VersaPower® Xtreme™

Induction Power Supply

Radyne Corporation

211 W. Boden Street
Milwaukee, Wisconsin, USA 53207-6277
(414) 481-8360, 1-800-236-8360
Fax (414) 481-830
E-mail:sales@radyne.com
Office Hours: 8:00 a.m. to 5:00 p.m. CST M-F

User Manual

RADYNE
An Inductotherm Group Company

CONTENTS

General Information 1
1.1 Equipment Overview 2
1.2 Contact Information 3
1.3 Manual Overview 4

Health & Safety 5
2.1 Equipment Safety Labels 6
2.2 Risk and Hazard Assessment 7
2.3 Notice of Applicable Safety Regulation Disclosure 9
2.4 Exposed High Voltage Areas 9
2.5 High Temperature Coolant 11
2.6 Lifting Aids 11
2.7 Occupational Noise 11
2.8 Required Operator Protective Equipment 12
2.9 Upstream Breaker Ratings 13
2.10 Zero Voltage Verification Requirement 13
2.11 Additional Safety Information 14
2.12 Discharging Capacitors 15
2.13 Energy Isolation & Restore Details 16
2.14 Protective Guarding Features 19
2.15 Safety Standards & Regulations (U.S.) 19

Power Supply Control 20
3.1 Purpose & Scope 21
3.2 General Induction Heating Theory 22
3.3 Output Inductor Design 23
3.4 Parameter Relationship Fundamentals 24
3.5 Output Magnitude Control 26
3.6 Power Supply Operation 29
3.7 Tuning & Impedance Matching 32

Installation, Setup & Removal 33
4.1 Overview & Personnel Qualifications 34
4.2 Receiving 35
4.3 Mounting & Placement 36
4.4 Output Inductor Attachment & Change Out 37
4.5 Power Connection & Inspection 38
4.6 Coolant System Connection & Inspection 39
4.7 PLC-Controlled Device Connection 40
4.8 Electrical & Water Supply Removal 41
4.9 Winterizing 42
4.10 Shipping Preparation 43

Normal Operation 44
5.1 Overview & Personnel Qualifications 45
5.2 Inductance Adjustment: Series Inductor 46
5.3 Capacitance Adjustment: Mounting Array 47
5.4 Single-Step Workpiece Heating 48
5.5 Multi-Step Workpiece Heating 48
5.6 Load Tuning 49

Interface Environment 51
6.1 Physical Layout 52
6.2 Menu System Overview 53
6.3 Fundamental Menu Interactions 57
6.4 Workpiece Heating Modes & Displays 63
6.5 Managing Security 67
6.6 Creating & Editing Recipes 69
6.7 Managing Recipe Storage 75
6.8 Managing Interface Control 77
6.9 Managing Firmware & Language 83
6.10 Using the Load Tuning Calculator 84

CONTENTS

Preventative Maintenance 85
7.1 Overview & Personnel Qualifications 87
7.2 Repairs & Servicing 87
7.3 Maintenance Schedule 88
7.4 Annual Subscription Plans 89

Troubleshooting & FAQs 89
8.1 Overview & Personnel Qualifications 90
8.2 Trip / Fault Shutdown Indication Codes 91
8.3 Equipment Service Request 98
8.4 Frequently Asked Questions (FAQs) 99

Technical Data 100
9.1 Specification: Electrical 101
9.2 Specification: Fluid Cooling System 102
9.3 Specification: Physical 104
9.4 Specification: PLC Interface 107
9.5 Connection Detail: PLC Functionality 108
9.5 Drawing: Output Mount 110
9.6 Drawing: Physical Layout (5 - 15 kW Models) 111
9.7 Drawing: Physical Layout (25 - 50 kW Models) 112

Accessories & Spare Parts 113

Terminology 117

Appendix 120
12.1 Lists of Tables & Figures 121
12.2 Product Warranty 122

Congratulations on your purchase of the new VersaPower® Xtreme™ induction power supply with Digital IQ™ controls; the most advanced induction power supply in the market. Radyne has outfitted the VersaPower® Xtreme to push the boundaries of what is considered “standard” in the industry with new features and benefits that combine ease of use with precise control capability. Engineered for flexibility, enhanced changeover speed, unrivaled performance, time-tested reliability, durability, and remote interface connectivity, the VersaPower® Xtreme™ is also ideal for today’ manufacturing environments, where networking is commonplace. The VersaPower® Xtreme™ induction power supply combines these state of the art advancements and an upgradeable platform officially preparing it to grow with the induction heating technology of tomorrow.

General Information

1.1 Equipment Overview 2

1.2 Contact Information 3

1.3 Manual Overview 4

Equipment Overview

General Description

The VersaPower® Xtreme™ is a product family of compact induction power supplies comprised of numerous different models capable of producing output frequencies within the ranges of 20 kHz to 80 kHz and 100 kHz to 400 kHz and power outputs between 3 kW and 30 kW. This product family also offers low and high voltage input flexibility to meet different the needs of differing shop environments. Each model is supported by Radyne's new Digital IQ™ control technology allowing incredible ease of use, advanced communication, control and programming features previously unseen in induction power supplies. Each unit is capable of rated output power ramp-ups from 0-100% in less than 500 microseconds. With unlimited recipe storage, the VersaPower® Xtreme™ product family utilizes Ethernet connectivity to manage, store, or share recipes. Administrative login protection gives you control and peace of mind when managing, creating, and editing recipe files. Additional features include:

- High contrast color LCD display

- Operator-friendly controls

- Dual output bus design

- Simplified tuning access

- Precision output power, voltage, & current regulation control

- Load tuning parameter calculator

Range of Operation

The VersaPower® Xtreme™ product range consists of 3 kW, 5 kW, 10 kW, 15 kW, 25 kW and 30 kW models. This wide range of power offers you the ability to perform a variety of heating applications from small parts (i.e. 1 mm thick wire), to large parts (i.e. tractor gears or cam shafts). The low frequency range output models (i.e. 20-80 kHz) work well for brazing applications like manifolds or heat sinks where a wide area of heat is desired, while their high frequency range counterparts (i.e.100-400 kHz) allow for the shallow case depths or precision heating required for hardening specific areas of a workpiece (i.e. threads of a fastener).

Contact Information

General inquiries may be made to RADYNE on the following numbers:

Telephone: 414-481-8360
Fax: 414-481-8303
E-mail: sales@radyne.com

Service and spare parts inquiries may be made on the following numbers:

Telephone: 414-481-8360
Fax: 414-481-8303
E-mail: spares@radyne.com

Or visit us at our web site at:

http://www.radyne.com/versapower.html

http://www.radyne.com

RADYNE
An Inductotherm Group Company

Manual Overview

Introduction

This operator's manual is divided into sections as detailed on the "Contents" pages. Each section begins with a cover page that lists the topics covered within that section. Special effort must be made to thoroughly review and understand the health and safety information contained within **Section 2**, as well as, through the manual. Be sure to review all sectional content pertaining to your specific activity before attempting that specified interaction with this equipment.

Responsibility

RADYNE will not be responsible for any malfunction of equipment as a result of the customer's failure to follow the instructions detailed within this manual. If you have any questions regarding the application of the information contained within this manual, contact your RADYNE representative before attempting that activity.

Scope

The following models and their respective convertors are covered by the scope of this manual:

5VXL480P
5VXL240P
5VXH480P
5VXH240P
10VXL480P
10VXL240P
10VXH480P
10VXH240P
15VXL480P
15VXL240P
15VXH480P
15VXH240P
25VXL480P
25VXL240P
25VXH480P
25VXH240P
30VXLS480P
30VXM480P

Terminology

Section 11 is dedicated to providing additional key explanatory details pertaining to the terminology used within this manual. It is recommended that you review and revisit (as necessary) the explanations within this section to ensure a more complete understanding of the material.

Symbols

Symbols are used within this manual to enhance readability, increase understanding, and accentuate mandatory application, safety, and equipment health notes and requirements. Each occurrence of one of these symbols includes a topic-specific detail that must be adhered to as written. The symbols used and their explanation is provided below.

Application Note:

This symbol indicates that the instruction or action provides for more proficient and/or efficient use of the power supply and its resources. Failure to comply with the accompanying details could result in inefficient and/or ineffective operation, leading to unsuccessful outcomes.

Safety Warning Note:

This symbol indicates that the instruction or action minimizes and/or eliminates a risk of injury to personnel. Failure to comply with the accompanying details could result in serious injury and/or death.

Equipment Wellness Note:

This symbol indicates that the instruction or action prevents serious damage to the equipment and/or its connected components. Damage resulting from a failure to comply with the accompanying details will result in the voiding of applicable warranty provisions.

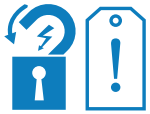
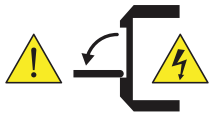
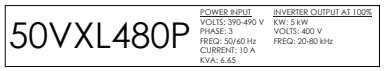
Health & Safety

2.1	Equipment Safety Labels	6
2.2	Risk and Hazard Assessment	7
2.3	Notice of Applicable Safety Regulation Disclosure	9
2.4	Exposed High Voltage Areas	9
2.5	High Temperature Coolant	11
2.6	Lifting Aids	11
2.7	Occupational Noise	11
2.8	Required Operator Protective Equipment	12
2.9	Upstream Breaker Ratings	13
2.10	Zero Voltage Verification Requirement	13
2.11	Additional Safety Information	14
2.12	Discharging Capacitors	15
2.13	Energy Isolation & Restore Details	16
2.14	Protective Guarding Features	19
2.15	Safety Standards & Regulations (U.S.)	19

Equipment Safety Labels

All labels attached to Radyne equipment are for the information of operators, maintenance engineers, etc. and relate to the safety and operation of the equipment. Labels are not to be removed, covered or altered in any way as this may affect the legal responsibility held by RADYNE.

Should any labels become detached or damaged please contact RADYNE immediately for a replacement.

Safety Label	Description
	Prevent accidental start-up by locking out (LOTO) all energy sources prior to removing panels or changing output inductors (see **Section 2.3**).
	Guarding needs to be in place to prevent accidental contact to exposed high voltage areas.
	No persons with electronic cardiac implants are permitted near the equipment while it is in operation.
	**CAUTION:** Equipment produces electromagnetic radiation.
	**CAUTION:** Exposed high voltage areas inside equipment panels.
	Model-specific voltage, current & power input/output ratings.

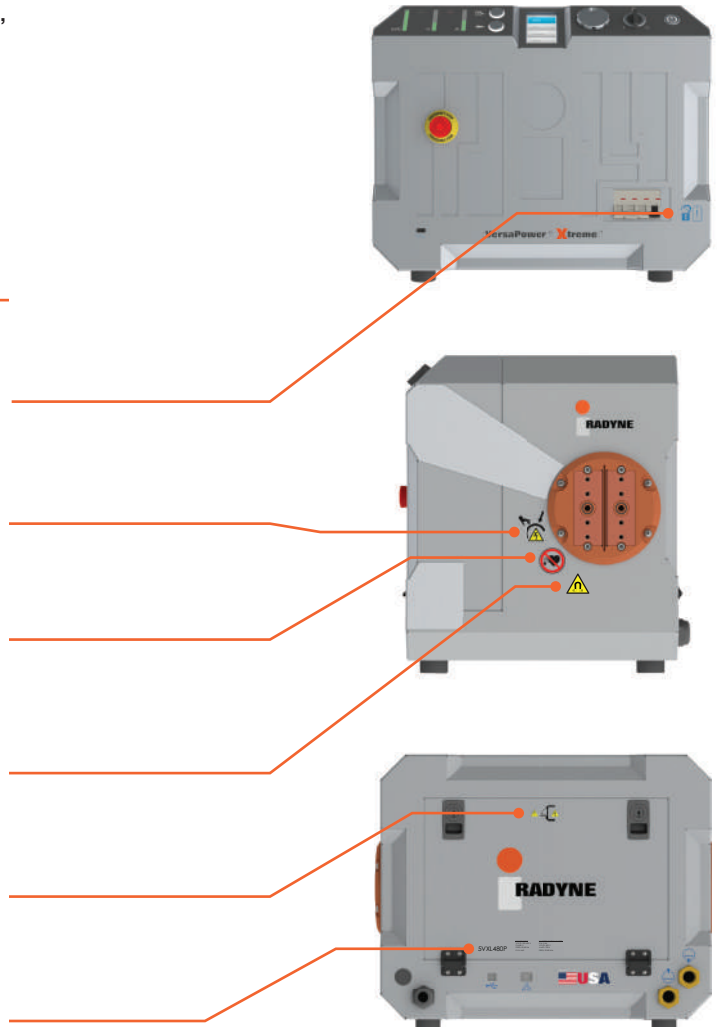


Figure 2-1: Safety Label Locations: Front, Side, and Rear View

Risk & Hazard Assessment

Designed Method of Use & Assessment Details

The VersaPower® Xtreme™ induction power supplies' range of convertors has been designed to the highest safety standards. Care has been taken, from design through manufacture, to eliminate or minimize any hazards and risks to the operator of the convertor.

It is the responsibility of RADYNE to make the customer aware of any hazards that may exist to operators of RADYNE equipment. The convertor is designed to produce high frequency electrical power for use in induction heating processes. Induction power supplies and coils operate using potentially lethal electrical power and, therefore, should be treated with the utmost caution and respect.

To the extent possible, protection has been provided to minimize and/or eliminate the hazard and its associated risk. All residual (remaining) hazard must be addressed via safe work practices and/or personal protective equipment (PPE) as deemed necessary by the governing safety regulations. All eliminated hazards are not considered a hazard and, therefore, are not included within the scope of this assessment.

The parameters specific to this risk and hazard evaluation correspond to the convertor during normal operation and are present from the point that the power supply is switched on to the point where it is switched off and verified to be at a zero energy state.

It is the full responsibility of the customer to ensure that the surrounding environment is made safe for the operators, following all the governing safety standards and regulations.

Risk & Hazard Assessment

Hazard & Risk Type	Risk & Responsibility Assessment
Unprotected contact with exposed live electrical components can cause **electrocution**	**Risk Assessment:** The risk is considered as probable and within the category as “critical” (serious injury or death). This is considered as unacceptable and action must be taken. **Responsible Action:** This has been minimized by enclosing the bus bars, etc. within the casing of the convertor and providing safety interlocked access doors. The remaining risk needs to be accepted by the customer. It is the responsibility of the customer to provide adequate guarding around the external bus bars as well as any indicated high voltage areas (**Section 2.4**) and ensure that all personnel are aware of the hazards and risks involved and are trained in the safe operation of this convertor.
Unprotected contact with heated components can cause **contact burns**	**Risk Assessment:** This risk is considered as occasional (may happen sometimes) and within the category “marginal” (minor injury or damage). This is considered as undesirable but may be acceptable with authoritative decision **Responsible Action:** This risk needs to be accepted by the customer. It is the responsibility of the customer to ensure that all personnel are trained in the safe operation of this convertor with respect to the excessive temperature of heated electrical and cooling system components.
Worn rings, jewelry, etc. heated by produced electromagnetic fields can cause **induced contact burns**	**Risk Assessment:** This risk is considered as occasional and within the category as “marginal” (minor injury or damage). This is considered as undesirable but may be acceptable with authoritative decision. **Responsible Action:** This risk needs to be accepted by the customer. It is the responsibility of the customer to ensure the operator does not wear rings or jewelry while operating equipment.
Electronic cardiac implants malfunction from electromagnetic fields can cause **death**	**Risk Assessment:** This risk is considered as probable and within the category as “critical” (serious injury or death). This is considered as unacceptable and action must be taken. **Responsible Action:** This risk is not acceptable. It is the responsibility of the customer to ensure that personnel operating the convertor (or standing near the equipment) do not have cardiac implants, or those that do, have taken advice from the relevant medical authority or the implant manufacturers and received assurance that the particular implant will not be affected.

Table 2-1: Hazard, Risk, and Responsibility Assessment

Notice of Applicable Safety Regulation Disclosure

The safety-related content within this **Health & Safety** section, as well as, all subsequent safety-related material referencing LOTO, OSHA, NFPA, etc. applies to equipment used within the United States. If this equipment is used within regions outside of the United States, it is the responsibility of the customer to, at minimum, meet the corresponding safety requirements of their respective governing safety regulations. However, injuries resulting from applying safety regulations that do not, at minimum, meet those set forth, as written, within this manual are the sole responsibility of the customer.

Exposed High Voltage Areas

Panels Closed

Figure 2-2 depicts the potential high voltage contact areas (with respect to the output inductor) while machine is in operation. All components electrically connected to these areas are also considered to be at dangerously high voltages.

WARNING:
The entire face of the exposed copper (shown yellow, **Figure 2-2**) output mount mount presents a potential hazard for electrical shock.

It is the responsibility of the customer to ensure that suitable and effective guarding is installed to protect the operator from risk of injury due to the presence of exposed live voltages with respect to both output mounts. (**Section 2.2**).

WARNING:
NEVER open the front panel while the equipment is plugged in without wearing the appropriate PPE and applying electrical safety work practices as required by NFPA 70E standards and OSHA 1910 Subpart S regulations (see **Section 2.3**).

Figure 2-2: High Voltage Areas (panels closed)

Exposed High Voltage Areas

Front Panel Opened

Figure 2-3 depicts the exposed high voltage areas (shown red, Figure 2-3, with respect to the circuit breaker switch) while the front panel is opened.

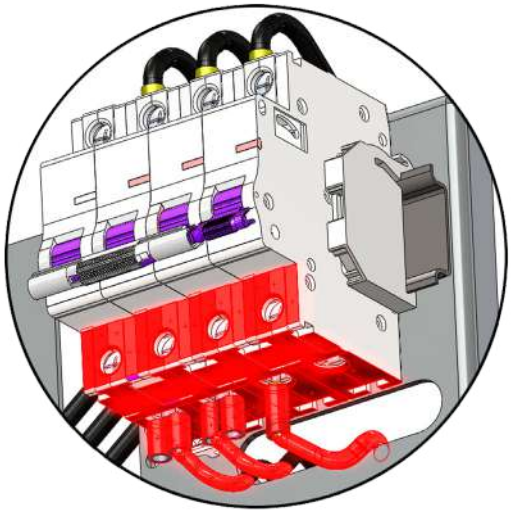


Figure 2-3: High Voltage Areas (inside front panel)

Rear Panel Opened

Figure 2-4 depicts the exposed high voltage areas (shown red, Figure 2-4, with respect to supply power) while the rear panel is opened.

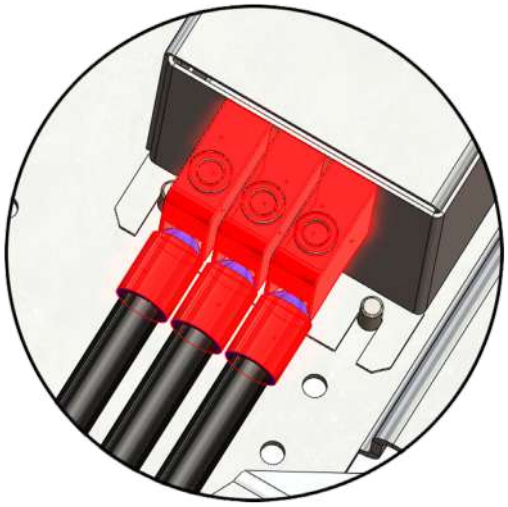


Figure 2-4: High Voltage Areas (inside rear panel)

WARNING:
Electric shock and arc flash/blast related injuries are possible if equipment panels are opened while the machine is plugged in.

NEVER open the front or rear panels without wearing the appropriate PPE and applying electrical safety work practices as required by NFPA 70E standards and OSHA 1910 regulations (see **Section 2.3**).

The front panel should only be opened by Radyne-Authorized Service Technicians.

High Temperature Coolant

The coolant within the cooling system can exceed 140°F (60°C) during normal operation of the induction power supply. Sufficient time must be given for the temperature of the coolant to reach a safe temperature level prior to implementing any work activity on the cooling system or its dedicated components.

Lifting Aids

The weight of the convertor and its components make it strongly advisable to use mechanical lifting aids wherever possible. To avoid the risk of injury, personnel are to ensure that the weight involved does not exceed their capabilities, as well as, the recommended limits set forth under the Health and Safety Act, or any other legislation, and that suitable protective clothing is worn as required (see **Section 2.3**).

Occupational Noise

This convertor can operate at frequencies which are within the audible range and could, therefore, present a hazard to persons nearby. Radyne has taken all reasonably practical measures to reduce noise to levels which are safe, and without risk of health to the normally fit operator. It is possible, however, that a noise levels in excess of 85 dBA may occur. Customers should make sound level measurements of the convertor and associated equipment following installation while operating under normal load conditions. The results of this analysis must be used to determine the required level of action in accordance with the following guidelines (see **Section 2.3**):

- For measurements below 85 dBA, additional protection for exposed persons (i.e. hearing protection) is reccommended.

- For measurements above 85 dBA, considerations for engineering improvements to the environment that reduce the noise level are required. Additional provisions for warning and exposed persons' protection (i.e. hearing protection) is required.

Required Operator Protective Equipment

Due to the nature of any manufacturing process and the hazards specific to this equipment (**Section 2.2**), the potential for serious personal injury to unsuspecting, unprotected, and/or untrained personnel is possible. All persons operating this equipment must wear, at minimum, the following protective equipment:

- **Safety glasses:** Approved eye protection must be worn while near equipment.

- **Safety shoes:** Open toes, heels, sandals, cloth, canvas or plastic shoes should be strictly prohibited.

- **Clothing:** Clothing and accessories must not create an additional hazard or risk to personal safety. Avoid loose fitting clothing that could catch fire.

- **Additional Gear:** Hard hat & other safety items or personal protective equipment (PPE) as required / recommended by OSHA (see **Section 2.3**).

WARNING:
The articles listed as protective equipment do not provide for protection from the hazards associated with the workpiece. Establishing additional protections and/or safe work practices to protect personnel from the dangers associated with the workpiece are the responsibility of the customer.

Upstream Breaker Ratings

Section 9.1 contains the electrical characteristics corresponding to each equipment model. Be sure to use this data when determining the ratings of the power distribution equipment according to the NEC calculation. Establishing the correctly rated upstream breaker design is the responsibility of the customer. Using a circuit breaker that does not meet the requirements of the maximum load as determined by specific methods set forth by the NEC can result in equipment damage, electric shock, arc flash/blast-related injuries and/or death (see **Section 2.3**).

Zero Voltage Verification Requirement

According to OSHA, a zero voltage state is not recognized until it has been verified with a meter. If meter lead placement requires any part of your body within the shock hazard or arc flash hazard boundaries, then shock-rated and/or arc flash-rated protection is required (NFPA 70E). All exposed parts are considered live until verified with a meter by a qualified person as defined by defined by OSHA 29 CFR Subpart S 1910.332 and 1910.147 (see **Section 2.3**).

Additional Safety Information

ALWAYS VERIFY that the front and rear panels are secured before attempting to plug in and/or turn the main power disconnect to the "ON" position.

NEVER UNPLUG the equipment as the primary means to de-energize the induction power supply Transient voltages may be present at the plug terminals for up to 2 minute after unplugging the equipment.

ALWAYS USE your local electrical disconnect as the primary means of de-energizing the induction power supply before opening access panels.

ALWAYS WAIT a minimum of one minute before attempting to unplug the power supply after performing an electrical disconnect at your local disconnect.

NEVER MODIFY the induction power supply or output inductor so that it will operate with any safety features disabled, short circuited, linked out or by-passed in any way.

NEVER PLACE the induction power supply or an output inductor back into operation following maintenance or rectification activities until it has been determined by a Radyne-Authorized Service Technician to be safe for operation.

ALWAYS OPEN/CLOSE the water supply valves, slowly, to allow for a normal rise of pressure in the lines.

ONLY QUALIFIED personnel, as defined by OSHA 29 CFR Subpart S 1910.332 and 1910.147, are permitted to perform LOTO, electrical-related service, troubleshooting, load tuning, and/or maintenance activities (see **Section 2.3**).

NEVER TEST live voltages without wearing the required PPE for protection from the dangers associated with arc flash/blast and electric shock (NFPA 70E Standard and OSHA 29 CFR 1910 Subpart S regulation for specifics) (see **Section 2.3**).

DO NOT OPERATE if there exists signs of leaking water, loose or damaged wiring and/or parts that are otherwise not connected and/or constructed in the manner established by Radyne at the time of manufacture.

BE ALERT for changes in the noise level or the presence of safety alerts while operating the induction power supply.

NEVER APPROACH the induction power supply while it is in operation. Never approach if you have implants, such as, pacemakers, heart valves, and/or any other medical condition that can be compromised by electromagnetic fields. Always consult your physician before approach.

NEVER TOUCH any exposed electrical output terminals or high voltage areas before first verifying with a meter that the exposed areas are at a zero energy (V_{AC} & V_{DC}) state.

NEVER HOLD/TOUCH heated work pieces or their thermally connected components while the equipment is in operation or while they are otherwise at temperatures that can cause injury.

NEVER WEAR conductive items such as: watches, rings, earrings etc. while the equipment is in operation. This includes the area immediately surrounding the output inductor.

DO NOT USE/STORE combustible materials near any work area or heated object associated with the induction power supply.

Discharging Capacitors

Induction heating necessitates the use of capacitors that store charge. There are two fundamental ways to release the stored energy within the capacitors. These are the resistor bank and a grounding rod.

Utilizing the Resistor Bank

The induction power supply is equipped with self-discharging resistive circuitry which serves to discharge the capacitors after powering down the equipment (**Figure 2-5**). This process can take up to 2 minutes to complete.

Utilizing a Grounding Rod

If the capacitor discharge circuit were to malfunction, the self-discharging circuitry would be ineffective (**Figure 2-6**). This leaves stored charge and a dangerously high voltage present in the capacitor bank, as well as, all electrically connected components, capable of producing electrical shock-related injuries. Utilizing a grounding rod can be an effective means to eliminate this hazard.

WARNING:
Always verify with a meter that the equipment is at a zero energy (V_{DC}) state after discharging capacitors.

WARNING:
Always inspect the capacitors for signs of physical damage or swelling before attempting any removal and/or other activities that place any part of your person near a stored charge area.

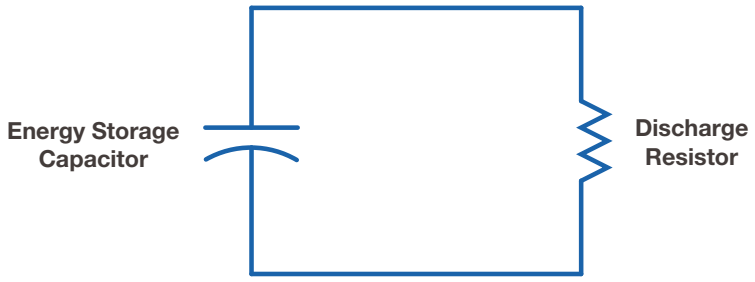


Figure 2-5: Capacitor Discharge Circuit Model (functioning condition)

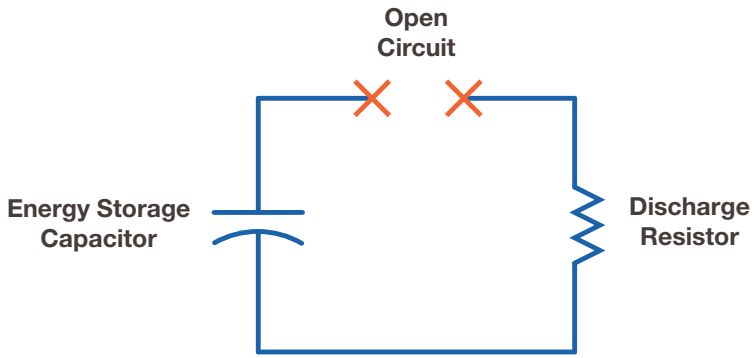


Figure 2-6: Capacitor Discharge Circuit Model (non-functioning condition)

Energy Isolation & Restore Details

The purpose of LOTO shutdown (**See Section 2.3**) procedure is to ensure that all energy sources are safely isolated and effectively controlled, prior to performing service and/or maintenance activity on the equipment. Effective LOTO procedures protect all persons from accidental injury and unnecessary damage to property due to unexpected equipment operation or movement and contact with live sources of energy. A representative example of the LOTO shutdown and restore power procedures for this equipment is provided below.

LOTO Shutdown Procedure

Step 1. Notify all affected persons

Step 2. Review energy specifications (**Table 2-1**)

Step 3. Shutdown equipment

Step 4. Isolate equipment from energy sources

Step 5. Apply lockout devices

Step 6. Dissipate all stored energy

Step 7. Visually inspect that all sources are disconnected, lockout devices are in place, tools, equipment, and personnel are removed from hazard areas

Step 8. Attempt restart

Step 9. Return all controls to their “Off” or “Neutral” condition

LOTO Restore Power Procedure

Step 1. Visually inspect that all tools, equipment and personnel are removed from hazard areas and all safeguarding and controls are operationally intact

Step 2. Verify that all controls are in their “Neutral” or “Off” positions

Step 3. Remove lockout devices

Step 4. Re-energize the equipment

Step 5. Notify all affected persons that the equipment is ready for use, if applicable

WARNING:
Never place the induction power supply or output inductor back into operation following maintenance or rectification activities until it has been determined by a Radyne Authorized Service Technician to be safe for operation.

Energy Isolation & Restore Details

Hazardous Sources of Energy and Isolation Specifications

Applying the information contained in **Table 2-2** is the responsibility of the customer and must be based on a hazard analysis specific to the type of troubleshooting and/or service work being performed. The responsibility of the customer is to also have a complete understanding of OSHA 1910.147 and NFPA 70E. The **Applicability** column was provided to assist in developing a task-specific plan. However, each scenario is different and careful consideration of the above named regulations is the only sure way to correctly apply current standards to the specifics of the task (See **Section 2.3**).

Hazardous Energy Type & Magnitude			Hazardous Energy Isolation Details			
Applicability	**Source(s)**	**Magnitude**	**Isolation Type**	**LOTO Locking Device**	**Method**	**Verification**
Line Side (All)	**Electrical** (System voltage)	**240/480V** 60 Hz, 3Φ	Plug	Plug lock	Isolate via breaker, wait 2 minutes, then unplug	Meter **(Section 2.10)**
Load Side (Only)	**Electrical** (System voltage)	**240/480V** 60 Hz, 3Φ	Panel Mounted Disconnect	Included lockout device (**Figure 2-7**)	Turn panel mounted disconnect to "OFF" position	Meter **(Section 2.10)**
Always	**Electrical** (Cap. tank circuit voltage)	> 1KVDC	Discharge with resistor bank or grounding rod **(Section 2.10)**			Meter **(Section 2.10)**
TBD by Client	**Coolant** (System pressure)	**100 PSI**	Valve	Ball valve lock	Close source valve, open return valve	Client Installed gauge (external)
TBD by Client	**Coolant** (Pump voltage)	**To be determined by customer**	**To be determined by customer**	**To be determined by customer**	**To be determined by customer**	**To be determined by customer**
Always	**Thermal** (heated compoents)	Up to 200˚F	Unless adequate PPE for the magnitude of the temperature is present, be sure to allow these parts to cool before attempting to touch.			

Table 2-2: Hazardous Energy & Isolation Specifications

Energy Isolation & Restore Details

Protective Boundaries Specifications

The purpose of the protective boundaries and their respective restrictions/ prohibitions is to protect persons from the hazards associated with electrical shock and arc flash/ blast events. The distances associated with each boundary is measured from the exposed live part. **Table 2-3** contains the specific protective boundary information applicable to the VersaPower® Xtreme™ induction power supply at the time of purchase. Maintaining compliance with NFPA 70E after date of purchase is the customer's responsibility (see **Section 2.3**).

