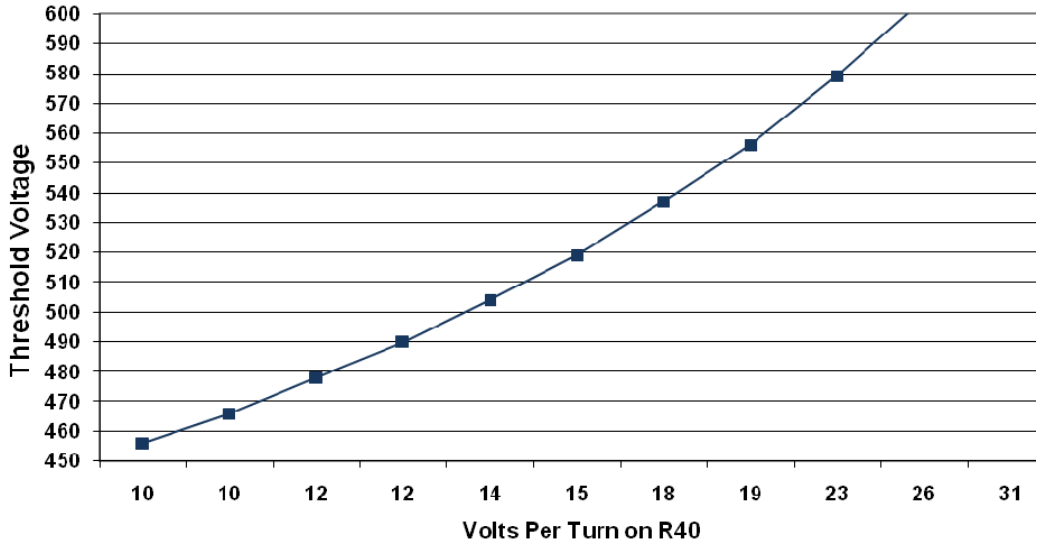


Figure 4-3: Discharge Curve Typical Cap Bank

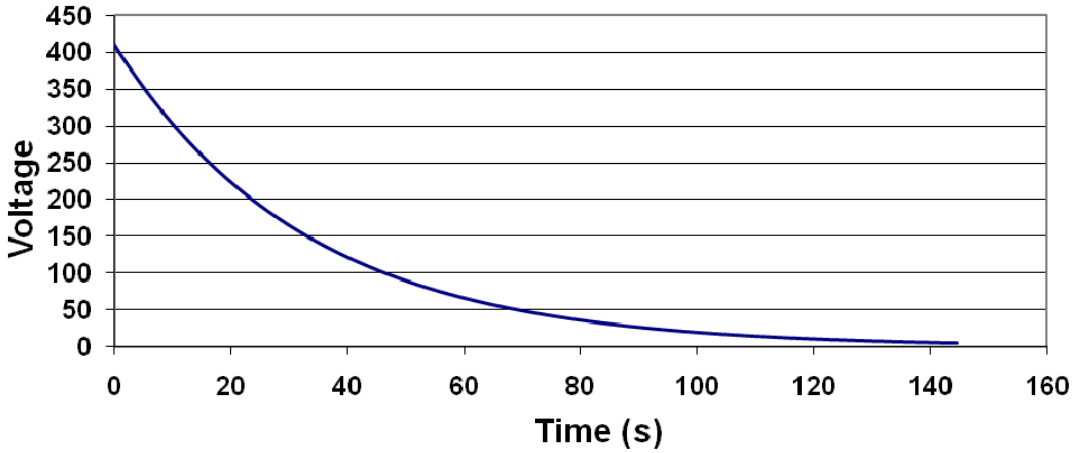
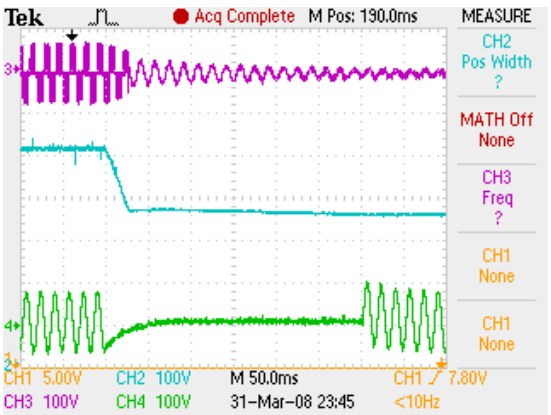


