

HIGH FREQUENCY WELD CONTROL

HF-2500A

USER MANUAL



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Revision Record

Revision	EO	Date	Basis of Revision
A	20411	03/05	None. Original edition.
B	21590	09/07	Weld Status Codes added to <i>Appendix E, Communications</i> .
C	34461	12/09	Updated technical information & specifications.
D	42840	10/13	Updated to new corporate name and logo.
E	43480	11/14	Updated to Amada Miyachi America name and logo.
F	43633	03/15	Updated Communication information.
G	43808	08/15	Updated to Amada Miyachi format.
H	45804	04/20	Updated Company Name (Amada Weld Tech) + Update Model Names + Corrected I/O Connector Signals
J	46311	04/21	See ECO for Details
K	47208	01/24	Update 'State Read' Command + Manual Title Change

FOREWORD

Thank you for purchasing an AMADA WELD TECH - HF-2500A High Frequency Weld Control. For the rest of this manual, the HF-2500A will be referred to simply as the **Power Supply**.

Upon receipt of your equipment, please thoroughly inspect it for shipping damage prior to its installation. Should there be any damage, please immediately contact the shipping company to file a claim, and notify us at:

AMADA WELD TECH INC.
1820 South Myrtle Avenue
Monrovia, CA 91016
Telephone: (626) 303-5676
FAX: (626) 358-8048
e-mail: info@amadaweldtech.com

The purpose of this manual is to supply operating and maintenance personnel with the information needed to properly and safely operate and maintain the HF-2500A Power Supply.

We have made every effort to ensure that the information in this manual is accurate and adequate. The contents of this manual are subject to change without notice.

Should questions arise, or if you have suggestions for improvement of this manual, please contact us at the above location/numbers.

AMADA WELD TECH is not responsible for any loss or injury due to improper use of this product.

This manual covers the following models:

Original Model Name	Original P/N		Current Model Name	Current P/N
HF25A10/240	1-315-01	→	HF-2500A/240	1-315-02
HF25A10/400	1-315-01-01	→	HF-2500A/400	1-315-02-01
HF25A10/480	1-315-01-02	→	HF-2500A/480	1-315-02-02

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SAFETY NOTES



DANGER

- **Lethal voltages exist within this unit.** Do **not** perform any maintenance inside this unit.
- **Never** perform any welding operation without wearing protective safety glasses.

This instruction manual describes how to operate, maintain and service the HF-2500A Power Supply, and provides instructions relating to its **safe** use. A separate manual provides similar information for the weld head used in conjunction with the power supply. Procedures described in these manuals **must** be performed, as detailed, by **qualified** and **trained** personnel.

For **safety**, and to effectively take advantage of the full capabilities of the weld head and power supply, please read these instruction manuals before attempting to use them.

Procedures other than those described in these manuals or not performed as prescribed in them, may expose personnel to electrical, burn, or crushing hazards.

After reading these manuals, retain them for future reference when any questions arise regarding the proper and **safe** operation of the power supply.

Please note the following conventions used in this manual:

WARNING: Comments marked this way warn the reader of actions which, if not followed, might result in immediate death or serious injury.

CAUTION: Comments marked this way warn the reader of actions which, if not followed, might result in either damage to the equipment, or injury to the individual if subject to long-term exposure to the indicated hazard.



Disposal

Properly handle and dispose of used materials.

For the disposal of electronic waste please contact AMADA WELD TECH.

LIMITED WARRANTY

GENERAL TERMS AND CONDITIONS FOR THE SALE OF GOODS

1. Applicability.

(a) These terms and conditions of sale (these “**Terms**”) are the only terms which govern the sale of the goods (“**Goods**”) by Amada Weld Tech Inc. (“**Seller**”) to the buyer identified in the Sales Quotation and/or Acknowledgment (as each defined below) to which these Terms are attached or incorporated by reference (“**Buyer**”). Notwithstanding anything herein to the contrary, if a written contract signed by authorized representatives of both parties is in existence covering the sale of the Goods covered hereby, the terms and conditions of said contract shall prevail to the extent they are inconsistent with these Terms.

(b) The accompanying quotation of sale (the “**Sales Quotation**”) provided to Buyer, and/or sales order acknowledgement (“**Acknowledgement**”) and these Terms (collectively, this “**Agreement**”) comprise the entire agreement between the parties, and supersede all prior or contemporaneous understandings, agreements, negotiations, representations and warranties, and communications, both written and oral. For clarification, after the Acknowledgement is received by Buyer, the order for Goods is binding and cannot be cancelled by Buyer for any reason and the full purchase price amount set forth in the Acknowledgement shall be due and payable by Buyer to Seller pursuant to the payment schedule set forth in the Acknowledgement unless otherwise agreed to in writing by Seller. All terms and conditions contained in any prior or contemporaneous oral or written communication which are different from, or in addition to, the terms and conditions in this Agreement are hereby rejected and shall not be binding on Seller, whether or not they would materially alter this Agreement. These Terms prevail over any of Buyer’s terms and conditions of purchase regardless whether or when Buyer has submitted its purchase order or such terms. Fulfillment of Buyer’s order does not constitute acceptance of any of Buyer’s terms and conditions and does not serve to modify or amend these Terms. Notwithstanding anything herein to the contrary, all orders for Goods must be for a minimum purchase price of \$100 or such orders will be rejected by Seller.

2. Delivery.

(a) The Goods will be delivered within a reasonable time after Seller provides Buyer the Acknowledgment, subject to availability of finished Goods. Seller will endeavor to meet delivery schedules requested by Buyer, but in no event shall Seller incur any liability, consequential or otherwise, for any delays or failure to deliver as a result of ceasing to manufacture any product or any Force Majeure Event. Delivery schedules set forth in the Acknowledgment are Seller’s good faith estimate on the basis of current schedules. In no event shall Seller be liable for special or consequential damages resulting from failure to meet requested delivery schedules.

(b) Unless otherwise agreed in writing by the parties in the Acknowledgement, Seller shall deliver the Goods to Seller’s plant in Monrovia, CA, USA (the “**Shipping Point**”) using Seller’s standard methods for packaging and shipping such Goods. Buyer shall take delivery of the Goods within three (3) days of Seller’s written notice that the Goods have been delivered to the Shipping Point. Buyer shall be responsible for all loading costs (including freight and insurance costs) and provide equipment and labor reasonably suited for receipt of the Goods at the Shipping Point. Seller shall not be liable for any delays, loss or damage in transit.

(c) Seller may, in its sole discretion, without liability or penalty, make partial shipments of Goods to Buyer, if applicable. Each shipment will constitute a separate sale, and Buyer shall pay for the units shipped whether such shipment is in whole or partial fulfillment of Buyer’s purchase order.

(d) If for any reason Buyer fails to accept delivery of any of the Goods on the date fixed pursuant to Seller’s notice that the Goods have been delivered at the Shipping Point, or if Seller is unable to deliver the Goods at the Shipping Point on such date because Buyer has not provided appropriate instructions, documents, licenses or authorizations: (i) risk of loss to the Goods shall pass to Buyer; (ii) the Goods shall be deemed to have been delivered; and (iii) Seller, at its option, may store the Goods until Buyer picks them up, whereupon Buyer shall be liable for all related costs and expenses (including, without limitation, storage and insurance).

3. Non-delivery.

(a) The quantity of any installment of Goods as recorded by Seller on dispatch from Seller’s place of business is conclusive evidence of the quantity received by Buyer on delivery unless Buyer can provide conclusive evidence proving the contrary.

(b) Seller shall not be liable for any non-delivery of Goods (even if caused by Seller’s negligence) unless Buyer gives written notice to Seller of the non-delivery within three (3) days of the date when the Goods would in the ordinary course of events have been received.

(c) Any liability of Seller for non-delivery of the Goods shall be limited to (in Seller’s sole discretion) replacing the Goods within a reasonable time or adjusting the invoice respecting such Goods to reflect the actual quantity delivered.

4. Shipping Terms. Unless indicated otherwise in the Acknowledgment, Delivery shall be made EXW (Incoterms 2010), Shipping Point, including without limitation, freight and insurance costs. If no delivery terms are specified on the Acknowledgement, the method of shipping will be in the sole discretion of Seller. Unless directed in writing otherwise by Buyer, full invoice value will be declared for all shipments.

5. Title and Risk of Loss. Title and risk of loss passes to Buyer upon delivery of the Goods at the Shipping Point. As collateral security for the payment of the purchase price of the Goods, Buyer hereby grants to Seller a lien on and security interest in and to all of the right, title and interest of Buyer in, to and under the Goods, wherever located, and whether now existing or hereafter arising or acquired from time to time, and in all accessions thereto and replacements or modifications thereof, as well as all proceeds (including insurance proceeds) of the foregoing. The security interest granted under this provision constitutes a purchase money security interest under the California Commercial Code.

6. Amendment and Modification. These Terms may only be amended or modified in a writing which specifically states that it amends these Terms and is signed by an authorized representative of each party.

HF-2500A HIGH FREQUENCY WELD CONTROL

7. Inspection and Rejection of Nonconforming Goods.

(a) Buyer shall inspect the Goods within two (2) days of receipt (“**Inspection Period**”). Buyer will be deemed to have accepted the Goods unless it notifies Seller in writing of any Nonconforming Goods during the Inspection Period and furnishes such written evidence or other documentation as required by Seller. “**Nonconforming Goods**” means only the following: (i) product shipped is different than identified in Buyer’s Acknowledgement; or (ii) product’s label or packaging incorrectly identifies its contents. Notwithstanding the foregoing, for shipped Goods that require field installation, the “re-verification” terms in the Acknowledgement shall apply and for custom installations, the inspection and verification shall take place at Buyer’s site immediately after the installation is completed.

(b) Seller will only accept Nonconforming Goods that are returned under Seller’s Return Material Authorization procedures then in effect (“**RMA**”). Buyer shall obtain a RMA number from Seller prior to returning any Nonconforming Goods and return the Nonconforming Goods prepaid and insured to Seller at 1820 South Myrtle Avenue, Monrovia, CA 91016 or to such other location as designated in writing by Seller for the examination to take place there. If Seller reasonably verifies Buyer’s claim that the Goods are Nonconforming Goods and that the nonconformance did not developed by use from Buyer, Seller shall, in its sole discretion, (i) replace such Nonconforming Goods with conforming Goods, or (ii) credit or refund the Price for such Nonconforming Goods pursuant to the terms set forth herein. Notwithstanding the foregoing, the only remedy for Nonconforming Goods that are custom systems is repair (not refund or replacement). No returns for Nonconforming Goods are allowed after thirty (30) days from the original shipping date.

(c) Buyer acknowledges and agrees that the remedies set forth in Section 7(a) are Buyer’s exclusive remedies for the delivery of Nonconforming Goods. Except as provided under Section 7(a) and Section 14, all sales of Goods to Buyer are made on a one-way basis and Buyer has no right to return Goods purchased under this Agreement to Seller.

8. Price.

(a) Buyer shall purchase the Goods from Seller at the prices (the “**Prices**”) set forth in Seller’s published catalogue literature in force as of the date of the Sales Quotation. However, the Prices shown in such catalogue literature or any other publication are subject to change without notice. Unless specifically stated to the contrary in the Sales Quotation, quoted Prices and discounts are firm for thirty (30) days from the date of the Sales Quotation. Unless otherwise stated, prices are quoted EXW (Incoterms 2010), Shipping Point. Unless otherwise stated in the Acknowledgement, if the Prices should be increased by Seller before delivery of the Goods to a carrier for shipment to Buyer, then these Terms shall be construed as if the increased prices were originally inserted herein, and Buyer shall be billed by Seller on the basis of such increased prices.

(b) All Prices are exclusive of all sales, use and excise taxes, and any other similar taxes, duties and charges of any kind imposed by any governmental authority on any amounts payable by Buyer. Buyer shall be responsible for all such charges, costs and taxes (present or future); provided, that, Buyer shall not be responsible for any taxes imposed on, or with respect to, Seller’s income, revenues, gross receipts, personnel or real or personal property or other assets.