Utilizing the Circuit Breaker Lockout Device

This device can be used to electrically isolate the output inductor circuit during output inductor change-outs and/or removals (**Section 4.3**). **Figure 2-7** depicts the process required to attach the included circuit breaker locking device.

WARNING:
In order to ensure that the device effectively eliminates accidental start-up, you must attempt to actuate the applicable electrical disconnect after securing it with a suitable lock.

Boundary Name	Boundary Distance	Persons Allowed to Breach	PPE Required
Arc Flash Protection Boundary	5' or 1.524 m	Protected Persons Only	Arc Flash-rated Protective Gear
Limited Approach Boundary	3' 6" or 1.07 m	Qualified or accompanied unqualified persons	Arc Flash-rated Protective Gear
Restricted Approach Boundary	1' or 0.305 m	Qualified persons only	Arc Flash-rated & Shock-rated Protective Gear
Prohibited Approach Boundary	1' or 0.305 m	Qualified persons only	Arc Flash-rated & Shock-rated Protective Gear

Table 2-3: Protective Boundaries Requirements

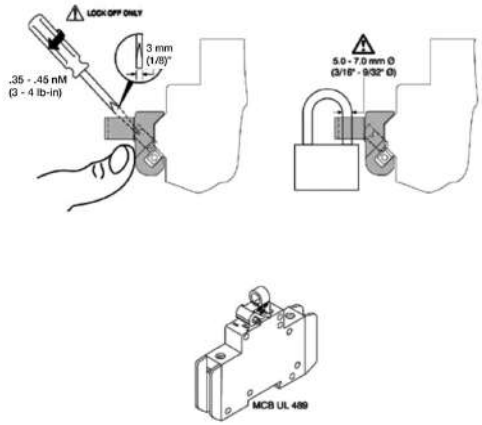


Figure 2-7: Circuit Breaker Lockout Device Attachment Procedure

Protective Guarding Features

- The front panel is secured with hardware that requires a tool to open. Securing it prior to operating prevents accidental exposure to energized components.

- The rear panel is secured with keyed-locks for safety and security. Using these as a method of control prevents unwanted tampering of equipment components, as well as, accidental exposure to energized components.

- Output mount covers (**Section 4.3**) must be installed on unused inductor output mounts, failure to do so will cause water to eject from the power supply when water pressure is applied.

Safety Standards & Regulations

Below is a list of regulations/standards related to the use of the VersaPower® Xtreme™ induction power supply, including but not limited to guarding & electrical safety. It is the sole responsibility of the customer to be familiar with and to maintain compliance with these regulations/standards while using this equipment, including all changes and/or rewrites enacted by the administrative body responsible for these listed regulations/standards, as well as, all other applicable regulations/standards after the date of purchase.

- Electrical Safe Work Practices Reference OSHA Subpart S 1910.333
- Standard for Electrical Safety in the Workplace NFPA 70E
- Guarding Reference ANSI B11.19-2003 Section 7
- Guarding Reference NFPA 70 (NEC) ARTICLE 665-5
- Guarding Reference OSHA 1910.212(a)
- LOTO Reference OSHA Subpart J 1910.147
- Personal Protection Reference OSHA Subpart S 1910.335
- Use of Equipment Reference OSHA Subpart S 1910.334

WARNING:
If operating this equipment outside of the United States, be sure to review the content of **Section 2.3** before continuing.

Power Supply Control

3.1	Purpose & Scope	21
3.2	General Induction Heating Theory	22
3.3	Output Inductor Design	23
3.4	Parameter Relationship Fundamentals	24
3.5	Output Magnitude Control	26
3.6	Power Supply Operation	29
3.7	Tuning & Impedance Matching	32

Purpose & Scope

The purpose of the content within this section is to assist you in becoming proficient with the VersaPower® Xtreme™ induction power supply and to empower you to take advantage of all the power supply has to offer. Please note that this information is not intended to present every aspect of any of these individual subjects, but merely explain the concepts in a way that will lead to more effective operation of the VersaPower® Xtreme™ induction power supply. If you desire in depth information for any of these, as well as, any other induction heating related topics, please contact Radyne. We encourage you to review this information in order to fully utilize all the capabilities and technological advancements of this power supply.

General Induction Heating Theory

Figure 3-1 depicts the general process of induction heating. As represented, a high frequency source of AC current (**Step 1)** travels through the output inductor. As this current passes through its turns, a large and rapidly changing magnetic field is generated (**Step 2**). When a conductive workpiece passes through this magnetic field, a voltage is developed that induces eddy currents to flow within it (**Step 3**). Workpiece resistance opposes the flow of these eddy currents and the energy required to overcome this opposition is released in the form of heat.

While **Figure 3-1** does accurately depict the basics physics process of induction heating, it doesn't express the frequency and temperature dependent complexities involved, which would lead to difficulty in predicting and controlling outcomes. For example, the rate and density of heat transfer, as well as, the depth of heat penetration are major considerations in induction heating and these are frequency and temperature dependent. Different heat propagation rates also play a significant role. For example, heat energy transferred as a result of the magnetic fields travels many times faster than does the heat transfer within the work piece, in absence of the magnetic field, as a result of the general energy movement from warmer to cooler regions.

Taking advantage of induction heating in spite of these inherited complexities requires cohesive agreement among the following four fundamental building blocks:

- A powerful and versatile induction heating power supply

- A precise output inductor design

- A simple and effective method of controlling and monitoring the complex parameter relationships

- A properly tuned load that achieves the best impedance match for a given heating application

When the agreement of these aspects of precision induction heating are combined with an effective recipe, you will find, that meeting your induction heating goals is simple.

For a more comprehensive explanation of the physics behind induction heating, contact Radyne and request a copy of *Basics of Induction Heating* by Chester A. Tudbury.

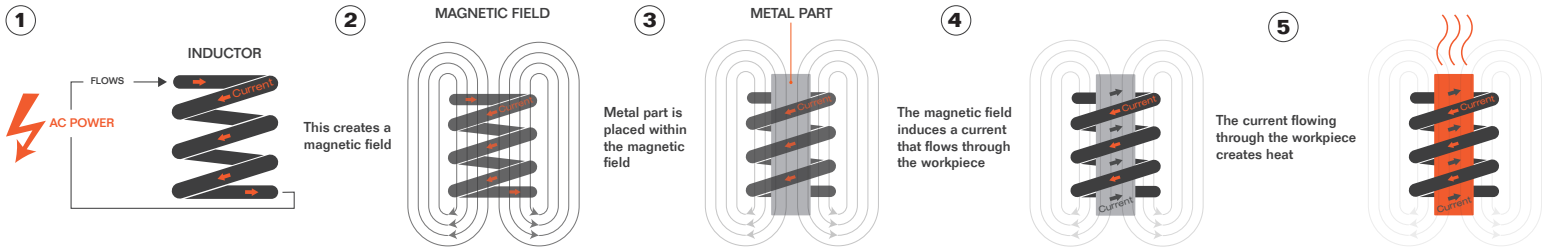


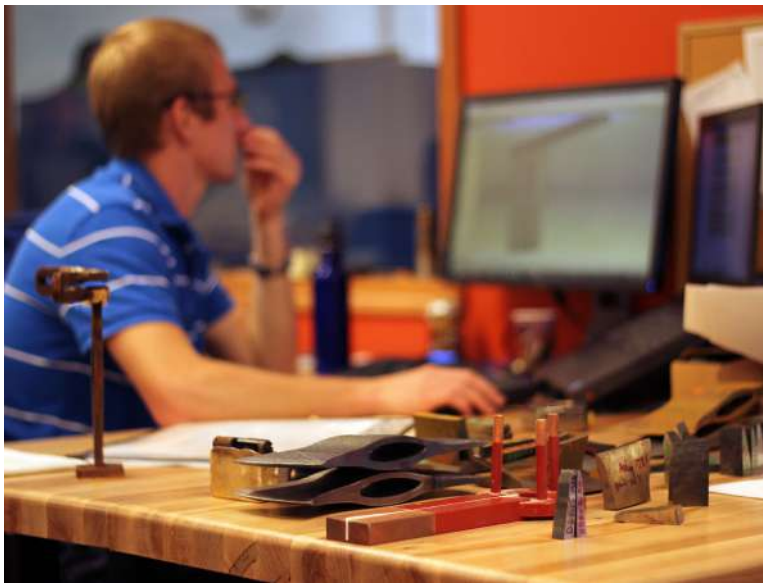
Figure 3-1: Process of Induction Heating

Output Inductor Design

As part of the sales process you have, at minimum, come to understand the importance of a precise output inductor design. In fact, if it were not for the precision of that design, most induction heating results would not be achievable and the ones that were would not be accomplished very efficiently.

If you have already purchased your output inductor from Radyne, be assured that output inductor geometry, turn quantity/orientation, inductance, as well as; work piece material, geometry, size, and load coupling were all precisely quantified, simulated, and analyzed to produce your specific heating outcomes. Also integrated into an output inductor designed and manufactured by Radyne are the insulation and cooling requirements needed to eliminate electrical arcing and workpiece to output inductor heat transfer, which when left unaccounted for, reduce the output inductor's life, efficiency, and power delivering capability.

If you haven't already done so, let the Radyne Coil Masters® expert inductor design and manufacture team put its 65 years of experience, electromagnetic/thermal computer simulation software, technologically advanced process development, and state of art research and testing laboratory to work for you. If you have any questions regarding an output inductor design or are in need of additional output inductor(s), please call the Radyne Aftermarket Service and Sales Department at 1-800-236-8360.



Parameter Relationship Fundamentals

At this point it is assumed that you have in your possession both a VersaPower® Xtreme™ induction power supply and an output inductor precisely designed to meet your induction heating goals. Therefore, the remainder of the material in this section is devoted to explaining some basic concepts influencing precision output magnitude control and how this power supply achieves it.

Interdependent Relationships

In order for you to become proficient with VersaPower® Xtreme™ induction power supply, there are six variables that you need to become, to a varying degree, familiar with. A general understanding of their interdependent relationships will ultimately produce effective recipe creation that produce precise outcomes. Based on the general operation of the induction power supply, the physics behind induction heating, and how you will interact within the process, we will now discuss temperature, frequency, power, voltage, current, and resonance as they relate to workpiece heating and one another. For simplicity, we will consider temperature and frequency as the input variables; power, voltage, and current as dependent outputs, and resonance as a state or condition. Keep in mind this viewpoint is strictly theoretical. Temperature is not an input in the classic sense, but viewing it that way does demonstrate how changes in temperature change how the load reacts to power, voltage, and current inputs. Additionally, viewing induction heating from this perspective does shed light on the complexity temperature change introduces to induction heating.

Temperature Dependency

Temperature plays a significant role in the magnitudes of power, voltage, and current during a heat cycle. However, if the temperature change did not involve crossing a material's Curie temperature, their relative magnitude change would be minimal when viewed alongside their much larger magnitudes. However, many applications involve surpassing a material's Curie temperature and the resulting impact cannot be overlooked. **Figure 3-2** shows how the magnitude and slope of the output power characteristic changes as a material passes through its Curie temperature. Notice if frequency were held constant while the blue plot was gradually changed into the red plot, that the magnitude of the output power would increase significantly as it passes through the maximum peak, then decreases on the low frequency side of the curve, before finally settling at a magnitude value much greater than at temperatures below Curie. Similar could be proved for the voltage and current characteristics as well.

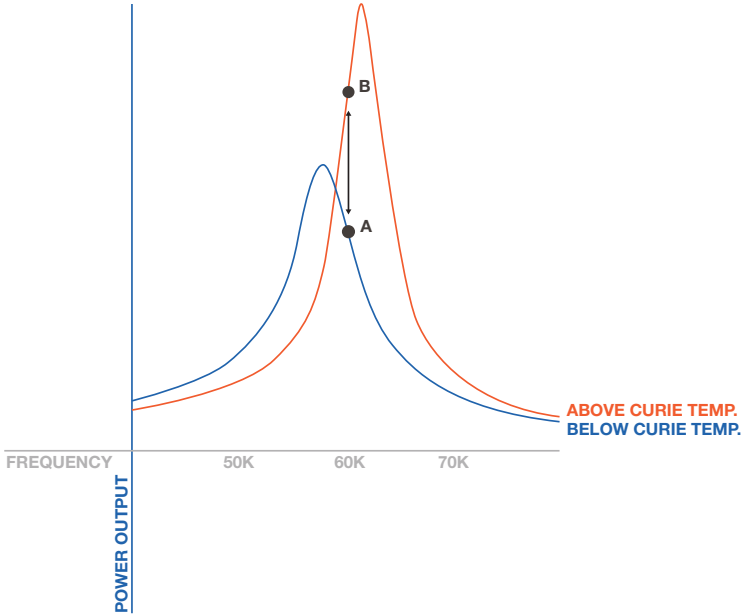


Figure 3-2: Power Output vs. Temperature (above/below Curie)

Parameter Relationship Fundamentals

Nonlinear Frequency Dependency

Figure 3-3 depicts the representative output characteristics for power, current, and voltage as functions of frequency. These plots represent the typical mid-range output inductor geometry, with a medium to high quality factor, and within a properly tuned load condition. Notice that all three approach maximum in response to some frequency. At this point it is convenient to think of these characteristic curves as representing what is possible as a result of a specific output inductor design and workpiece material type before the induction power supply is actually turned on (temperature change ignored).

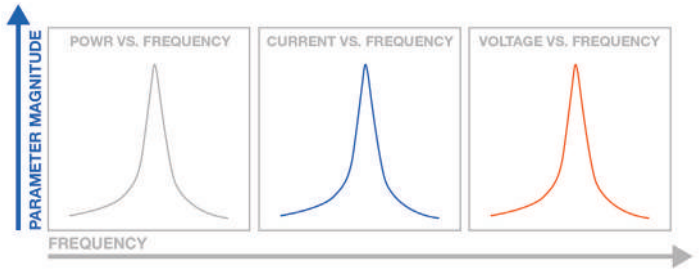


Figure 3-3: Magnitude vs. Frequency (individual plots-all)

The three plots of **Figure 3-3** appear identical, however, their differences become readily apparent once we superimpose all three characteristics and the associated phase characteristic (used to establish the resonance condition), on a single plot and narrow the focus to the area immediately surrounding their maxima (**Figure3-4**). Notice for this particular case, that, current approaches its maxima first (higher frequency), followed by power, voltage, and the resonance condition. Considering, that, real power (useful for heating) is dependent on voltage, current, and phase and that all of these change differently in response to temperature and frequency, shows the complexity associated with the dynamics of these parametric relationships. However, in terms of precision induction heating, they all can be directly related to a single controllable variable, namely, frequency even though they each relate differently to it.

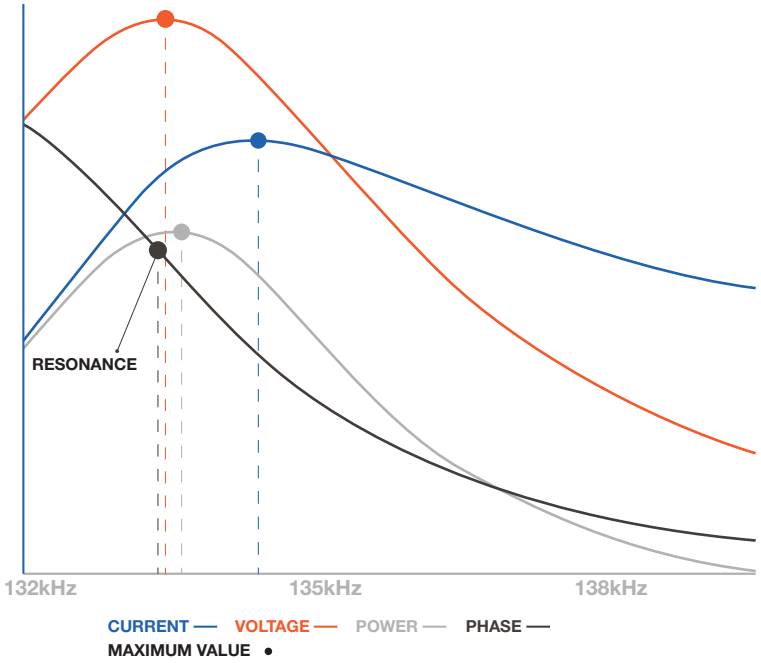


Figure 3-4: Magnitude vs. Frequency (narrow range-all)

Output Magnitude Control

Introduction

In the previous section, the key parameters of induction heating were identified. Also discussed was the complexities of their parametric relationships and the fact, that, these relationships nonlinearly change in response to temperature (more so when passing through Curie) and frequency. Lastly, frequency was identified as the primary parametric variable for relating output magnitudes to input conditions. You may, now, wonder how, amidst all the parametric complexities, could you, as an operator, know what to set the magnitudes of various inputs to in order to establish and maintain the required parameters during an entire heating cycle. The short answer is you don't have to. The VersaPower® Xtreme™ induction power supply utilizes limit-based control and once you have a simple understanding of the basic principles behind it, you are well on your way to achieving successful induction heating outcomes, proficiently.

Hard & Soft Limits

With limit-based control, there are essentially two general categories of magnitudes that you need to be familiar with. These categories are hard limits and soft limits.

Hard limits: Non-adjustable limits corresponding to a magnitude range between a minimum and maximum value based on power supply design, component ratings, and the applicable safety standards. Hard limits directly relating to power supply output performance are: low and high frequency, power, voltage, current, and resonance.

Soft limits: Digitally adjustable limits are set by the operator or the recipe creator within the respective hard limit ranges via the LCD interface (**Section 6-4**). The digitally adjustable output magnitudes are: power, voltage, and current.

Output Magnitude Control

Limit-based Control

Limit-based control is a method of controlling output magnitudes by setting the adjustable soft limits magnitudes, which the power supply cannot be exceeded during a heat cycle. **Figure 3-5** depicts how the soft limit, hard limit, and maximum (peak) magnitudes relate to one another as a function of frequency during an ideal heating moment in time. At any given instance the magnitude of all three is determined by the soft limit of output condition that has its soft limit at a magnitude which is realized at the highest frequency.

Figure 3-5 represents the ideal scenario in other ways, namely, the respective ordering of the soft limit, hard limit, and maximum value are same for each plot, all three values within each plot are very close to one another, and all contain the clustering near their respective maxima. Similar results can be expected for properly tuned loads where the output power is the near maximum possible value. Conversely, under poorly tuned load conditions, the hard and soft limits appear much farther away from the corresponding maximum values or do not intersect the output characteristic plot at all. Achieving successful heating outcomes requires that the person responsible for load tuning and recipe creation know the fundamental ideas behind how the three plot magnitudes relate and the consequence of a poorly tuned load condition.

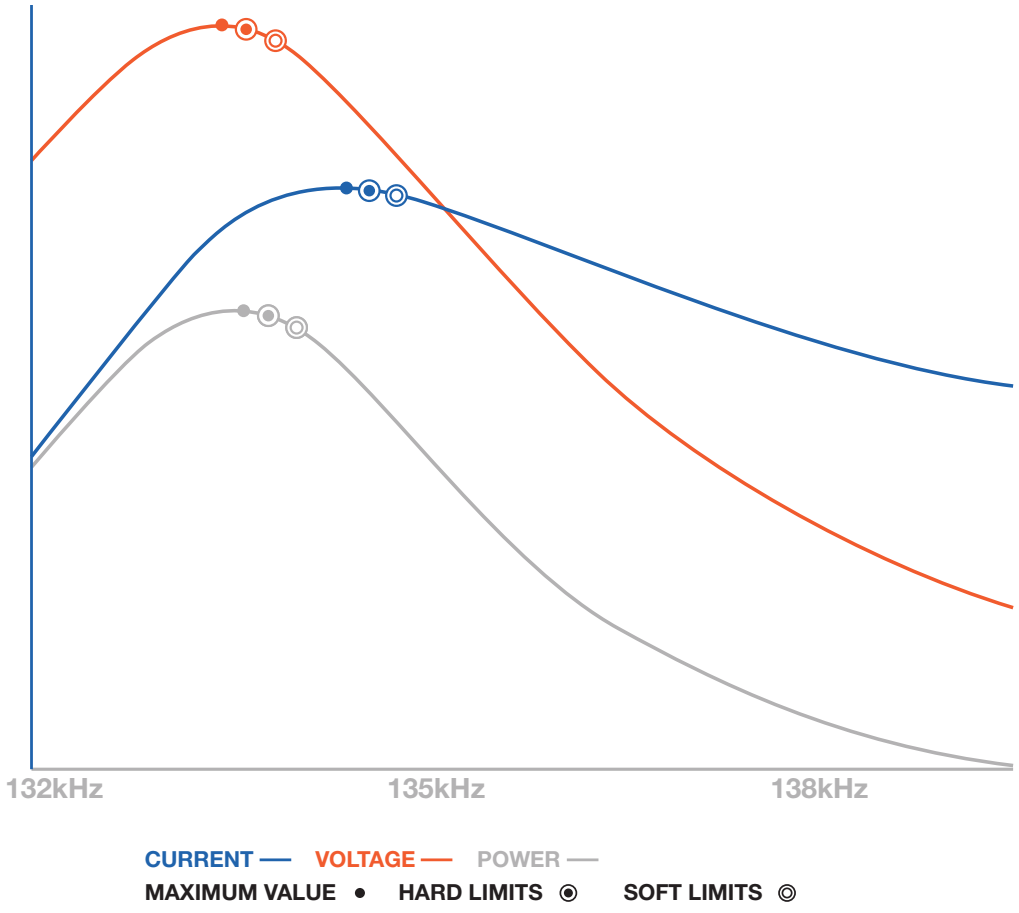


Figure 3-5: Output vs. Frequency (ideal limit relationships)

Output Magnitude Control

Dual-Directional Frequency-based Tracking

The resonance plot and the directed frequency tracking, **Figure 3-6**, shows the general way in which the power supply achieves the output magnitudes during the heat cycle. This will serve to consolidate all the principles previously discussed. Upon starting a heat cycle, the power supply begins a frequency-based tracking routine starting at the applicable model's highest allowable operating frequency. Measurements are taken for each output condition and phase and then compared to the model specific hard limits, the phase angle for the resonance condition, and the soft limits set by the operator.

The initial magnitudes for all three output conditions (power, voltage, and current) are established by whichever limit or maxima the power supply encounters first as it pursues the condition of resonance. For example, if the soft limit magnitude for power was set at 'B', then all output magnitudes would be lower and the dominating limit for the heating cycle would be power. However, for a power soft limit setting at 'A', current would be the dominating limit and all other output magnitudes would be as shown in **Figure 3-6**.

During the heating cycle, when load conditions change as a function of temperature, the dual directional frequency tracking technology of the VersaPower® Xtreme™ induction power supply, allows the power supply to respond by changing the direction of this initial frequency sweep. This capability coupled with the continual pursuit of resonance means that no matter what the scenario, as far as the power supply is concerned, it seeks to produce the most efficient power output possible. These advanced features greatly simplify the VersaPower® Xtreme™ induction power supply for the recipe creation process and establishes repeatability, thereby, making the desired heating outcome a reality.

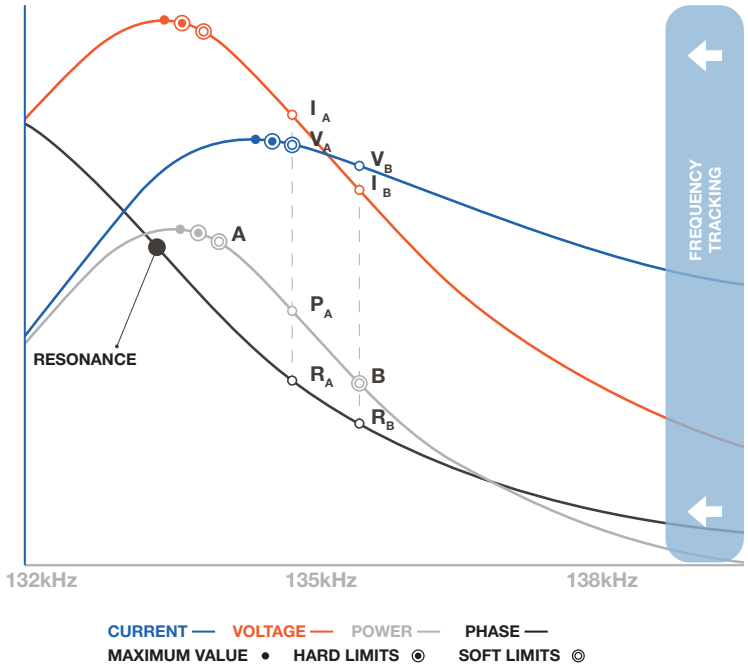


Figure 3-6: Output Characteristics vs. Frequency (dominating limit)

Power Supply Operation

Theory of Operation

The block diagram of **Figure 3-7**, depicts the fundamental circuit blocks (Protection, Power, Output, and Control) of the VersaPower® Xtreme™ induction power supply. Here, the power circuit block converts a 3-phase 50/60Hz input to a high frequency AC power and delivers it to the output circuit block. The output circuit block serves mainly as an interface between this delivered power and the desire heating outcome, whereby, a variety of output inductors can be connected to achieve the desire heating outcome. However, as indicated previously, it is controlling and maintaining the desired output parameters specific to the desired heating outcome. This accomplished via the control circuit block. The control circuit block continually monitors the respective "real world" magnitudes and compares them to the soft/hard limit settings. A single "cycle" is completed when the control circuit block communicates the required adjustments to the power circuit block, thereby maintaining the soft limit parameters and ultimately, the desired heating outcome. This process is repeated continually until the heating cycle has concluded.

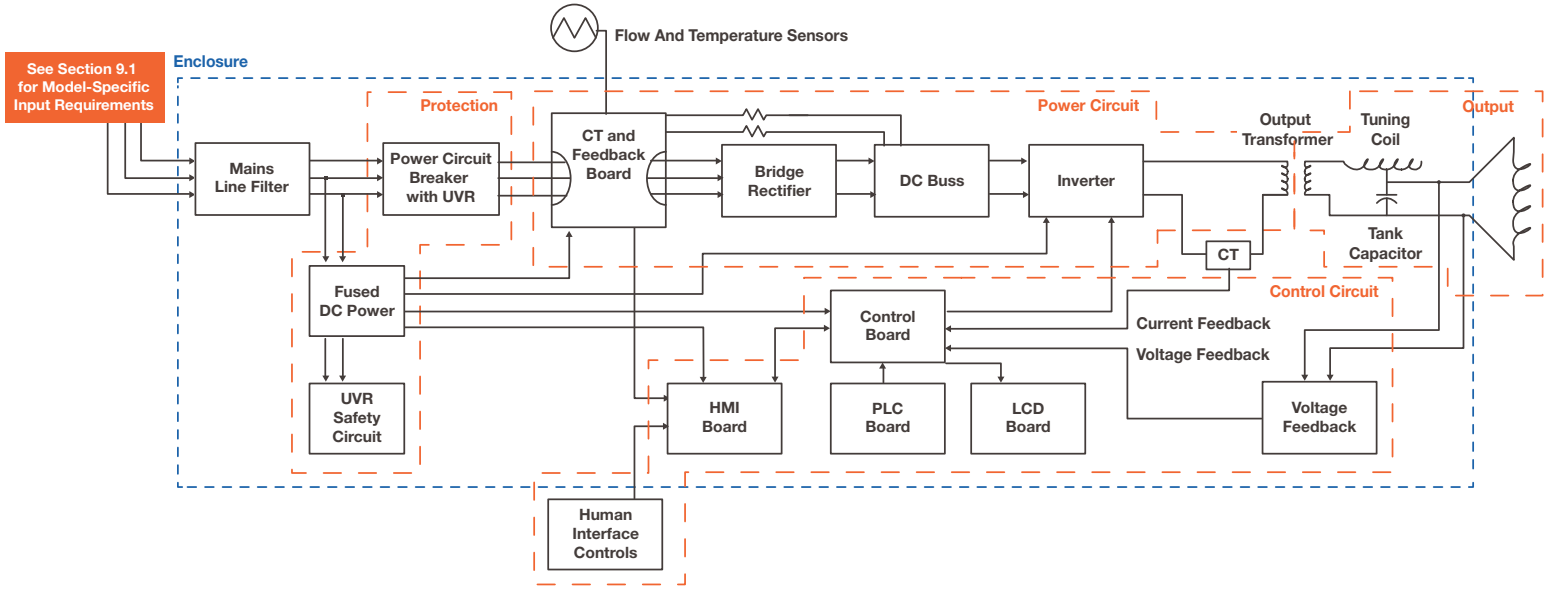


Figure 3-7: Power Suply Operation Block Diagram

Power Supply Operation

Protection Circuit Block

Figure 3-8 represents the protection circuit block. This circuit breaker is a means to safely prevent energy from transferring to the power circuit. The under voltage relay (UVR) will automatically disconnect power during unsafe conditions. The fused DC power supply provides the correct voltage to the control circuit and other circuit boards, while the UVR safety circuit is responsible for the automatic triggering of the UVR. Unsafe conditions such as open doors or an actuated e-stop button will trigger the UVR and disconnect power via the power circuit breaker.

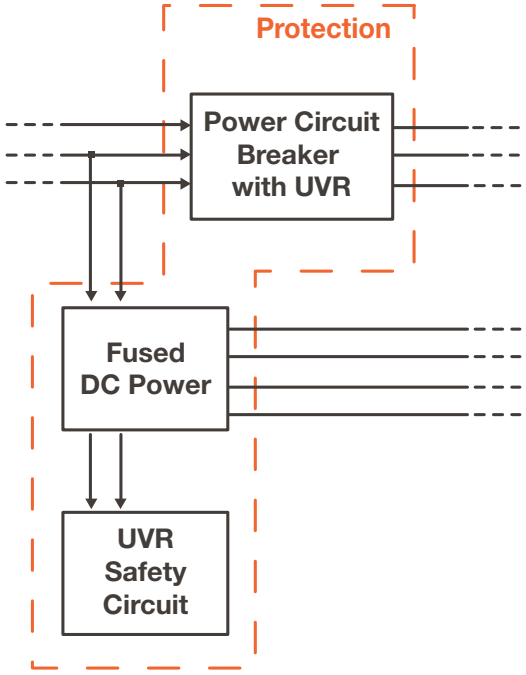


Figure 3-8: Protection Circuit Block Diagram

Output Circuit Block

Figure 3-9 represents the output circuit block. The output circuit utilizes a paralleled tuned "tank" circuit consisting of an adjustable capacitor bank, an adjustable series inductor, as well as, the output inductor. The capacitance of the capacitor bank, as well as, the combined contribution of the series and output inductance determines the natural resonant frequency of the tank circuit. The resonant frequency must be within the range of the inverter for the VersaPower® Xtreme™ to operate. Output voltage is measured here and fed back to the control system. The output inductor is attached to the terminals of the parallel "tank" circuit via the output inductor mount.

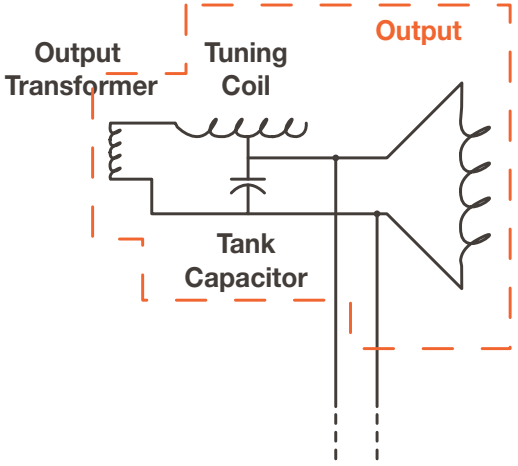


Figure 3-9: Output Circuit Block Diagram

Power Supply Operation

Power Circuit Block

Figure 3-10 represents the power circuit block. Here a 390-490 V_{AC} 3Φ 50/60Hz supply voltage is fed through the protection circuit block into a 3Φ full wave bridge rectifier where it is converted into DC power. The purpose of the inverter is to convert the DC power into a higher frequency AC power required for the output circuit's load. The inverter consists of MOSFETs arranged in a full bridge configuration. Inverter current is measured here and fed back to the control system.