Figure 4-4: Drive without Ride-Thru



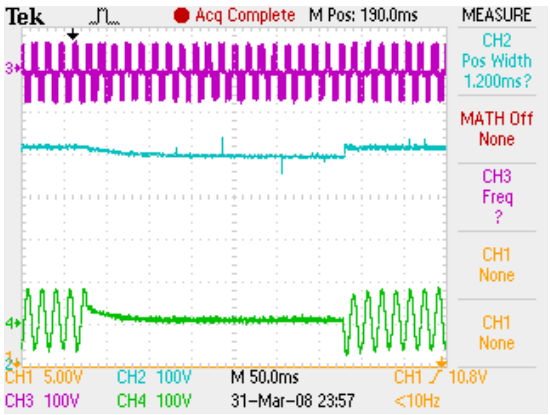
Motor output

DC bus

↔

AC line

Figure 4-5: Drive with Ride-Thru



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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. MAINTENANCE RECORDS

Figure 5-1: Maintenance record

DATE	MODEL	SERIAL #	RECENT ACTIVITY COUNTER	TOTAL ACTIVITY COUNTER	DRIVE BUS VOLTAGE	STORAGE BUS VOLTAGE	THRESHOLD	RIDE-THRU TIME

MAINTENANCE NOTES

_____

_____

_____

_____

_____

_____

_____

_____

Bonitron welcomes input from end users concerning our product. Please share any comments - good or bad - and any maintenance data recorded here so that we may design better and longer lasting Ride-Thru Systems. Information may be sent to Ride-Thru Dept at Bonitron via regular mail or email to jwehman@bonitron.com

5.2. PERIODIC TESTING

5.2.1. PERIODIC MAINTENANCE PROCEDURES FOR M3534UR WITH DIAGNOSTIC DISPLAY OPTIONS

The Bonitron Ride-Thru is designed to be low maintenance. Because the M3534UR units are part of a Ride-Thru system that uses capacitors, Bonitron recommends a yearly test of the system in order to ensure the electronics package and caps are operating. The following steps can be taken to ensure reliability and give comfort that the system is still able to ride thru a sag event.

1. Check Active cycle counters (if equipped).
   - More than 10 counts per month may mean the Ride-Thru is improperly adjusted. Refer to Section 4.4.1 for adjustment details.
   - Note count for factory records.
   - Report count to Bonitron via your local service representative.
2. Monitor front panel LEDs for the DP17 Display Panel:
   - **POWER** LED should be **ON**.
   - RIDE-THRU ACTIVE LED should be OFF.
   - **OVERTEMP** LED should be **OFF**.
3. Verify DC bus current meter.
   - Meter should read zero amps under normal conditions.
4. Verify DC bus voltage meter.
   - Ride-Thru bus should be about 10–35VDC below the Inverter bus.
5. Verify battery voltage meter. See Table 7-1.
6. Monitor DP18 panel LEDs.
   - **POWER** should be **ON.**
   - **CHARGE** LED should be **OFF** unless recent discharge has occurred.
   - All other LEDs should be **OFF**
7. Verify THRESHOLD and outage time by opening the AC disconnect to the Ride-Thru module (if equipped). Refer to Section 4.4.
   - The DC bus voltage should drop until it reaches the threshold.
   - Current meter should read according to power required by inverter.
   - **RIDE-THRU ACTIVE** LED should begin to flash.
   - DC bus should hold at the threshold.
   - This threshold level should be 10-30 volts below the nominal loaded inverter bus. See Table 4-4.
   - Consider full TEST when outage time reaches spec.

To verify Threshold using the TEST feature, continue with step 8 and refer to Section 4.4.

Each Bonitron Ride-Thru should be tested under load during initial start-up to verify the functionality of the test circuit and that the test does not negatively affect the process. However, Bonitron recommends that, if the process is critical, the test cycle be initiated only during a shutdown to avoid unforeseen problems.

8. Verify switching circuits by initiating the TEST sequence while running the inverter at full load.
   - Ride-Thru should not have AC power when inverter does not.