9. Payment Terms.

(a) Unless otherwise provided in the Acknowledgement, if Buyer has approved credit with Seller, Buyer shall pay all invoiced amounts due to Seller within thirty (30) days from the date of Seller’s invoice. If Seller does not have Buyer’s financial information and has not provided pre-approved credit terms for Buyer, the payment must be made in cash with order or C.O.D. in US dollars. If Buyer has approved credit terms, the payment may be made by cash with order, wire transfer of immediately available funds, or check in US dollars. Certain products require a down payment. Any payment terms other than set forth above will be identified in the Acknowledgement. Notwithstanding anything herein to the contrary, all prepaid deposits and down payments are non-refundable. If a deposit is not received when due, Seller reserves the right to postpone manufacturing of Goods until payment is received. Seller will not be responsible for shipment delays due to deposit payment delays.

(b) In Seller’s sole discretion, Seller may access Buyer interest on all late payments at the lesser of the rate of 1.5% per month or the highest rate permissible under applicable law, calculated daily and compounded monthly. Buyer shall reimburse Seller for all costs incurred in collecting any late payments, including, without limitation, attorneys’ fees. In addition to all other remedies available under these Terms or at law (which Seller does not waive by the exercise of any rights hereunder), Seller shall be entitled to suspend the delivery of any Goods if Buyer fails to pay any amounts when due hereunder and such failure continues for ten (10) days following written notice thereof.

(c) Buyer shall not withhold payment of any amounts due and payable by reason of any set-off of any claim or dispute with Seller, whether relating to Seller’s breach, bankruptcy or otherwise.

10. Intellectual Property; Software License.

(a) To the extent that any Goods provided under this Agreement contains software, whether pre-installed, embedded, in read only memory, or found on any other media or other form (“**Software**”), such Software and accompanying documentation are licensed to Buyer, not sold and shall remain the sole and exclusive property of Seller or third party licensors of Seller. Seller grants Buyer a non-exclusive license to use the Software solely as provided in and in connection with the use of the Goods in which such Software is contained and in accordance with any applicable user documentation provided with such Goods and subject to the provisions of this Agreement. Certain of Seller’s Goods may include third party software such as computer operating systems. Licenses to such third party software are subject to the terms and conditions of any applicable third party software license agreements. Unless identified in the Acknowledgement, no license is granted by Seller with respect to such third party software products that may be provided with the Goods (if any). Seller makes no warranties regarding any third party software that may accompany the Goods or otherwise and such software is explicitly included in the definition of Third Party Products below.

(b) Buyer shall not copy, modify, or disassemble, or permit others to copy, modify, or disassemble, the Software, nor may Buyer modify, adapt, translate, reverse assemble, decompile, or otherwise attempt to derive source code from the Software. Buyer shall not transfer possession of the Software except as part of, or with, the Goods, and each such transfer shall be subject to the restrictions contained herein. Buyer may not sublicense, rent, loan, assign or otherwise transfer the Software or documentation, and Buyer shall retain on all copies of the Software and documentation all copyright and other proprietary notices or legends appearing therein or thereon. Seller may terminate this license upon written notice for any violation of any of the terms of this license

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(d) If Buyer is the United States Government or any agency thereof, each of the components of the Software and user documentation are a "commercial item," and "computer software" as those terms are defined at 48 C.F.R. 2.101, consisting of "commercial computer software" and "commercial computer software documentation," as such terms are used in 48 C.F.R. 12.212. Consistent with 48 C.F.R. 12.212 and 48 C.F.R. 227.7202-1 through 227.7202-4, all United States government Buyers acquire only those rights in the Software and user documentation that are specified in this Agreement.

11. Installation and Other Services. Seller shall provide installation services ("Installation Services") to Buyer if set forth in the Acknowledgment. If Installation Services are provided for in the Acknowledgment, Buyer will prepare the location for the installation consistent with Buyer's written specifications and Buyer will install necessary system cable and assemble any necessary equipment or hardware not provided by Seller, unless agreed otherwise in writing by the parties. For Goods that will be operated on or in connection with Buyer supplied hardware or software, Buyer is responsible for ensuring that its hardware and software conform with Seller minimum hardware and software requirements as made available to Buyer. Seller shall provide other field services, such as maintenance visits and field repairs (the "Other Services" and together with the Installation Services, the "Services") if set forth in the Acknowledgment.

12. Limited Warranty.

(a) Subject to the exceptions and upon the conditions set forth herein, Seller warrants to Buyer that for a period of one (1) year from the date of shipment ("Warranty Period"), that such Goods will be free from material defects in material and workmanship.

(b) Notwithstanding the foregoing and anything herein to the contrary, the warranty set forth in this Section 12 shall be superseded and replaced in its entirety with the warranty set forth on **Exhibit A** hereto if the Goods being purchased are specialty products, which include, without limitation, laser products, fiber markers, custom systems, workstations, Seller-installed products, non-catalogue products and other custom-made items (each a "Specialty Product").

(c) EXCEPT FOR THE WARRANTY SET FORTH IN SECTION 12(A), SELLER MAKES NO WARRANTY WHATSOEVER WITH RESPECT TO THE GOODS (INCLUDING ANY SOFTWARE) OR SERVICES, INCLUDING ANY (a) WARRANTY OF MERCHANTABILITY; (b) WARRANTY OF FITNESS FOR A PARTICULAR PURPOSE; (c) WARRANTY OF TITLE; OR (d) WARRANTY AGAINST INFRINGEMENT OF INTELLECTUAL PROPERTY RIGHTS OF A THIRD PARTY; WHETHER EXPRESS OR IMPLIED BY LAW, COURSE OF DEALING, COURSE OF PERFORMANCE, USAGE OF TRADE OR OTHERWISE.

(d) Products manufactured by a third party and third party software ("Third Party Product") may constitute, contain, be contained in, incorporated into, attached to or packaged together with, the Goods. Third Party Products are not covered by the warranty in Section 12(a). For the avoidance of doubt, **SELLER MAKES NO REPRESENTATIONS OR WARRANTIES WITH RESPECT TO ANY THIRD PARTY PRODUCT, INCLUDING ANY (a) WARRANTY OF MERCHANTABILITY; (b) WARRANTY OF FITNESS FOR A PARTICULAR PURPOSE; (c) WARRANTY OF TITLE; OR (d) WARRANTY AGAINST INFRINGEMENT OF INTELLECTUAL PROPERTY RIGHTS OF A THIRD PARTY; WHETHER EXPRESS OR IMPLIED BY LAW, COURSE OF DEALING, COURSE OF PERFORMANCE, USAGE OF TRADE OR OTHERWISE.** Notwithstanding the foregoing, in the event of the failure of any Third Party Product, Seller will assist (within reason) Buyer (at Buyer's sole expense) in obtaining, from the respective third party, any (if any) adjustment that is available under such third party's warranty.

(e) Seller shall not be liable for a breach of the warranty set forth in Section 12(a) unless: (i) Buyer gives written notice of the defect, reasonably described, to Seller within five (5) days of the time when Buyer discovers or ought to have discovered the defect and such notice is received by Seller during the Warranty Period; (ii) Seller is given a reasonable opportunity after receiving the notice to examine such Goods; (iii) Buyer (if requested to do so by Seller) returns such Goods (prepaid and insured to Seller at 1820 South Myrtle Avenue, Monrovia, CA 91016 or to such other location as designated in writing by Seller) to Seller pursuant to Seller's RMA procedures and Buyer obtains a RMA number from Seller prior to returning such Goods for the examination to take place; and (iii) Seller reasonably verifies Buyer's claim that the Goods are defective and that the defect developed under normal and proper use.

(f) Seller shall not be liable for a breach of the warranty set forth in Section 12(a) if: (i) Buyer makes any further use of such Goods after giving such notice; (ii) the defect arises because Buyer failed to follow Seller's oral or written instructions as to the storage, installation, commissioning, use or maintenance of the Goods; (iii) Buyer alters or repairs such Goods without the prior written consent of Seller; or (iv) repairs or modifications are made by persons other than Seller's own service personnel, or an authorized representative's personnel, unless such repairs are made with the written consent of Seller in accordance with procedures outlined by Seller.

(g) All expendables such as electrodes are warranted only for defect in material and workmanship which are apparent upon receipt by Buyer. The foregoing warranty is negated after the initial use.

(h) Subject to Section 12(e) and Section 12(f) above, with respect to any such Goods during the Warranty Period, Seller shall, in its sole discretion, either: (i) repair or replace such Goods (or the defective part) or (ii) credit or refund the price of such Goods at the pro rata contract rate, provided that, if Seller so requests, Buyer shall, at Buyer's expense, return such Goods to Seller.

(i) THE REMEDIES SET FORTH IN SECTION 12(H) SHALL BE BUYER'S SOLE AND EXCLUSIVE REMEDY AND SELLER'S ENTIRE LIABILITY FOR ANY BREACH OF THE LIMITED WARRANTY SET FORTH IN SECTION 12(A). Representations and warranties made by any person, including representatives of Seller, which are inconsistent or in conflict with the terms of this warranty, as set forth above, shall not be binding upon Seller.

13. Limitation of Liability.

(a) IN NO EVENT SHALL SELLER BE LIABLE FOR ANY CONSEQUENTIAL, INDIRECT, INCIDENTAL, SPECIAL, EXEMPLARY, OR PUNITIVE DAMAGES, LOST PROFITS OR REVENUES OR DIMINUTION IN VALUE, LOSS OF INFORMATION OR DATA, OR PERSONAL INJURY OR DEATH ARISING IN ANY WAY OUT OF THE MANUFACTURE, SALE, USE, OR INABILITY TO USE ANY GOODS, SOFTWARE OR SERVICE, OR ARISING OUT OF OR RELATING TO ANY BREACH OF THESE TERMS, WHETHER OR NOT THE POSSIBILITY OF SUCH DAMAGES HAS BEEN DISCLOSED IN ADVANCE BY BUYER OR COULD HAVE BEEN REASONABLY

FORESEEN BY BUYER, REGARDLESS OF THE LEGAL OR EQUITABLE THEORY (CONTRACT, TORT OR OTHERWISE) UPON WHICH THE CLAIM IS BASED, AND NOTWITHSTANDING THE FAILURE OF ANY AGREED OR OTHER REMEDY OF ITS ESSENTIAL PURPOSE.

(b) IN NO EVENT SHALL SELLER'S AGGREGATE LIABILITY ARISING OUT OF OR RELATED TO THIS AGREEMENT, WHETHER ARISING OUT OF OR RELATED TO BREACH OF CONTRACT, TORT (INCLUDING NEGLIGENCE) OR OTHERWISE, EXCEED THE TOTAL OF THE AMOUNTS PAID TO SELLER FOR THE GOODS SOLD HEREUNDER.

(c) ALL WARRANTIES SET FORTH HEREIN, DIRECT OR IMPLIED, ARE VOIDED IF THE INITIAL INSTALLATION AND START-UP OF THE SUBJECT GOOD IS NOT SUPERVISED BY AN AUTHORIZED REPRESENTATIVE OF SELLER. AFTER INSTALLATION, ANY RE-ALIGNMENT, RE-CLEANING, OR RE-CALIBRATION, PROVIDED THEY ARE NOT RELATED TO A PROVEN DEFECT IN MATERIALS OR WORKMANSHIP, SHALL BE PERFORMED BY AN AUTHORIZED REPRESENTATIVE OF SELLER AT THE CURRENT SERVICE RATES.

(d) WHERE GOODS ARE SUBJECT TO A MOVE TO ANOTHER LOCATION AFTER THE ORIGINAL INSTALLATION HAS BEEN MADE, THE WARRANTY MAY BE MAINTAINED ONLY IF SUPERVISED BY AN AUTHORIZED REPRESENTATIVE OF SELLER. SELLER, FOR A SERVICE CHARGE, WILL ARRANGE FOR AND SUPERVISE THE DISCONNECTION, TRANSPORTATION, REINSTALLATION AND START-UP OF THE EQUIPMENT. CLAIMS FOR DAMAGE IN SHIPMENT ARE THE RESPONSIBILITY OF BUYER AND SHALL BE FILED PROMPTLY WITH THE TRANSPORTATION COMPANY.

14. Return Goods Policy. Seller's products may be returned to Seller for credit within sixty (60) days of shipment subject to the following conditions.

(a) In order to return products for credit, Buyer must obtain a RMA number from Seller. Upon receipt, it must be executed by an authorized person and then returned with the Goods. Goods returned to Seller without a RMA will be returned at Buyer's expense.

(b) Goods are to be returned to Seller at 1820 South Myrtle Avenue, Monrovia, CA 91016 with Freight Prepaid. Seller will not accept collect shipments.