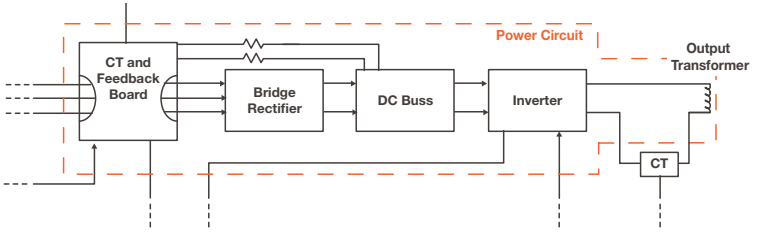


Figure 3-10: Power Circuit Block Diagram

Control Circuit Block

Figure 3-11 represents the control circuit block. The purpose of the control circuit is to receive the operator's commands, control the operation of the equipment, and monitor/display statuses of the operating parameters of the equipment. The control circuit takes the soft limit set points and drives the MOSFET inverter frequency to control the output inductor. The control circuit also consists of remote interface subsystem where the equipment can be switched on and off manually, remotely or if desired, be controlled automatically as part of a large process control assembly.

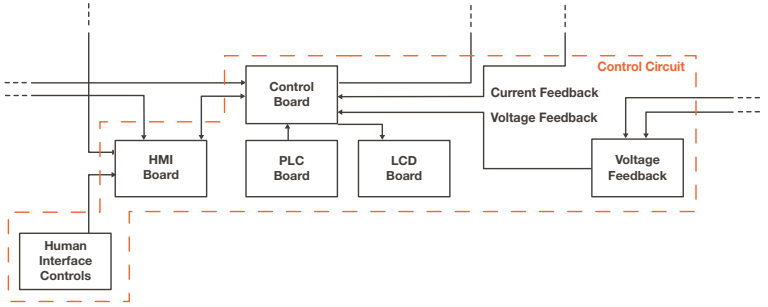


Figure 3-11: Control Circuit Block Diagram

Tuning & Impedance Matching

Introduction

In order to deliver full rated power from the power supply to the workpiece it is essential that the load impedance be as closely matched to the power supply output impedance as possible. Load tuning is the process, whereby, this is accomplished.

The process of load tuning can conveniently be divided into two specific processes. One side of the ledger pertains to the desired heating process outcomes which are directly related to the desired operating frequency range and quality factor (Q). The values of these two criteria are determined by the desired heating depth, material type, and the specific heating process. The second aspect of load tuning involves the VersaPower® Xtreme™ induction heating power supply and the physical component adjustments (**Section 5.2** & **Section 5.3**). This process is greatly assisted by the power supply itself, in the form of the load tuning calculator (**Section 5.6** & **Section 6.10**) and monitoring output magnitudes while conducting manual mode single step heating (**Section 5.4** & **Section 6.4**).

Adjusting Series Inductance

Adjusting the inductance value of the series inductor to achieve an optimally tuned condition is just as simple. Increasing the VersaPower® Xtreme™ induction power supply's series inductor tap setting increases the total inductance (**Section 5.2**). The maximum achievable inductance of the series inductor depends on the mode of operation. When operating normally, the maximum inductance is 4.2 µH, while operating with the Extended Range enabled provides for a maximum total inductance of 10.54 µH (**Section 6.10**). All that remains to achieve proper load tuning is to understand when to adjust the specific values of inductance. Because many factors could complicate this decision, the VersaPower® Xtreme™ induction power supply is equipped with a load tuning calculator that makes this process extremely simple.

Adjusting Capacitance

The design of the VersaPower® Xtreme™ induction power supply makes adjusting the parallel capacitance to achieve an optimally tuned state easy. **Section 5.3** provides the step-by-step procedure to physically adjust capacitor components. Understanding how each specific adjustment (increase/decrease) affects operating frequency and ultimately load tuning is all that is required in order to achieve the desired optimally tuned condition. Capacitors installed on the capacitor mounting array are interconnected in parallel, therefore simple add the capacitance values of the installed capacitors provides the total capacitance.

Installation, Setup & Removal

4.1	Overview & Personnel Qualifications	34
4.2	Receiving	35
4.3	Mounting & Placement	36
4.4	Output Inductor Attachment & Change Out	37
4.5	Power Connection & Inspection	38
4.6	Coolant System Connection & Inspection	39
4.7	PLC-Controlled Device Connection	40
4.8	Electrical & Water Supply Removal	41
4.9	Winterizing	42
4.10	Shipping Preparation	43

Overview & Personnel Qualifications

The procedures within this section address the activities specific to receiving, installation, set-up, and winterizing for the VersaPower® Xtreme™ induction power supply. These activities prepare the induction power supply for normal operation and shipping. There are several factors which have a bearing on the health and safety aspects concerned with this induction power supply and its corresponding output inductors. These factors include: weight, live voltage, electromagnetic waves, and heat.

Persons performing activities that prepare this power supply for normal operation (**Section 5**) must be suitably qualified person possessing the knowledge and experience required for this type of activity. At no time is it acceptable to overcome manufacturer provided guards or safety interlocks. It is the responsibility of the customer to ensure that all and earth/ground circuits are correctly fitted and fully functional, as well as, making sure the induction power supply and coil are in a safe condition to be operated. Never allow the handling, installation, commissioning, operation, maintenance, fault finding or rectification of this induction power supply or output inductor to be carried out by personnel other than those who have been suitably trained and declared competent to carry out such tasks.

Before interacting with this equipment in the manner described within this section, be sure to review and understand the entire procedure, all referenced section material, and all **Section 2** content. If you have any questions about direct application of the procedures within this section or the safety and health factors related to it, please contact Radyne before implementing the activity.

Receiving

Equipment & Components

- VersaPower® Xtreme™ induction power supply

- CD-ROM or flash drive of the VersaPower® Xtreme™ operations manual

- 2 security lock keys

- Capacitors
  6 x 2.40 uF (20 - 80 kHz models)
  6 x 0.66 uF (100 - 400 kHz models)

- Tuning nut
  3 - 10kW models (5 / 16” - 18 thread x 1” hex)*
  15 - 30 kW models (3 / 8” - 16 thread x 3/8” hex)*

- External PLC cable

- Circuit breaker locking device

If any of the listed equipment or components are missing, please contact Radyne.

Do not discard equipment packaging. To prevent physical damage, the original equipment packaging should be used when shipping the equipment.

Process:

Step 1. Remove all packaging

Step 2. Inventory contents

Step 3. Inspect for damage

Report all equipment and/or component damage immediately to the shipping carrier and Radyne.

Do not attempt to install, use, and/or operate this equipment, its dedicated spare parts, and/or accessories when damaged.

*** Not available on series VX units (series units have a designation of ‘S’ in the model number)**

Moving & Placement

Equipment & Components

- Lifting aid (recommended)

- Phillips screw driver (customer to provide)

- 4- vibration-damping sandwich mounts* (Radyne P/N 13493)

*Can be supplied by Radyne Corporation by contacting the Aftermarket Sales and Service Department at 1-800-236-8360

Process:

Step 1. Plan transport (weight, route, lifting aids, etc.)

Step 2. Determine required spacing (equipment dimensions, panel doors swing radius, operator spacing, etc.) (**Section 9**)

Step 3. Determine effective operator height (optimum viewing angle) (**Section 9**)

Step 4. Inspect placement/mounting surface (flat, free of debris, free of moisture, etc.)

Step 5. Drill required mounting holes (**Section 9**)

Step 6. Remove standard feet (**Figure 4-1**)

Step 7. Thread the stud portion (sandwich mounts)

Step 8. Locate Induction power supply on surface

Step 9. Secure sandwich mounts to surface with included hardware

Spacing and transport safety requirements must meet the applicable governing safety regulations and industry standards (**Section 2.15**).

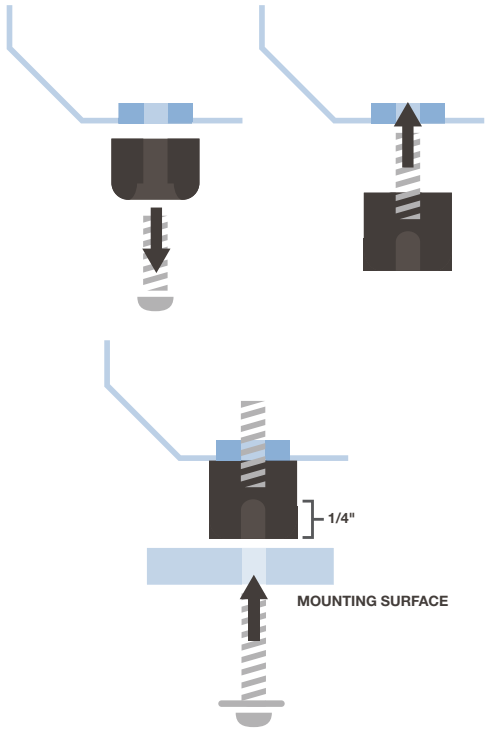


Figure 4-1: Feet Removal & Replacement

If you are not securing the induction power supply with vibration-damping sandwich mounts, place power supply on surface after **Step 4.**

See **Figure 4-1** to reference necessary thread engagement and adjust screw length based on mounting surface thickness.

Output Inductor Attachment & Change Out

Equipment & Components

- Radyne manufactured output inductor (w/ hardware)*

- Non-Radyne manufactured output inductor
  Connection hardware:* (thread < 1 inch; nonferrous fasteners only)
  Screw Sizes include:
  4 Brass screws (¼"-20 thread x 1" or 1.25")
  4 Brass washers
  4 Lock washers

- Output mount cover (w/ hardware)*

- Bucket(s)

*Can be supplied by Radyne Corporation by contacting the Aftermarket Sales and Service Department at 1-800-236-8360

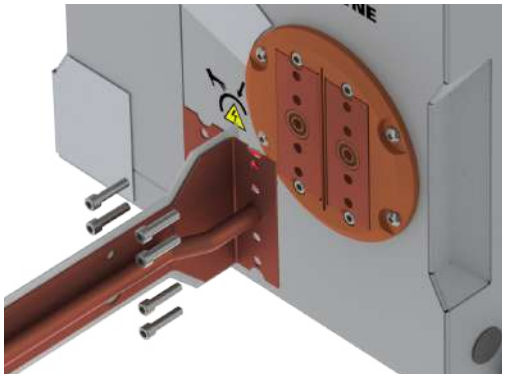


Figure 4-2: Output Inductor Installation/Removal

Process:

Step 1. Implement effective equipment energy shutdown procedure (**Section 2.13**)

Step 2. Close water supply/return valves

Step 3. Install/remove output inductor (**Figure 4-2**)

Step 4. Install output mount cover on unused side(s) (**Figure 4-3**)

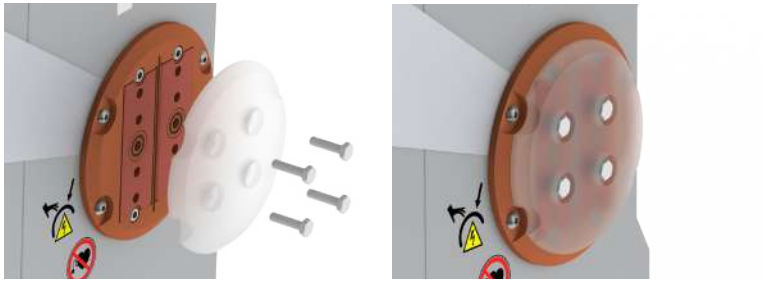


Figure 4-3: Output Inductor Mount Cover (attached)

See **Section 4.6**, if output inductor mount cover installation required.

WARNING:
Be sure to verify a zero voltage state before changing output inductors and/or output mount covers (**Section 2.10**).

Power Connection & Inspection

Equipment & Components

- N/A

Process:

Step 1. Verify upstream breaker design/rating (**Section 9.1**)

Step 2. Verify operating voltage match (**Figure 4-4**)

Step 3. Plug in equipment

Step 4. Press the power button

Step 5. Trip circuit breaker, verify operational

Step 6. Actuate E-stop, verify operational

WARNING:
If power supply assembly requires hardwired installation a qualified/licensed electrician is required.

WARNING:
Do not operate if the circuit breaker or E-stop is ineffective (**Step 5** & **Step 6**), and contact Radyne immediately.

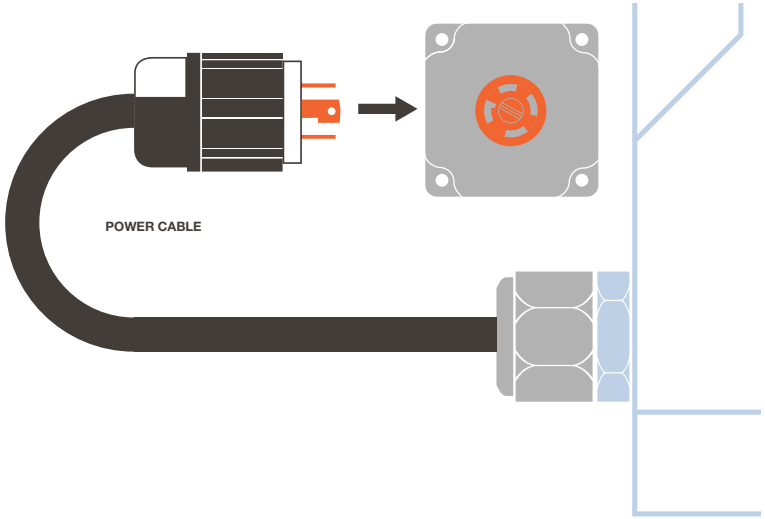


Figure 4-4: Power Cord Assembly

Coolant System Connection & Inspection

Equipment and Components

- Connection fittings* (brass or stainless steel only)

- 2 Output inductor mount covers

- Security lock key

*Can be supplied by Radyne Corporation by contacting the Aftermarket Sales and Service Department at 1-800-236-8360

Process:

Step 1. Connect fittings as shown (**Figure 4-5**)

Step 2. Install output mount covers and/or output inductor (**Section 4.3**)

Step 3. Attach water supply/return lines

Step 4. Open supply/return valves

Step 5. Test/inspect for leaks

WARNING:
Do not turn on water supply until both output mounts have output inductors and/or output mount covers secured to them.

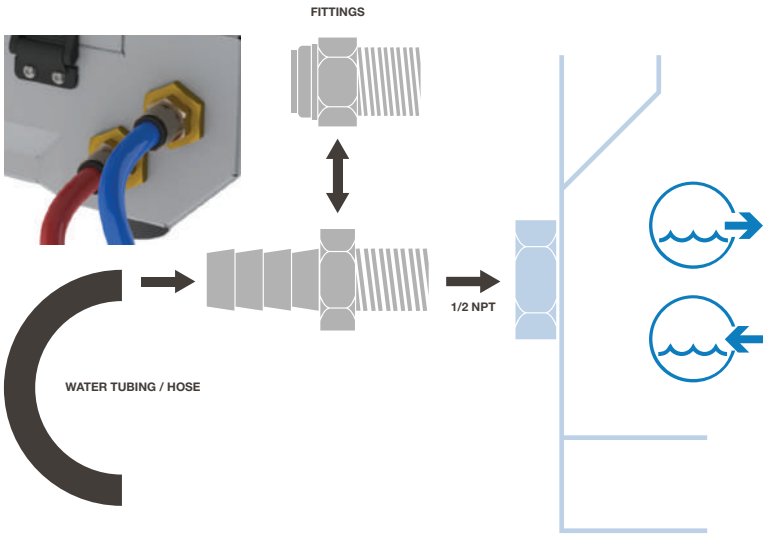


Figure 4-5: Coolant Fluid Connection Assembly

PLC-Controlled Device Connection

Equipment & Components

- PLC connected device(s)

Process:

Step 1. Review and apply all applicable **Section 2** safety-related content

Step 2. Implement effective equipment energy shutdown procedure (**Section 2.13**)

Step 3. Ensure PLC connected device electrical and functionality characteristic match with the PLC Specifications (**Section 9.4** & **Section 9.5**)

Step 4. Determine specific PLC electrical connections and function desired

Step 4. Implement menu interface settings (**Section 9.6** & **Section 6.8**)

Step 5. Press the Menu button to verify settings

Step 6. Remove PLC Connector protective plug and connect

Step 7. Ensure the correct functionality of PLC device for all applicable scenarios

Step 8. Train operator(s) in the safe use of the PLC device(s)

All damage resulting from improper installation of a PLC device is the responsibility of the customer and will void applicable warranty provisions.

WARNING:
Do not attempt to connect PLC devices without fully reviewing and applying the applicable safety requirements and protections contained within **Section 2 (Health & Safety)**.

Electrical & Water Supply Removal

Equipment & Components

- Bucket

- 2 Cap plugs

- Security lock key

- Out of service tag

Process:

Step 1. Implement effective equipment energy shutdown procedure (**Section 2.13**)

Step 2. Close water supply/return valves

Step 3. Wait 2 minutes then discharge capacitors (**Section 2.12**)

Step 4. Verify zero energy (V_{AC} & V_{DC}) state (**Section 2.10**)

Step 5. Locate bucket to collect water exiting from water in/out ports

Step 6. Disconnect water supply/return line connections from equipment

Step 7. Remove all standing water

Step 8. Plug the NPT water in/out ports with cap plugs

Step 9. Remove hard-wired electrical connection (if applicable)

Step 10. Tag the unit with an out of service label

WARNING:
Be sure to review all applicable **Section 2** safety content before attempting this process.

Winterizing

Equipment & Components

- 2 Output inductor mount covers (w/hardware*)
- Output inductor (w/hardware*)
- 6 - 8 oz premixed Glycol solution
- Winterized warning label
- Pressurized air supply
- Air nozzle
- Squeeze bottle
- Bucket
- 2 Cap plugs

*Can be supplied by Radyne Corporation by contacting the Aftermarket Sales and Service Department at 1-800-236-8360.

Winterizing the VersaPower® Xtreme™ induction power supply is required when outside weather temperatures are likely to reach near freezing anytime during the day or night. This prevents damage to the internal fluid cooling system during temperatures that are near freezing. If this equipment is not winterized prior to shipping and temperatures reach near/below freezing, the applicable warranty provisions will be voided and all weather-related damage is the responsibility of the customer.

Process:

Step 1. Install one output mount cover and one output inductor (Section 4.3)

Step 2. Locate bucket to collect water exiting from water out port

Step 3. Remove the NPT water in/out ports with cap plugs

Step 4. Blow air through the water in port (Do not exceed 30 psi) until dry

Step 5. Squirt 6 to 8 oz. of propylene glycol or ethylene glycol solution into cooling system through the water in port

Step 6. Force the glycol-based solution with pressurized air through the water in port (Do not exceed 30 psi)

Step 7. Repeat Step 5 and Step 6 until the glycol solution begins to exit the water out port

Step 8. Remove the output inductor and replace it with an output cover (Section 4.6)

Step 9. Plug the NPT water in/out ports with cap plugs

Step 10. Tag the unit with a winterized warning label

WARNING:
Be sure to implement the Electrical & Water Supply Removal procedure (**Section 4.7**) before attempting this procedure.

Use the glycol solution mix tables (**Section 9.2**) to determine the correct glycol-based solution.

Shipping Preparation

Equipment & Components

- Original Equipment packaging

- Shipping materials (as indicated)

Be sure to implement the Winterizing procedure (**Section 4.8**) if applicable.

Process:

Step 1. Coil and zip tie the power cord (if applicable)

Step 2. Bubble wrap the entire plug housing (if applicable)

Step 3. Place induction power supply into packaging (lifting aid recommended)

Step 4. Place keys (security lock) into a small plastic bag and place into packaging

Step 5. Verify the cord grip in the rear of the unit is lined up with the dedicated foam cutout section

Step 6. Place the top foam section over the unit and close the top flaps of the box

Step 7. Securely tape the box shut

Step 8. Attach necessary shipping labels

Step 9. Band and skid as appropriate

If the original packaging was not retained, be sure that packaging materials are rated for the weight of your model number (**Section 9**), that the foam inserts are a minimum of 2” (50mm) in depth so that they create a minimum distance between package walls and the equipment of 2” (50mm), and that the Induction power supply is snug within the packaging to protect the induction power supply from damage due to shipping vibrations. Damage resulting from poor packaging will void applicable warranty provisions.

Normal Operation

5.1	Overview & Personnel Qualifications	45
5.2	Inductance Adjustment: Series Inductor	46
5.3	Capacitance Adjustment: Mounting Array	47
5.4	Single-Step Workpiece Heating	48
5.5	Multi-Step Workpiece Heating	48
5.6	Load Tuning	49

Overview & Personnel Qualifications

The procedures within this section address the activities specific to normal operations for the VersaPower® Xtreme™ induction power supply. These activities are defined as those that utilize the induction power supply to produce the conditions for creating the final workpiece. There are several factors which have a bearing on the health and safety aspects concerned with this induction power supply and its corresponding output inductors. These factors include: weight, live voltage, electromagnetic waves, and heat.

Persons performing these activities with the induction power supply must be suitably qualified person possessing the knowledge and experience required for this type of activity. At no time is it acceptable to overcome manufacturer provided guards or safety interlocks. It is the responsibility of the customer to ensure that all and earth/ground circuits are correctly fitted, fully functional, and the induction power supply, as well as, its connected components are in a safe operating condition. Never allow operation of the induction power supply to be carried out by personnel other than those who have been suitably trained and declared competent to carry out such tasks.

The procedures within this section do not specifically address the actions required for presenting or removing a workpiece with respect to the output inductor. The responsibility for safe implementation of these and related activities is the responsibility of the customer.

Before interacting with this equipment in the manner described within this section, be sure to review and understand the entire procedure, all referenced section material, and all **Section 2** content. If you have any questions about direct application of the procedures within this section or the safety and health factors related to it, please contact Radyne before implementing the activity.

Inductance Adjustment: Series Inductor[1]

Equipment & Components

- Wrench*

- Security lock key

*Can be supplied by Radyne Corporation by contacting the Aftermarket Sales and Service Department at 1-800-236-8360.

1. This adjustment is not available on series based VersaPower® Xtreme™ units (series based units are denoted with a 'S' in the model number).

Process:

Step 1. Implement effective equipment energy shutdown procedure (**Section 2.13**)

Step 2. Unlock/open the rear equipment panel

Step 3. Remove and place tuning nut as desired (**Figure 5-1**)

Step 4. Secure tightly

Step 5. Close/lock the rear equipment panel

⚠ Be sure to verify a zero energy (V_{AC} & V_{DC}) state before beginning this procedure (**Section 2.10** & **Section 2.12**).

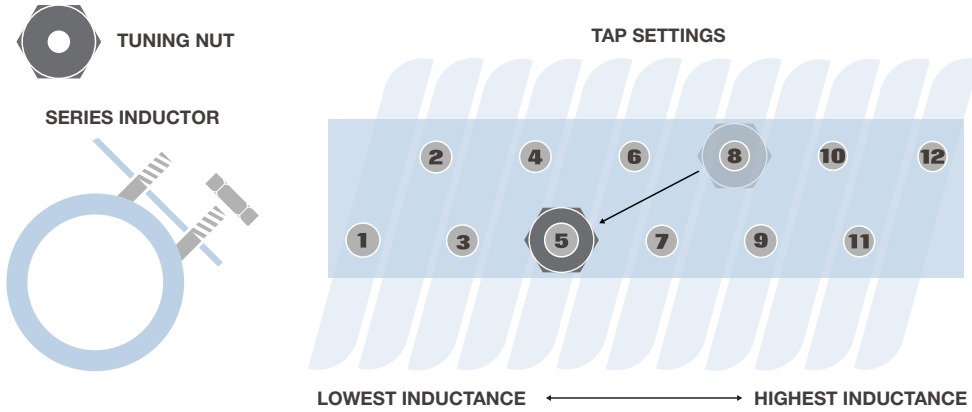


Figure 5-1: Series Inductor Adjustment

Capacitance Adjustment: Mounting Array

Equipment & Components:

- Capacitors*

- 5 / 32” alan wrench

- Rear panel locking apparatus

*Can be supplied by Radyne Corporation by contacting the Aftermarket Sales and Service Department at 1-800-236-8360.

Process:

Step 1. Implement effective equipment energy shutdown procedure (**Section 2.13**)

Step 2. Unlock/open the rear equipment panel

Step 4. Remove/add capacitors to mounting array (**Figure 5-2**).

Step 5. Securely fasten the securing bolts

Step 6. Close/lock the rear equipment panel

Be sure to verify a zero energy (V_{AC} & V_{DC}) state before beginning this procedure (**Section 2.10** & **Section 2.12**).

Capacitors installed on the Capacitor Mounting Array (**Figure 5-2**) are in parallel. However, for optimal results, populate the array closet to series inductor first and attempt to use equivalent values capacitors. If tuning specifications require the use of differing capacitor values, always place the largest valued capacitors nearest to the series inductor.

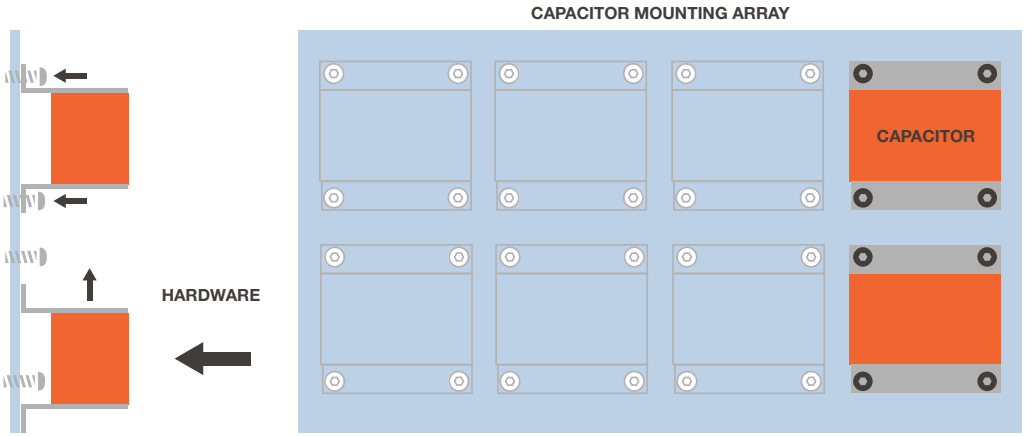


Figure 5-2: 8-Capacitor Mounting Array

Single-Step Workpiece Heating

Equipment & Components

- N/A

Process:

Step 1. Implement equipment startup procedure **(Section 5.6)** if applicable

Step 2. Present workpiece to output inductor as required

Step 3. Implement Workpiece Heating (**Manual Mode**) (**Section 6.4**)

Step 4. Turn heat “on” (specific actions based on PLC and Control settings)

Step 5. Remove workpiece

Multi-Step Workpiece Heating

Equipment & Components

- N/A

Process (Edit Mode):

Step 1. Implement equipment startup procedure **(Section 5.6)** if applicable

Step 2. Present workpiece to output inductor as required

Step 3. Implement Workpiece Heating (**Edit Mode**) (**Section 6.4**)

Step 4. Turn heat “on” (specific actions based on PLC and Control settings)

Step 5. Remove workpiece

Process (Production Mode):

Step 1. Implement equipment startup procedure **(Section 5.6)** if applicable

Step 2. Present workpiece to output inductor as required

Step 3. Implement Workpiece Heating (**Production Mode**) (**Section 6.4**)

Step 4. Turn heat “on” (specific actions based on PLC and Control settings)

Step 5. Remove workpiece

Equipment Startup

Equipment & Components

- N/A

Process:

Step 1. Verify panel-mounted electrical disconnect is open (down)

Step 2. Plugin and/or actuate local disconnect

Step 3. Reset E-Stop button (Turn counter-clockwise)

Step 4. Press control power button

Step 5. Close panel-mounted electrical disconnect (up)

Step 6. Actuate E-Stop button, verify panel-mounted electrical disconnect is open (down)

Step 7. Reset E-Stop button (turn counter-clockwise)

Step 8. Close panel-mounted electrical disconnect (up)

⚠ Be sure to implement the equipment startup procedure **(Section 5.4)** at the beginning of each shift, operator, or work piece heating application changeover that involves implementing equipment shutdown **(Section 5.5)**.

Equipment Shutdown

Equipment & Components

- N/A

Process:

Step 1. Verify that the heat is off, in Manual Mode the screen will not have a green background

Step 2. Verify panel-mounted electrical disconnect is open (down) or actuate E-stop (push in)

Step 3. Turn the unit off by pressing the control button

Step 4. Wait two minutes and unplug equipment, if applicable

Load Tuning

Required Equipment and Components

- N/A

Process:

Step 1. Identify the dominating limit on the LCD feedback display (Section 6.4)

Step 2. Locate Actual limit and the Desired limit in **Table 5-1**

Step 3. Review all applicable row-specific details

Step 4. Attempt **LCD-based Actions** by setting the corresponding limits as indicated and incrementing the limit labeled **Increment** in 10% increments until maximum is reached or desired result is achieved

Step 5. If the desired result not achieved, implement the **Physical Component Change** action as indicated. (**Section 5.2** & **Section 5.3**) and repeat from **Step 1** until desired result achieved or all **Table 5-1** actions completed

If this process does not produce the results required, you may have to consider an output inductor design change. For assistance with output inductor design, call Radyne Aftermarket Sales and Service Department at 1-800-236-8360.

If using an output inductor not provided by Radyne for this equipment, be sure it is adequately rated for the power, current, and/or voltage produced by your model of VersaPower® Xtreme™ induction supply. If unsure if the output inductor used while implementing this procedure can handle all the maximum magnitudes please contact Radyne before continuing. All damage to the output inductor as a result of improper rating is the responsibility of the customer and will void other applicable warranty provisions.

If the desired dominating limit does not appear, but a different dominating limit does, begin from **Step 1** using that new dominating limit.

Load Tuning

LCD Feedback Display Action Criteria		LCD-based Actions (Soft Limit Adjustment)			Physical Component Change	
Actual	Desired	Power	Voltage	Current	Inductance Adjustment	Capacitance Adjustment
Current	Power	Increment	100%	100%	More	-
	Resonance	See Application Note			More	-
	Voltage	100%	Increment	100%	More	-
Power	Current	100%	100%	Increment	More	-
	Resonance	See Application Note			More	-
	Voltage	100%	Increment	100%	More	Less
Resonance	Current	100%	100%	Increment	Less	-
	Power	Increment	100%	100%	Less	-
	Voltage	100%	Increment	100%	Less (2nd)	Less (1st)
Voltage	Current	100%	100%	Increment	Less	-
	Power	Increment	100%	100%	Less	More
	Resonance	See Application Note			More (2nd)	More (1st)

Figure 5-3: Load Tuning Recommendations Matrix

Resonance and power limits are closely associated. Typically, to obtain a resonance limit requires a physical tuning adjustment that specifics establishes power supply output to be set so that 100% Power is not achievable, which may not be advantageous for establishing desired power output.