- Ride-Thru DC bus current should flow during the 2-second test cycle.
- Inverter input current should drop.
- Ride-Thru DC bus voltage should rise to 17% above the threshold.
- Inverter DC bus voltage should rise to 17% above the threshold.
- RIDE-THRU ACTIVE LED should turn ON.
- Motor speed should remain constant.
- Active cycle counter should increment.

This completes the maintenance procedure.

5.2.1.1. ULTRA CAP DISCHARGE PROCEDURE

In case of maintenance, or for the purpose of capacity testing, the ultra cap bank must be discharged. This is accomplished by loading the cap bank to drain the energy until the voltage reaches safe levels.

Some BPS models have permanently installed discharge circuits, and some make use of connectors used in conjunction with a portable cap discharge unit.

Once caps are discharged, they can build up a residual charge. It is recommended that a shorting wire or low ohmage resistor is connected across the cap bank terminals to ensure the voltage stays at safe levels during maintenance.

5.2.1.1.1. FOR SYSTEMS WITH MANUAL DISCHARGE CONFIGURATION:

1. Remove power to BPS system by turning off maintenance disconnect switch.
   - In a few seconds the BPS will become active. In a few seconds after that the BPS will "time out" and switching will stop, at which point the output DC bus will begin to drop.
2. Once the output bus begins to drop, open the cabinet door to access the discharge circuits.

*For models with permanent internal discharge components continue with step 3,

*For models using the portable discharge unit skip to step 4.

3. Connect the remote discharge to the ENABLE connector on cabinet door. Skip to step 5.
4. Connect the Superior plugs to the provided connector at the upper left of cabinet. Connect one at a time, ensuring the portable discharge switch is set to the OFF position.
   - DC LED will turn on.

Plug the 115VAC power cord into a hot outlet.

5. Apply enable or turn discharge switch to the DISCHARGE position.
   - Active or Enable LED should turn on
   - Capacitor voltage should begin to decrease.
6. Once capacitor voltage has dropped to 5v or less, a shorting strap or low ohmage resistor (something below 1k ohm) may be connected across the capacitor terminals to prevent a residual charge from building up on the cap bank.

The BPS system is now ready for maintenance.

5.2.1.1.2. FOR SYSTEMS WITH AUTOMATIC DISCHARGE CONFIGURATION:

1. Turn OFF maintenance DISCONNECT.
   - Capacitor voltage should begin to decrease
2. Once cap voltage and drive bus voltage drop to a safe level defined by local standards, the cabinet door may be opened.

In Automatic Discharge mode, IGBT switch internal supply has 2.5 minutes of energy once cap bank voltage drops below 25-VDC. Do not abort discharge below 250V for extended periods or discharge may not complete. If this occurs, re-apply power and charge caps up to 300VDC. Wait 1 minute and re-initiate discharge.

5.3. MAINTENANCE ITEMS

5.3.1. CAPACITOR REPLACEMENT RECOMMENDATIONS

5.3.1.1. ELECTROLYTIC CAPACITOR REPLACEMENT CRITERIA

Bonitron Model 3534UR Ride-Thru uses high quality aluminum electrolytic capacitors and is designed for long life without maintenance. While a typical inverter may require capacitor replacement after a certain time due to the heavy ripple currents, the M3460 typically is in a standby mode waiting for a power disturbance, and by design has 50% more capacitance than needed.

With typical operating conditions of 35°C, caps running at 75% rated voltage, and a duty cycle of one sag per month, Bonitron recommends the capacitors be checked or replaced every 20 years.

The recommended test is to measure the voltage across each series set of capacitors. Any voltage difference greater than 15% between each set of series caps would indicate a change in value in one cap and would constitute a more detailed out of circuit capacitance check. (A difference of 5% is allowed at time of production.)

5.3.1.2. ELECTROLYTIC CAPACITOR TESTING PROCEDURE

1. With power applied, measure voltage across each cap and make note for future reference.
   - Any voltage difference more than 15% indicates a substantial change in capacitance.
   - Example: DC bus = 540V, each series cap = 270V.
     15% of 270 = 40.5V cap 1 = 290V, cap 2 = 250V.
2. Remove power and replace both capacitors.