(c) Restocking fees will be assessed in accordance with the following schedules: (i) Goods returned within the first thirty (30) days from shipment date will be restocked less twenty percent (20%) of the amount billed on the original invoice. (ii) Goods returned over thirty (30) days of shipment but less than sixty (60) days will be restocked less thirty percent (30%) of the amount billed on the original invoice. (iii) No returns are allowed after sixty (60) days from the original shipping date.

(d) The restocking fees set forth above are the minimum fees. If a returned Good requires rework to restore it to a saleable condition, further charges will be assessed. Seller's quality assurance department will document the condition of the Goods when received by Seller and report their findings to Buyer.

(e) Notwithstanding the foregoing provisions of this Section 14, the following Goods cannot be returned, are not eligible for any credit and cannot be restocked: (i) custom or modified products and (ii) any expendable product(s) that have been used.

15. Compliance with Law and Indemnification. Buyer shall comply with all applicable laws, regulations and ordinances. Buyer shall maintain in effect all the licenses, permissions, authorizations, consents and permits that it needs to carry out its obligations under this Agreement. Buyer shall comply with all export and import laws of all countries involved in the sale of the Goods under this Agreement or any resale of the Goods by Buyer. Goods, Services and technical data delivered by Seller shall be subject to U.S. export controls. Buyer shall, and shall cause its customers to, obtain all licenses, permits and approvals required by any government and shall comply with all applicable laws, rules, policies and procedures of the applicable government and other competent authorities. Buyer will indemnify and hold Seller harmless for any violation or alleged violation by Buyer of such laws, rules, policies or procedures. Buyer shall not transmit, export or re-export, directly or indirectly, separately or as part of any system, the Goods or any technical data (including processes and Services) received from Seller, without first obtaining any license required by the applicable government, including without limitation, the U.S. government. Buyer also certifies that none of the Goods or technical data supplied by Seller under this Agreement will be sold or otherwise transferred to, or made available for use by or for, any entity that is engaged in the design, development, production or use of nuclear, biological or chemical weapons or missile technology. No Buyer information will be deemed "technical data" unless Buyer specifically identifies it to Seller as such. Buyer assumes all responsibility for shipments of Goods requiring any government import clearance. Seller may terminate this Agreement if any governmental authority imposes antidumping or countervailing duties or any other penalties on Goods. For all international shipments, Seller requires that all required Export Control documentations, including Form BIS-711 Statement by Ultimate Consignee and Purchases, are submitted by Buyer along with the purchase order. Seller reserves the right to postpone shipment until all documentations are completed and submitted to Seller. Seller will not be responsible for shipment delays due to non-compliance by Buyer of the foregoing two sentences.

16. Termination. In addition to any remedies that may be provided under these Terms, Seller may terminate this Agreement with immediate effect upon written notice to Buyer, if Buyer: (i) fails to pay any amount when due under this Agreement and such failure continues for ten (10) days after Buyer's receipt of written notice of nonpayment; (ii) has not otherwise performed or complied with any of these Terms, in whole or in part; or (iii) becomes insolvent, files a petition for bankruptcy or commences or has commenced against it proceedings relating to bankruptcy, receivership, reorganization or assignment for the benefit of creditors.

17. Waiver. No waiver by Seller of any of the provisions of this Agreement is effective unless explicitly set forth in writing and signed by Seller. No failure to exercise, or delay in exercising, any rights, remedy, power or privilege arising from this Agreement operates or may be construed as a waiver thereof. No single or partial exercise of any right, remedy, power or privilege hereunder precludes any other or further exercise thereof or the exercise of any other right, remedy, power or privilege.

18. Confidential Information. All non-public, confidential or proprietary information of Seller, including, but not limited to, specifications, samples, patterns, designs, plans, drawings, documents, data, business operations, customer lists, pricing, discounts or rebates, disclosed by Seller to Buyer, whether disclosed orally or disclosed or accessed in written, electronic or other form or media, and whether or not marked, designated or otherwise identified as "confidential," in connection with this Agreement is confidential, solely for the use of performing this Agreement and may not be disclosed or copied unless authorized in advance by Seller in writing. Upon Seller's request, Buyer shall promptly return all documents and other materials received from Seller. Seller shall be entitled to injunctive relief for any violation of this Section 18. This Section 18 does not apply to information that is: (a) in the public domain through no fault of Buyer; (b) known to Buyer at the time of disclosure without restriction as evidenced by its records; or (c) rightfully obtained by Buyer on a non-confidential basis from a third party.

HF-2500A HIGH FREQUENCY WELD CONTROL

19. Force Majeure. Seller shall not be liable or responsible to Buyer, nor be deemed to have defaulted or breached this Agreement, for any failure or delay in fulfilling or performing any term of this Agreement when and to the extent such failure or delay is caused by or results from acts or circumstances beyond the reasonable control of Seller including, without limitation, acts of God, flood, fire, earthquake, explosion, governmental actions, war, invasion or hostilities (whether war is declared or not), terrorist threats or acts, riot, or other civil unrest, national emergency, revolution, insurrection, epidemic, lock-outs, strikes or other labor disputes (whether or not relating to either party's workforce), or restraints or delays affecting carriers or inability or delay in obtaining supplies of adequate or suitable materials, materials or telecommunication breakdown or power outage (each a "**Force Majeure Event**"), provided that, if the event in question continues for a continuous period in excess of thirty (30) days, Buyer shall be entitled to give notice in writing to Seller to terminate this Agreement.

20. Assignment. Buyer shall not assign any of its rights or delegate any of its obligations under this Agreement without the prior written consent of Seller. Any purported assignment or delegation in violation of this Section 20 is null and void. No assignment or delegation relieves Buyer of any of its obligations under this Agreement.

21. Relationship of the Parties. The relationship between the parties is that of independent contractors. Nothing contained in this Agreement shall be construed as creating any agency, partnership, joint venture or other form of joint enterprise, employment or fiduciary relationship between the parties, and neither party shall have authority to contract for or bind the other party in any manner whatsoever.

22. No Third-Party Beneficiaries. This Agreement is for the sole benefit of the parties hereto and their respective successors and permitted assigns and nothing herein, express or implied, is intended to or shall confer upon any other person or entity any legal or equitable right, benefit or remedy of any nature whatsoever under or by reason of these Terms.

23. Governing Law. All matters arising out of or relating to this Agreement is governed by and construed in accordance with the internal laws of the State of California without giving effect to any choice or conflict of law provision or rule (whether of the State of California or any other jurisdiction) that would cause the application of the laws of any jurisdiction other than those of the State of California.

24. Dispute Resolution.

(a) If Buyer is an entity formed under the laws of the United States of America, or any of its states, districts or territories ("**U.S. Law**"), then any dispute, legal suit, action or proceeding arising out of or relating to this Agreement shall be adjudicated and decided in the federal courts of the United States of America or the courts of the State of California in each case located in the City of Los Angeles and County of Los Angeles, California and each party irrevocably submits to the exclusive and personal jurisdiction of such courts in any such dispute, suit, action or proceeding.

(b) If Buyer is an entity formed under the laws of any country, state, district or territory other than U.S. Law, then the parties irrevocably agree that any dispute, legal suit, action or proceeding arising out of or relating to this Agreement shall be submitted to the International Court of Arbitration of the International Chamber of Commerce ("**ICC**") and shall be finally settled under the Rules of Arbitration of the ICC. The place and location of the arbitration shall be in Los Angeles, California, pursuant to the ICC's Rules of Arbitration and shall be finally settled in accordance with said rules. The arbitration shall be conducted before a panel of three arbitrators. Each party shall select one arbitrator and the two arbitrators so selected shall select the third arbitrator, who shall act as presiding arbitrator. Notwithstanding the foregoing, if the matter under dispute is \$500,000 or less, there shall only be one arbitrator who shall be mutually selected by both parties. If the party-selected arbitrators are unable to agree upon the third arbitrator, if either party fails to select an arbitrator, or in the case that only one arbitrator is required and the parties are unable to agree, then the International Court of Arbitration shall choose the arbitrator. The language to be used in the arbitral proceeding shall be English. The arbitrator(s) shall have no authority to issue an award that is contrary to the express terms of this Agreement or the laws of the State of California or applicable US Federal Law, and the award may be vacated or corrected on appeal to a court of competent jurisdiction for any such error. The arbitrator(s) shall be specifically empowered to allocate between the parties the costs of arbitration, as well as reasonable attorneys' fees and costs, in such equitable manner as the arbitrator(s) may determine. The arbitrator(s) shall have the authority to determine issues of arbitrability and to award compensatory damages, but they shall not have authority to award punitive or exemplary damages. Judgment upon the award so rendered may be entered in any court having jurisdiction or application may be made to such court for judicial acceptance of any award and an order of enforcement, as the case may be. In no event shall a demand for arbitration be made after the date when institution of a legal or equitable proceeding based upon such claim, dispute or other matter in question would be barred by the applicable statute of limitations. Notwithstanding the foregoing, either party shall have the right, without waiving any right or remedy available to such party under this Agreement or otherwise, to seek and obtain from any court of competent jurisdiction any interim or provisional relief that is necessary or desirable to protect the rights or property of such party, pending the selection of the arbitrator(s) hereunder or pending the arbitrator(s)' determination of any dispute, controversy or claim hereunder.

25. Notices. All notices, request, consents, claims, demands, waivers and other communications hereunder (each, a "**Notice**") shall be in writing and addressed to the parties at the addresses set forth on the face of the Acknowledgement or to such other address that may be designated by the receiving party in writing. All Notices shall be delivered by personal delivery, nationally recognized overnight courier (with all fees pre-paid), facsimile (with confirmation of transmission) or certified or registered mail (in each case, return receipt requested, postage prepaid). Except as otherwise provided in this Agreement, a Notice is effective only (a) upon receipt of the receiving party, upon confirmation of delivery by nationally recognized overnight courier or upon forty-eight (48) hours after being sent by certified or registered mail (as applicable), and (b) if the party giving the Notice has complied with the requirements of this Section 25.

26. Severability. If any term or provision of this Agreement is invalid, illegal or unenforceable in any jurisdiction, such invalidity, illegality or unenforceability shall not affect any other term or provision of this Agreement or invalidate or render unenforceable such term or provision in any other jurisdiction.

27. Survival. Provisions of these Terms which by their nature should apply beyond their terms will remain in force after any termination or expiration of this Order including, but not limited to, the following provisions: Compliance with Laws, Confidentiality, Governing Law, Dispute Resolution, Survival, and the restrictions on Software in Sections 10(b), (c) and (d).

HF-2500A HIGH FREQUENCY WELD CONTROL

CHAPTER 1

Description

Section I: Features

The **HF-2500A Power Supply** precisely controls and monitors both electrical and mechanical weld parameters.

Power Supply Features

- Constant Current, Voltage & Power modes
- Monitor Energy and Resistance
- Force Control
- Monitor Displacement and Force

Weld Quality Process Tools

- Envelope Function
- Active Part Conditioning
- Pre-weld Check
- Weld to Limits

Descriptions of the various control modes and process tools are located in *Chapter 3, System Configuration*, and *Chapter 4, Introduction to Feedback Modes and Weld Monitoring*.

Detailed instructions on using these features are located in *Chapter 5, Operating Instructions*.



This manual covers the following models:

MODEL NUMBER	STOCK NUMBER
HF-2500A/240	1-315-02
HF-2500A/400	1-315-02-01
HF-2500A/480	1-315-02-02

NOTE: For the rest of this manual, the AMADA WELD TECH HF-2500A High Frequency Weld Control will simply be referred to as the **Power Supply**.

Section II: Introduction

The Power Supply is a 25 kHz, three-phase, state-of-the-art inverter power supply for joining precision small parts at high speed with controllable rise times. The delivered welding energy is in the form of DC welding energy. High speed (40 microseconds) digital feedback automatically controls weld current, voltage, or power, providing more welding consistency compared to traditional direct energy (AC) or capacitive discharge (CD) technologies. This microprocessor technology automatically compensates for changes in work piece resistance, load inductance, weld transformer saturation, and changes in line voltage. In addition, special power device technology precisely controls the weld energy at both high and low energy levels.