Interface Environment

6.1	Physical Layout	52
6.2	Menu System Overview	53
6.3	Fundamental Menu Interactions	57
6.4	Workpiece Heating Modes & Displays	63
6.5	Managing Security	67
6.6	Creating & Editing Recipes	69
6.7	Managing Recipe Storage	75
6.8	Managing Interface Control	77
6.9	Managing Firmware & Language	83
6.10	Using the Load Tuning Calculator	84

Physical Layout

Front Panel Features

Figure 6-1 shows the physical actuators and indicators that are located on the front equipment panel of the VersaPower®-Xtreme™ induction power supply.

Rear Panel Features

Figure 6-2 shows the physical connection points/ports that are located on the rear equipment panel of the VersaPower®-Xtreme™ induction power supply.

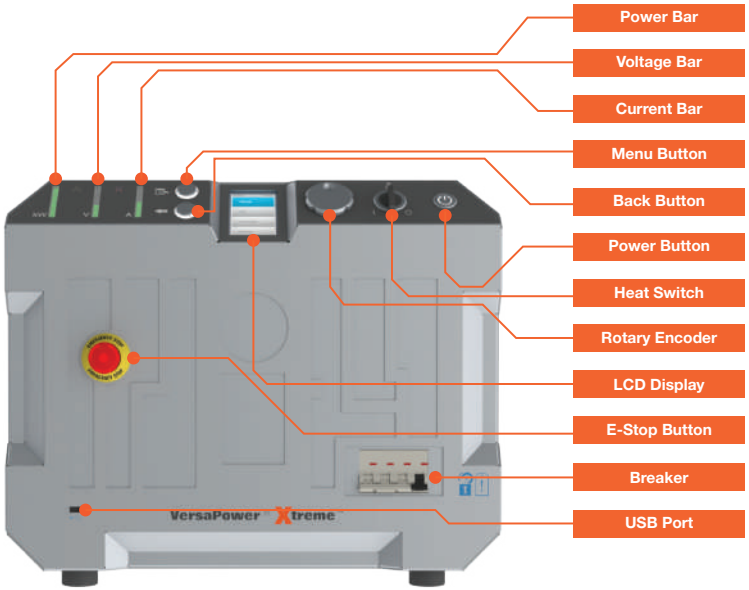


Figure 6-1: Front Panel View

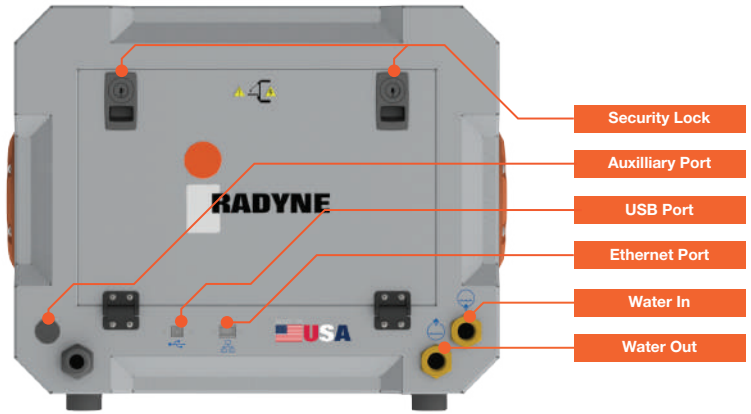


Figure 6-2: Rear Panel View

Menu System Overview

Introduction

Speed, power concentration, cleanliness, repeatability, and efficiency are perhaps the main reasons that induction heating has found its rightful place in industry. However, these benefits would mean very little if they could not be controlled with precision. The menu interface environment of the VersaPower® Xtreme™ induction power supply combines all the well-known advantages of induction heating with a technology rooted in control. An advantage greatly simplified by the intuitive design of the menu system layout. In this subsection you will learn the basic structure of the menu interface environment. It is strongly encouraged that each new operator reviews the material of this section in order to better understand how operator and power supply interaction is organized.

The Main Menu

Starting from the Main Menu screen (**Figure 6-3**) there are four selectable options and each of these contains options with respect to each button name. The four selectable options are:

- **Manual**

- **Edit**

- **Production**

- **Settings**

The remaining content of this subsection is dedicated to describing each of these modes.

Selectable options appear as virtual pushbuttons.

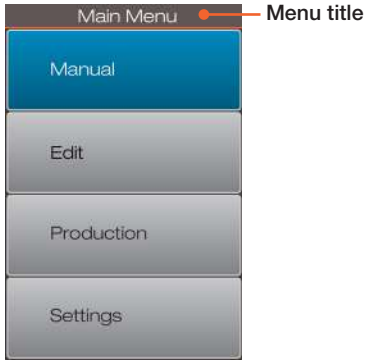


Figure 6-3: Main Menu Screen

Menu System Overview

The Manual Mode Menu

Figure 6-4 shows the Manual Mode menu. In this mode the operator can set the soft limit (power, voltage, and current) magnitudes for single-step workpiece heating. Also from this menu, many processes including the following are implemented:

- Single step heating by heat switch actuation

- Testing work piece heating response

- Adjusting/monitoring power supply performance

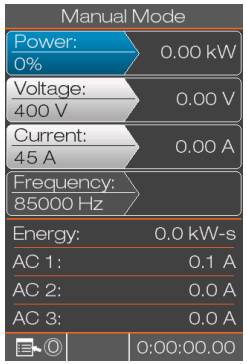


Figure 6-4: Manual Mode Menu

Figure 6-5: Edit Mode Menu

The Edit Mode Menu

You may find it useful to think of the Edit Mode as really a “Recipe Editor” (**Figure 6-5**). Activities implemented within the “Recipe Editor” are as the name suggests, editing-based. This mode, also, serves as the location for recipe creation and workpiece testing. **Figure 6-6** shows the various actions performed within this mode.

The VersaPower® Xtreme™ induction power supply categorizes recipes in three distinct ways:

Current Recipe: This recipe designation corresponds to either the last recipe created, edited, executed, or loaded. Once any recipe is loaded into the “Recipe Editor” it becomes the (NEW) Current Recipe for future editing, creating, and executing operations. Temporary storage for this recipe category is RAM.

New Recipe: This recipe is in essence an empty shell ready to be programmed. Selecting this option replaces the RAM stored recipe (Current Recipe) with this new recipe shell.

Load Recipe: This category of recipes are located either on an external drive (USB storage device), or saved locally. Selecting this option replaces the RAM stored recipe (Current Recipe) with the retrieved recipe.

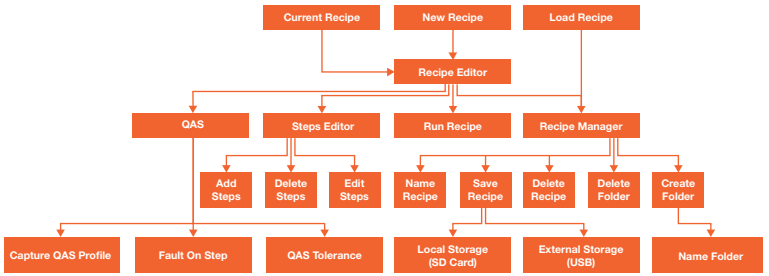


Figure 6-6: Edit Mode (Recipe Editor) Action Flow Diagram

Menu System Overview

The Production Mode Menu

Figure 6-7 shows the Production Mode menu. In this mode, multi-step workpiece heating (recipe) is implemented. Recipe retrieval (Load Recipe) for production purposes is mainly accomplished within this mode. Like Edit Mode workpiece heating, the operator cannot change output settings during the heating cycle.

Settings Menu

In general, the Settings menu option (Figure 6-8) contains the menu progressions pertaining to the bulk of the administrative activities. Functions such as PLC configurations, operator interface option set-up, and tuning related activities are all performed from the Settings menu progression. For that reason, many of the activities can only be utilized if you are logged-in as an Administrator (i.e. deleting and renaming previously saved recipes and/or folders). There are seven general set-up, managerial, and administrative-based related processes which can be performed within this menu progression. A brief explanation of the specific processes pertaining to each follows.

Controls: This selectable menu option provides for setting heat control, PLC setup, device configuration, and LCD Feedback display memory.

Tune: This selectable menu option opens the load tuning calculator that provides reliable series inductor tap settings and capacitance value ranges used for load tuning.

Remote: This selectable menu option provides for setting remote connectivity and configurations for tasks related to establishing IP addresses, hosts, etc.

Admin: This menu option is where administrative login can be initiated. With administrative login, full LCD interface capability is realized.

Language: This selectable menu option is reserved for changing the language of the LCD display. Available languages are: English, German, and Spanish.

Update: This selectable menu option provides for updating firmware as newer versions of the menu interface are made available. Updating the firmware is via the USB port located on the front of the unit.

About: This selectable menu option provides a reference display for the power supply, software serial number, model number, and version related information.

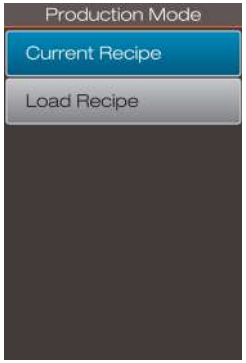


Figure 6-7: Production Mode Menu

Figure 6-8: Settings Menu

Additional login prompts appear if attempts to perform a restricted action are made without having logged-in as an administrator prior to the attempt.

Menu System Overview

Sitemap

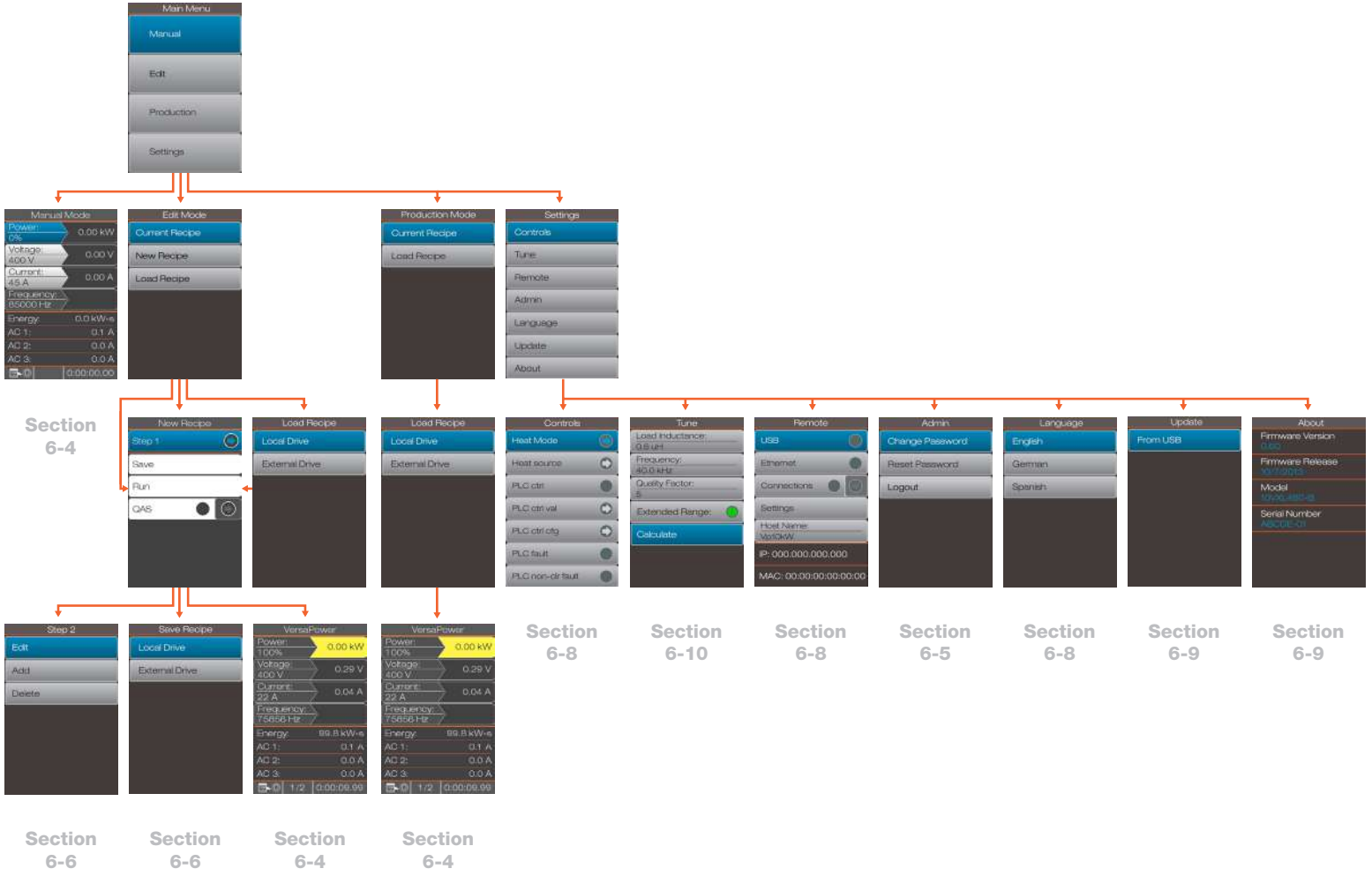


Figure 6-9: Menu System Sitemap

Fundamental Menu Interactions

Introduction

Now that you have learned about the functionality and the design layout of the menu system, it is important that you understand how to interact within this menu system in order to accomplish your induction heating goals proficiently.

We want you to be successful and therefore encourage you to review the following methods of interaction and different LCD feedback displays that are at the heart of communicating with this equipment. Within this section you will find descriptions, action steps, and application strategy that will allow you to have complete control of the induction power supply. If you have any questions about the menu interface, please contact Radyne and we will gladly take you step by step to your end goal.

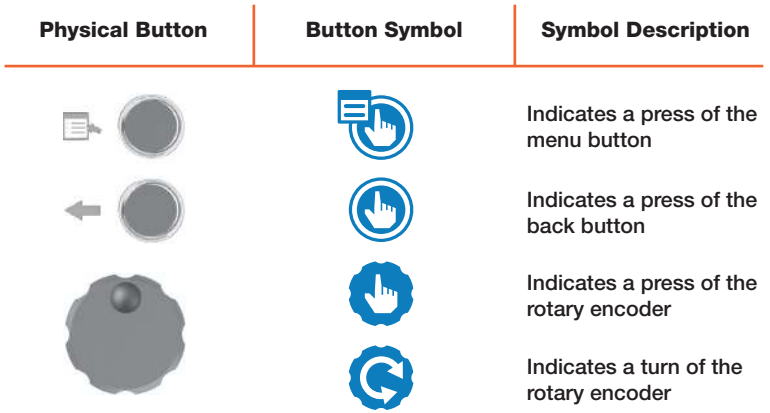


Figure 6-10: Section Symbol Key

Section Symbols

Throughout this section are series of action-based menu tutorials to perform all tasks available within the menu interface environment. **Figure 6-10** contains this section's symbol key. You will notice that these symbols are used to express the next action required. (i.e. **Figure 6-11**). Without exception, the symbols that appear below a series of menus are for navigating from menu to menu, while the symbols that are displayed vertically alongside a menu are for performing different activities within the menu (i.e. changing a value). Each page also contains a similar key corresponding to the button functionality required for the specific tasks on the applicable page. At Radyne we believe in hands-on learning, so we encourage you to power up the menu display of the VersaPower® Xtreme™ induction power supply and perform these actions while going through this section.

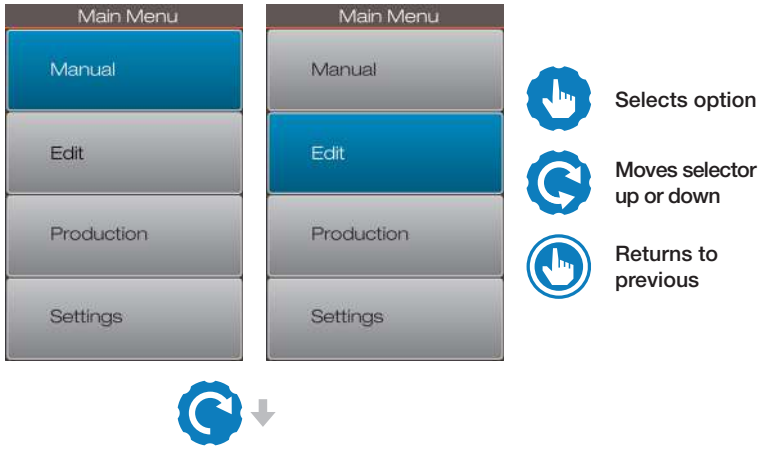
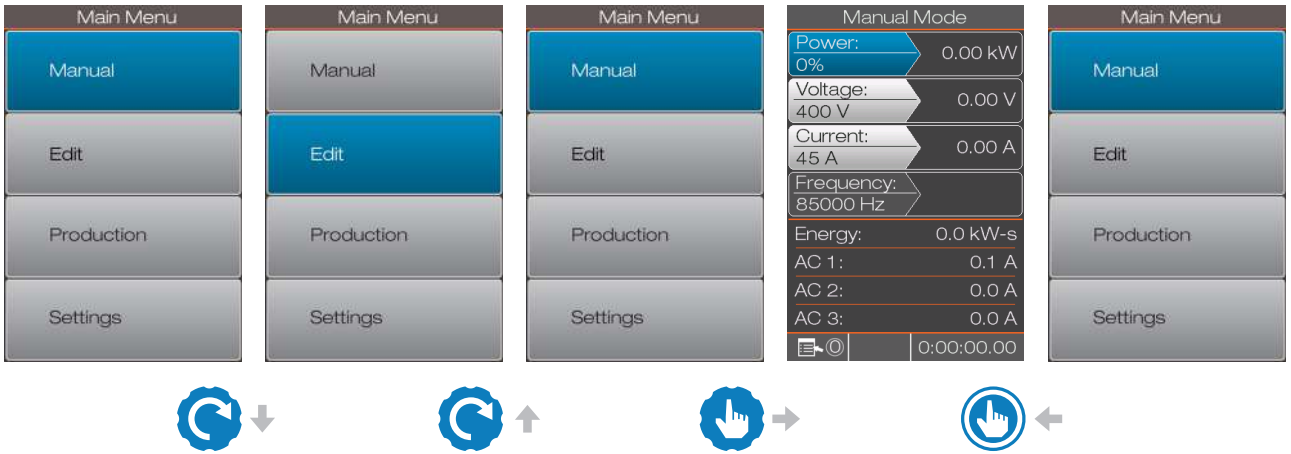


Figure 6-11: Changing Selector Position

Fundamental Menu Interactions

Selecting Options & Advancing Menus

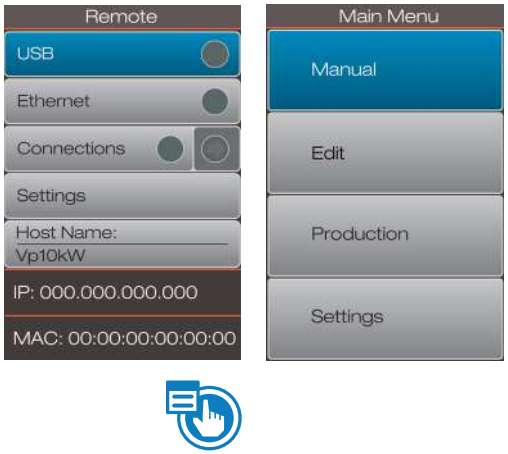


Selects option

Moves selector up or down

Returns to previous

Using the Menu Button



Returns to Main Menu

Fundamental Menu Interactions

Viewing Off-Screen Options

Selects option

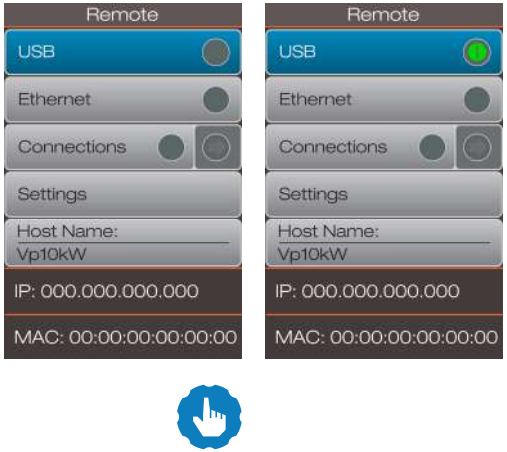
Moves selector up or down

Returns to previous

Off-screen menu options shown in grey.

The menu scrolls when the selector reaches the bottom of the screen.

Utilizing Bar-Toggle Button Styles

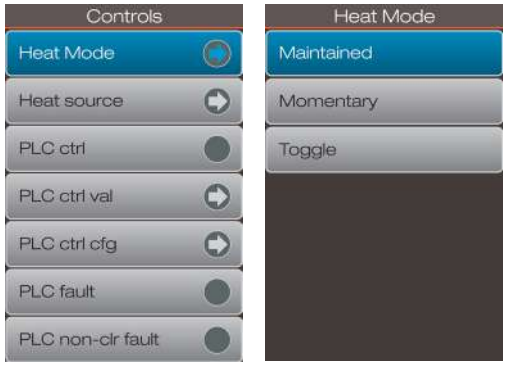


Selects option

Moves selector up or down

Returns to previous

Utilizing Bar-Arrow Button Styles



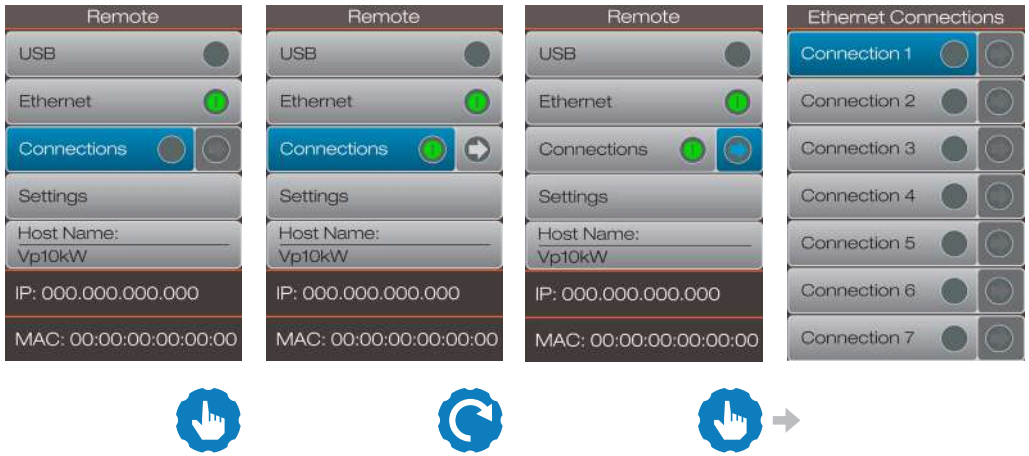
Selects option

Moves selector up or down

Returns to previous

Fundamental Menu Interactions

Utilizing Bar-Arrow Button Styles



Selects option

Moves selector up or down

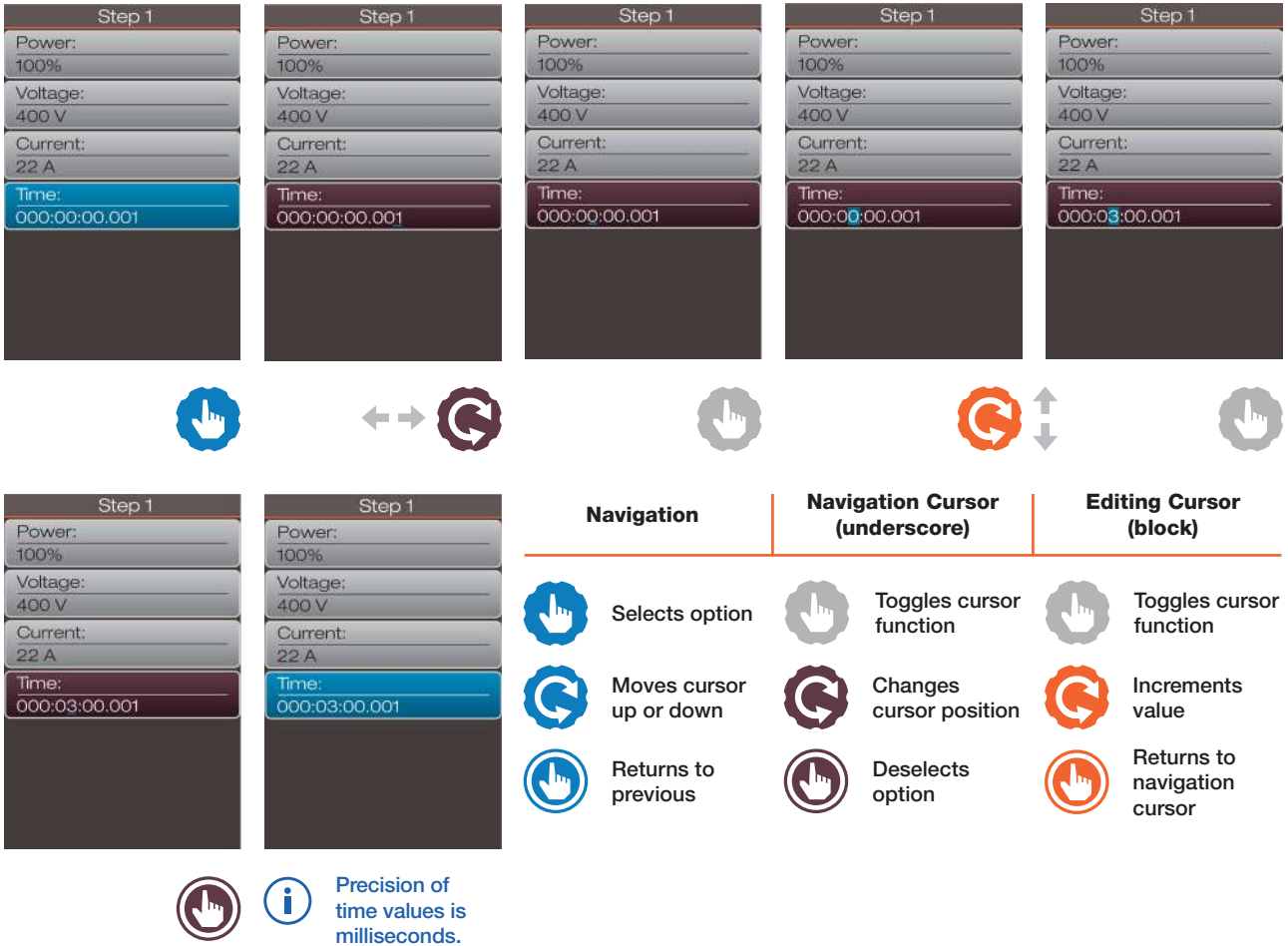
Returns to previous

Editing Soft Limit Magnitudes

Navigation	Editing
Selects option	Deselects option
Moves selector up or down	Increments value
Returns to previous	Deselects option

Fundamental Menu Interactions

Editing Numerical Values

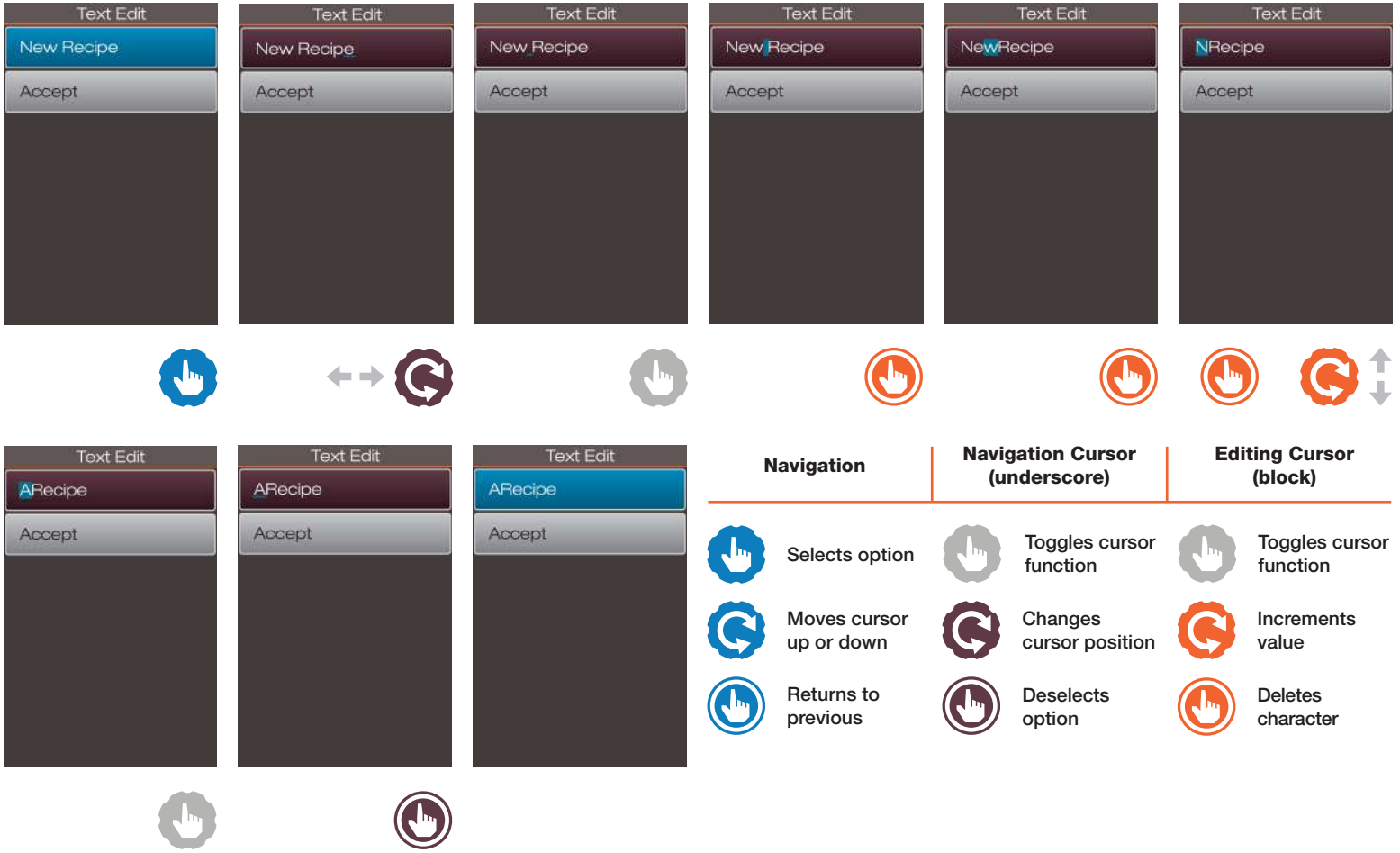


Navigation	Navigation Cursor (underscore)	Editing Cursor (block)
Selects option	Toggles cursor function	Toggles cursor function
Moves cursor up or down	Changes cursor position	Increments value
Returns to previous	Deselects option	Returns to navigation cursor

Precision of time values is milliseconds.

Fundamental Menu Interactions

Editing Text Characters



Workpiece Heating Modes & Displays

Introduction

The menu interface environment of VersaPower® Xtreme™ induction power supply implements workpiece heating in three different modes (**Manual Mode**, **Edit Mode**, and **Production Mode**). Each of these modes offers advantages for certain applications. The information contained within this section is dedicated to explaining each of these modes, the uniqueness of their feedback displays, and the different feedback values contained in each.

Manual Mode

Typically, **Manual Mode** workpiece heating should be used when single step induction heating is required. Within this mode soft limit magnitudes (power, voltage, and current) can be changed during the heating process (**Figure 6-12**). This is a distinct advantage over **Edit Mode** workpiece heating, when it comes to testing power supply performance and workpiece response to varying the heating output.