5.3.1.3. ULTRA CAPACITOR REPLACEMENT CRITERIA

Ultra capacitors are designed for long life without maintenance. While a typical battery will degrade quickly under normal conditions, ultra capacitors will maintain their power storage capability longer and under more severe conditions. An emerging definition of Ultra Cap life is considered to be a 30% drop in capacitance, and a 1.5x increase in ESR under 60°C or 100% rated voltage conditions. Keeping the Ultra Cap under rated voltage and temp can increase its life beyond 10 years.

Like electrolytic caps, relative capacitance can be checked by measuring the voltage across each series cap provided the series

storage is not a full voltage. Unlike electrolytic caps, internal cell balancing circuits are used and will equal out all series cap voltages if the series string is run at 100% voltage. If any voltage is above the capacitors rating, the complete series string should be checked in detail. If any cap is 10% different than the others it should be replaced.

5.3.1.4. ULTRA CAPACITOR TESTING PROCEDURE

1. Open door or access panel to ultra cap bank. Remove any protective covers.
2. With power applied and caps charged, measure the voltage across each cap
   - Voltages should be within 5% of each other
   - Each cap voltage must be below its nameplate rating
3. Connect discharger and remove power to the BPS cabinet.
4. Initiate a discharge cycle and calculate the total capacitance from the discharge curve.

See Figure 5-1 for typical discharge curves.
See Section 7.1 for discharge calculations.

5.3.1.5. CLEANING

- Cleaning off dust, debris, or chemical build-up on high voltage bus bars or other exposed components may be necessary. If cleaning is needed:
  - Remove power and allow all voltages to drain.
  - Check for residual voltages with meter.
  - Clean affected areas with rag, brush or denatured alcohol, depending on the type of contamination.
  - Once area is clean and dry, reapply power.

5.3.1.6. FANS

- Fans inside the Booster and Charger modules run only while RT is active and should have a life of 20 years if the RT is properly adjusted. To check operation of fan, temporarily initiate activity:
  - 20 and 40 Amp models: Fan should run for 2-3 minutes after activity stops.
  - 85 Amp models: Fan should run for 30 minutes after activity stops.
  - If fan does not run, replace with equivalent 24V fan.
- The cabinet fan runs off of 115VAC and runs continuously to prevent heat and hydrogen build-up inside the cabinet. This fan should be checked yearly and replaced every 4 years.

5.4. TECHNICAL HELP – BEFORE YOU CALL

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

- Serial number of unit
- Name of original equipment supplier
- Brief description of the application
- Drive and motor hp or kW
- The line to line voltage on all 3 phases
- The DC Bus voltage
- KVA rating of power source
- Source configuration Wye/Delta and grounding

5.5. TROUBLESHOOTING

Table 5-1: Troubleshooting Guide

SYMPTOM	ACTION
No front panel LEDs	• Check incoming power • Check power supply from booster • Check isolated power supply out of the 3534I2 interface
RTA always ON	• Check DC Bus levels on BPS panel and drive panel. • Check for overheated precharge ckt • 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 booster module • Lower threshold by at least 10V

RTA never ON	• Check DISABLE command
	• Initiate test cycle or remove power
	  • Watch and listen for signs of activity
	  • Check RTA contact and LED
	  • Ticking sound
	• Check power quality data to confirm sag events should have caused activity to occur
	• If never any activity, replace booster module

Overtemp	• Check for constant current on the negative or positive DC bus links • Check temp sensors on IGBT heatsink and on chokes • Check activity record – too much activity may cause overtemp • Check precharge network for overheating – (cause of constant activity)
Blown Fuse LED ON	• Check stage fuses – BF LED on 3534P3 or 3534P6 will be ON • If all stage fuses are OK replace 3534P3 or 3534P6 power pcb
Blown stage fuses	• Check for shorted IGBT • Replace 3534R2 or 3534P3 or 3534P6 or repair gate drive circuits if IGBT is shorted • Check activity record – too much activity may cause fuse fatigue
Undervoltage LED ON	• Indicates battery input dropped below level in Table 6-2
Overvoltage LED ON	• Indicates battery charge level is too high
TEST won't work	• Check DC bus level – too high causes no test • Check TEST jumper on back of display pcb
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

Stays in TEST mode	• Threshold way too high
	  • Only appears to be in test mode
	  • Can occur in 400V systems if RT is factory set for 585V
	• Check TEST switch on DP17 display