- You can program the Power Supply from the front panel, using simplified key clusters and on-screen data fields. A **MAIN MENU** screen allows you select all of the system setup options for working with inputs from external equipment.
- The **RUN** screen allows you to easily modify any time period, current, voltage, or power value.
- The **MONITOR** screen provides instant visual feedback on the actual current, voltage, or power used to make each weld. It permits you to program adjustable limits for both weld pulses.

<MAIN MENU>

1. SETUP

2. WELD COUNTER

3. COPY A SCHEDULE

4. CALIBRATION

5. SYSTEM SECURITY

6. COMMUNICATION

7. RELAY

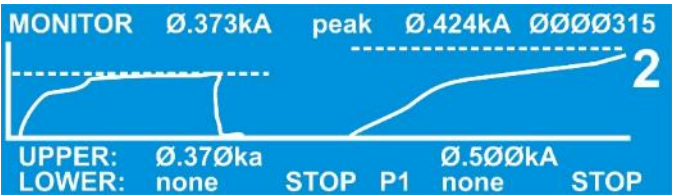
8. RESET TO DEFAULTS

9. CHAIN SCHEDULES

NUMBER Select an item



Run Screen



Monitor Screen

- Rear-mounted RS-232 and RS-485 connectors allow for remote programming, weld schedule selection, and data logging for SPC purposes. The Power Supply has communication and data options that allow you to connect a single Power Supply, or multiple Power Supplies, to a printer or a computer in order to:
 - Compile, store, view, and print weld history data for detailed analysis.
 - Remotely program weld schedules on the Power Supply(s).
 - Remotely program menu items on the Power Supply(s).

Appendix E, Communications in this manual lists all of the commands that the Power Supply will respond to, and instructions on how to format commands sent to the Power Supply so it will respond properly.

- The design of the Power Supply is directed toward compactness, lightweight, operational simplicity, and ease of repair. Metric hardware is used throughout the chassis to facilitate international servicing and repair.
- The 25 kHz operating frequency ensures that the integral welding transformer is light and compact. The input / output connectors on the rear panel provide for quick-connect signal I/O cabling, facilitating interface with automation systems.

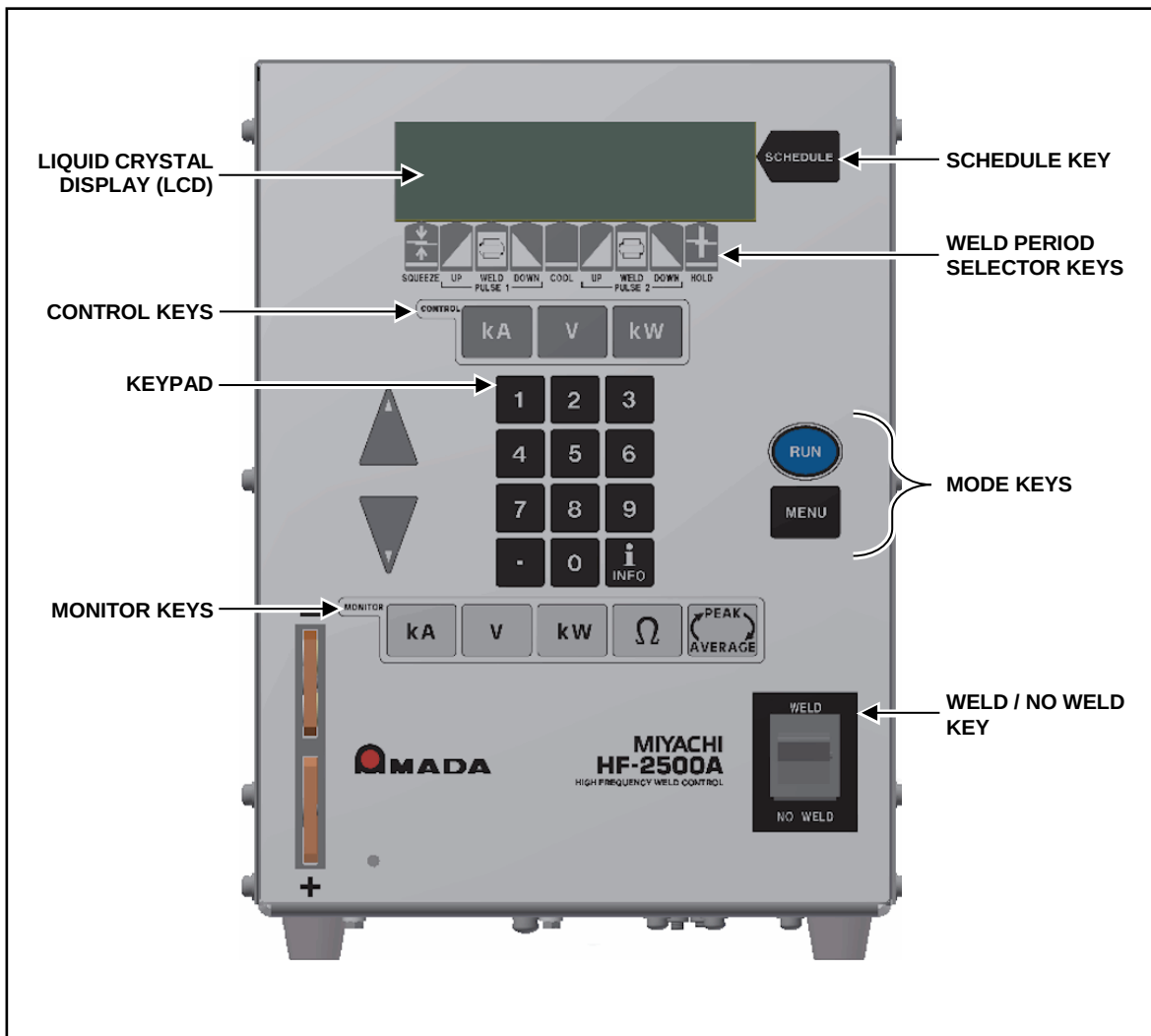
Section III: Major Components

Major Components

The major components are the front panel, which contains the operator's controls and indicators, and the rear panel, which contains fuses, circuit breakers and power and signal connectors. The rear panel connections are discussed in *Chapter 2, Installation and Setup*.

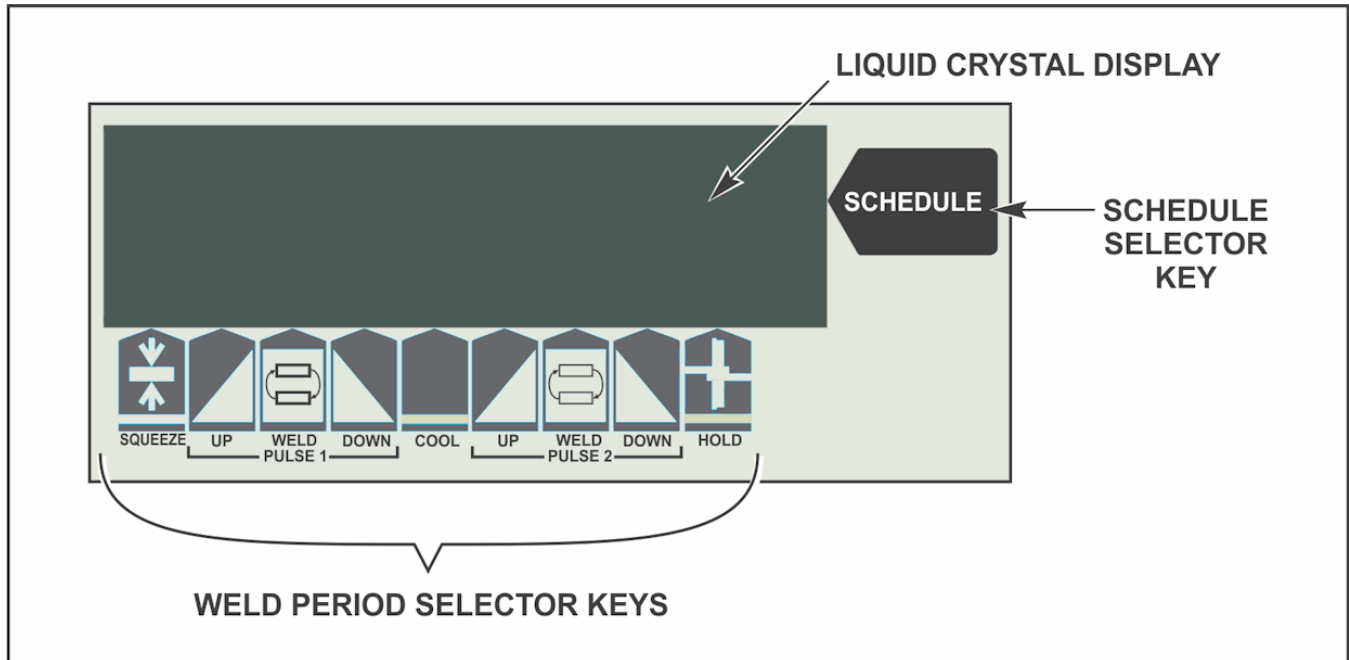
Front Panel Display and Display Controls

The front panel of the Power Supply below shows controls and indicators. The function of each item is described on the following pages.



Front Panel Controls

Display



Liquid Crystal Display (LCD)

The Liquid Crystal Display (LCD) on the front panel allows you to locally program the Power Supply with the front panel controls, and read the results of a weld process following its initiation. The LCD has three distinct functions, depending on the active mode of the Power Supply. In the run mode, the display permits you to:

- View the entire weld schedule profile, individual weld periods, and weld energy parameters.
- View individual weld parameter program changes as you enter them via the weld period selector keys.
- View completed weld feedback data and use the data to modify the weld schedule.

In the menu mode, the display presents system setup options for you to select. In the monitor mode, the display is your means of programming the energy limits monitor and viewing actual out of limit conditions.

Display Controls

There are three display control functions:

- **SCHEDULE** Selector Key
- Weld Period Selector Keys
- Time/Energy Selector Keys

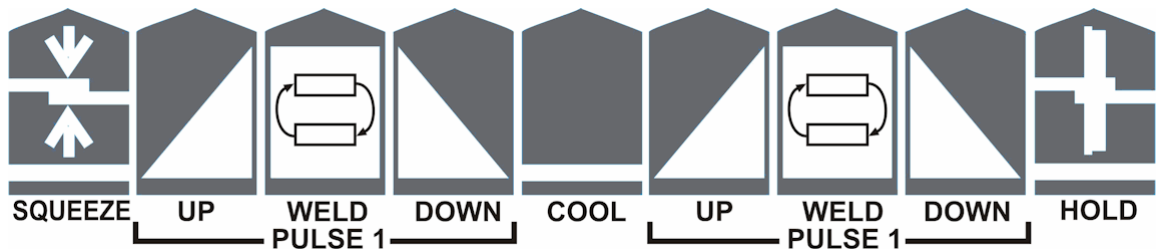
CHAPTER 1: DESCRIPTION

SCHEDULE Key



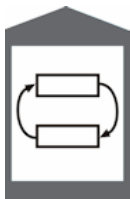
Puts the Power Supply into the weld schedule selection mode. Use the keypad to directly enter a desired weld schedule (refer to *Front Panel Data Entry and Mode Controls* in this section), then press the **RUN** key.

Weld Period Selector Keys



Select individual weld periods and weld energy fields in the weld schedule profile for programming. See *Front Panel Data Entry and Mode Controls*.

Time/Energy Selector Keys

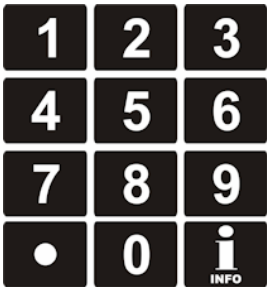


These two switches, one for each of the **PULSE 1** and **PULSE 2** weld periods, select either the bottom line of data or the second-to-bottom line of data on the screen to be programmed. The bottom line of data is weld period time in milliseconds. The second-to-bottom line is **Weld Energy**, in the units selected by the energy units selection keys. See *Front Panel Data Entry and Mode Controls*.

Front Panel Data Entry and Mode Keys

Key Pad

The keypad consists of the numeric keys and the up/down/left/right keys.



Numeric Keys: The numeric keys allow you to:

- Enter or modify weld period time and energy values
- Enter or modify monitor and limit values
- Directly recall a specific weld schedule.

To use the numeric keypad, you must first select a time/energy weld period key or the schedule key.

Mode Keys. The mode keys consist of the **RUN** key and the **MENU** key.