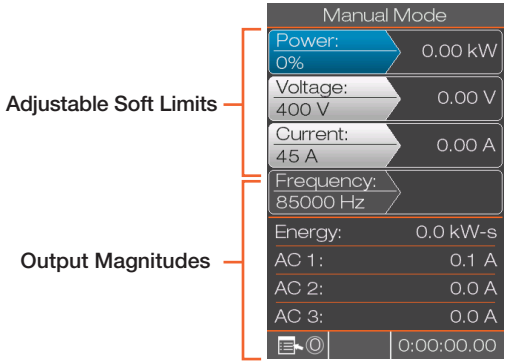
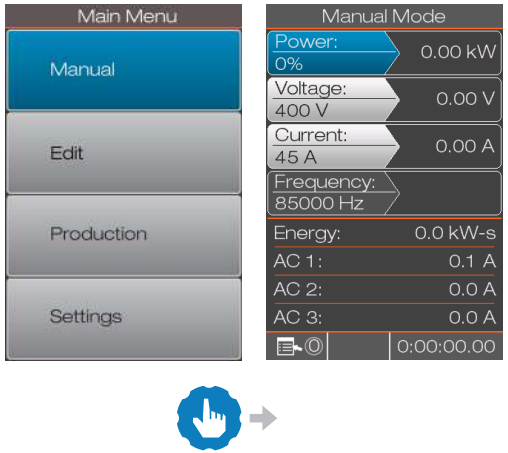


Figure 6-12: Workpiece Heating-Manual Mode Menu

Workpiece Heating (Manual Mode)



To change Power, Voltage, and Current values See Editing Soft Limits.

Changing Manual Mode Feedback Displays

Changes feedback display menu options

Workpiece Heating Modes & Displays

Edit Mode

Typically, **Edit Mode** workpiece heating should be used when an existing recipe needs to be adjusted and you want to investigate the effect that the change has on power supply performance and workpiece heating outcomes before replacing the original recipe. This mode of workpiece heating is ideal for the recipe creation process as well, including effective load tuning. For example, in heating applications that require the material to cross over the Curie temperature, the load conditions change so dramatically that optimal load tuning is not possible for both above and below Curie. In these cases executing a partial recipe, to determine the best soft limit settings for each step, as well as, the entire recipe as a whole makes the final decision for capacitance and inductance adjustment greatly simplified.

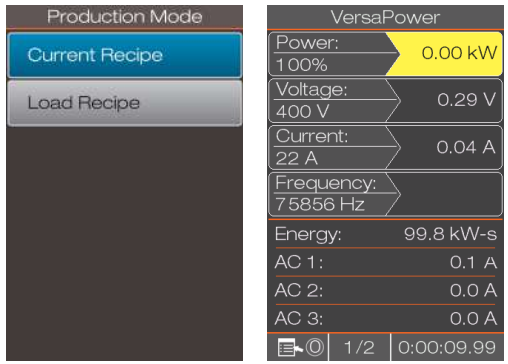
Production Mode

Production Mode workpiece heating is provided to execute recipes for the purpose of production. It is ideal for producing multiple parts according to a specific preset recipe. When in this mode, there is no chance to change a setting as in **Manual Mode**. This eliminates operator error and makes the final results repeatable.

Workpiece Heating (Edit Mode)

See Retrieving a Saved Recipe to load recipe.

Workpiece Heating (Production Mode)



See Retrieving a Saved Recipe to load recipe.

Workpiece Heating Modes & Displays

LCD Feedback Return Descriptions

Power: Displays the power measured at the inverter measured in kW multiplied by number of inverters which is dictated by the kW magnitude of the equipment model (Refer to **Section 9.1)**

Voltage: Displays the voltage of the parallel capacitor bank measured in V_{DC}. For model-specific ranges refer to the input power specifications table (**Section 9-1**)

Current: Displays the current measured in amps (A) from an inverter module. This current is assumed to be the same across all inverter modules

Freq: Displays the output frequency of the power supply measured in Hz

Time: Displays the time measured in seconds for the current heat cycle. It is cumulative for multi-step workpiece heating

DC kW: This displays power calculated from the DC voltage and the DC current off the rectifier measured in kW

DC V: This displays the DC voltage from the rectifier measured in V_{DC}

DC I: This displays the DC current going through the rectifier measured in A_{DC}

AC I: This displays the 3Φ average current coming in from the line measured in A_{RMS}

Water in: The displays the temperature of the water going into the unit measured in °F

Coil out: This displays the temperature of the water leaving the coil circuit measured in °F

Power out: This displays the temperature of the water leaving the power/component circuit measured in °F

Coil flow: This displays the flow rate of the water leaving the coil circuit measured in GPM

Power flow: This displays the flow rate of the water leaving the power/component circuit measured in GPM

Humidity: This is the relative humidity percentage inside the unit in percent

V Int: This displays the amount of output voltage measured in V-s put into the part from the unit

Line kW: This displays the total power delivered to the part measured in kW

Energy: This displays the amount of energy during the heat cycle measured in kW-s

AC 1: This displays the line current from the first phase measured in amps (A)

AC 2: This displays the line current from the second phase measured in amps (A)

AC 3: This displays the line current from the third phase measured in amps (A)

Ambient: This displays the temperature of the ambient air inside the unit in °F

See Changing Feedback Display Menus for information about how to change feedback display.

Workpiece Heating Modes & Displays

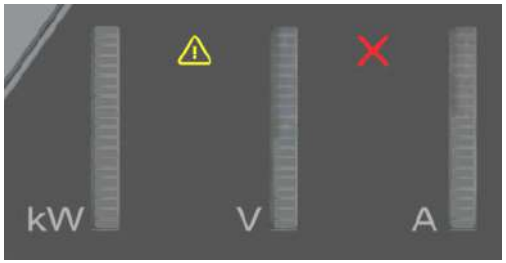
LCD Display Trip/Fault Indicators

The VersaPower® Xtreme™ induction power supply has many built-in protective mechanisms that prevent components from becoming damaged from unsafe operation. When these red flag conditions occur during workpiece heating, a trip/fault shutdown occurs and heat is automatically suspended. **Figure 6-13** and **Figure 6-14** show the display changes that occur when one of these conditions exist. Additional information about the type and cause of the shutdown is communicated by way of a Trip/Fault Shutdown indication code. In order to take full advantage of the feedback provided, it is essential that you set Feedback in the Controls menu to Keep Last. This will allow you to see the output magnitudes associated with a trip/fault shutdown event. There are two different types of faults (latched and unlatched). Latched faults require an action to clear them after the condition that caused is eliminated, while unlatched do not. For details specific to clearing latched faults, approved clearing activities, explanations, and suggested actions are detailed in **Section 8.2**.

Be sure to read **Section 8.1** for warnings and personnel qualifications specific to troubleshooting processes prior to attempting any suggested course of action with respect to clearing these conditions.

It is possible that more than one trip/fault shutdown condition occurs at the same time.

Figure 6-13: Trip/Fault Shutdown Indicator (menu display)



Red "X" indicates a trip/fault shutdown condition exists.

Yellow caution symbol indicates a trip/fault shutdown condition exists.

Figure 6-14: Trip/Fault Shutdown Indicator (front panel)

Managing Security

Introduction

Protecting recipe file data, current PLC set-up configurations, and settings is easily accomplished through administrative password protection. Logging on as an administrator provides full access to all interface activity. While the administrator is logged-out, activity is limited to workpiece heating in Manual Mode and Production Mode, new recipe creation, and other activities that do not involve changing a permanent record or preset function. **Figure 6-15** shows the menu screen that appears when attempting an activity that requires administrative login while you are not currently logged in. There are four activities pertaining to managing security, these are:

- Login/Logout

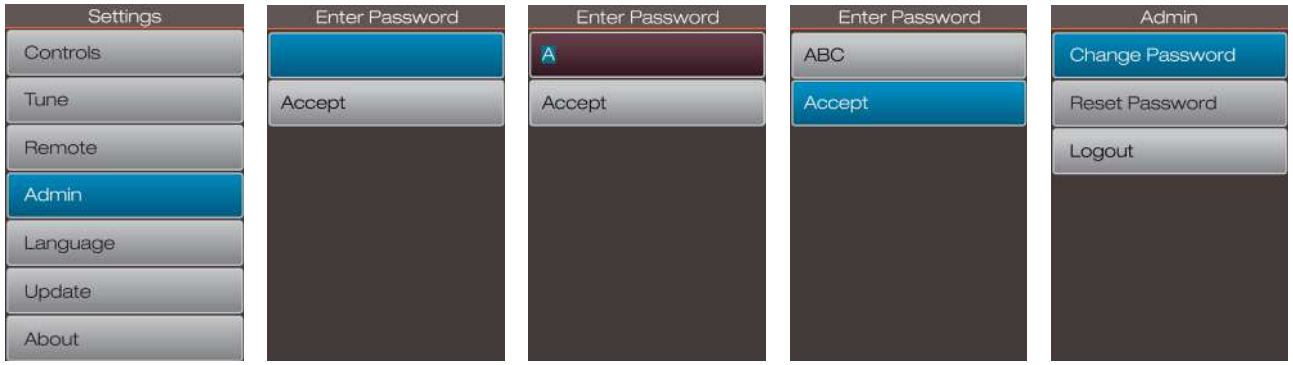
- Calibrate DCV

- Change password

- Reset Password

Figure 6-15: Access Denied Error Message

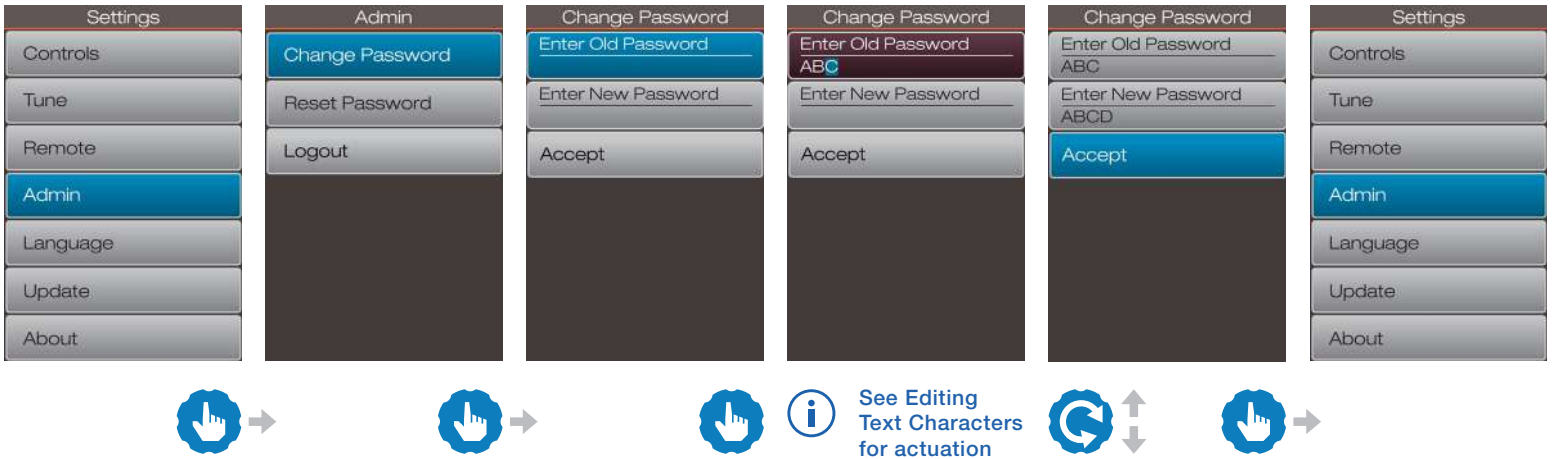
Admin Login



See Editing Text Characters for actuation sequence.

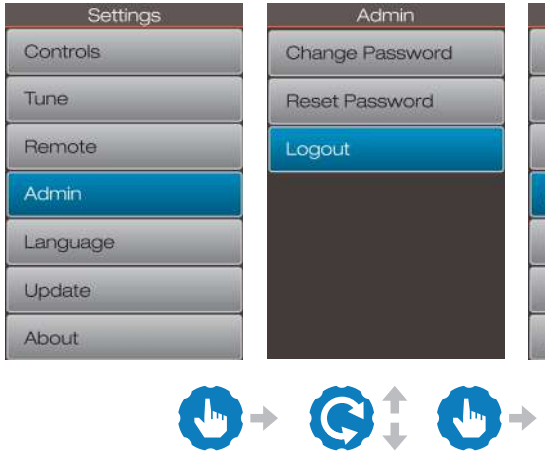
Managing Security

Changing Admin Password

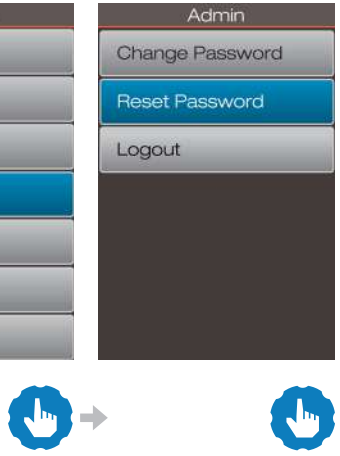


See Editing Text Characters for actuation sequence.

Admin Logout



Resetting Admin Password



Creating & Editing Recipes

Introduction

Creating and editing recipes is perhaps the most important way that operators will interact with the VersaPower® Xtreme™ induction power supply. Precision and control are what make menu interactions within the "Recipe Editor" valuable. From this progression of menus and recipe related actions are performed. **Figure 6-16** shows the basic recipe shell. The menu interface system provides for virtually an unlimited storage for recipes and up to 99 steps per recipe. The material within this subsection is dedicated to acquainting you with every individual activity that you will need to create recipes that meet your workpiece heating goals. These individual activities include:

- Creating new recipes

- Retrieving/deleting current or saved recipes

- Creating, editing and deleting recipe steps

- Renaming, replacing and overwriting recipes

- Enabling the QAS on a recipe

Edit Mode also allows the user to be able to set a feature that allows the comparison of measurements between a process being currently run versus a process that was tested and proved to provide parts that have desired characteristics after the heat treat process. This feature is called the QAS. Inside each recipe you can enable the QAS, set it to fault if the measured values fall outside the acceptable bound range, and widen/narrow the band of acceptable values that produce a successful heat treat process.

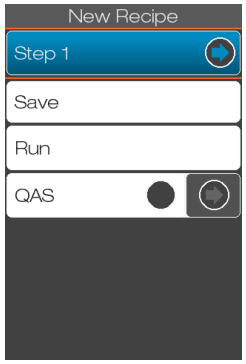


Figure 6-16: New Recipe Shell

Creating & Editing Recipes

Recipe Managing Overview

A recipe can be generally thought of as a multi-step induction heating process. Most induction heating outcomes require very specific power ramp-ups, time-specific power saturations, intermittent cool downs, etc. In order to provide for all the versatility of your induction heating application, the VersaPower® Xtreme™ induction power supply is designed to allow for precise timing and power outputs. **Figure 6-17** shows a basic 4 step recipe that reveals some of the functionality of the menu interface system with respect to recipe creation. **Step 1** and **Step 3** represent controlled power ramp-ups. Simply set the power value you wish to achieve and the time you want the power supply to take to achieve it. **Step 2** shows a time specific power saturation, where consistent power output is achieved by the power supply for the period of time determined by the recipe creator. Simply set the power level of **Step 2** equivalent to the final power magnitude of the previous step and set the step time value for the period of the desired power saturation. **Step 4** shows a time specific power ramp down. Gradually reducing power through multiple steps during a ramp down, provides limitless control of the heat propagation process. If you haven't yet had a chance to read through **Section 3** of this manual, you are encouraged to do so now. That section contains valuable insight on how the power supply achieves the desired output and understanding how that works will make you much more proficient at the recipe creation process.

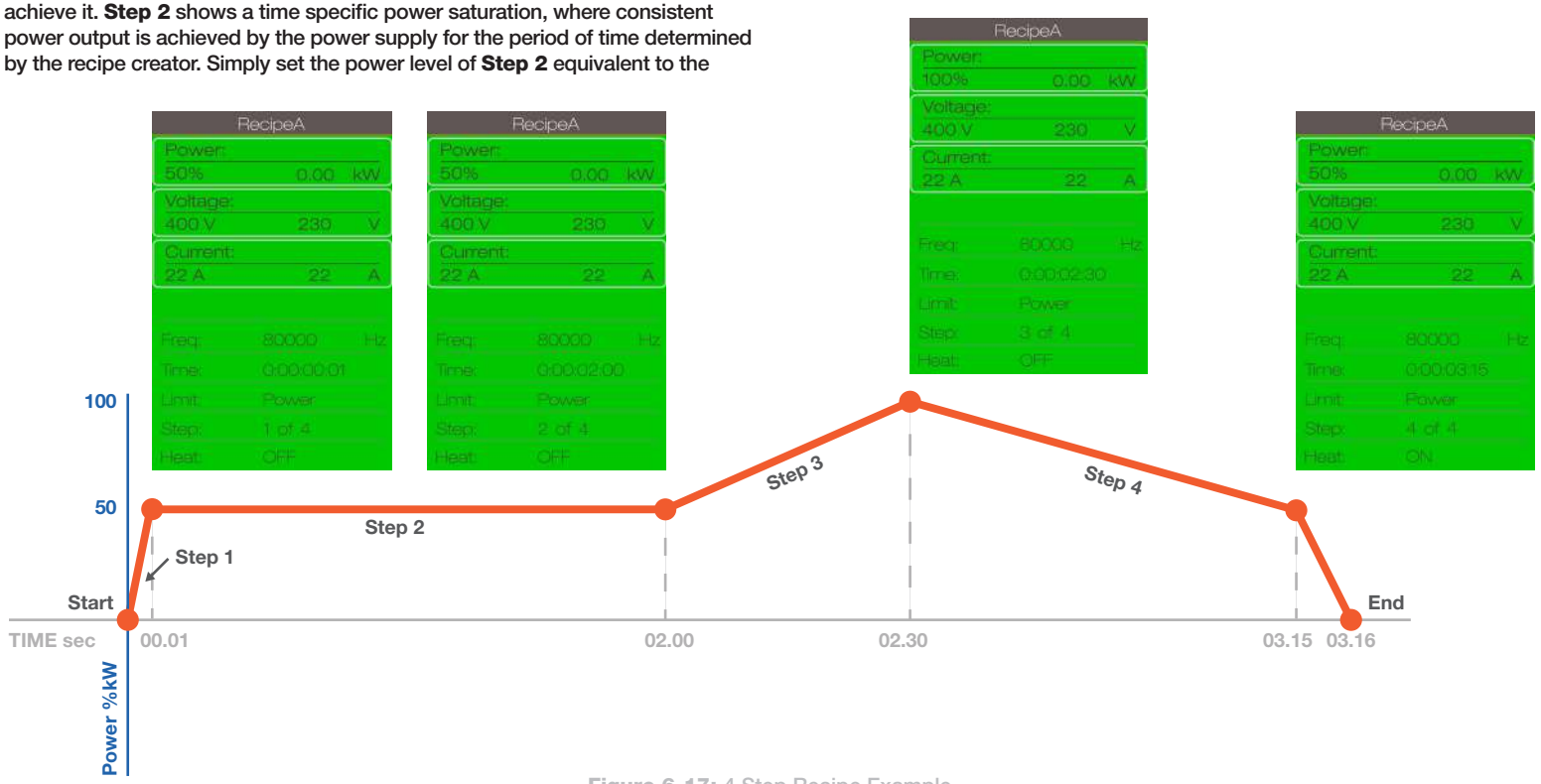
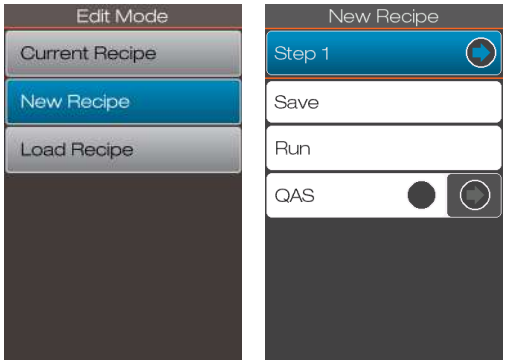


Figure 6-17: 4 Step Recipe Example

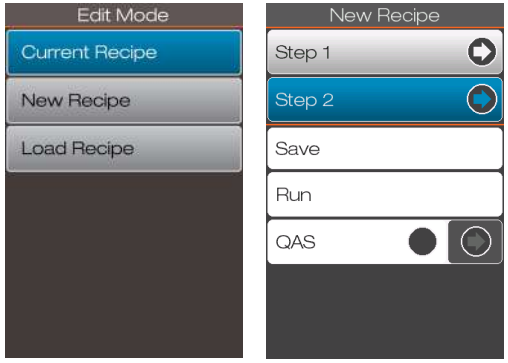
Creating & Editing Recipes

Creating a New Recipe



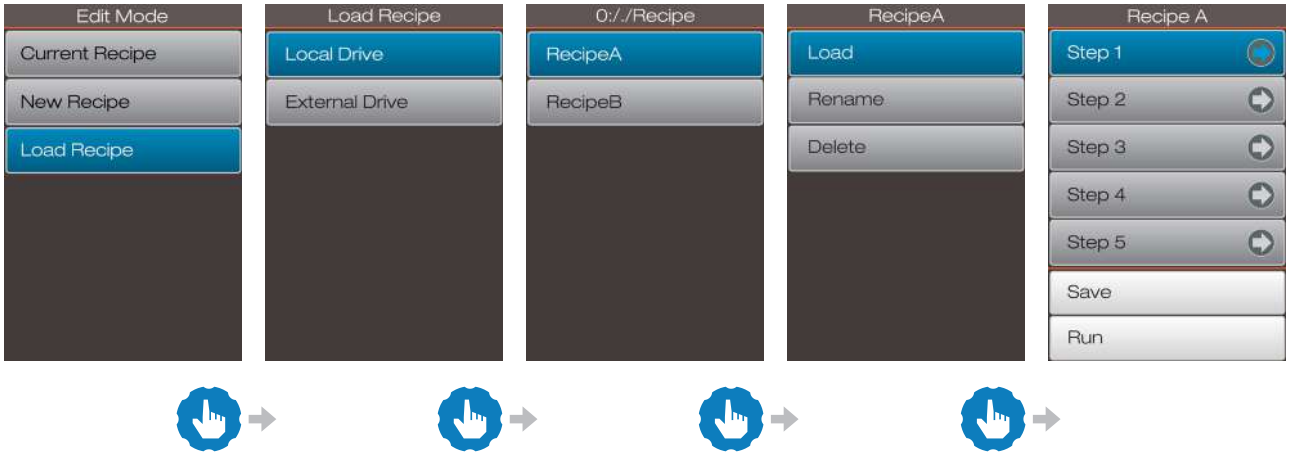
See Editing Recipe Steps for details on recipe editing.

Retrieving the Current Recipe



See Editing Recipe Steps for details on recipe editing.

Retrieving a Saved Recipe

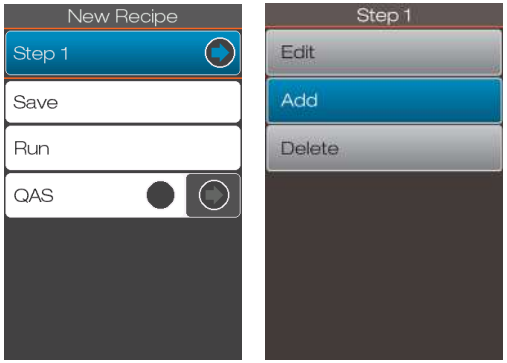


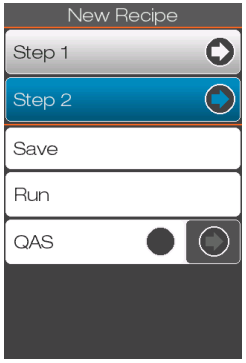
See Editing Recipe Steps for details on recipe editing.

When retrieving from an external drive, connect a USB storage device before choosing the External Drive option. The Local Drive is titled “0:” with the folder name “Recipes”. An External Drive is titled “1:”.

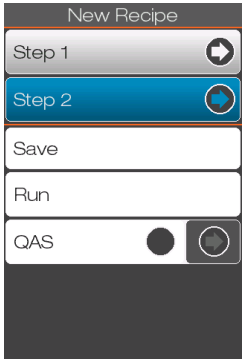
Creating & Editing Recipes

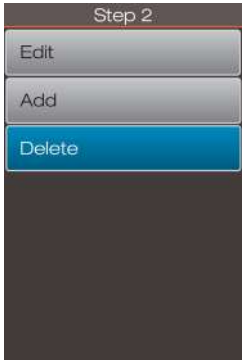
Creating Recipe Steps

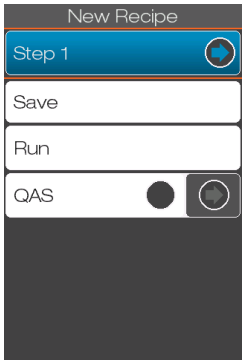




Deleting a Recipe Step

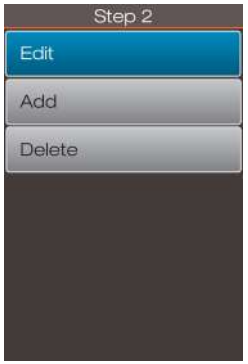






The new step appears directly below where the blue bar indicator was positioned and is defaulted to be the current selection.

Editing Recipe Steps

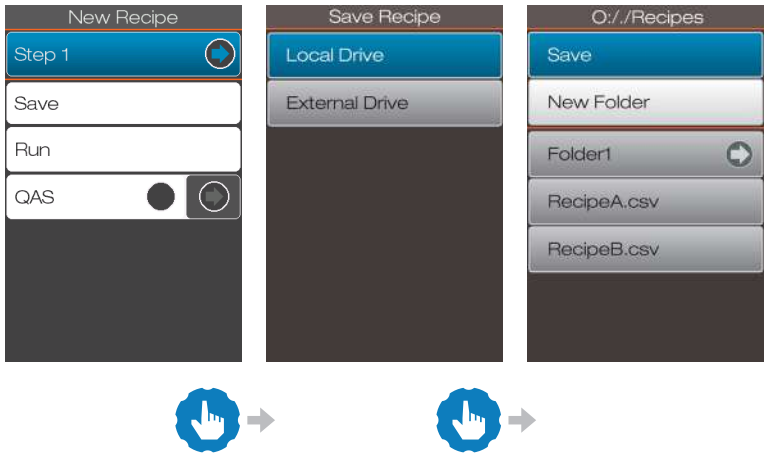


To change Power, Voltage, and Current values See Editing Soft Limits.

To change time values, see Editing Numerical Values.

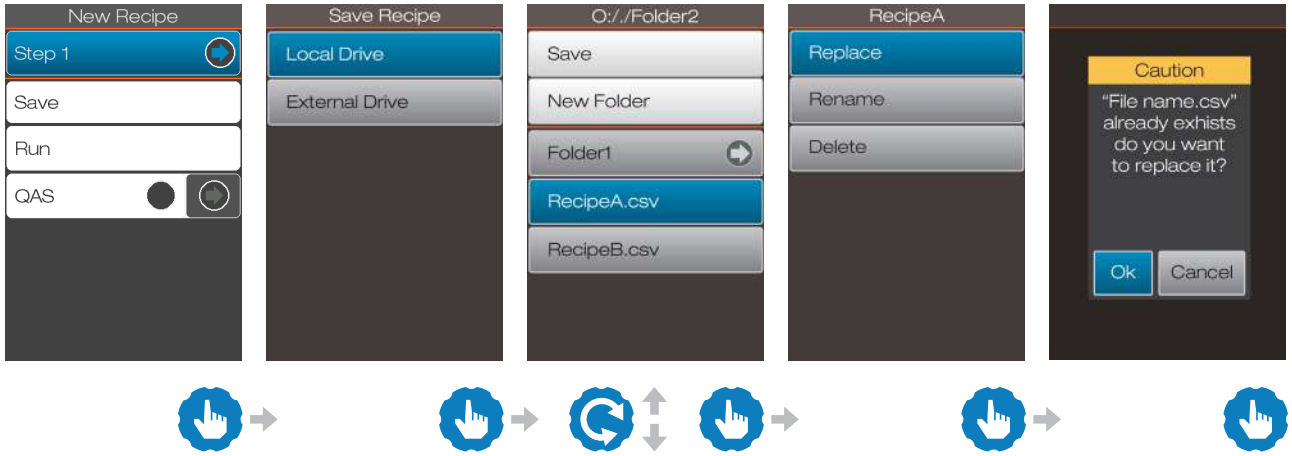
Creating & Editing Recipes

Saving a Recipe



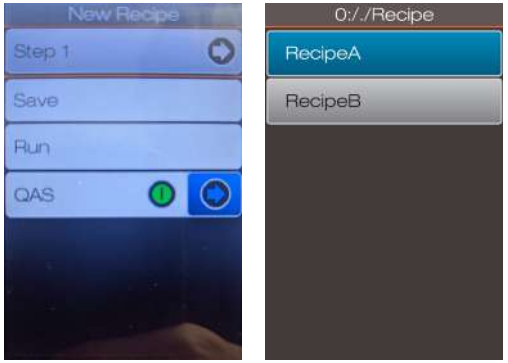
To manage recipe folders, See Managing Recipe Folders.

Overwriting a Saved Recipe



Creating & Editing Recipes

Enabling and Setting the QAS



Capture QAS Profile

This option runs the recipe and stores the data/profile to be compared against for subsequent processes.

QAS Tolerance

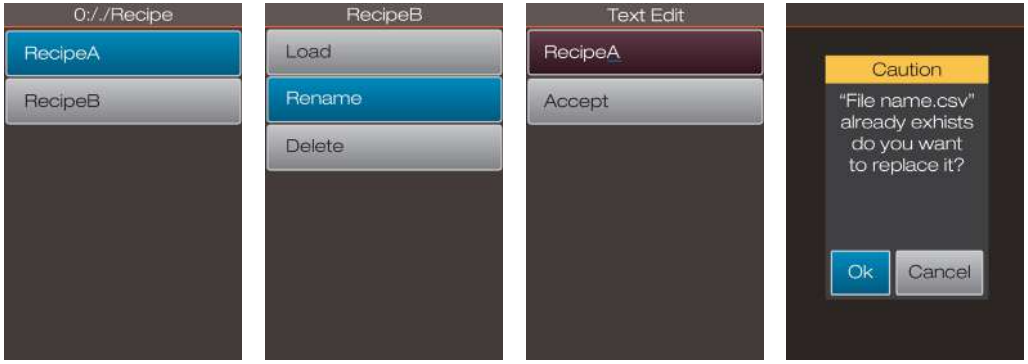
How wide the acceptable range of values/profile is before causing a fault to occur.

Fault On Step

This turns on the fault the occurs when outside the bounds/profile of the acceptable values.

Creating & Editing Recipes

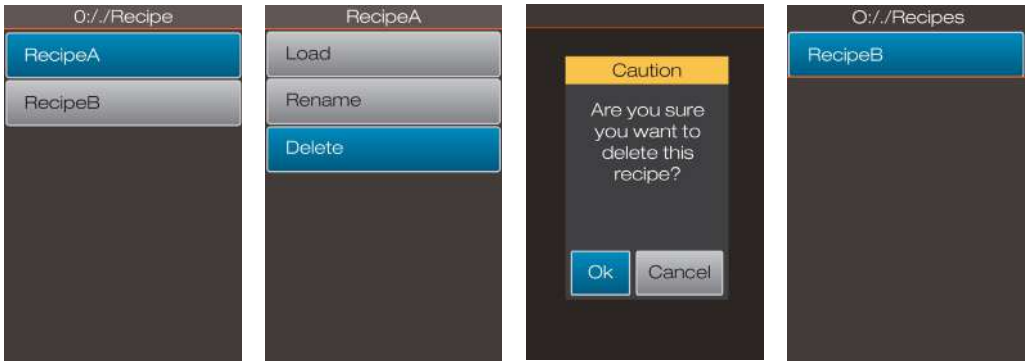
Renaming a Recipe



Additional warning appears if the recipe name already exists.