6. ENGINEERING DATA

6.1. RATINGS CHARTS

Table 6-1: Model M3534RT Ride-Thru Module Ratings @ 2 Sec

MODEL NUMBER	AC INPUT (VAC)	MAX OUTPUT POWER	RECOMMENDED FUSE RATINGS (DC INPUT / DC OUTPUT)	MAX DC OUTPUT CURRENT	CHASSIS SIZE (H X W X D INCHES)
M3534RT-EH020	380-460	12kW	A70Q30 / A70Q25	20ADC	12.5 x 5.1 x 9.5
M3534RT-EH040	380-460	24kW	A70Q75 / A70Q50	40ADC	20 x 7.12 x 10.5
M3534RT-EH085	380-460	50kW	A60Q125 / A70Q80	85ADC	22 x 9 x 10.3

Table 6-1 Notes:

For higher ratings, 85 Amp units can be paralleled. See the RT Manual for more information.

Table 6-2: Model M3534RT Ride-Thru Module Voltage Levels

AC INPUT VOLTAGE	OUTPUT DC BUS VOLTAGE LEVELS		INPUT DC BUS VOLTAGE LEVELS	
	THRESHOLD	NOMINAL	MINIMUM	MAXIMUM
115VAC	145VDC	160VDC	80	145
230VAC	285VDC	320VDC	160	285
400VAC	500VDC	565VDC	280	500
460VAC	585VDC	640VDC	320	585

Table 6-2 Notes:

The THRESHOLD column in the table above lists the voltage level at which the DC bus will be maintained when the RTM is active during a power loss. This is usually calibrated about 90% of the nominal DC bus level and will drop another 7V when fully loaded.

The NOMINAL column in the table above lists the normal operating DC bus voltage level.

6.2. WATT LOSS

Typical in Standby mode

- 50 watts for 12kW "UR" systems
- 75 watts for 24kW "UR" systems
- 100 watts for 50kW "UR" systems

6.3. CERTIFICATIONS

M3534RT-EH010 is certified by PSL Laboratory to exceed Semi-47 requirements.

6.4. FUSE/CIRCUIT BREAKER SIZING AND RATING

6.4.1. RECOMMENDED INPUT POWER WIRING SIZES AND POWER SOURCE FUSING

The following data is supplied for assistance in selecting the appropriate field wiring sizes and power source fuse ratings for the Model M3534UR Cabinet Mounted and Open-chassis Ride-Thru systems.

- 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 M3534UR Ride-Thru is one 2-second run every 200 seconds. (1% duty cycle)

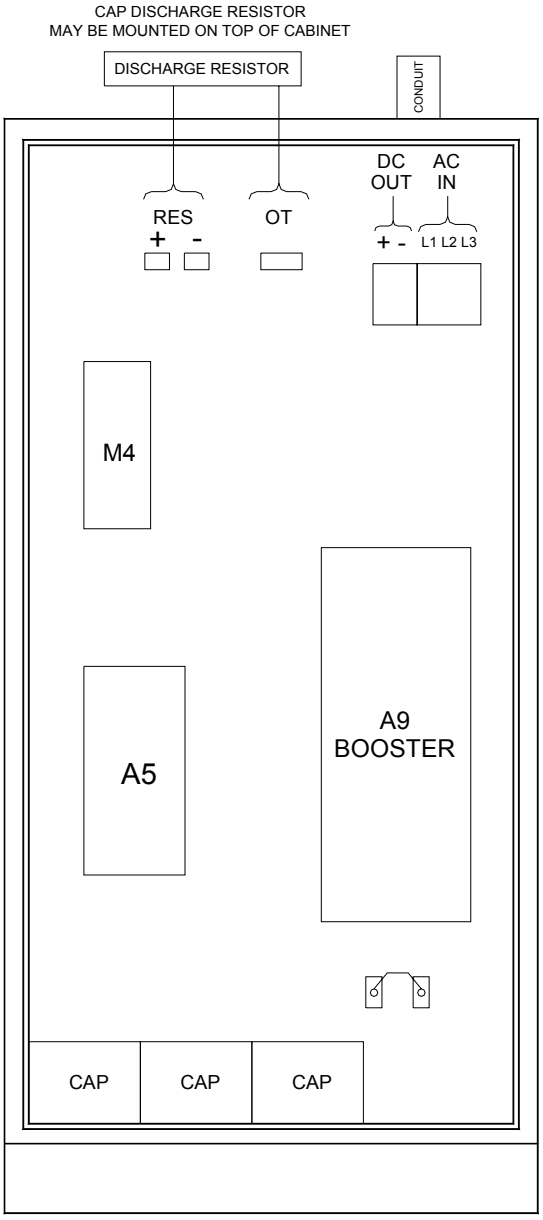
Table 6-3: Input Power Wiring Sizes and Fusing