RUN Key: Sets the Power Supply to the operating mode. Used to terminate program mode if already in the **RUN** screen.



MENU Key: You access the menu screen with this key. Menu items control system parameters such as setup and weld counter operation. Refer to *Menus* in *Chapter 3, Section II* for details of the functions accessible through that screen.

Control Keys



Control Mode Selection Keys. These keys allow you to select the control mode when programming with the **WELD** (time/energy) selector keys.



Pressing the **kA** key selects current as the control mode for this schedule. The control will output the current waveform shown on the LCD.



Pressing the **V** key selects voltage as the control mode for this schedule. The control will output the voltage waveform shown on the LCD.

NOTE: Selecting the voltage feedback mode requires you to make a test weld when the voltage or weld pulse time is changed. The test weld optimizes the Power Supply feedback performance. The weld status message **TEST** disappears after the internal control parameters are optimized.



Pressing the **kW** key selects power as the control mode for this schedule. The control will output the power waveform shown on the LCD.

Monitor Keys



These keys allow you to view the results of the last weld and to set the limits of the welding parameters beyond which the energy limits monitor terminate the weld and/or initiate alarms.

CHAPTER 1: DESCRIPTION



Pressing the **kA** key displays the current monitor. This screen shows the results of the most recent weld. This screen also allows the operator to set limits that automatically interrupt the weld when they are reached. You can also program the current monitor to output an alarm when the limits are exceeded.



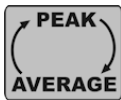
Pressing the **V** key displays the voltage monitor. This screen shows the results of the most recent weld. This screen also allows the operator to set limits that automatically interrupt the weld when they are reached. You can also program the voltage monitor to output an alarm when the limits are exceeded.



Pressing the **kW** key displays the power monitor. This screen shows the results of the most recent weld. This screen also allows the operator to set limits that automatically interrupt the weld when they are reached. You can also program the power monitor to output an alarm when the limits are exceeded.



Pressing the **Ω** key displays the resistance monitor. This screen shows the results of the most recent weld.



The Power Supply is always monitoring both the **PEAK** and **AVERAGE** of current, voltage, power, and resistance. When you press this key, the top line in the LCD screen toggles back and forth between displaying **PEAK** and **AVERAGE**.

WELD/NO WELD Switch



When the switch is in the **WELD** position, the programmed weld sequence can initiate weld energy.

When you set this switch to the **NO WELD** position, *no* weld current can flow. However, the Power Supply *can* execute a complete weld sequence. This function is required to adjust the weld head prior to operation.

Emergency Stop Switch Operation

If your work station is equipped with an emergency stop switch (connected to the emergency stop connection of the Power Supply), operate the switch to immediately stop the welding process. All power to the air valves and power circuits will be disconnected. To restart the Power Supply, you must press the RUN key on the front panel.

CHAPTER 2

Installation and Setup

Section I: Installation

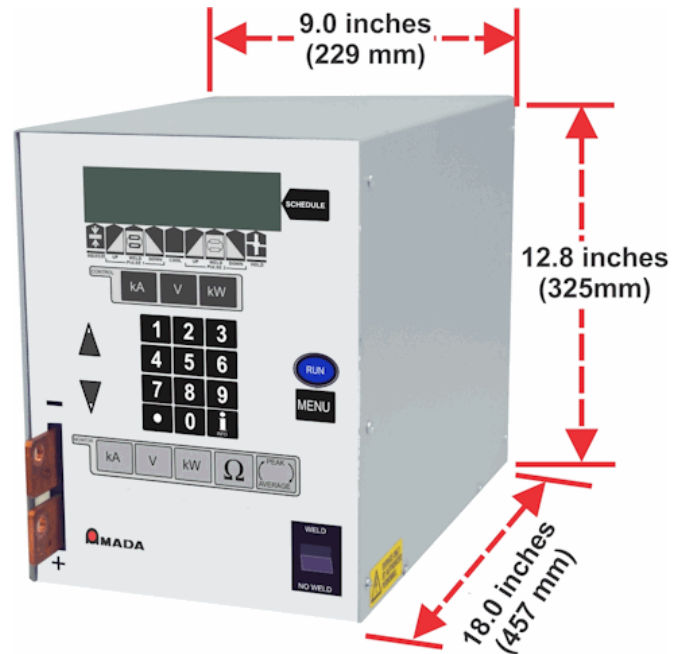
Unpacking

The Power Supply is shipped to you completely assembled, together with the accessories you ordered and a shipping kit.

Verify that the Power Supply shows no signs of damage. If it does, please contact the carrier. Also, contact AMADA WELD TECH Customer Service immediately at the postal or e-mail address or telephone or FAX number shown in the Foreword of this manual.

Space Requirements

- Allow ample workspace around the Power Supply so that it will not be jostled or struck while welding.
- Allow sufficient clearance around both sides and back of the Power Supply for power and signal cabling runs.
- Install the Power Supply in a well-ventilated area that is free from excessive dust, acids, corrosive gases, salt and moisture.
- Other installation considerations are:
 - The work surface must be level, stable, free from vibration, and capable of supporting the combined weight of the total welding system. The weight of the Power Supply is 62 lb. (28 kg).
 - The Power Supply must be far enough from the weld head to avoid contact with weld splash.
 - There are no sources of high-frequency energy close by.



CHAPTER 2: INSTALLATION AND SETUP

Utilities

Power

Because of the different electrical requirements for the countries in which the Power Supply is used, the Power Supply is shipped without a power cable connector. The required connections for your power cable connector are described in *Appendix B, Electrical and Data Connections*. Input power requirements for the Power Supply are as listed below.

Power Input Specifications

HF-2500A Model	Input Voltage, 50-60 Hz, 3 phase (Vrms)	Circuit Breaker Current (A rms)	Copper Wire Gauge, 7 strands (AWG)	Wire Dia (mm)	Fuses F1, F2	
					Amps/ Volts	AMADA WELD TECH P/N
HF-2500A/240	240	25	10	2.5	6.3	330-096
HF-2500A/400	400	20	10	2.5	3.15	330-095
HF-2500A/480	480	13	10	2.5	3.15	330-097

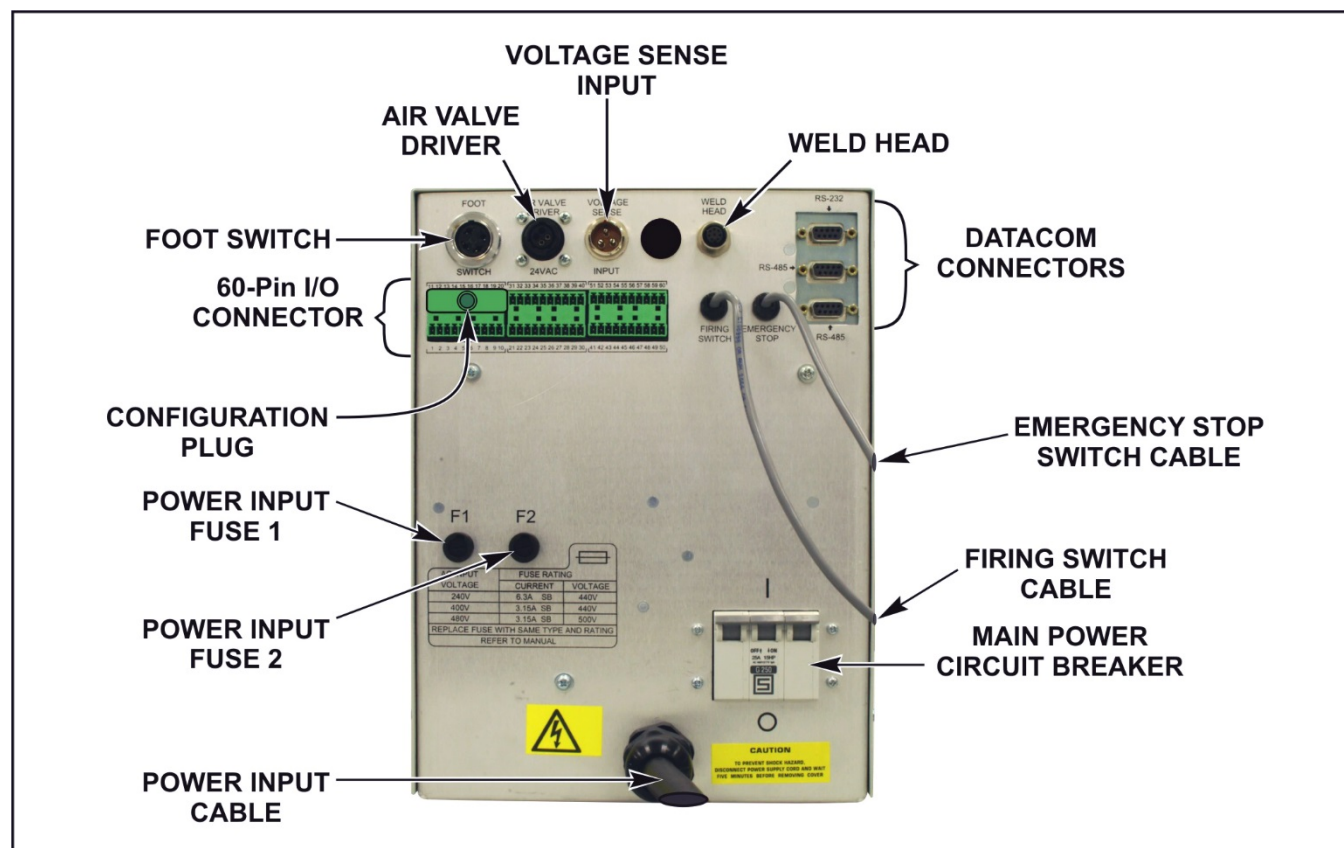
Compressed Air and Cooling Water

If you require compressed air and cooling water service for the weld head, please refer to the weld head manufacturer's user's manual for service specifications.

Section II: Setup

Connections to External Equipment

All connections, other than the weld cable connections, between the Power Supply and external equipment are made through the rear panel.



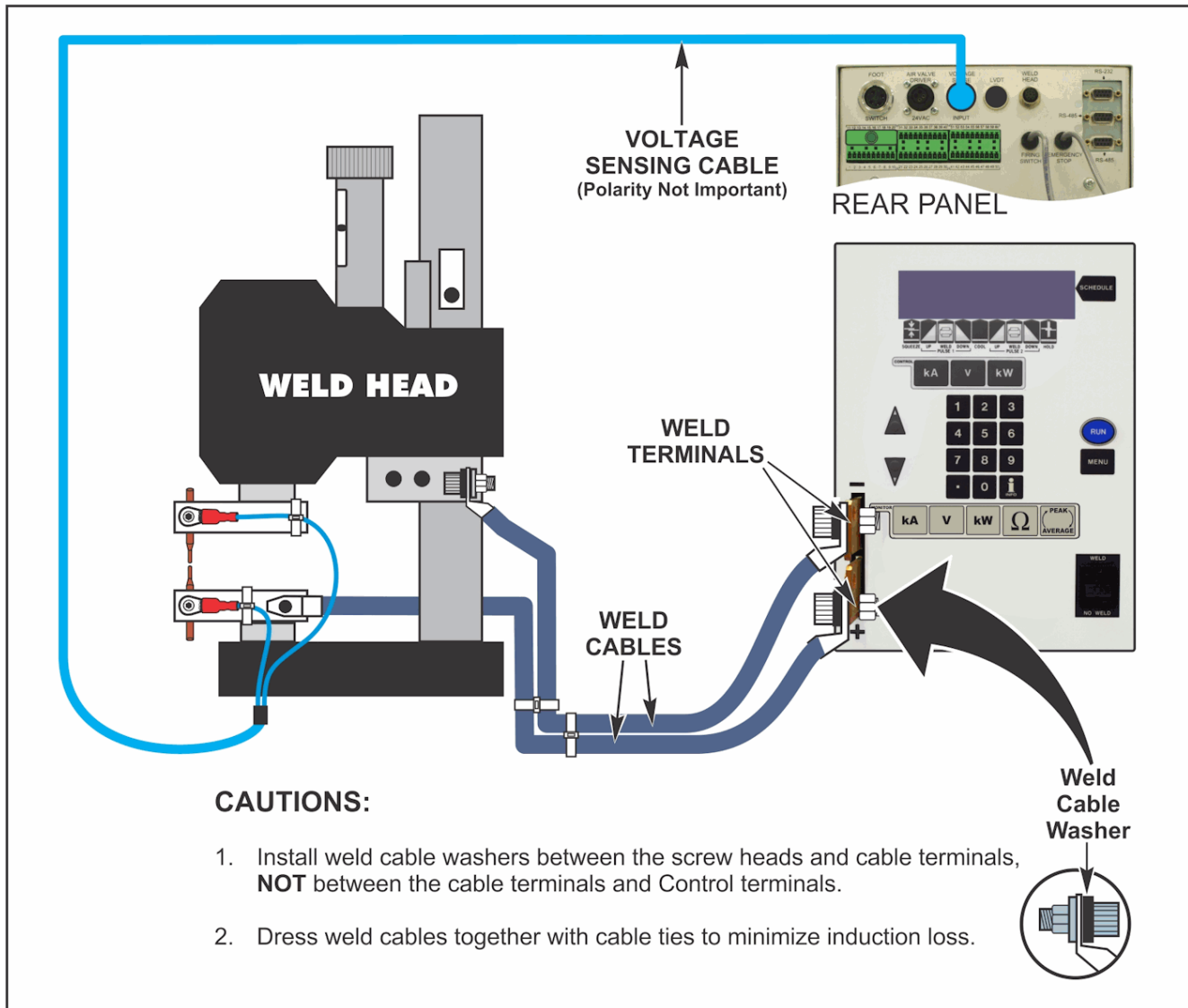
Rear Panel Components and Connectors

NOTES:

- The weld cable connections from the weld head are made at the weld cable terminals on the front panel.
- The pre-wired **Configuration Plug** above is colored red for clarity, actual color may vary. This plug allows the use of AMADA WELD TECH standard foot switches and weld heads without further configuration. The Power Supply requires configuration of the I/O's to accept *any* inputs. For normal use, this plug must be connected to pins **11** through **20** on the 60-pin connector. For other configurations, see *Appendix B, Electrical and Data Connections*.

CHAPTER 2: INSTALLATION AND SETUP

Weld Head Connections

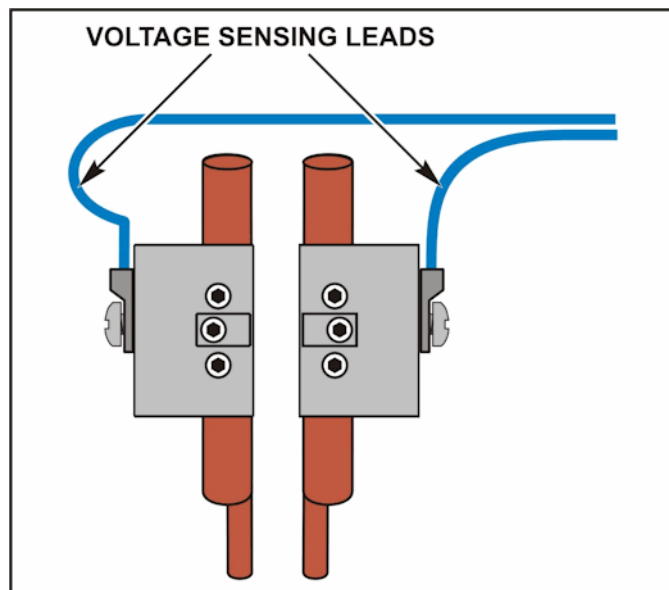


1. Connect one end of a weld cable to the negative (-) welding transformer terminal on the Power Supply.
2. Connect one end of the second weld cable to the positive (+) welding transformer terminal on the Power Supply.
3. Connect the other end of the weld cables to the weld head.
4. Attach the voltage sensing cable connector to the **VOLTAGE SENSE INPUT** connector.
5. Install electrodes in the weld head electrode holders.

NOTE: If you need additional information about the weld heads, please refer to their user's manuals.

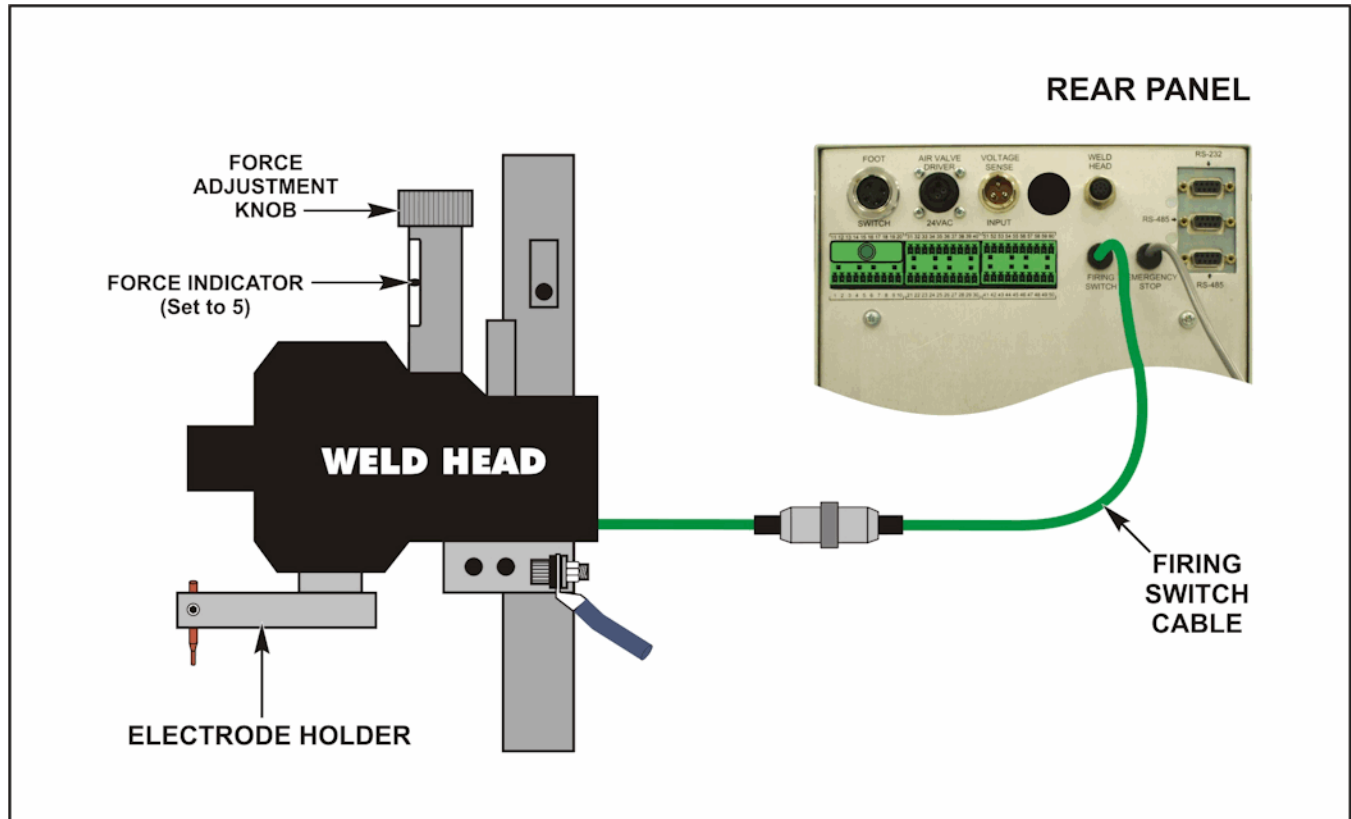
6. Connect the voltage sensing cable clips that are packed in the shipping kit to the voltage sensing cable leads. Use either the 1/4" or 1/8" diameter clip, as appropriate to the electrode diameter.
7. Attach a clip directly to each electrode as shown on the right.
8. Put a strain relieve on each voltage sensing lead to its corresponding electrode holder so that the lead clips will not break away under heavy operating conditions.

NOTE: Do *not* attach the firing switch, foot switch or **EMERGENCY STOP** cables at this time.

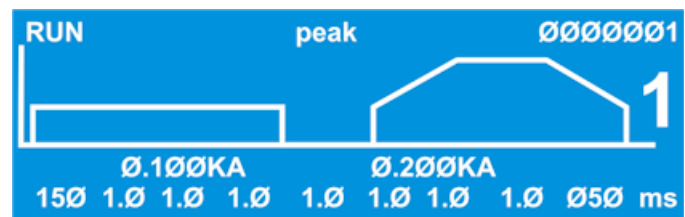


CHAPTER 2: INSTALLATION AND SETUP

Foot Pedal-Actuated Weld Head Connection

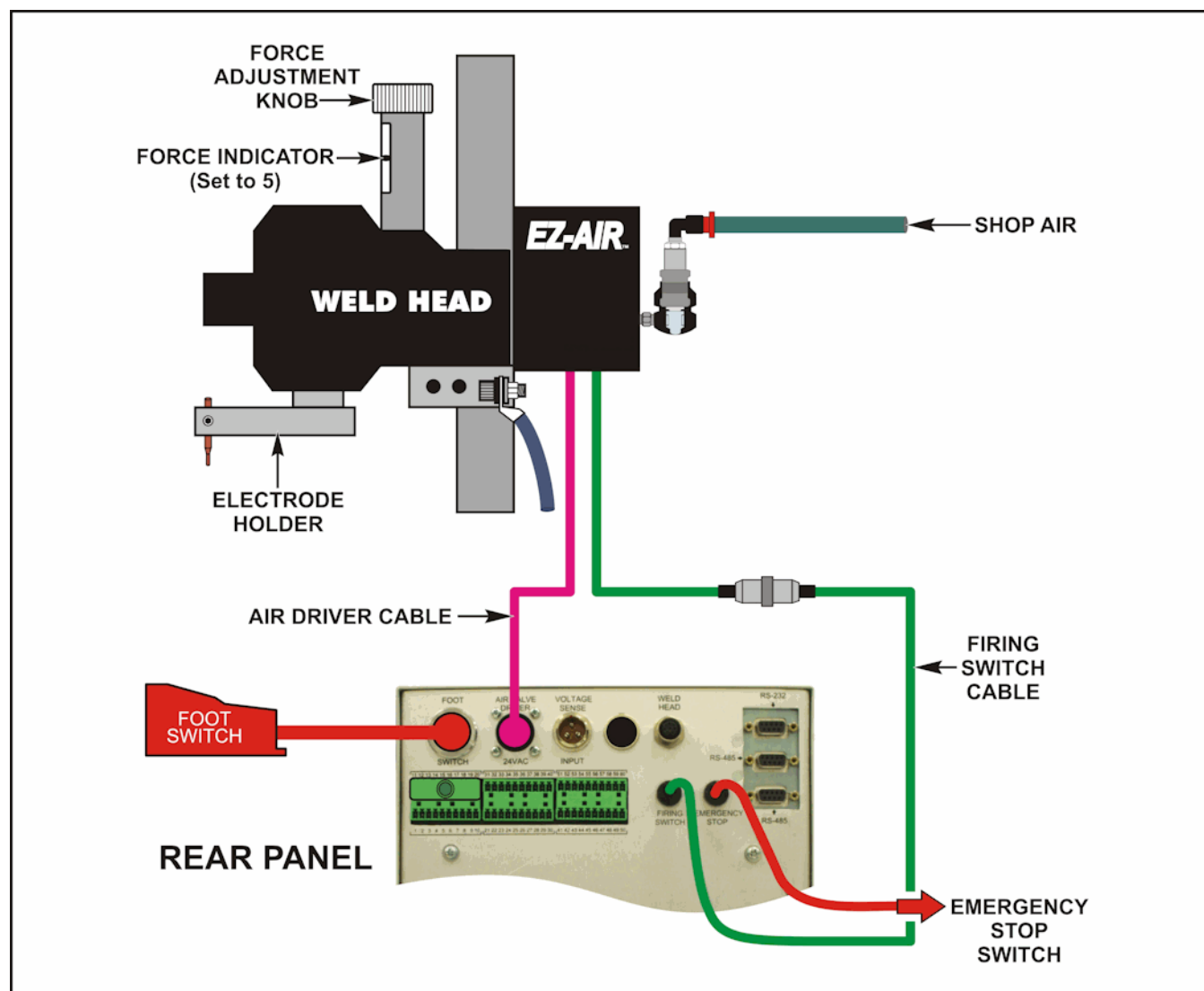


1. Adjust the weld head force adjustment knob to produce 5 units of force, as displayed on the force indicator index.
2. Connect the weld head firing switch cable connector to the Power Supply firing switch cable connector.
3. Connect a normally closed, approved, emergency stop switch across the two leads of the operator emergency stop switch cable. This switch, when operated (open), will immediately stop the weld cycle. See *Appendix B. Electrical and Data Connections* for circuit details.
4. Set the **WELD/NO WELD** switch on the Power Supply front panel to the **NO WELD** position. In this position, the Power Supply cannot deliver weld energy, but the firing switch connection can be verified.
5. Set the circuit breaker on the rear panel of the Power Supply to the ON position. The default **RUN** screen will be displayed. You will use this screen to enter welding parameters.