See Editing Text Values for actuation sequence.

Deleting a Recipe

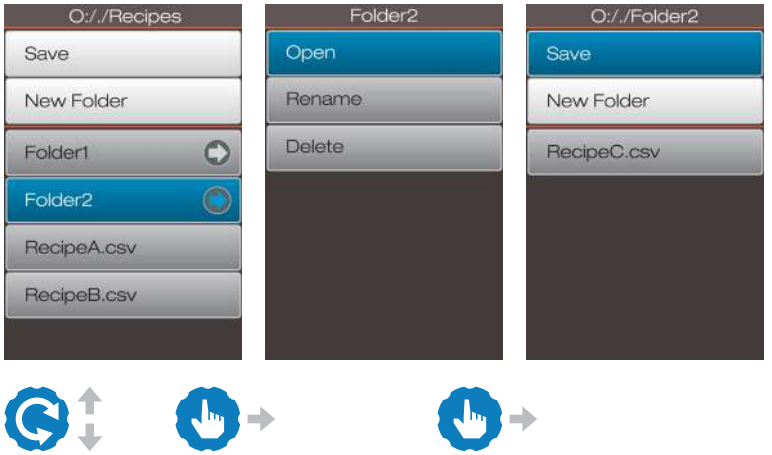


Managing Recipe Storage

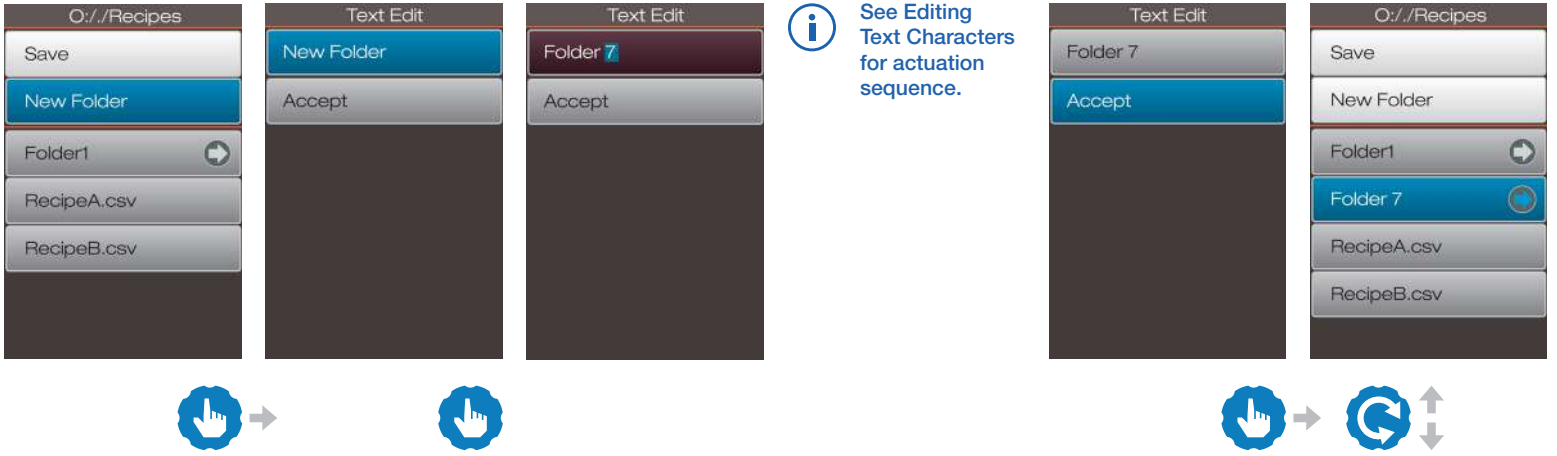
Introduction

Recipe managing is defined as activities specific to creating, opening, renaming, and deleting folders. The VersaPower® Xtreme™ induction power supply allows for these folders to be stored locally or externally. There isn't a significant difference between operations implemented with recipes and folders, however, great care must be taken to not delete folders unless you are absolutely sure that the contents of the folder is disposable. To avoid lost data we recommend that you logout as an administrator each time you conclude recipe storage and folder manipulation activity.

Opening A Recipe Folder

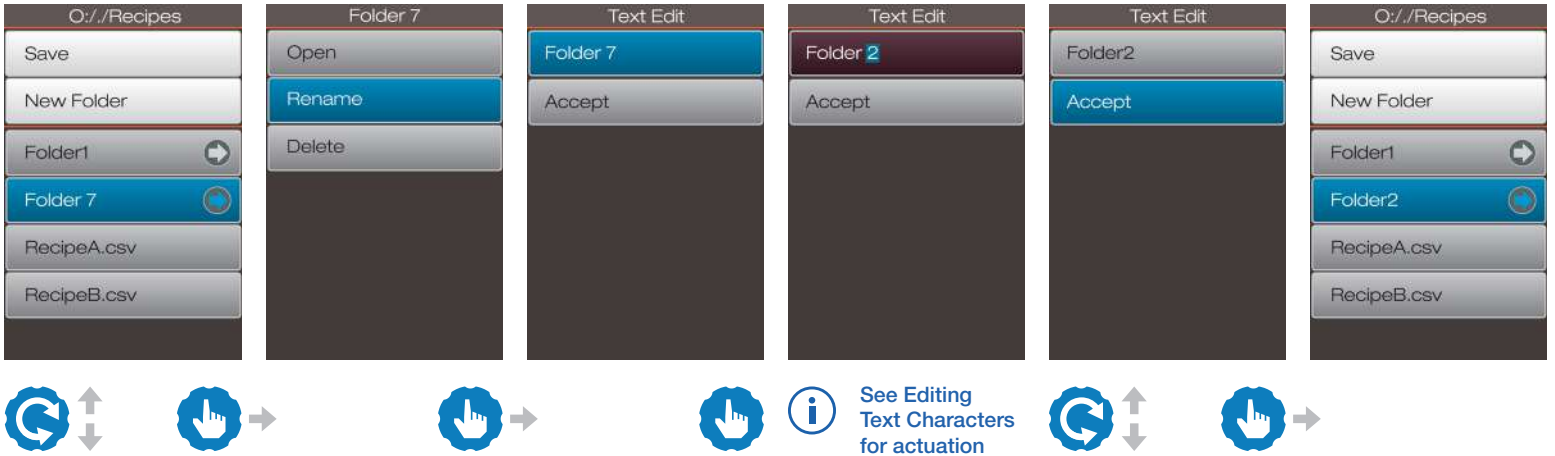


Creating A Recipe Folder



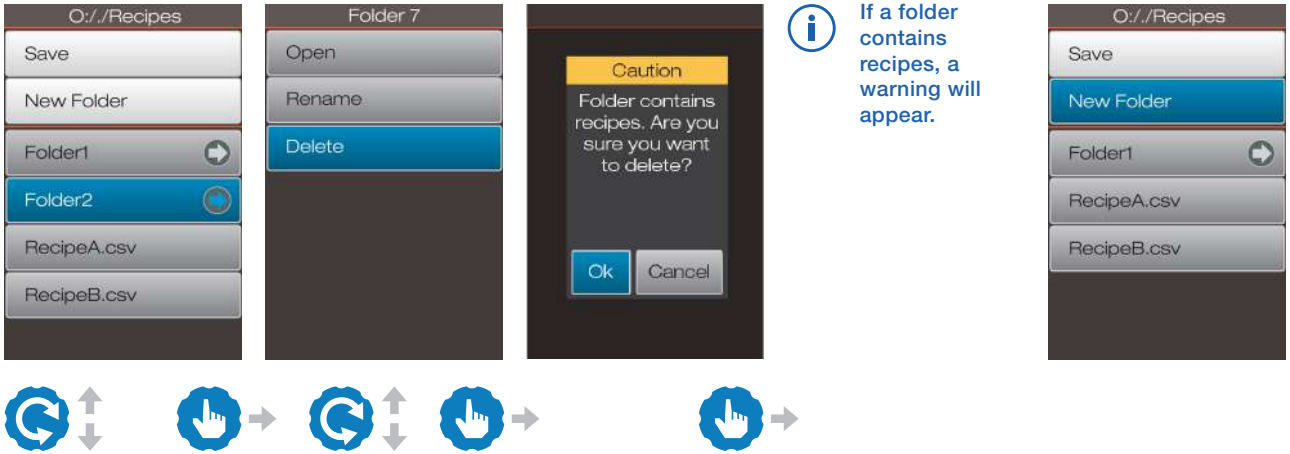
Managing Recipe Storage

Renaming A Recipe Folder



See Editing Text Characters for actuation sequence.

Deleting A Recipe Folder



If a folder contains recipes, a warning will appear.

Managing Interface Control

Setting and Extending Heat Control

The heat control source, type, and method of VersaPower® Xtreme™ induction power supply can be extended to external devices. In order to enable the advantages of this extended interfacing it is necessary to set-up the specifics of the external controller functionality with respect to the source of heat control from the Controls menu display. **Figure 6-17** shows the two primary ways that setting heat source control can be implemented. Both of these are described below.

Heat Mode: This option changes the functionality of the heat switch between three options:

- Maintained: If you want the heat switch to operate like a two-position switch, where one actuation turns the heat to the "on" state and turning the switch the other direction turns the heat to the "off" state

- Momentary: If you want heat switch actuation to allow work piece heating only while the switch is held in the actuated "on" state

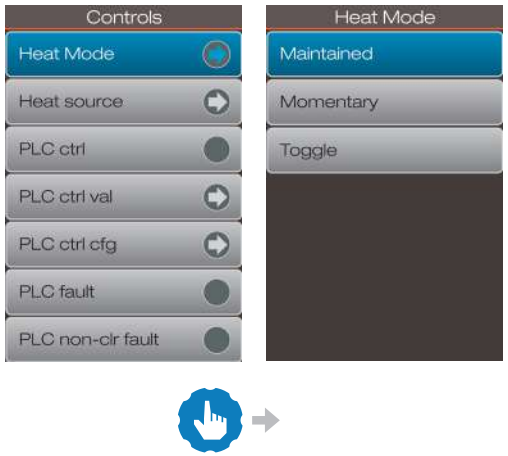
- Toggle: If you want the heat switch to operate like a pushbutton, where one actuation turns the heat to "on" state and a second actuation turns the heat to the "off" state.

Heat Source: This option determines heat related interactions are controlled from the internal front panel (default) or external devices via PLC, Ethernet, or USB.

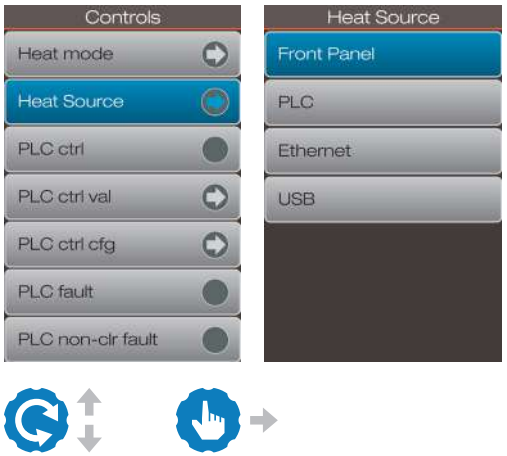
Login prompts appear if attempting to change control settings without having logged in as an administrator prior to the attempt.

Figure 6-18: Heat Control Options (controls menu)

Changing Heat Mode Actuation Style



Changing the Heat Control Source



Managing Interface Control

Setting External Device Function Capability via the PLC Connector

The VersaPower® Xtreme™ induction power supply comes equipped with a PLC board, which provides for external devices to be able to control various power supply interactions via the PLC Connector (**Section 9.4**). In order to enable the advantages of this extended interfacing it is necessary to set-up the specifics of this extended functionality from the Controls menu display. **Figure 6-18** depicts the seven general categories of PLC device interfacing set-up options. Each of these is briefly described below:

PLC ctrl: Selecting this option transfers specific control of power supply functionality to the external device(s). This option must be selected in order to use the external device for the desired function.

PLC ctrl val: This option determines the soft limit (power, voltage or current) for which control is transferred to the PLC connected or other external control device.

PLC ctrl cfg: Setting up the signal interface type for PLC board is configured from this menu option and include the ranges of: 0-20mA, 0-5V, and 0-10V.

PLC fault: This menu option provides for additional safety, while using the external device by allowing a trip/fault shutdown to occur if a preset condition occurs (i.e. a foot switch is not actuated). Information specific to setting this functionality up is provided here and in **Section 9.5.**

PLC non-clr fault: Unlike PLC fault, this is a unlatched fault type and does not require a physical reset in order to clear (**Section 9.5**).

PLC fault reset: This menu option works in tandem with the PLC fault option and provides for the resetting action to occur from the external device after a PLC fault shutdown condition (PLC- AUC-O) has occurred.

PLC debug: This menu option provides a display for the analog control value in counts being recieved by the power supply from the connected PLC for reference.

Be sure to press the menu button after implementing changes within the controls menu. This action allows the power supply to confirm the changes.

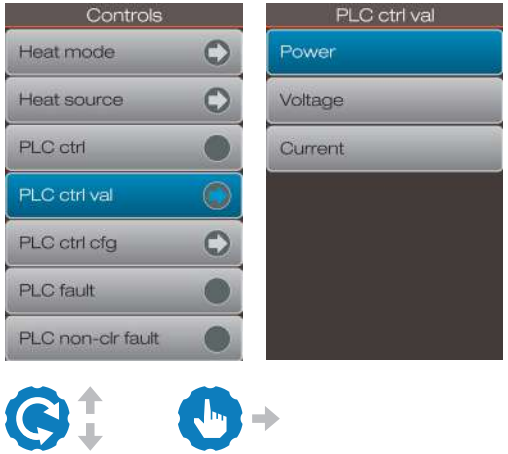
For menu items that use the bar-toggle button style, see Utilizing Bar-Toggle Button Styles for actuation sequence.

Off-screen menu options shown.

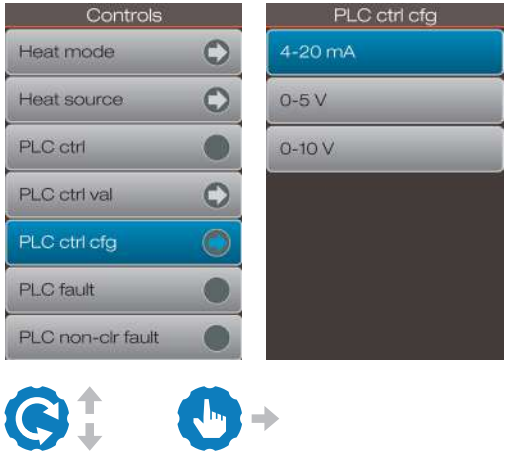
Figure 6-19: External Device Interfacing Set-up Menu Display

Managing Interface Control

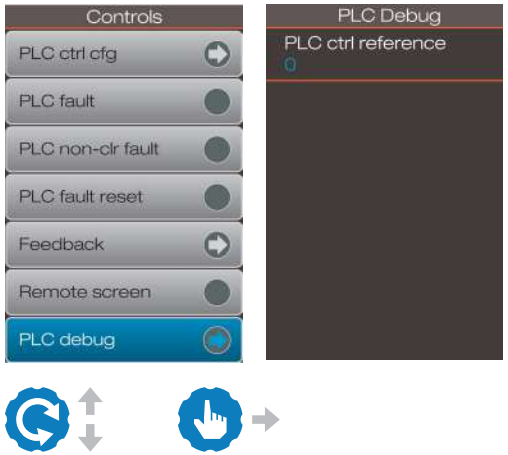
Changing External Soft Limit Control



Changing PLC-Control Configuration



Locating PLC Debug Reference



Managing Interface Control

Remote

Figure 6-19 shows the Remote menu. This is where network settings, protections, and connectivity designations can be established. These designations and setting configurations include: USB and Ethernet Connectivity, Host Name, IP and MAC addresses, and DHCP enabling for static or dynamic IP allocation.

Login prompts appear if attempting to change remote settings without having logged in as an administrator prior to the attempt.

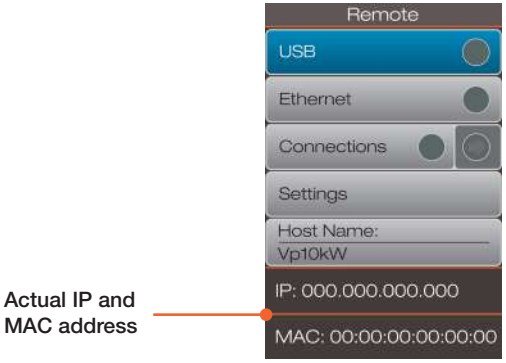
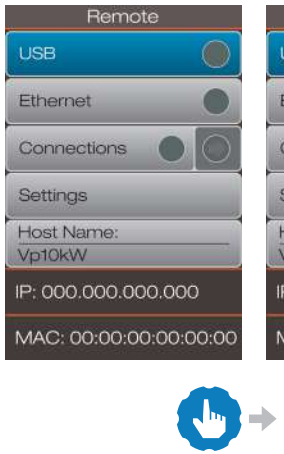


Figure 6-20: Remote Connectivity Set-up (remote menu)

Setting USB Connectivity



Setting Ethernet Connectivity

Managing Interface Control

Setting up Network Connections

See Utilizing Bar-Arrow Button Styles for actuation sequence.

See Utilizing Bar-Arrow Button Styles for actuation sequence.

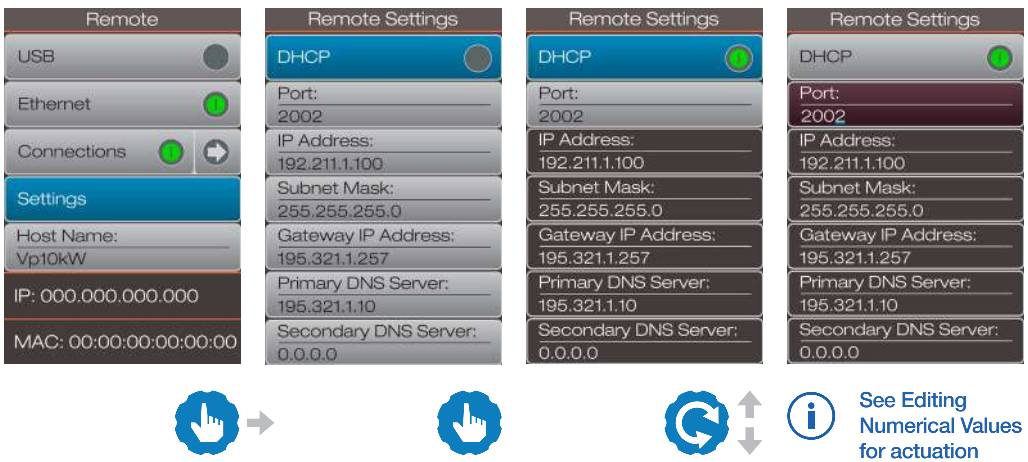
See Editing Text Characters for actuation sequence.

Changing Host Name

See Editing Text Characters for actuation sequence.

Managing Interface Control

Creating a DHCP Remote Connection

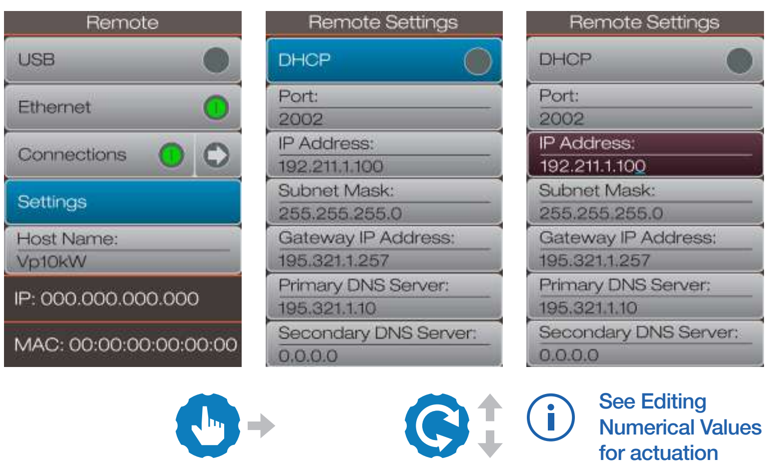


In order for the Remote Settings to take effect, the Ethernet option in the Remote menu must be enabled.

Enabling DHCP automatically fills these fields.

See Editing Numerical Values for actuation sequence.

Manually Changing Remote Connectivity Settings



In order for the Remote Settings to take effect, the Ethernet option in the Remote menu must be enabled.

In order to edit these values, verify that DHCP is disabled.

See Editing Numerical Values for actuation sequence.

Managing Firmware & Language

Updating Firmware

Changing Interface Language

Locating the Current Firmware Version

Using the Load Tuning Calculator

Introduction

Figure 6-20 depicts the top level Tune menu. By selecting the appropriate option and inserting the applicable values for Load Inductance, Frequency (operating frequency), and Quality Factor the VersaPower® Xtreme™ induction power supply calculates a suggested capacitance range and series inductor tap setting that is most likely to produce the desired load tuning settings used for inductance and capacitance. Enabling Extended Range provides for an additional range of inductance. This additional range extends the maximum inductance is 4.2 µH to a maximum total inductance of 10.54 µH.

Load Inductance and Quality Factor are determined by testing and measurement (See Inductor Manufacturer or call Radyne for assistance to determine inductance).

For more information related to Load Tuning and physically adjusting capacitance values and tapping the series inductor, see **Section 3.7.**

Figure 6-21: Load Tuning Calculator (input) Menu Display

Using the Load Tuning Calculator

Tap settings (i.e. Tap 1) and adjacent capacitance values are paired to produce a tuned load.

See Editing Numerical Values for actuation sequence.

See Editing Soft Limits for actuation sequence.

Preventative Maintenance

7.1	Overview & Personnel Qualifications	87
7.2	Repairs & Servicing	87
7.3	Maintenance Schedule	88
7.4	Annual Subscription Plans	89

Overview & Personnel Qualifications

The procedures within this section address the activities specific to preventative maintenance for the VersaPower® Xtreme™ induction power supply. These maintenance activities do not require access to inside the front or rear equipment panels. Any maintenance activity that requires gaining access to inside these equipment panels should only be performed by a Radyne Authorized Service Technician. Damage caused by performing unauthorized maintenance activity is the responsibility of the customer and will void applicable warranty provisions.

Persons performing activities within the scope of this section must be suitably qualified person possessing the knowledge and experience required for this type of activity. At no time is it acceptable to overcome manufacturer provided guards or safety interlocks. Never allow the inspection or other preventative maintenance activity to be performed by personnel other than those who have been suitably trained and declared competent to carry out such tasks.

Before interacting with this equipment in the manner described within this section, be sure to review and understand the entire procedure, all referenced section material, and all **Section 2** content. If you have any questions about direct application of the procedures within this section or the safety and health factors related to it, please contact Radyne before implementing the activity.

Maintenance Schedule

Daily

- Visually inspect the outside of the convertor for signs of water leaks, arcing or component overheating

- Inspect the water filter upstream from the induction power supply for blockages, debris, etc. Refer to **Section 9.2** for fluid cooling requirements & filtration

- Report any changes in the induction power supply operation, as well as, any trip faults/shutdown indications, either actual, or suspected to the maintenance engineer or a member of his staff

- Verify doors are closed and secure before operating the equipment

- Clean/remove debris and/or standing water from immediate area surrounding the equipment

It is the responsibility of the maintenance engineer to ensure that any and all guards, safety interlocks, and ground (earth) circuits are correctly fitted, fully functional and the convertor is in a safe operational condition before allowing equipment to be operated (**Section 2.11**).

Weekly

- Carry out the daily maintenance schedule

- Check output terminals for signs of oxidation

If oxidation is present, remove O-rings and use a Scot-Brite (3M 7447) very fine mesh sanding pad or equivalent to remove oxidation & debris on the copper terminals. Always use soap or detergent & water to remove debris and grease from the copper terminals and O-rings. Use a silicone based O-ring lubricant on the O-rings to re-apply them to the copper terminal O-ring grooves.

- Inspect control panels, lamps, switches, and buttons for damage

- Test all actuators and indicators for functionality

- Verify water circuit temp and flow sensors are reading correct values via the LCD display (**Section 6.4**)

- Remove any buildup of debris from around the installation

If operation is inhibited or damage of any components are suspected contact Radyne or your local VersaPower® Xtreme™ induction power supply distributor for repair services.

Annually

- Carry out the weekly maintenance

- Flush water system and check for leaks, corrosion, or blockages. Inspect filtration and change filters as required

When flushing a unit of the fluid circuit you may use compressed air to clear the unit of water. The PSI should not exceed 30psi for risk of damaging the flow and or other internal component sensors. Damage resulting from exceeding 30 PSI is the responsibility of the customer and will void applicable warranty provisions.

Annual Subscription Plans

The Silver Package

Our **Silver Package** offers an annual subscription that allows upgrades to your VersaPower® Xtreme™ induction power supply firmware. It also includes a Digital-iQ™ manager software license with which allows you to control and monitor multiple VersaPower® Xtreme™ induction power supplies simultaneously. You can also create, edit, manage, and load recipes to any induction power supply in your facility from one location and toggle between multiple production lines to monitor feedback values.

The Gold Package (coming soon)

Our **Gold Package** offers an annual subscription that includes everything in the silver package plus features that allow you to set limits for data elements, record and time stamp when those limits are exceeded for up to five power supplies with automatic email alerts. It also records the number of recipes executed and each type and the number of compliant and non-compliant recipe runs. The **Gold Package** also includes our rapid shipment program with a loaner induction power supply for use while your induction power supply is being repaired, thereby minimizing downtime.

The Platinum Package (coming soon)

Our **Platinum Package** offers an annual subscription that included everything in the Gold Package plus features like setting limits for data elements, record and time stamp when those limits are exceeded for an unlimited number of power supplies available on your network. It also includes automatic monitoring software that provides predictive alerts for maintenance. The predictive software works in conjunction with our high availability service where a loaner power supply is delivered to your door step prior to a predicted failure. Allowing you to swap the power supplies at your leisure and send your unit back for repairs, eliminating any downtime.

For more information about our Annual Service Plans please call the Radyne Aftermarket Sales and Service department at 414-481-8360.

Troubleshooting & FAQs

8.1	Overview & Personnel Qualifications	90
8.2	Trip / Fault Shutdown Indication Codes	91
8.3	Equipment Service Request	98
8.4	Frequently Asked Questions (FAQs)	99

Overview & Personnel Qualifications

The procedures within this section address the activities specific to troubleshooting activity for the VersaPower® Xtreme™ induction power supply. These activities are limited to the detail indicated for the specific trip/shutdown indication code. Any troubleshooting activity not explicitly listed within this section, should only be performed by a Radyne Authorized Service Technician. Damage caused by performing unauthorized troubleshooting activity is the responsibility of the customer and will void applicable warranty provisions.

Persons performing activities within the scope of this section must be suitably qualified person possessing the knowledge and experience required for this type of activity. At no time is it acceptable to overcome manufacturer provided guards or safety interlocks. Never allow troubleshooting activity to be performed by personnel other than those who have been suitably trained and declared competent to carry out such tasks.

Before interacting with this equipment in the manner described within this section, be sure to review and understand the entire procedure, all referenced section material, and all **Section 2** content. If you have any questions about direct application of the procedures within this section or the safety and health factors related to it, please contact Radyne before implementing the activity.

Trip / Fault Shutdown Indication Codes

Introduction

The information contained in this subsection was provided to offer assistance for clearing of trip/fault shutdown conditions that can occur as a result of the safety, PLC extended, and component protective features designed and/or added into the VersaPower® Xtreme™ induction power supply. The suggestions and procedures offered in the "Suggested Corrective Action" subsections serve as the pre-approved repair and/or troubleshooting activity that can be performed on the by qualified persons, other than Radyne Authorized Service Technician, without risking warranty provisions provided they are implemented in a manner consistent with what is indicated. Faults are defined as either latched or unlatched. Latched faults require a clearing/reset action in order to clear the LCD display of the trip/fault shutdown indication and allow for normal power supply operation. Unlatched faults are self clearing once the control circuit required condition for the fault is eliminated (**Section 6.4**). Each specific trip/fault shutdown indication code (**Section 8.2**) is organized and described with the following four subsections:

Description: A basic description of how the applicable indication is triggered and whether or not the fault is latched (i.e. requires clearing) or unlatched.

Special Notes: Additional details regarding how the condition is measured, locations of support information regarding maximum or minimum triggering range quantities, and other important useful information for suggested corrective action or cause.

Feedback Display Category: The feedback display category(s) that are associated with the real-time magnitudes for the fault.

Suggested Corrective Action: Actions that could eliminate the trip/fault shutdown indication code and its originating condition(s). In the event that the corresponding suggestions were unsuccessful, information is provided to complete the Equipment Service Request (**Section 8.3**).

WARNING:
Section 2 (Health & Safety) contains mandatory safety-related information applicable to activity within the scope of this section. It is essential that you familiarize yourself with this information before attempting any trip/fault clearing-related activity that involves opening or otherwise removing equipment panels and/ or places any part of your person near any high voltage or temperature area.

Clearing a latched fault is accomplished by cycling the heat switch. However, if PLC fault reset is enabled from the Controls menu (**Section 6.8**). When the PLC fault reset is enabled, a closed connection between Pin 5 and PLC ground must occur. The specific way this is accomplished is based on how the peripheral device response was configured and how it was connected to the respective pins.

Trip / Fault Shutdown Indication Codes

BUS-INV-L (Bus Input Voltage Low)

Description: This code occurs when the bus voltage is below the mandatory power supply input voltage requirement.

Special Notes: The value that establishes this code condition is set at 100 V for all models. This is most commonly related to an open equipment mounted circuit breaker or a mains line voltage falling below 100 V. This is an unlatched fault that clears automatically as soon as the bus voltage exceeds the 100 V minimum requirement.

Feedback Display Category: N/A

Suggested Corrective Action: Verify the E-Stop is pulled out. Verify the power is on (LCD lit up). Verify the rear equipment panel is closed and secured (security key). Verify the front equipment panel is closed and secured. If you are unsure the front panel is completely secure, gently press against the front equipment panel near the circuit breaker. If you hear a clicking sound the front panel is not secured. If the code still appears, either there is a problem in your mains voltage, or the DC fuse is blown. If your mains voltage supply is not the issue, complete the Equipment Service Request (Section 8.3) or contact Radyne Service Department at 1-800-236-8360 and request service.

BUS-INV-H (DC Bus Exceeded Maximum Voltage)

Description: This code occurs when the DC bus exceeded the maximum allowable voltage for the power supply

Special Notes: The value that establishes this code condition is set at 1000 V for 480 V models and 600 V for 240 V models. This is a latched fault that requires clearing after the DC bus voltage drops below the maximum value

Feedback Display Category: N/A

Suggested Corrective Action: Check input power circuit protection for a blown fuses. If none of upstream fuses are blown check power distribution system equipment ratings based on your specific model's power requirements (**Section 9.1**). If your power distribution system ratings meet the power requirements for the equipment, the power supply may need servicing. Complete the Equipment Service Request (**Section 8.3**) or contact Radyne Service Department at 1-800-236-8360 and request assistance.

CAP-ARV-H (Capacitor Average RMS Voltage High)

Description: This code occurs when the average capacitor tank voltage for a specified sample period exceeds the recommended safe operating value of the capacitors.