SYSTEM HP	SYSTEM kW	RIDE-THRU DC BUS CURRENT RATING	MIN. SOURCE FUSING SEMICONDUCTOR	RECOMMENDED FIELD WIRING SIZES	MCM EQUIVALENT WIRING SIZES
13 - 16	10 - 12.5	20 Amps	30 Amps	14 AWG	4 MCM
27 - 32	20 - 24	40 Amps	60 Amps	8 AWG	16 MCM
57 - 67	43 - 50	85 Amps	125 Amps	4 AWG	41 MCM

6.5. DIMENSIONS AND MECHANICAL DRAWINGS

Figure 6-1: M3534UR D41 Cabinet Dimensional Outline

Figure 6-2: M3534UR D41 Cabinet Internal Layout



SHOWN: 50KW CABINET (D41)

Figure 6-3: M3534UR E69-D Cabinet Dimensional Outline

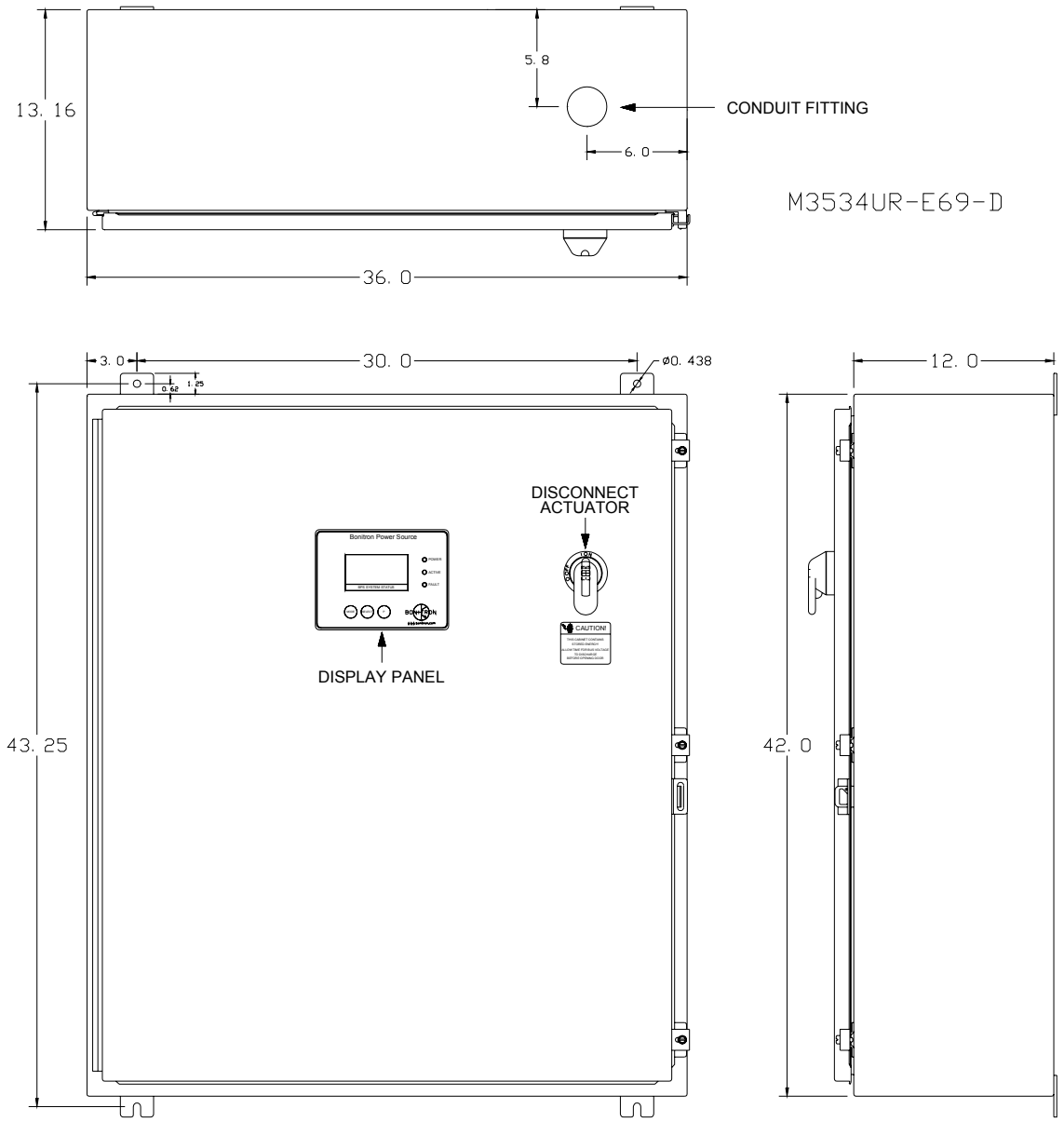
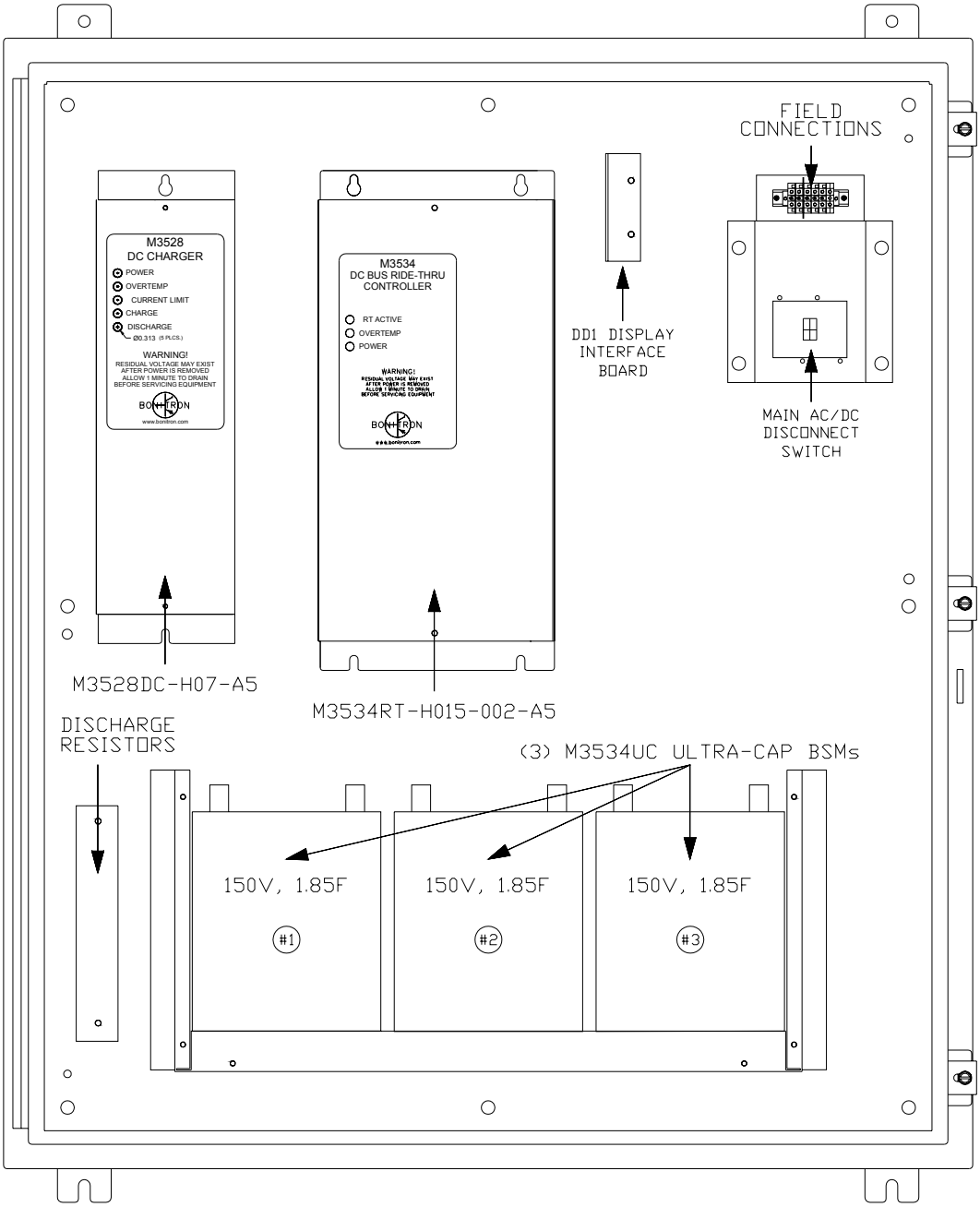