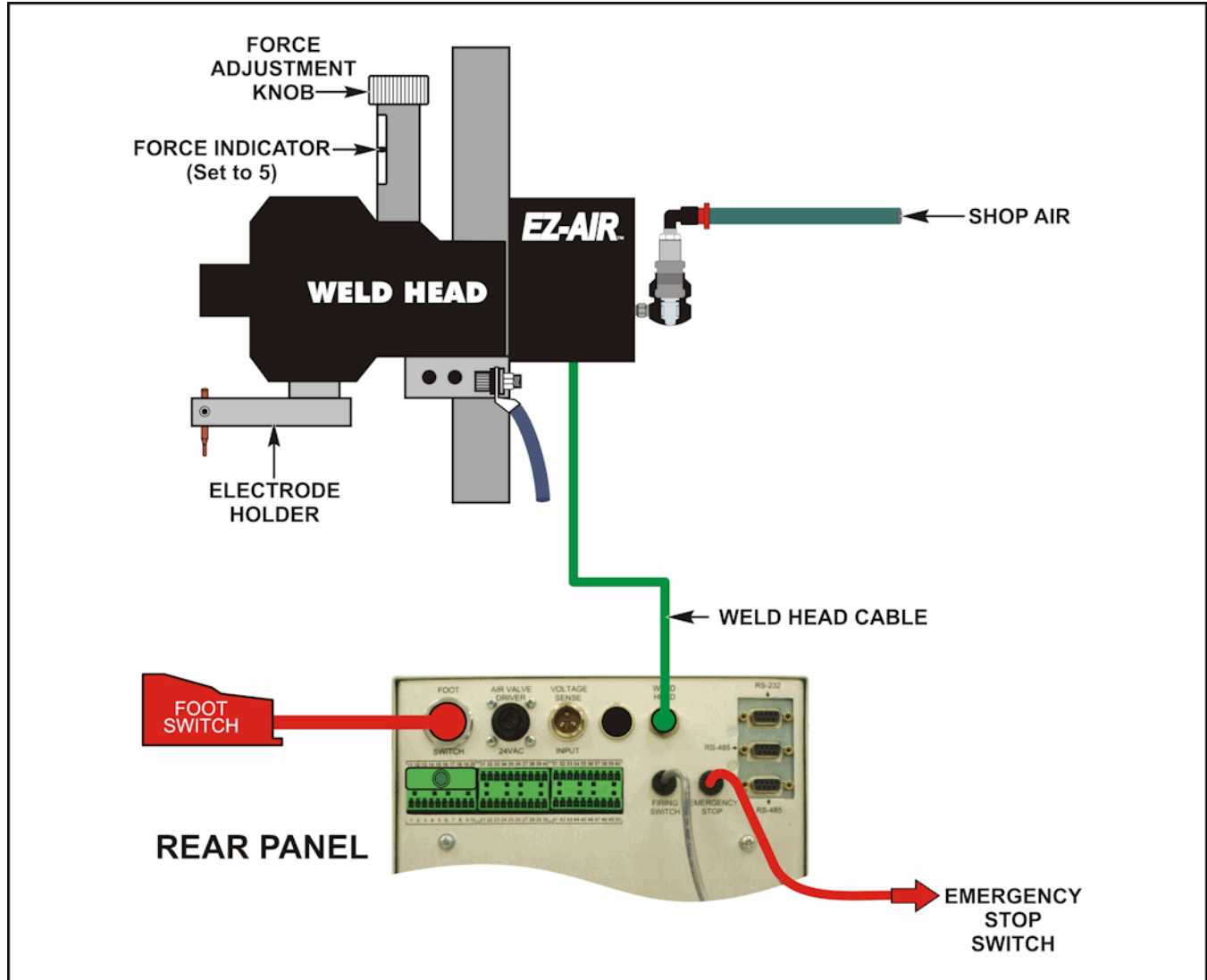
EZ-AIR Weld Head Connections

AC EZ-AIR Weld Head Connection



CHAPTER 2: INSTALLATION AND SETUP

DC EZ-AIR Weld Head Connection



1. Adjust the weld head force adjustment knob to produce 5 units of force, as displayed on the force indicator index.
2. Connect the weld head firing switch cable connector to the Power Supply firing switch cable connector.
3. Connect a normally closed, approved, emergency stop switch across the two leads of the operator emergency stop switch cable. This switch, when operated (open), will immediately stop the weld cycle and retract the weld head. See *Appendix B. Electrical and Data Connections* for circuit details.
4. Connect a Model FS2L or FS1L Foot Switch to the Power Supply **FOOT SWITCH** connector.

5. Refer to the weld head manufacturer user's manual. Connect the weld head air valve solenoid cable connector to the Power Supply **AIR VALVE DRIVER** connector.

NOTE: This connector supplies 24 VAC power only, and will **not** drive 115 VAC air valves.

6. Connect a properly filtered air line to the air inlet fitting on the weld head. Use 0.25 inch O.D. by 0.17 inch I.D. plastic hose with a rated burst pressure of 250 psi. Limit the length of the air line to less than 40 in. (1 m) or electrode motion will be very slow.

NOTE: Use a lubricator **only** with automated installations.

7. Turn on the air system and check for leaks.
8. Set the **WELD/NO WELD** switch on the Power Supply front panel to the **NO WELD** position. In this position, the Power Supply cannot deliver weld energy, but it can control the weld head.
9. Set the circuit breaker on the rear panel of the Power Supply to the ON position. The default **RUN** screen will display.

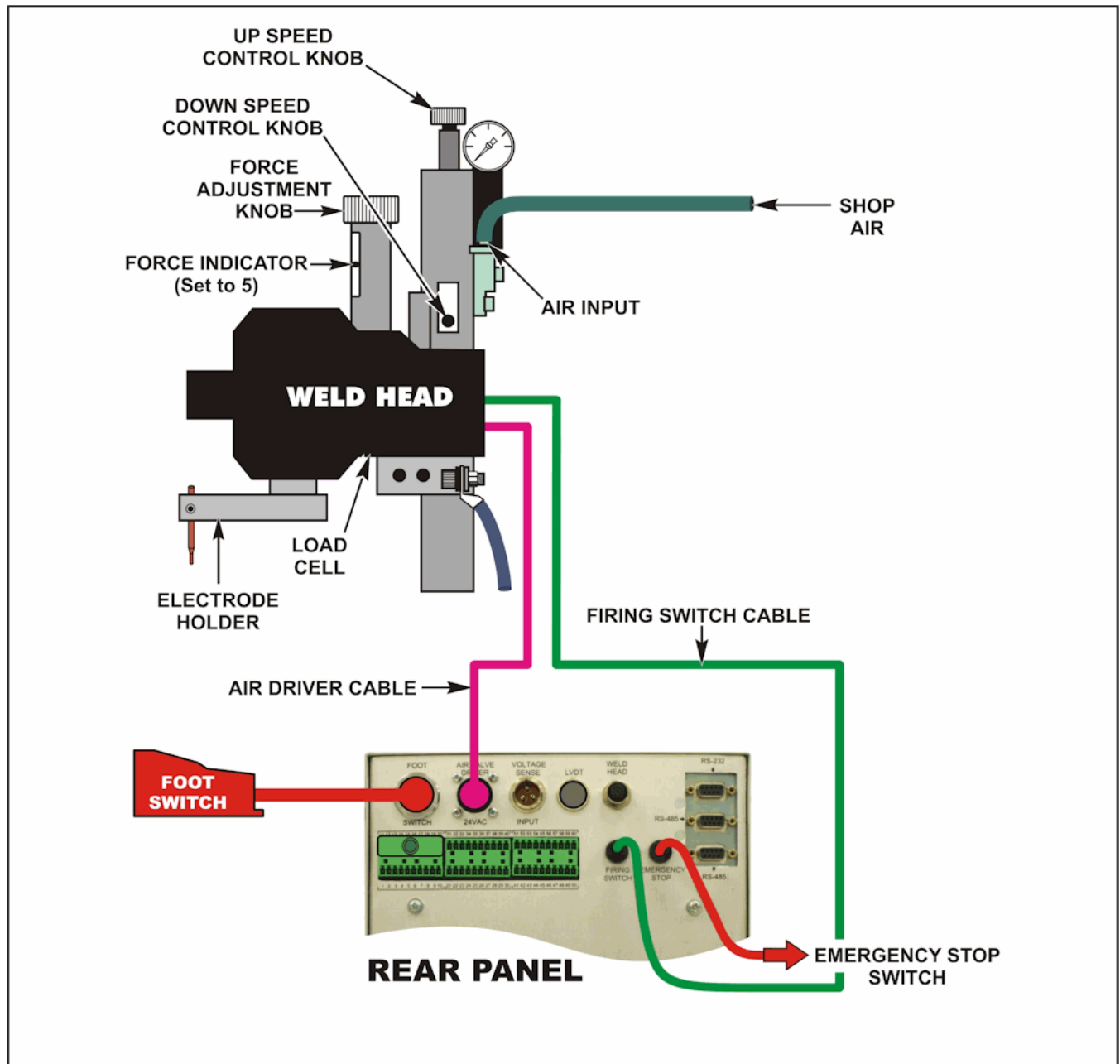


10. Press the foot switch to actuate the first level. The weld head upper electrode should descend smoothly to the DOWN position. When it reaches the down position, release the foot switch and proceed to Step 12. If it does not descend smoothly, proceed to Step 11.
11. Adjust the weld head down speed control knob and repeat Step 10 until the upper electrode descends smoothly.
12. Press the foot switch all the way down to close both levels. The weld head upper electrode should descend smoothly to the DOWN position, and send the firing switch signal back to the Power Supply when the preset electrode force is reached. The upper electrode should then ascend smoothly back to the UP position.

CHAPTER 2: INSTALLATION AND SETUP

Non-EZ-AIR Weld Head Connections

Non-EZ-AIR heads may be connected to the Power Supply as shown below, however you should refer to the manual provided with the weld head you are using for specific instructions.



CHAPTER 3

System Configuration

Section I: Menus

Before You Start

Configuration is simply a matter of selecting various **MENU** options so the Power Supply will work with all the components of your welding system.

- Verify that all connections have been made according to the instructions in *Chapter 2, Installation and Setup*.
- Turn the Power Supply ON.
- Turn the shop air supply ON.

Overview

You program the system settings of the Power Supply through the **MAIN MENU** screen and its sub-menus. You go to the **MAIN MENU** screen by pressing the **MENU** key on the front panel of the Power Supply.

All of the menu screens have similar prompts that tell you how to go to a function on the menu and/or get to the next menu.

<MAIN MENU>

1. SETUP	6. COMMUNICATIONS
2. WELD COUNTERS	7. RELAY
3. COPY A SCHEDULE	8. RESET DEFAULTS
4. CALIBRATION	9. CHAIN SCHEDULES
5. SYSTEM SECURITY	

Number Select an item

- At the **NUMBER** Select an item prompt, use the numeric keypad to select one of the functions on the menu.
- Press the down ▲▼ keys to go to the next or previous menu. Each additional menu gives you choices for additional functions.
- Press the **MENU** key to return to the main menu.

Main Menu

1. SETUP

From the **MAIN MENU** screen, press **1** to go to the **SETUP 1** screen.

The **SETUP 1** screen is shown on the right with typical settings.

<SETUP, page 1 of 3>

1. FOOTSWITCH WELD ABORT	:	OFF
2. SWITCH DEBOUNCE TIME	:	10 ms
3. FIRING SWITCH	:	AUTO

Number Select an item, ▼ Page, **RUN** or **MENU**

CHAPTER 3: SYSTEM CONFIGURATION

From the **SETUP 1** screen, press the ▼ key.