Special Notes: Sample period is frequency dependent. Safe operating values determined by model and capacitor specifications. This is a latched fault that requires clearing after the average capacitor tank voltage for a specified sample period returns to the recommended safe operating value.

Feedback Display Category: Voltage

Suggested Corrective Action: Adjust power supply performance and/or load tuning settings in order to produce less current or frequency. Clear fault and attempt restart. If the code reappears, apply **Section 8.3** procedure using voltage as the incremented soft limit, complete the Equipment Service Request, or contact Radyne Service Department at 1-800-236-8360 and request service.

CAP–PKV-H (Capacitor Peak Voltage High)

Description: This code occurs when the capacitor tank voltage signal peak exceeds capacitor output capabilities causing the output waveform to clip.

Special Notes: This is a latched fault that requires clearing after capacitor tank voltage signal drops below the capacitor peak output capabilities. Repetitive occurrences usually signify a more serious condition (i.e. faulty inverter board).

Feedback Display Category: Voltage

Suggested Corrective Action: Inspect the output inductor and the capacitor mounting array for foreign materials, damage, or shorted conditions. Clear fault and attempt restart. If the code reappears, apply **Section 8.3** procedure using voltage as the incremented soft limit, complete the Equipment Service Request, or contact Radyne Service Department at 1-800-236-8360 and request service.

Trip / Fault Shutdown Indication Codes

EDB-OVF-H (Feedback Overflow)

Description: This code occurs when the there is an internal calculation error.

Special Notes: This is a latched fault that requires clearing. However, all tested scenarios resulted in the code reappearing after clearing the fault.

Feedback Display Category: N/A

Suggested Corrective Action: Unit will need servicing, complete the Equipment Service Request (**Section 8.3**) or contact Radyne Service Department at 1-800-236-8360 and request assistance.

FBB-COM-E (Feedback Board Communication Error)

Description: This code occurs when there is a communication problem between the control board and the feedback board/HMI.

Special Notes: Some models may include the HMI connection as associated with this fault. If the originating condition is HMI related, the actual display of this trip/fault will not appear as the entire digital interface environment will be rendered inoperative unless in the Manual Mode menu. This is a latched fault that requires clearing after the communication problem or HMI-related fault condition is eliminated.

Feedback Display Category: N/A

Suggested Corrective Action: Clear fault and attempt restart. If this code still appears, complete the Equipment Service Request (**Section 8.3**) or contact Radyne Service Department at 1-800-236-8360 and request service.

H2O-CWT-H (Coolant Fluid Output Inductor Temperature High)

Description: This code occurs when the coolant fluid temperature flowing through the output inductor exceeds the recommended safe operating value.

Special Notes: The value that establishes code condition is set at 165 °F for all models. This is a latched fault that requires clearing after the output inductor temperature drops below the maximum value. There are a variety of factors that could contribute to excessively high output inductor coolant fluid temperature including inductor design. If output inductor coolant fluid temperature prevents the needed heating process requirements, additional output inductor cooling systems may be required. Contact Radyne Service and Aftermarket Sales at 1-800-236-8360.

Feedback Display Category: Coil Out

Suggested Corrective Action: Verify and test external coolant fluid system and coolant fluid according to the quality specifications contained in **Section 9.2**. If all specifications are met, clear fault and attempt a restart to determine how close the feedback display category magnitude for Coil Out is to the respective maximum value. Check for an internal cooling system leaks. If no leak present, lower the upstream coolant fluid temperature by a few degrees, clear fault, and attempt to restart. If the code reappears, apply **Section 8.3** procedure using power as the incremented soft limit, complete the Equipment Service Request (**Section 8.3**) or contact Radyne Service Department at 1-800-236-8360 and request service.

Trip / Fault Shutdown Indication Codes

H20-FLR-C (Coil Flow Circuit Fluid Rate Low)

Description: This code occurs when the flow rate of the coolant fluid through the output inductor circuit drops below the recommended safe operating value.

Special Notes: The value that establishes this code condition is 0.3 GPM for the 5 kW models and 0.5 GPM for all other models. This code is most commonly caused by the external coolant fluid system and/ or coolant fluid quality related issues. This is a latched fault that requires clearing after the output inductor coolant flow rate(s) increase above the minimum requirement.

Feedback Display Category: Coil Flow

Suggested Corrective Action: Verify and test external coolant fluid system and coolant fluid according to the quality specifications contained in **Section 9.2**. If all specifications are met, clear fault and attempt a restart to determine how close the feedback display category magnitude for Coil Flow is to the minimum value. Check for an internal cooling system for leaks, if no leak present, change the pressure differential clear fault and attempt restart. If the code reappears, complete the Equipment Service Request (**Section 8.3**) or contact Radyne Service Department at 1-800-236-8360 and request service.

H2O-FLR-P (Power Circuit Flow Rate Low)

Description: This code occurs when the flow rate of the coolant fluid through the power circuit drops below the recommended safe operating value.

Special Notes: The value that establishes this code condition is set at 1 GPM for all models. This code is most commonly caused by the external coolant fluid system and/or coolant fluid quality related issues. This is a latched fault that requires clearing after the applicable coolant flow rate(s) increase above the minimum requirement.

Feedback Display Category: Power Flow

Suggested Corrective Action: Verify and test external coolant fluid system and coolant fluid according to the quality specifications contained in **Section 9.2**. If all specifications are met, clear fault, and attempt a restart to determine how close the feedback display category magnitude for Power Flow is to the minimum value. Check for an internal cooling system for leaks, if no leak present, change the pressure differential clear fault and attempt restart. If the code reappears, complete the Equipment Service Request (**Section 8.3**) or contact Radyne Service Department at 1-800-236-8360 and provide the requested information.

H2O-INT-H (Coolant Fluid Input Temperature High)

Description: This code occurs when the coolant fluid temperature coming into the power supply's internal coolant fluid system exceeds the recommended safe operating value.

Special Notes: The value that establishes this code condition is set at 110 °F for all models. This is a latched fault that requires clearing after the input coolant temperature drops below the maximum value.

Feedback Display Category: Water In

Suggested Corrective Action: Verify line/connection integrity from the Water In port upstream. Verify that the temperature of the coolant fluid upstream from the power supply is within the model specific range (Section 9.2). Adjust accordingly, clear fault and attempt a restart. If this code reappears, verify and test external coolant fluid system and coolant fluid according to the quality specifications contained in Section 9.2. When all specifications are met, clear fault, and attempt a restart to determine how close the feedback display category magnitude for Water In is to the maximum value. Check for an internal cooling system for leaks. If no leak present, clear fault and attempt restart. If the code reappears, complete the Equipment Service Request (Section 8.3) or contact Radyne Service Department at 1-800-236-8360 and request service.

QAS-RST-H (Mini QAS Fault High)

Description: This code occurs when the QAS measured values goes outside the tolerance percentage value set in the mini QAS settings of the recipe.

Special Notes: Make sure the tolerance percentage of acceptable values is greater than 0%. 0% corresponds to values extremely close to the original part ran. While the VX is very good about producing the same results over and over, there is always a slight variance down to the position of the part inside the coil or the amount of energy put into the part.

Feedback Display Category: N/A

Suggested Corrective Action: Verify that the part that faulted was placed inside the heating area in the same way the part was placed in the heating area when the QAS was recording the initial values for the recipe. Alternately, you can open the tolerance percentage so that a wider range of acceptable values are available to avoid tripping the Mini QAS fault.

Trip / Fault Shutdown Indication Codes

H2O-OUT-H (Coolant Exiting Power Temperature High)

Description: This code occurs when the coolant temperature exiting the power circuit exceeds the recommended safe operating value.

Special Notes: The value that establishes this code condition is set at 130 °F for all models. This is a latched fault that requires clearing after the coolant within the power circuit drops below the maximum value.

Feedback Display Category: Power Out

Suggested Corrective Action: Verify and test external coolant fluid system and coolant fluid according to the quality specifications contained in **Section 9.2**. If all specifications are met, clear fault and attempt restart. If this code still appears to determine how close the feedback display category magnitude for Power Out is to the respective max value. Check for an internal cooling system leak. If no leak present, lower the upstream coolant fluid temperature by a few degrees. Clear fault and attempt restart. If this code still appears, apply **Section 8.3** procedure using power as the incremented soft limit, complete the Equipment Service Request, or contact Radyne Service Department at 1-800-236-8360 and request service.

INV-ARI-H (Inverter Average RMS Current High)

Description: This code occurs when the average inverter current for a specified sample period exceeds the recommended safe operating value of the inverter board.

Special Notes: This is a latched fault that requires clearing after the average inverter current drops below the safe operating limit. Sample period is frequency dependent. Safe operating values are determined according to model and inverter board specifications.

Feedback Display Category: Current

Suggested Corrective Action: Adjust power supply performance and/or load tuning settings in order to produce less current or frequency. Clear fault and attempt restart. If the code reappears, apply **Section 8.3** procedure using current as the incremented soft limit, complete the Equipment Service Request, or contact Radyne Service Department at 1-800-236-8360 and request service.

INV-PKI-H (Inverter Peak Current High)

Description: This code occurs when the inverter current signal peak exceeds its output capabilities causing the output waveform to clip.

Special Notes: This is a latched fault that requires clearing after the peak inverter current drops below the maximum value. Repetitive occurrences usually signify a more serious condition (i.e. faulty inverter board).

Feedback Display Category: N/A

Suggested Corrective Action: Inspect the output inductor and the capacitor mounting array for foreign materials, damage, or shorted conditions. Then, clear fault and attempt to restart. If the code reappears, apply **Section 8.3** procedure using current as the incremented soft limit, complete the Equipment Service Request, or contact Radyne Service Department at 1-800-236-8360 and request service.

Trip / Fault Shutdown Indication Codes

INV-TRV-P (Inverter Transistor Voltage Present)

Description: This code occurs when there is an uncharacteristic voltage across any transistor on the inverter board modules while the respective transistor is in the “active” state.

Special Notes: This is a latched fault that requires clearing after the uncharacteristic voltage is eliminated. The circumstances surrounding this code usually represent the seriousness of the originating condition(s).

Feedback Display Category: N/A

Suggested Corrective Action: Adjust power supply performance and/or load tuning settings in order to produce less current or frequency, clear fault, and attempt to restart. If the code reappears, apply Section 8.3 procedure using current as the incremented soft limit, complete the Equipment Service Request, or contact Radyne Aftermarket Sales and Service Department at 1-800-236-8360 and request service. Also be sure to include or to have ready the responses to the following questions on the form:

- Is the shutdown condition a one-time occurrence?

- Is there sparking?

- Does the shutdown occur immediately after starting the recipe or upon beginning a certain recipe step?

- Is the output inductor shorted?

- Is there any unusual and periodic audible noise (i.e. high pitch hissing or loud popping)?

- Does the output inductor meet the inductance range specification of the power supply?

- Does the code occur while operating under 60% of current maximum?

LCT-IMB-E (Line Current Phase Imbalance)

Description: This code occurs when one of the 3 line current phases is greater than 50% of the other two.

Special Notes: This is a latched fault that requires clearing after the line current phase imbalance is corrected.

Feedback Display Category: N/A

Suggested Corrective Action: Clear fault and attempt a restart. If this code reappears, check the upstream breaker line to determine if one or more fuses are blown. If they are replace the necessary fuses, clear fault, and attempt restart. If the code reappears and the fuses remain functional, the power supply may need servicing. Complete the Equipment Service Request (**Section 8.3**) or contact Radyne Service Department at 1-800-236-8360 and request assistance.

PLC-AUC-O (PLC Pin 4 Connection Opened)

Description: This code occurs when the PLC connected device’s predetermined fault set-up results in an open condition for Pin 4 (**Section 9.5**).

Special Notes: This is a latched fault that requires clearing after the PLC connected device establishes a closed connection between Pin 4 and PLC ground. The specific causes of this code are based on how the peripheral device response was configured and how it was connected via the PLC fault connection terminals.

Feedback Display Category: N/A

Suggested Corrective Action: Check to verify the peripheral device has not malfunctioned and the physical connection from Pin 4 to PLC ground is secure and continuous. Then, clear fault, and attempt to restart. If this code reappears, complete the Equipment Service Request, or contact Radyne Service Department at 1-800-236-8360 and request service.

Trip / Fault Shutdown Indication Codes

PLC-COM-E (PLC Board Connection Error)

Description: This code occurs when there is a communication problem between the control board and the feedback board/HMI.

Special Notes: Some models may include HMI connection as part of the PLC-COM-E trip/fault shutdown indication code. If the originating cause of this code is HMI related, the actual display of this trip/fault will not appear as the entire digital interface environment is rendered inoperative. If code appears and the digital interface is still operative, the most likely cause is PLC related, and could be attributable to the peripheral device connection. This is an unlatched fault that clears automatically as soon as the originating condition for the error is eliminated.

Feedback Display Category: N/A

Suggested Corrective Action: Attempt to restart. If this code still reappears, complete the Equipment Service Request (**Section 8.3**) or contact Radyne Service Department at 1-800-236-8360 request service.

PLC-DVC-O - (PLC Pin 7 Connection Opened)

Description: This code occurs when the PLC connected device's predetermined fault set-up results in an open condition for Pin 7 (**Section 9.5**).

Special Notes: This is an unlatched fault that clears automatically once the PLC connected device establishes a closed connection between Pin 7 and PLC ground The specific causes of this code are based on how the peripheral device response was configured and how it was connected to Pin 7 and PLC ground.

Feedback Display Category: N/A

Suggested Corrective Action: Check to verify the peripheral device has not malfunctioned and the physical connection from Pin 7 to PLC ground is secure and continuous and attempt to restart. If this code reappears, complete the Equipment Service Request, or contact Radyne Service Department at 1-800-236-8360 and request service.

Equipment Service Request

Introduction

The "Equipment Service Request" is provided to assist Radyne Service Engineers with needed information that can shorten your downtime. **Figure 8-1** contains a representative sample of the form. The main purpose of this form is to collect information with respect to a re-occurring trip/fault shutdown condition codes (**Section 8.2**). When completing this form it is essential that you indicate as much information as possible within the "Trip/Fault Shutdown Information" subsection. This information is found on the LCD feedback Display for your workpiece heating mode (**Section 6.4**). The "Additional Observations" subsection is where answers for specific questions specific to a trip/fault shutdown code (**Section 8.2**) or other important details are entered. After completing the form submit it, via email to Radyne Aftermarket Sales and Service Department (spares@radyne.com).

WARNING:
It is the customer's responsibility to ensure that all trip/fault shutdown clearing activity is done so in manner that agrees with the safety requirements of Section 2, as well as, the applicable governing regulations.

Process:

Step 1. Review Section 8.1 and code specific detail in **Section 8.2**

Step 2. Apply applicable safe work practices and protections (**Section 2**)

Step 3. Set "soft limit to increment" to minimum and all others to maximum (**Section 8.2**)

If you have set the PLC to control power, voltage, or current be sure that you, first, set the PLC ctrl val (**Section 6.8**) to the correct "soft limit to increment" as indicated within the trip/fault shutdown indication code "Suggested Corrective Action" detail (**Section 8.2**). By default the other two will be set to maximum.

Step 4. Implement Single-step Workpiece Heating (**Section 5.4**)

Step 5. Increment "soft limit to increment" by 10% at approximately 3 second time intervals until trip/fault shutdown indication code appears

Step 6. Record feedback display values (**Equipment Service Request**)

Service Request Equipment Audit

Company:
Model Number:
Address:
City, State, zip:
Date:

RADYNE

Trip/Fault Shutdown Information (Refers to values/information at the time of the shutdown)

	Trip/Faut Shutdown Code(s)		LCD Feedback Display Magnitude(s)	
Coolant System	H20-EXT-H	☐	Coil Flow	
	H20-FLR-L	☐	Power Flow	
	H20-FLR-C	☐	Water In	
	H20-INT-H	☐	Coil Out	
	H20-OIT-H	☐	Power Out	
Electrical	BUS-INV-H	☐	Freq	
	BUS-INV-L	☐	DC kW	
	CAP-ARV-H	☐	DCV	
	CAP-PKV-H	☐	DC I	
	INV-ARI-H	☐	AC I	
	INV-PKI-H	☐	Power	
	INV-TRV-P	☐	Current	
	LCT-IMB-E	☐	Voltage	
PLC/Ext Devices/Other	EDB-OVF-H	☐	Limit	
	FBB-COM-E	☐		
	PLC-AUC-O	☐		
	PLC-COM-E	☐		
	PLC-DVC-O	☐		
	QAS-RST-H	☐		

Additional Observations (i.e. malfunctioning components, odd smells, PLC device details, etc.)

An electronic copy of the this form is available at www.radyne.com or by requesting a copy via email (service@radyne.com) or by calling (414) 481-8360 or 1-800-236-8360

Frequently Asked Questions (FAQs)

How do I control heat on/off remotely? In order to control heat on/off remotely, go to Setting>Controls>Heat Source then select the control source (see **Section 6.8**).

How do I control power, voltage, or current remotely? In order to control power, voltage, or current via PLC connection see **Section 9.5** & **Section 6.8**. You can also control power through Ethernet or USB connection by going to Settings>Controls>Heat Source then select Ethernet or USB depending on what is connected. Ethernet or USB heat source enabled will override PLC ctrl if its enables as well (**Section 6.8**).

Why are the edit mode and production mode virtual buttons greyed out? These virtual buttons grey out when PLC or Ethernet control is enabled. To remove this you must change the heat source to Front Panel Settings>Control>Heat Source, disable the Ethernet and PLC control Settings>Remote>Ethernet and Settings>Controls>PLC ctrl (**Section 6.8**).

Why do I have to enter a password every time I want to change control settings or save a recipe? If you have to keep entering a password to change control settings or save a recipe it is because you are not in admin mode. (**Section 6.5**)

Why won't the breaker go up? The following scenarios could cause this to occur:
- Verify the E-Stop is pulled out
- Verify the Power is on (LCD lit up)
- Verify the rear equipment panel is closed and secured (security key)
- Verify the front equipment panel is closed and secured, if unsure gently press against the front equipment panel near the circuit breaker, if you hear a clicking sound it is not secured

Why do I keep getting a DC bus voltage low trip (BUS-INV-L)? Review **Section 8.1** and lookup BUS-INV-L in **Section 8.2** for specific details

How do I clear a flow trip? If the coil flow trip occurs make sure that the coil circuit has at least 0.3 GPM for 5kW and 0.5 GPM for everything else by going to Manual Mode> then push the menu button to toggle between the feedback screens. Also check to the see the power flow trip the GPM must be 1.0 GPM.

How do I clear a current imbalance trip (LCT-IMB-E)? If a line current imbalance trip occurs, check your line input fuses going from your 3 phase into the VersaPower® Xtreme™ induction power supply, one of them might be blown (See **Section 8.2** for more details).

How do I switch heat on/off control from maintained to momentary or toggle control? If you are changing the heat on source to PLC remember the default control is latched (maintained). In order to turn it off you need to engage the heat off contact or switch the heat mode to momentary or toggle so that one wire can control turning the heat on and off. If your switch has a two conductor connection you can control the switch with maintained, momentary, or toggle. In order to switch the controls go to Settings>Controls>Heat Mode then select between Maintained, Momentary, or Toggle (**Section 6.8**).

How do I turn the heat off? The most common way is through the heat on/off selector switch located on the front of the unit turn the switch counter clockwise or to the left. If you're in an emergency situation and/or your controls are set up differently (so the selector switch is not enabled) you can kill heat via the E-Stop pushbutton on the front panel or pushing the circuit breaker in the down position also located on the front of the unit.

What do I do if the equipment did not update correctly and the LED bar graphs flash on and off? You need to boot into factory mode by holding the encoder knob down and turning the power on. Don't release the knob until the main menu screen comes up. From this screen you can attempt to re-update the machine.

I had a fault occur and I fixed the condition- why will the fault not go away? Latched faults must be cleared with the heat on/off selector switch after fixing the condition. Turn the heat on/off selector switch counterclockwise or to the left to clear a fault. All faults are latched with the exception of the BUS-INV-L-(bus input voltage low) and PLC-DVC-O-(PLC Pin 7 Connection Opened) do not clear automatically after condition is fixed, in order to clear all other faults you must use the heat on/off selector switch. However, if you using a PLC connected device to implement fault resets, then the control of this function is transferred from the heat on/off selector switch to the PLC connected and configured device (**Section 9.5** & **Section 6.8**).

Technical Data

9.1	Specification: Electrical	101
9.2	Specification: Fluid Cooling System	102
9.3	Specification: Physical	104
9.4	Specification: PLC Interface	107
9.5	Connection Detail: PLC Functionality	108
9.5	Drawing: Output Mount	110
9.6	Drawing: Physical Layout (5 - 15 kW Models)	111
9.7	Drawing: Physical Layout (25 - 50 kW Models)	112

Specification: Electrical

Input Magnitudes Requirements (nominal)

Model	Input Voltage (V_{AC}, 50/60 @3Φ)			Current (A)	Apparent Power (KVA)
	Min	Max	Nom		
3VXL480P	390	490	480	10	3.99
3VXL240P	195	245	240	20	
3VXH480P	390	490	480	10	
3VXH240P	195	245	240	20	
5VXL480P	390	490	**480**	10	6.65
5VXL240P	195	245	**240**	20	
5VXH480P	390	490	**480**	10	
5VXH240P	195	245	**240**	20	
10VXL480P	390	490	**480**	20	13.3
10VXL240P	195	245	**240**	40	
10VXH480P	390	490	**480**	20	
10VXH240P	195	245	**240**	40	
15VXL480P	390	490	**480**	30	19.95
15VXL240P	195	245	**240**	60	
15VXH480P	390	490	**480**	30	
15VXH240P	195	245	**240**	60	
25VXL480P	390	490	**480**	44	29.26
25VXL240P	195	245	**240**	87	
25VXH480P	390	490	**480**	44	
25VXH240P	195	245	**240**		
30VXL480P	390	490	**480**	87	39.9
30VXH480P					

Table 9-1: Electrical Input Magnitude Requirements (normal)

Output Magnitude Requirements (typical @ 100%)

Model	Voltage (V_{DC})	Min Frequency	Max Frequency	Power (kW)
3VXL	400	20	80	3
3VXH	500	100	400	
5VXL	400	20	80	5
5VXH	500	100	400	
10VXL	400	20	80	10
10VXH	500	100	400	
15VXL	400	20	80	15
15VXH	500	100	400	
25VXL	400	20	80	25
25VXH	500	100	400	
30VXL	400	20	80	30
30VXH	500	100	400	

Table 9-2: Electrical Output Magnitudes (typical @ 100%)

Specification: Fluid Cooling System

Coolant Fluid Quality

Table 9-3 contains the required coolant fluid quality specifications for the VersaPower® Xtreme™ induction power supply. To ensure the correct operation of the induction heating coolant system, it is essential that these coolant fluid specifications be maintained. Regularly testing coolant fluid for compliance with these quality characteristics is the customer's responsibility and is required. Operating the induction power supply while using coolant fluid that does not meet these specifications may cause equipment failure and consequently, void applicable warranty provisions.

Heat Dissipation Characteristics

Heat dissipation is an important consideration in induction heating. Output inductor size/electrical characteristics, work piece material, power supply efficiency, and the actual work piece heating objectives all play a significant role in determining the rate by which heat is added and removed. **Table 9-4** contains the glycol solution mixture ratios for the VersaPower® Xtreme™ induction power supply.

Connections Specification

Suitable gate/ball valves (brass & stainless steel fittings only) and filters (30 mesh) must be installed at the incoming cooling fluid connection ports of the power supply. Please refer to coolant system connection (**Section 4.5**) for connection details.

A water to water or water to air type cooling system designed to operate with this induction power supply can be supplied by Radyne by contacting our aftermarket sales and service department at 1-800-236-8360.

Quality Characteristic	Acceptable Range
Glycol Additive	Propylene (NO Ethylene Allowed)
pH Level	Between 6.8 and 7.8
Dissolve Solids Level	< 300 PPM
Conductivity	< 300 micro mhos/cm
Hardness Level	< 150 PPM
Sulphate Level	< 30 PPM
Chloride Level	< 100 PPM
Alkalinity to Chloride	< 4:1

Table 9-3: Coolant Fluid Quality Levels

Propylene Glycol Solution		Freezing Point	
% by mass	% by volume	°F	°C
0	0	32	0
10	10	26	-3
20	19	18	-8
30	29	7	-14
40	40	-8	-22
50	50	-29	-34
60	60	-55	-48

Table 9-4: Propylene Glycol Mixture Ratio

Operating the induction power supply while using cooling fluid that does not meet these specifications may cause equipment failure and will void applicable warranty provisions.

Specification: Fluid Cooling System

Coolant Fluid Temperature

Table 9.5 contains the absolute ratings pertaining to coolant fluid temperature for the various models of the VersaPower® Xtreme™ induction power supply. Maximum inlet temperature of the coolant fluid when it enters the induction heating power supply's internal coolant system is 114 ºF (45.56 ºC). This is the maximum temperature as measured on the secondary side of a water to water heat exchanger system or at a point just prior to the inlet of the induction power supply. In addition to this high temperature limit, care must be taken to ensure that the inlet temperature of the coolant fluid is high enough to prevent condensation within the internal coolant system. Specific low temperature limits are not provided as these values can and will vary depending on the climatic conditions of the power supply's immediate area.

Coolant System Flow Rate & Pressure Differential

Table 9-5 also contains the absolute ratings pertaining to flow rates and system pressure for the various models of the VersaPower® Xtreme™ induction power supply. Operating the power supply at flow rates and system pressures outside of the absolute ratings will cause equipment failure and output inductor damage and consequently, void applicable warranty provisions. Additionally, it is recommended that when attempting to establish optimal cooling, a pressure differential of 6.75 PSI be used as the starting point. Depending on the specific coolant fluid mixture and system set-up, flow rates can be varied within acceptable ranges to achieve different cooling outcomes. One effective way to accomplish the desired cooling is to utilize the indications of the LCD display. By simply monitoring the values associated with Water In, Coil Out, and Power Out on the feedback display during the recipe creation process and adjusting the flow rate and coolant fluid temperature upstream, an optimal flow rate for the heating outcome can be readily achieved.

Quality Characteristic	Value	Applicable Models
Max Pressure (PSI)	100	All
Min ΔP (PSI)	30	All
Min Coil Flow Circuit (GPM)	0.3 | 0.5 | X	3VX & 5VX | 10VX & 15VX | 25VX & 30VX
Max Coil Flow Circuit (GPM)	9.2	All
Min Power Flow Circuit (GPM)	1 | 1.5 | X	3VX & 5VX | 10VX & 15VX | 25VX & 30VX
Max Power Flow Circuit (GPM)	9.2	All
Max Water In (°F)	114	All
Max Coil Out (°F)	165	All
Max Power Out (°F)	130	All

Table 9-5: Cooling Fluid System (absolute ratings)

Specification: Physical

Table 9-6 contains the physical height, width, and weight of the various models of the VersaPower® Xtreme™ induction power supply. These specifications must be used when determining transport, shipping, moving, and operator spacing requirements for this equipment.

For additional unit dimensions refer to drawings in Section 9.7 and Section 9.8.

Net Weight, Shipping Weight & Dimensions

Model	Unit Dimensions		Unit Weight		Package Dimensions		Packaged Weight	
	in	mm	lbs	kg	in	mm	lbs	kg
3VX	16.15L x 20.26W x 16.75H	410.2L x 514.6W x 425.5H	68	30.84	19L x 25W x 19.25H	482.6L x 635W x 488.95H	77	34.93
5VX			68	30.84			77	34.93
10VX			72	32.66			81	36.74
15VX	16.15L x 20.26W x 26.13H	410.2L x 514.6W x 663.6H	76	34.47	*	*	85	38.56
25VX			100	45.36			*	*
30VX			135 ± 5	61.24 ± 2.28				

* Air Ride packages only

Table 9-6: Physical Dimensions Specifications

Specification: PLC Interface

Introduction

Control of the VersaPower® Xtreme™ induction heating power supply can be extended by way of the VersaPower® Xtreme™ PLC Connector Option (**Figure 9-1**). The connector can be found on the rear of the power supply, by the power cord entry. On power supplies which do not have this option installed, the connector hole is covered with a protection plug. If your model does not have this option currently and you would like more information about its advantages or how to have your current model outfitted with PLC capability, please contact Radyne.

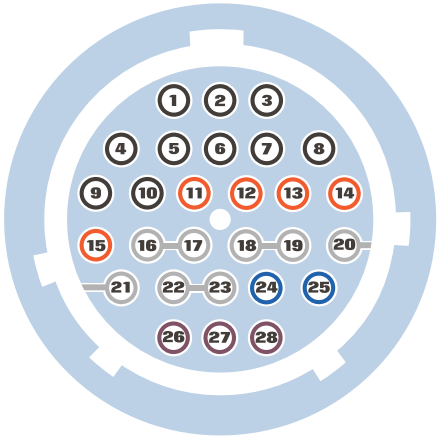


Figure 9-1: PLC Connector

ANALOG IN		
1. GND	Black	
2. HEAT ON	White	
3. HEAT OFF	Red	
4. PLC FAULT	Green	
5. RESET	Orange	
6. GND	Blue	
7. PLC-NON-CLR	White/Black	
8. RESERVED	Red/Black	
9. RESERVED	Green/Black	
10. ANALOG CONTROL	Orange/Black	
ANALOG OUT		
11. GND	Blue/Black	
12. POWER	Black/White	
13. VOLTAGE	Red/White	
14. CURRENT	Green/White	
15. FREQUENCY	Blue/White	
RELAYS OUT		
16. HEAT IS ON	Black/Red	
17. HEAT IS ON	White/Red	
18. INV READY	Orange/Red	
19. INV READY	Blue/Red	
20. RESERVED	Red/Green	
21. RESERVED	Orange/Green	
22. RESERVED	Black/White/Red	
23. RESERVED	White/Black/Red	
EMERGENCY STOP		
24. E-STOP	Not Used	
25. E-STOP GND	Not Used	
OTHER		
26. DRAIN	Red/Black/White	
27. N/C	Green/Black/White	
28. N/C	Shield Drain Wire	

Table 9-7: PLC Connector Cable Wiring Details

Pins 1, 6, and 11 are the same ground connection. This ground is galvanically isolated from power supply chassis ground. All inputs and outputs are provided with ESD and over-voltage protection.

Specification: PLC Interface

Connector/Component (Absolute Ratings)

Pin Configuration	Quantity	Minimum	Maximum	Unit
All Inputs	Voltage	-0.5	10.5	V_{DC}
	Current	-50	50	mA
Analog Outputs	Voltage	-0.5	10.5	V_{DC}
	Current	-50	50	mA
Dry Contact Outputs	Current	0	700	V_{RMS}
	Standoff Voltage	-	200	mA
	Isolation Voltage	-	2500	A_{RMS}

Table 9-8: PLC Connector (absolute ratings)

Utilizing the PLC connector with magnitudes beyond those listed in **Table 9.7** may cause malfunction and permanent damage and void applicable warranty provisions.

Typical Characteristics (Input)

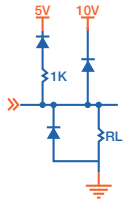
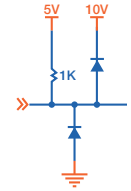
Description (Mode)	Circuit	Value	Tolerance	Unit
4-20mA (Current)		RL = 250	10%	Ω
0-5V (Voltage)		RL = 40K	2%	
0-10V (Voltage)		RL = 26.7K		
Open Collector Switch Mode		Pull-up = 1K	5%	
Hysteresis, Rising Threshold	Open Collector Mode (Only)	2.8		V
Hysteresis, Falling Threshold		2.2		
Analog Input Bandwidth	All Modes	1.6	3.2	kHz
Analog Input Bandwidth		200		Sa/s

Table 9-9: PLC Connector (typical input characteristics)

Before making any connections, be sure to review **Section 6.12** to determine how to enable the PLC external device configurations.