Figure 6-4: M3534UR E69-D Cabinet Internal Layout



6.6. RECOMMENDED SPARE PARTS

6.6.1. SPARE PARTS LIST

The part numbers listed in the Table 6-4 represent a listing of all major components and the quantities of each used in various Bonitron Model M3534RT modules.

This list is intended for use as a reference if ordering spare parts for the Ride-thru modules becomes necessary. Please remember to refer to the complete Bonitron part number when ordering parts.

Each printed circuit board has a serial sticker (i.e. 3534R3D10 #125. Please refer to Table 6-4 below). Remember to include every character when ordering spare pcbs to help ensure a proper order.

Parts should be ordered by the responsible party through your local distributor or system integrator.

Table 6-4: Example of PCB Serial Sticker

MODEL #	FUNCTION	LAYOUT VERSION	COMPONENT VERSION	SERIAL NUMBER
3534	R3	D	10	125

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7. APPENDIX

7.1. APPLICATION NOTES

For applications with SEMI-47 or 50% sag specifications, a standard M3534RT series RTM is the most cost effective solution for holding up a fixed bus inverter. When an application requires full outage protection, a standard RTM is used as a voltage regulator for a series of battery or capacitor energy storage Bus Support Modules (BSMs) to form the Model M3534BR (Battery Regulator) or M3534CR (Capacitor Regulator).

For systems requiring up to 0.5 seconds of full outage protection, a M3534CR system utilizing one or more model M3534EC Electrolytic Capacitor BSMs can provide a cost effective solution. However, for applications needing 0.5 to 5 seconds of full outage protection, using an M3534UC Ultra Capacitor BSM as part of the M3534CR can be a more cost effective solution.

For applications with full outage specifications ranging from a few seconds to 15 minutes, the model M3534BR, incorporating a battery reservoir and the M3528DC Charger module should be considered.

Contact Bonitron for assistance in selecting the optimal solution for your ride-thru requirements.

7.2. INSTALLATION CONSIDERATIONS

The following items should be considered when installing a Bonitron Ride-Thru Module:

1. Inverter logic voltage must be "backed up"
   - Most new Inverters derive logic supply from DC bus
   - Install 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 UPS on circuits with AC feed
3. Determine the maximum motor voltage needed
   - To ensure "Threshold" level is sufficient to supply motor
     - Most inverters automatically compensate RMS to motor
4. Verify actual AC line voltage and DC bus level
   - To ensure "Threshold" level is set – 10% of nominal DC bus level
   - To ensure valleys of ripple do not cause unwanted activity
5. Determine Inverter low bus trip point
   - To ensure "Threshold" level is above inverter dropout
6. Determine Inverter high bus trip point
   - To ensure "Test" level will not over voltage inverter
7. Inverter ground fault circuits
   - (Ride-Thru currents on 20 amp model may use inverter bridge neg diodes during operation)
   - Circuits can be de-sensitized
   - External ground fault circuits may be added
8. Electrical safety
   - Ride-Thru should not have AC power when inverter does not
     - RT and Inverter should feed from same point
     - Use shunt trip interlock between Inverter and Ride-Thru if RT power is not fed downstream of inverter power switch
     - Label inverter as having two power sources
9. DCS monitoring of status signals
   - Alarm contacts
10. Input feed should be capable of 2x rated current during the 2 sec 50% dip for 3534RT models
    - RT RMS rating is 1 percent of system kW
    - Most inverter feeds have been sized for a 150-200% surge for motor starting
11. IR drop of wiring
    - (this subtracts from the 50% dip spec)
12. Maximum wire sizes allowed into Ride-Thru
    - Different models have standard max sizes
13. Local wiring codes
14. Ambient temperature
    - (under 50°C)
15. Corrosive environment
    - Determines cabinet type

NOTES

NOTES