Specification: PLC Interface

Typical Characteristics (Analog Output)

Quantity	Minimum	Maximum	Unit
Load Current	0	10	mA
Load Resistance	1k	-	Ω
Dynamic Resistance	0.1		
DAC Sample Rate	400	-	Sa/s
Settling Time	10		µs
Analog Bandwidth	200		kHz
Capacitive Load (No Oscillation)	CL = 10nF		-

Table 9-10: PLC Connector Typical Analog Output Characteristics

Typical Characteristics (Dry Contact Output)

Quantity	Conditions	Min	Max	Unit
Contact Resistance	On State	-	1.4	Ω
Switching Speed	Vs = 100V,RL = 1kΩ	-	5	ms

Table 9-11: PLC Connector Typical Dry Contact Output Characteristics

Connection Detail: PLC Functionality

Heat Control Extension Detail

Controls Menu Settings: Heat Source must be set to PLC and PLC ctrl must be enabled (**Section 6.8**).

Electrical Connection: Close connection between Pin 2 and PLC ground (Pin 1, Pin 6, or Pin 11) to send a “heat on” signal to the power supply. Close connection between Pin 3 and PLC ground (Pin 1, Pin 6, or Pin 11) to send a “heat off” signal to the power supply.

Additional Details:
- When the Heat Mode is set as Maintained, close the Pin 2 and PLC ground connection to turn the heat on and close Pin 3 and PLC ground or a recipe time-out turns heat off. If the Pin 3 and PLC ground connection is closed, closing the Pin 2 and PLC ground connection will not turn the heat on signal to the power supply.

- When the Heat Mode is set as Momentary, the Pin 2 and PLC ground connection must remain closed to in order to keep the heat on. If this option is used, closing the Pin 3 and PLC ground connection will not turn the heat off.

- When the Heat Mode is set as Toggle, closing the Pin 2 and PLC ground connection will toggle the heat on and off. If this option is used, closing the Pin 3 and PLC ground connection will not turn the heat off.

This extended functionality can be implemented via Ethernet and USB. See **Section 6.8** for connectivity setup.

Do not attempt to connect PLC devices without fully reviewing and applying the applicable safety requirements and protections contained within **Section 2** (**Health & Safety**).

Always verify that the electrical requirements of the PLC connected device coincide with the specifications for the PLC (**Section 9.4**). All damage resulting from improper installation of a PLC device is the responsibility of the customer and will void applicable warranty provisions.

External Fault Extension Detail

Controls Menu Settings: PLC fault must be enabled and/or PLC non-clr fault must be enabled, and/or PLC fault reset must be Enabled (**Section 6.8**). The PLC fault and PLC non-clr fault options are not related. They provide for two different fault extension set-up via PLC connected electrical connections. PLC fault is a latched fault, while PLC non-clr fault is an unlatched fault. If PLC fault reset is enabled, all functionality to clear any latched trip/fault shutdown indication code (**Section 8.2**) is transferred to the PLC fault reset connected device.

Electrical Connection:
- For PLC fault, an open connection between Pin 4 and PLC ground (Pin 1, Pin 6, or Pin 11) results in a fault condition. Close connection between Pin 4 and PLC ground (Pin 1, Pin 6, or Pin 11) to set fault as inactive.
- For PLC non-clr fault, an open connection between Pin 7 and PLC ground (Pin 1, Pin 6, or Pin 11) results in a fault condition. Close connection between Pin 7 and PLC ground (Pin 1, Pin 6, or Pin 11) to set fault as inactive.
- For PLC fault reset, a closed connection between Pin 5 and PLC ground (Pin 1, Pin 6, or Pin 11) clears latched faults.

External Soft Limit Control Extension Detail

Controls Menu Settings: PLC ctrl must be enabled, PLC ctrl val set to power, voltage, or current, and PLC ctrl cfg set to the applicable configuration of either 0-20mA, 0-5 V, or 0-10 V (**Section 6.8**). Whichever two control values not selected are automatically set to 100%. The current circuit will saturate at 5V, so any voltage above that will be considered 100%.

Electrical Connection:
- Analog control input signal must connected to Pin 10 while common ground may be connected to any PLC ground (Pin 1, Pin 6, or Pin 11).

Additional Details:
3 kW, 5 kW, and 10 kW models can produce up to 125% of their rated power outputs, while 15kW, 25 kW, and 30 kW models can produce 110% of their rated outputs (**Section 9.1**).

Connection Detail: PLC Functionality

External Feedback Monitoring Extension Detail

Controls Menu Settings: N/A

Electrical Connection:
- For output power monitoring connect to Pin 12 and PLC ground (Pin 1, Pin 6, or Pin 11).
- For output voltage (RMS tank voltage) monitoring connect to Pin 13 and PLC ground (Pin 1, Pin 6, or Pin 11).
- For output current (RMS inverter current) monitoring connect to Pin 14 and PLC ground (Pin 1, Pin 6, or Pin 11).
- For operating frequency monitoring connect to Pin 15 and PLC ground (Pin 1, Pin 6, or Pin 11).
- For heat signal monitoring connect Pin 16 to Pin 17, a closed condition corresponds to a “heat on” state, and an open condition corresponds to a “heat off” state.
- For an inverter ready signal monitoring connect Pin 18 to Pin 19, a closed condition corresponds to a no fault condition, and an open condition corresponds to a fault present condition.

Additional Details:
Check model specific input/output magnitudes to determine what your normalized magnitudes for monitoring and control represent (**Section 9.1**).

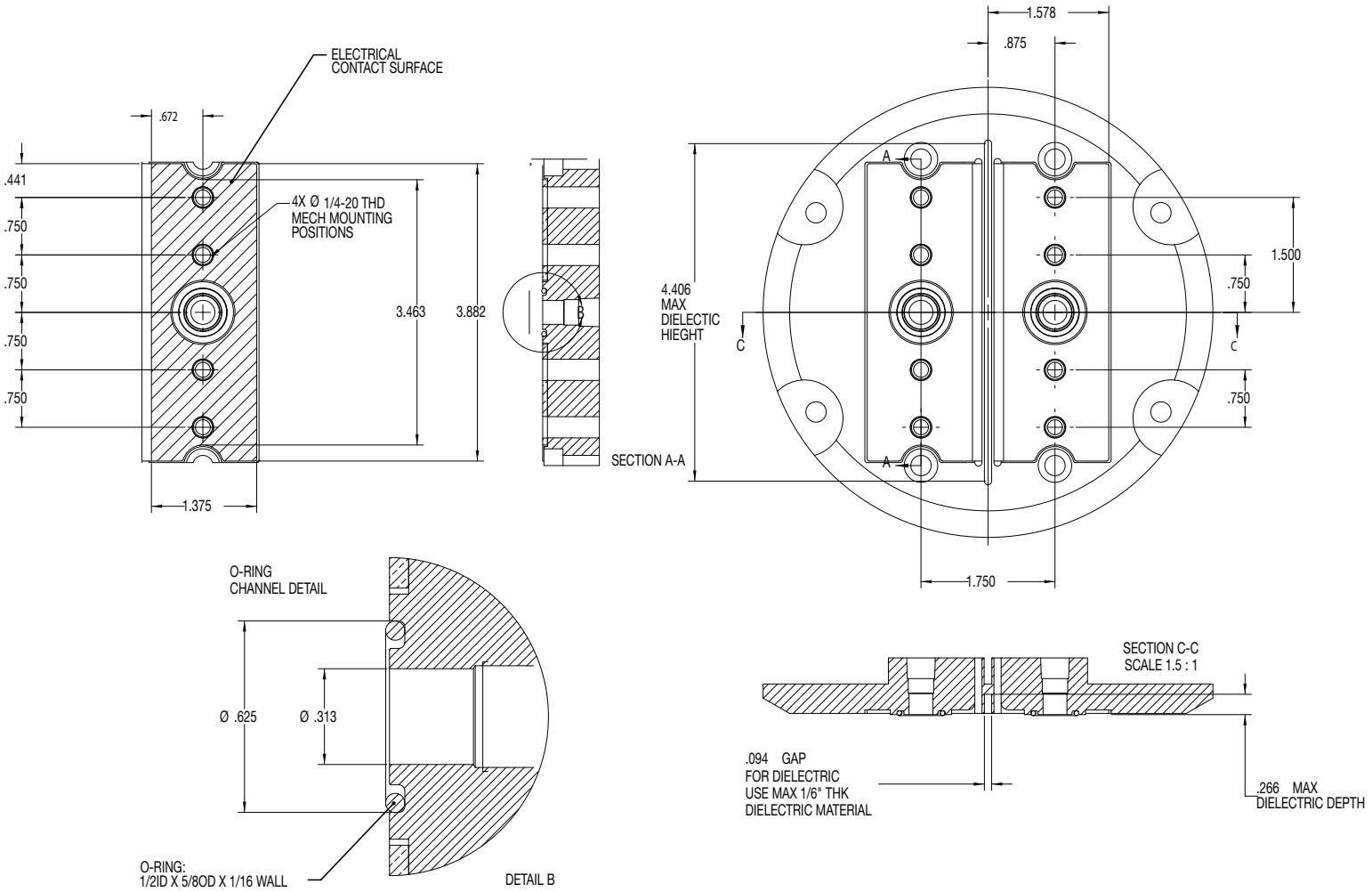
External E-stop Extension Detail

Controls Menu Settings: N/A

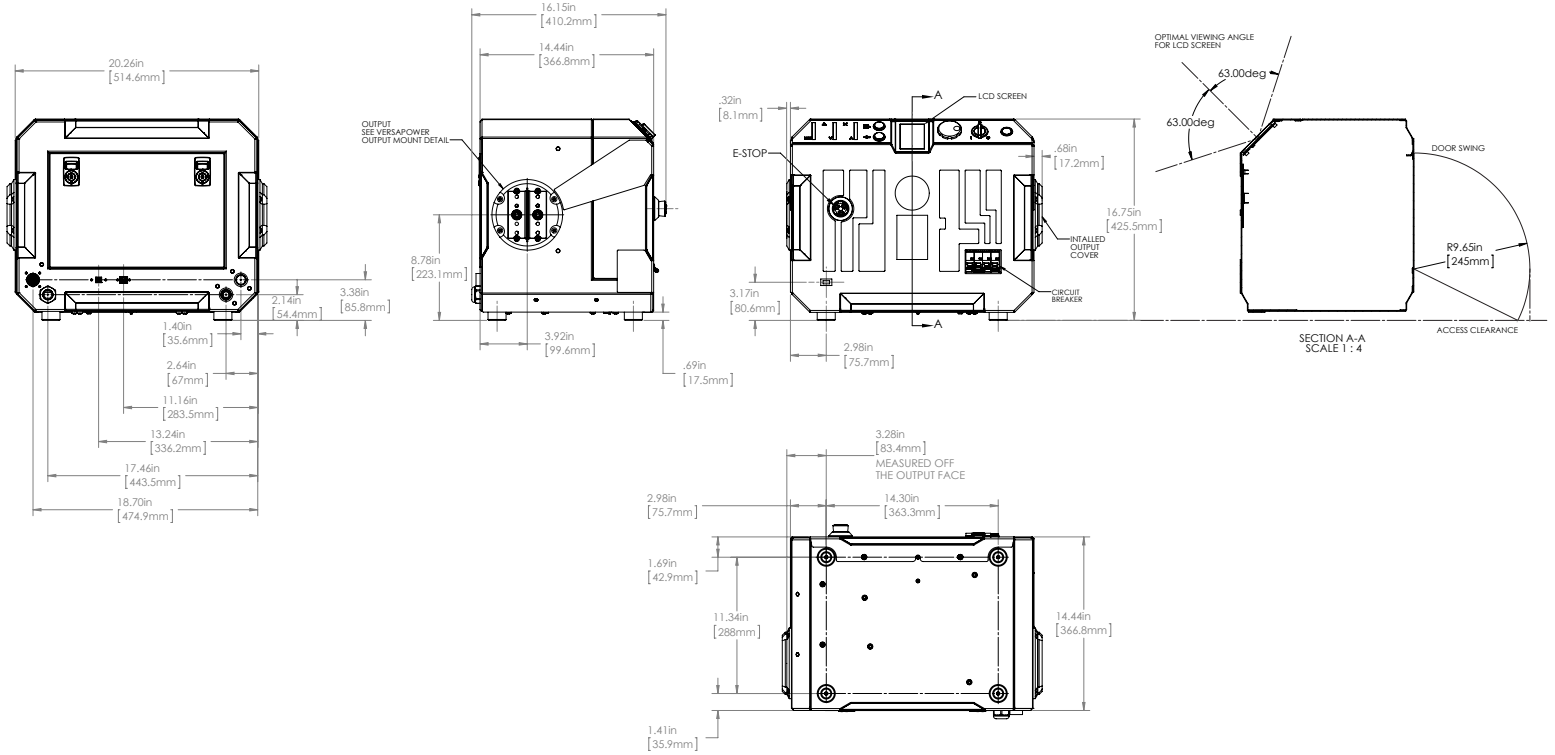
Electrical Connection:
- Open connection between Pin 24 and Pin 25 (E-stop ground) to trigger an E-stop shutdown. Close connection between Pin 24 and Pin 25 (E-stop ground) to restore full power supply functionality.

Additional Details:
When an E-stop shutdown is triggered, the front panel mounted circuit breaker opens and power supply cannot provide output power. To implement a safeguard switch chain, use normally closed (N.C.) contacts wired in series to Pin 24 and Pin 25.

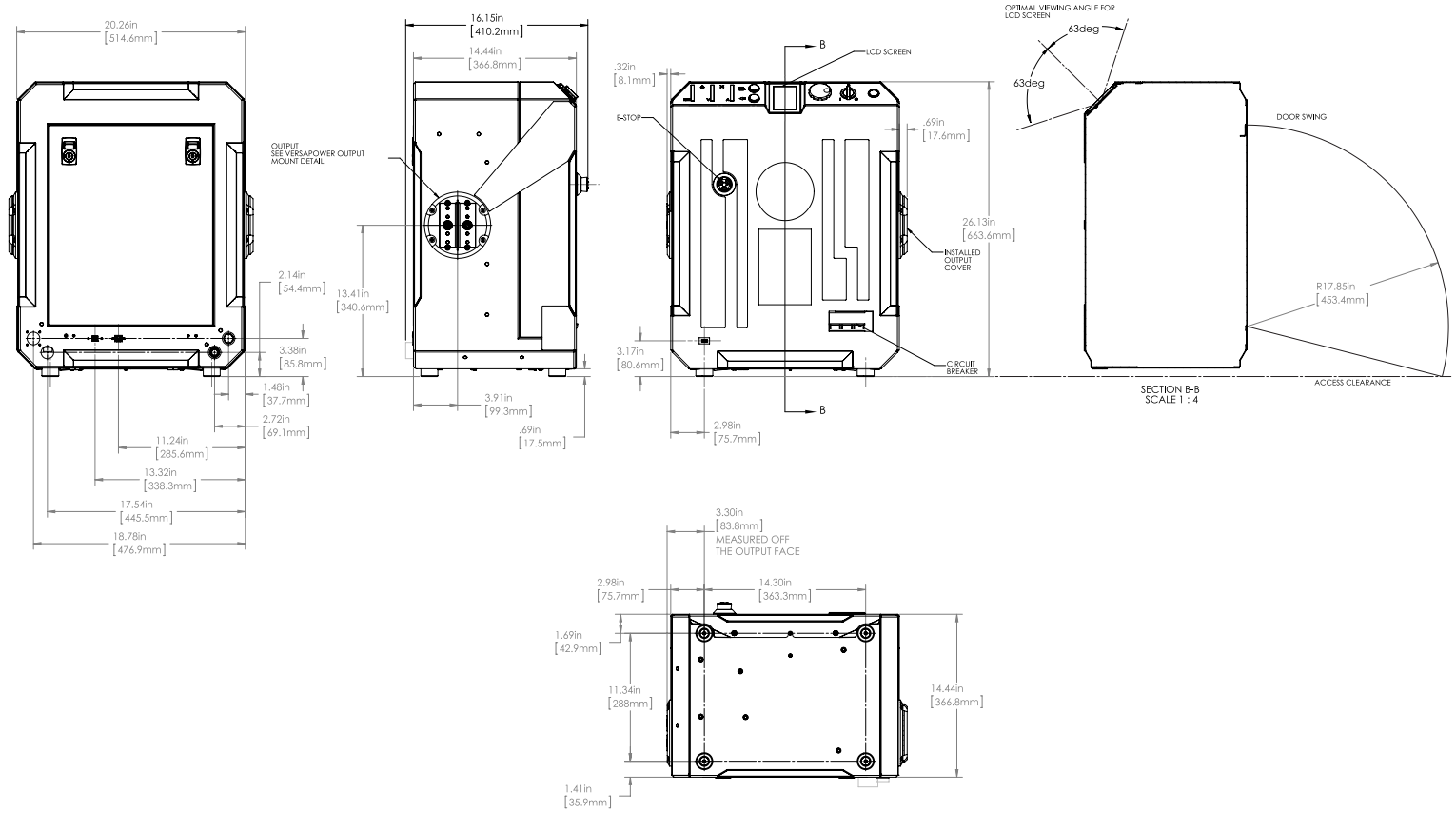
Drawing: Output Mount



Drawing: Physical Layout (5 - 15kW Models)



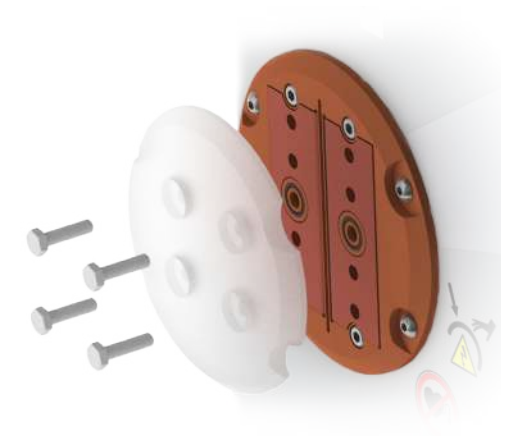
Drawing: Physical Layout (25 - 50kW Models)



Accessories & Spare Parts

Accessories & Spare Parts

The following list of accessories & replacement parts can be purchased for the VersaPower® Xtreme™ induction power supply. For more information regarding any of these products, please contact Radyne Aftermarket Sales Department at 1-800-236-8360.



Accessories & Spare Parts

Spare Parts

Item	Part #	Description
2.40uF Capacitor	32260	2.40 uF capacitor for low frequency models (20-80 kHz) only
1.20uF Capacitor	32261	1.20 uF capacitor for low frequency models (20-80 kHz) only
5.00uF Capacitor	32262	5.00 uF capacitor for low frequency models (20-80 kHz) only
0.66uF Capacitor	32257	0.66 uF capacitor for high frequency models (100-400 kHz) only
0.21uF Capacitor	32258	0.21 uF capacitor for high frequency models (100-400 kHz) only
0.33uF Capacitor	32259	0.33 uF capacitor for high frequency models (100-400 kHz) only
Output Mount Cover	34324	Output mount cover (see **Figure 4-6**)
Output Mount Hardware Kit	46426	Kit Includes: spare stainless steel inductor hardware (screws, washers, and lock washers), output mount nylon hardware and O-rings
Tuning Hardware Kit (3-10kW)	46427	Kit includes: stainless steel capacitor mounting hardware (see Figure 5-2) and a 5 / 16" - 18 thread x 1" hex tuning nut (see **Figure 5-1**)
Tuning Hardware Kit (15-30kW)	46428	Kit includes: stainless steel capacitor mounting hardware (see Figure 5-2) and a 3 / 8" - 16 thread x 3/8" hex tuning nut (see **Figure 5-1**)
Standard External PLC Cable	46165	External PLC I/O cable assembly

Table 10-1: Spare Parts Inventory

Accessories & Spare Parts

Accessories

Item	Part #	Description
Table-top Mounting Hardware Kit	46429	Kit includes: 4-vibration damping sandwich mounts for mounting the power supply to tabletop surfaces as well as assorted hardware for varying surface thicknesses (see **Figure 4-1**).
Customized Output Inductors		Pancake, channel, solenoid, and MIQ scanning types.
Adapter Paddles		Adapter blocks for output inductors, quick disconnects, cable assemblies, etc.
Output Inductor Quick Disconnect		Toggle clamping style which is advantageous for changing output inductors quickly and is great for systems that require multiple inductor change-outs.
280A Remote Heat Station	VXHS4C120C	Separates workpiece heating from the induction power supply, ideal for power supplies located in small spaces.
Temperature Paints		Indicates temperature during the heating process and is great for determining specific recipe settings.
Foot Switch		Remotely control the induction power supply's Heat On/Off switch.
External PLC Cables		Non-standard external PLC cables in a variety of connector styles and lengths to any application requirement.
Safety Guarding		Provides for a safer operator environment and is customizable to specification.
Chiller Cooling Systems		Portable coolant system for mobile induction heating.
Controlled Atmosphere Inductor Tooling Chambers		Prevents oxidation by providing for a contained nitrogen gas mixture induction heating chamber.

Table 10-2: Accessories Inventory

Terminology

Terminology

Affected employee (person):
An employee whose job requires him/her to operate or use a machine or equipment on which servicing or maintenance is being performed under LOTO (see **Section 2.3**) or whose job requires him/her to work in an area in which such servicing or maintenance is being performed.

Arc flash-rated protection:
Personal protective equipment (PPE) which is effectively rated to protect against the injurious hazards associated with arc flash/blast dangers (see NFPA 70E for specific ratings and details).

Curie:
This is the temperature at which a ferromagnetic material becomes paramagnetic.

DHCP (Dynamic Host Configuration Protocol):
A remote connectivity setting, that, when enabled determines if your IP is static or dynamic and the length of time an IP address is assigned. These settings are controlled by a DHCP server.

Differential pressure:
The measurement of one known pressure compared to another known pressure. The pressure measured is the difference between the two pressures.

Dominating limit:
The first soft or hard limit, encountered during a frequency sweep. Actual power supply output magnitudes for power, voltage, current, and frequency are set by this limit.

Firmware:
Firmware is the combination of read-only memory, program code, and stored data.

Hard limits:
Magnitudes for power, voltage, current, and high/low frequency that are limited by the power supply component capability and safety requirements.

Immediate area:
Any area where exposure to hazards exist as a result of a particular operation, repair, or equipment.

Inverter:
It is an electrical device that changes direct current (DC) to alternating current (AC).

Limited Approach Boundary:
NFPA 70 defines Limited Approach Boundary as: A shock protection boundary to be crossed by only qualified persons (at a distance from a live part) and which is not to be crossed by unqualified persons unless escorted by a qualified person. The limited approach boundary is the minimum distance from the energized item where unqualified personnel may safely stand. No untrained personnel may approach any closer to the energized item than this boundary (see **Section 2.3**).

LOTO:
It is a safety procedure which is used in United States industries and research settings to ensure that dangerous machines are properly shut off and not started up again prior to the completion of maintenance or servicing work. It requires that hazardous power sources be “isolated and rendered inoperative” before any repair procedure is started (see **Section 2.3**).

Lockout device:
A device that utilizes a positive means such as a lock, either key or combination type, to hold an energy isolating device in the off position and prevent the energizing of a machine or equipment. Included are blank flanges and bolted slip blinds.

Soft limits:
The specific parameter set by the operator as well as the model frequency range that limits power supply. The soft limits are power, current, voltage, and frequency.

Output inductor:
The inductor designed to transfer the magnetic field to the work piece. This inductor is coupled with the work piece.

Prohibited Approach Boundary:
A shock protection boundary to be crossed by only qualified persons (at a distance from a live part) which, when crossed by a body part or object, requires the same protection as if direct contact is made with a live part. Only qualified personnel wearing appropriate personal protective equipment (PPE), having specified training to work on energized conductors or components, and a documented plan justifying the need to perform this work may cross the boundary and enter this prohibited space (see **Section 2.3**).

Qualified persons:
Persons so defined by OSHA 1910.147 (see **Section 2.3**).

Recipe:
A multi-step work piece heating process.

Terminology

Relative humidity:
It is defined as the ratio of the partial pressure of water vapor in an air-water mixture to the saturated vapor pressure of water at a prescribed temperature. The relative humidity can be changed in two ways: (1) by changing the amount of moisture in the air or (2) by changing the air's temperature. Adding moisture to the air, while keeping the temperature constant, increases the relative humidity. Removing moisture lowers the relative humidity. When the water vapor content of air remains at a constant level, a decrease in air temperature results in an increase in relative humidity, while and an increase in temperature causes a decrease in relative humidity.

Restricted Approach Boundary:
A shock protection boundary to be crossed by only qualified persons (at a distance from a live part) which, due to its proximity to a shock hazard, require the use of shock protection techniques and equipment when crossed. To cross the Restricted Approach Boundary into the Restricted Space, the qualified person, who has completed required training, must wear appropriate personal protective equipment (PPE). Also, he must have a written approved plan for the work that they will perform and plan the work to keep all parts of the body out of this prohibited space
(see **Section 2.3**).

Series inductor:
Adjustable inductor that matches the inverter output to the resonant tank which has the tank capacitor and the output inductor.

Shock hazard-rated protection:
Personal protective equipment (PPE) which is effectively rated to protect against the injurious hazards associated with electrical shock-related dangers (See NFPA70E for specific ratings and details).

Unqualified persons:
All persons who are not defined as qualified persona (see qualified person).

Workpiece:
The object of the induction heat process.

Zero energy (V_{AC} & V_{DC}) state:
A measurement verified state that guarantees that energy is safely at a zero value. This verification must be implemented with an independent measurement device and measured in a manner consistent with OSHA 1910 and NFPA 70E regulations and standards (see **Section 2.3**).

Appendix

12.1 Lists of Tables & Figures 121

12.2 Product Warranty 122

Lists of Tables and Figures

Figure 2-1: Safety Label Locations: Front, Side, and Rear View 6
Figure 2-2: High Voltage Areas (panels closed) 9
Figure 2-3: High Voltage Areas (inside front panel) 10
Figure 2-4: High Voltage Areas (inside rear panel) 10
Figure 2-5: Capacitor Discharge Circuit Model (functioning condition) 15
Figure 2-6: Capacitor Discharge Circuit Model (non-functioning condition) 15
Figure 2-7: Circuit Breaker Lockout Device Attachment Procedure 18
Figure 3-1: Process of Induction Heating 22
Figure 3-2: Power Output vs. Temperature (above/below Curie) 24
Figure 3-3: Magnitude vs. Frequency (individual Plots-all) 25
Figure 3-4: Magnitude vs. Frequency (narrow range-all) 25
Figure 3-5: Output vs. Frequency (Ideal limit relationships) 27
Figure 3-6: Output Characteristics vs. Frequency (dominating limit) 28
Figure 3-7: Power Suply Operation Block Diagram 29
Figure 3-8: Protection Circuit Block Diagram 30
Figure 3-9: Output Circuit Block Diagram 30
Figure 3-10: Power Circuit Block Diagram 31
Figure 3-11: Control Circuit Block Diagram 31
Figure 4-1: Feet Removal & Replacement 36
Figure 4-2: Output Inductor Installation/Removal 37
Figure 4-3: Output Inductor Mount Cover (attached) 37
Figure 4-4: Power Cord Assembly 38
Figure 4-5: Coolant Fluid Connection Assembly 39
Figure 5-1: Series Inductor Adjustment 46
Figure 5-2: 8-Capacitor Mounting Array 47
Figure 5-3: Load Tuning Recommendations Matrix 50
Figure 6-1: Front Panel View 52
Figure 6-2: Rear Panel View 52
Figure 6-3: Main Menu Screen 53
Figure 6-4: Manual Mode Menu 54
Figure 6-5: Edit Mode Menu 54
Figure 6-6: Edit Mode (Recipe Editor) Action Flow Diagram 54
Figure 6-7: Production Mode Menu 55
Figure 6-8: Settings Menu 55
Figure 6-9: Menu System Sitemap 56
Figure 6-10: Section Symbol Key 57
Figure 6-11: Changing Selector Position 57
Figure 6-12: Workpiece Heating-Manual Mode Menu 63
Figure 6-13: Trip/Fault Shutdown Indicator (menu display) 66
Figure 6-14: Trip/Fault Shutdown Indicator (front panel) 66
Figure 6-15: Access Denied Error Message 67
Figure 6-16: New Recipe Shell 69
Figure 6-17: 4 Step Recipe Example 70
Figure 6-18: : Heat Control Options (controls menu 77
Figure 6-19: External Device Interfacing Set-up Menu Display 79
Figure 6-20: Remote Connectivity Set-up (remote menu) 81
Figure 6-21: Load Tuning Calculator (input) Menu Display 85
Figure 9-1: PLC Connector 106
Table 2-1: Hazard, Risk, and Responsibility Assessment 8
Table 2-2: Hazardous Energy & Isolation Specifications 17
Table 2-3: Protective Boundaries Requirements 18
Table 9-1: Electrical Input Magnitude Requirements (normal) 102
Table 9-2: Electrical Output Magnitudes (typical @ 100%) 102
Table 9-3: Coolant Fluid Quality Levels 103
Table 9-4: Propylene Glycol Mixture Ratio 103
Table 9-5: Cooling Fluid System (Absolute Ratings) 104
Table 9-6: Physical Dimensions Specifications 105
Table 9-7: PLC Connector Cable Wiring Details 106
Table 9-8: PLC Connector (Absolute Ratings) 107
Table 9-9: PLC Connector (Typical Input Characteristics) 107
Table 9-10: PLC Connector Typical Analog Output Characteristics 108
Table 9-11: PLC Connector Typical Dry Contact Output Characteristics 108
Table 10-1: Spare Parts Inventory 116
Table 10-2: Accessories Inventory 117

Product Warranty

Seller warrants that the equipment supplied shall conform to the description in the quotation. In the event that any parts, excepting expendable items such as, but not limited to, coils, part touch tooling, coil liners, thermocouples, refractories and other similar consumable items that fail due to defects in material or workmanship within the first twelve (12) months of startup of equipment or eighteen (18) months after shipment, whichever occurs first, or in the case of field service, repairs, or replacement parts, within ninety (90) days of supplying such field service, repair or part, seller shall at its option, repair or replace EXW (Ex works), such defective part or parts. If the equipment, service, repair or replacement part included software, seller warrants, for a period of twelve (12) months of startup or eighteen (18) months after shipment, whichever occurs first, that the software supplied or serviced will meet its published functional specifications. Should software fail to meet the specifications, or be otherwise defective, seller shall promptly correct errors or non-conformities. If correction is not possible, seller shall replace defective software, or, at seller's option, refund the purchase price paid for such software. The warranty obligations of seller with respect to equipment not manufactured by seller shall conform to and be limited to the warranty actually extended to seller by its suppliers. Notice of a claim for alleged defective equipment must be given within fifteen (15) days after purchaser learns of the defect. The defective part or parts shall be returned to seller, freight prepaid, unless otherwise directed by seller.

This warranty shall be exclusive and in lieu of any other warranties and seller makes no warranty of merchantability or warranties of any other kind express or implied, including any implied warranty of fitness for a particular purpose which extend beyond the warranty as set forth above. Seller's liability for any and all losses and damages to purchaser resulting from defective parts of equipment shall in no event exceed the cost of repair or replacement, EXW of defective parts or equipment.

IN NO EVENT SHALL SELLER BE LIABLE FOR INCIDENTAL, SPECIAL OR CONSEQUENTIAL DAMAGES OF ANY KIND OR NATURE WHATSOEVER.