The **SETUP 2** screen is shown on the right with typical settings.

<SETUP, page 2 of 3>

1. DISPLAY CONTRAST	:	50
2. BUZZER LOUDNESS	:	40
3. END OF CYCLE BUZZER	:	OFF
4. UPDATE GRAPH AFTER WELD	:	ON
5. LANGUAGE	:	ENGLISH

Number Select an item, ▲▼ Page, RUN or MENU

From the **SETUP 2** screen, press the ▼ key.

The **SETUP 3** screen is shown on the right with typical settings.

<SETUP, page 3 of 3>

1. DO TEST WELD	:	ALWAYS
-----------------	---	--------

Number Select an item, ▲ Page, RUN or MENU

2. WELD COUNTER

1. From the **MAIN MENU**, press the **2** key to go to the **WELD COUNTERS** screen. The total welds counter increments each time a weld is made in any weld schedule.

<WELD COUNTERS>

1. TOTAL WELDS	:	0000000
2. OUT OF LIMITS HIGH	:	000000
3. OUT LIMITS LOW	:	000000
4. WITHIN LIMITS	:	000000

Number Select an item, , RUN or MENU

NOTE: The Power Supply breaks down the weld count into three additional categories, as determined by the energy limits monitor: rejects due to higher than programmed weld energy, rejects due to lower than programmed weld energy, and the number of welds within limits.

2. To select the weld counters, press the **1**, **2**, **3** or **4** key to select the desired weld counter. The example below shows the **TOTAL WELDS** screen.
3. To reset the counter, press the **0** key.
4. To input a preset number, use the numeric keys.
5. If you accidentally reset the wrong counter, press the period (.) key. The original count will reappear. Press the **MENU** key to return to the **MAIN MENU** screen.

<WELD COUNTERS>

1. TOTAL WELDS	:	0000000
----------------	---	---------

NUMBER Change, [,] Restore, ▲ Page, MENU

3. COPY A SCHEDULE

The Power Supply can store **99** (numbered **1** through **99**) individual weld energy profiles. This function allows you to copy any weld schedule from one numbered weld schedule to another numbered weld schedule

1. From the **MAIN MENU**, press the **3** key to go to the **COPY SCHEDULE** screen.
2. Using the numeric keys, enter **1** in the source schedule number field.
3. Press the **►** key to select the destination schedule number field.
4. Using the numeric keys, enter **2** in the destination schedule number field.
5. Press the **SCHEDULE** key to copy the schedule and exit the screen.
6. Press the **MENU** key to return to the main menu. The contents of Weld Schedule 1 will be copied to Weld Schedule 2, overwriting the previous contents of Weld Schedule 2. Note that this function will copy schedule settings, monitor limits and envelope offsets, but it will not copy the reference waveforms for envelope limits.

<COPY SCHEDULE>
COPY SCHEDULE [**1**] TO SCHEDULE [**2**]

Enter **NUMBERS** followed by **SCHEDULE**

<COPY SCHEDULE>
COPY SCHEDULE [**1**] TO SCHEDULE [**2**]

Enter **NUMBERS** followed by **SCHEDULE**

4. CALIBRATION

From the **MAIN MENU**, press the **4** key to go to the **CALIBRATION** screen. Refer to the appendix for calibration setup.

<*** CAUTION ***>

CALIBRATION SHOULD BE PERFORMED BY A
QUALIFIED TECHNICIAN ONLY.
REFER TO MANUAL FOR CALIBRATION SETUP

▼ Next, **RUN** or **MENU**

5. SYSTEM SECURITY

From the **MAIN MENU**, press the **5** key to go to up **SYSTEM SECURITY** screen. With this screen, you can protect the weld schedules from unauthorized changes by programming the Power Supply with a user-defined protection code.

<SYSTEM SECURITY>
1. SCHEDULE LOCK : OFF
2. SYSTEM LOCK : OFF
3. CALIBRATION : OFF

NUMBERS Select an item, **RUN** or **MENU**

CHAPTER 3: SYSTEM CONFIGURATION

1. Schedule Lock

This function prevents unauthorized users from selecting any weld schedule other than the displayed schedule, and from changing any weld energy/time parameters within the weld schedule.

2. System Lock

This function prevents unauthorized users from changing any of the options on the main menu. It also prevents unauthorized users from changing weld energy/time parameters within weld schedules 1-99. Note that schedule 0 is a “scratchpad” and can still be edited when the System Lock is ON. This security level allows you to select different schedules from the front panel.

3. Calibration

This function prevents unauthorized users from modifying any of the calibration settings.

NOTE: All security options use the *same* procedure to enter a security code and to turn the security code OFF.

1. Press the **1** key to select **SCHEDULE LOCK**. This will bring up the **CHANGE STATUS** screen, as shown at the right.
2. Enter a 7-digit number, from **0000001** to **9999999**, in the code field, and then enter a period. This will bring up the **SYSTEM SECURITY** menu screen, this time with **SCHEDULE LOCK: ON**. With **ON** selected, all other weld schedules are locked out and cannot be modified or used for welding.
3. To unlock the Power Supply from security protection, return to the **CHANGE STATUS** screen and enter the code that you entered in Step 2. This will bring up the **SYSTEM SECURITY** menu screen, this time with **SCHEDULE LOCK: OFF**.
4. If you forget the security code and wish to unlock the Power Supply from security protection:
 - Return to the **CHANGE STATUS** screen.
 - Enter a security code of **280**.

<CHANGE STATUS>

PASSWORD :

NUMBERS for code followed by [.]

6. COMMUNICATION

The following menu screens tell you how to set the Power Supplies communication role and data options. You will need to select between “Host” and “Client” communications role (see below for details) and data options such as baud rate, RS-232 or RS-485 protocol, and the ID number for the weld control.

Rear-mounted RS-232 and RS-485 connectors allow for remote programming, weld schedule selection, and data logging for SPC purposes. Data output provides the necessary process documentation for critical applications and permits data logging for SPC purposes.

Appendix E, Communications in this manual lists all of the commands that the Power Supply will respond to, and instructions on how to format commands sent to the Power Supply so it will respond properly.

The Power Supply contains internal software that gives you a great deal of flexibility in the setup and use of your welding system. The Power Supply software displays various menu screens on the LCD, each containing prompts telling you which of the Power Supplies front panel controls to use in order to customize operating parameters, set the Power Supply for use in an automated welding system, and program communication settings for use with data-gathering devices such as a host computer.

1. Communication Role

1. From the **MAIN MENU**, press the **6** key to go to the **COMMUNICATION** menu (shown with default settings).
From the **COMMUNICATION** menu, toggle the **1** key to select **HOST** or **CLIENT**. The **COMMUNICATION ROLE** line will now reflect your role selection.

<COMMUNICATION>	
1. COMMUNICATION ROLE	: CLIENT
2. BAUD RATE	: 9600
3. RS232/485 SELECT	: RS232
4. I.D. NUMBER	: 1

NUMBERS Select an item, RUN or MENU

- In the **HOST** role, the Power Supply will:
 - Send weld data to the host computer after each weld operation.
 - Send text data to a serial printer, providing a printout of the average voltage and current values for each weld, generating a "paper history" of welds performed.
 - In the **CLIENT** role, the Power Supply will send weld data only when requested by the host computer. You **must** use this role for RS-485 installations with multiple controls on one communications channel.
2. Press **MENU** to return to the **MAIN MENU**.

CHAPTER 3: SYSTEM CONFIGURATION

2. Baud Rate

The baud rate at which the data is sent must match the baud rate of the host computer. To enter the baud rate, proceed as follows:

1. From the **COMMUNICATION** menu, press the **2** key to get the **BAUD RATE** selection screen.
2. Use the numeric keypad to select the baud rate of the receiving device. The display automatically returns to the **COMMUNICATION** menu, which shows the new baud rate.
3. Press **MENU** to return to the **MAIN MENU**.

<BAUD RATE>	
1. 1200	6. 19.2K
2. 2400	7. 28.8K
3. 4800	8. 38.4K
4. 9600	
5. 14.4K	

Number Select, ▲ Page, RUN or MENU

3. RS232/485 SELECT

Pressing the 3 key will alternately select either RS-232 or RS-485 communications. The default selection is RS-232.

4. I.D. Number

The host computer may be used to talk with multiple Power Supplies using a single RS-485 communications line. Each Power Supply sharing that line *must* have a unique identification number. To enter an identification number for the Power Supply, proceed as follows:

1. From the **MAIN MENU**, press the **6** key to go to the **COMMUNICATIONS MENU**.
2. From the **COMMUNICATIONS MENU** screen, press the **3** key to get the **I.D. NUMBER** entry screen.

<I.D. NUMBER>	
I.D. NUMBER	: 01

Number Select, ▲ Page, RUN or MENU

3. Enter a two-digit number, from **01** to **30**, in the **I.D. NUMBER** field.
4. Press the **MENU** key to get the **COMMUNICATION** menu screen. This time the **I.D. NUMBER** line will display your I.D. number entry.
5. Press **MENU** to return to the **MAIN MENU**.

7. RELAY

- From the **MAIN MENU**, press the **7** key to go to the **RELAY** output state selection menu, shown at the right. The Power Supply has four relays that can provide dry-contact signal outputs under many different conditions.

```

                                <RELAY>
1. RELAY1:ON    OTHER
2. RELAY2:ON    ALARM
3. RELAY3:ON    ALARM
4. RELAY4:ON    ALARM
  
```

Number Select an item, RUN or MENU

See *Appendix C, System Timing* for the timing diagrams for the four relays.

- From the **RELAY** menu, press the **1** key to go to **RELAY 1** shown at the right.
- Press the **1** key to toggle the relay contact signal state: **ON** (closed) or **OFF** (open).

```

                                <RELAY 1>
1. SET RELAY TO    : ON
2. WHEN            : ALARM
  
```

Number Select, ▲ Page, RUN or MENU

- Press the **2** key to select the **WHEN** menu, shown at the right.

```

                                <WHEN>
1. ALARM                6. P1LOW
2. OUT OF LIMITS        7. P2HIGH
3. WELD                  8. P2LOW
4. END OF WELD           9. MG3 SYNC
5. P1HIGH
  
```

Number Select, ▲ Page, RUN or MENU

- Press the **2** key to select **OUT OF LIMITS** as the condition for initiating the **Relay 1** output signal. This will bring up the **RELAY 1** menu screen, where the **WHEN** line will now reflect **OUT OF LIMITS**.

```

                                <RELAY 1>
1. SET RELAY TO    : ON
2. WHEN            : OUT OF LIMITS
  
```

Number Select, ▲ Page, RUN or MENU

- Choosing **WHEN** options **1 - 4** or **9** will complete the relay programming process. Choosing options **5 - 8** or **0** will bring up the **RELAY (1, 2, 3, or 4)** screen with a **new** option, number **3**. Press **3** to access the next level menus which are shown on the next page.

```

                                <RELAY 1>
1. SET RELAY TO    : ON
2. WHEN            : OUT OF LIMITS
  
```

Number Select, ▲ Page, RUN or MENU

CHAPTER 3: SYSTEM CONFIGURATION

8. RESET TO DEFAULTS

From the **MAIN MENU**, press the **8** key to go to the **RESET TO DEFAULTS** menu, as shown at the right. Through this menu, you may reset all system programmed parameters and all weld schedules to the original factory default settings (see the table below).

<RESET TO DEFAULTS>
1. **RESET SYSTEM PARAMETERS**
2. **RESET ALL SCHEDULES**
3. **RESET SCHEDULE LIMITS**

Number Select an item, **RUN** or **MENU**

Factory Default System Parameters

System Parameter	Default Setting	System Parameter	Default Setting
Foot Switch Weld Abort	OFF	Weld Counters	All "0"
Switch Debounce Time	10 ms	Communication Role	CLIENT
Firing Switch	AUTO	Baud Rate	38.4 K
Display Contrast	50%	ID Number	1
Buzzer Loudness	40%	Relays 1,2,3 and 4	ON WHEN ALARM
End of Cycle Buzzer	OFF		
Update Graph After Weld	ON		
Language	ENGLISH		
Do Test Weld	ALWAYS		

1. RESET SYSTEM PARAMETERS

1. With the reset to defaults screen displayed, press the **1** key. This will bring up the **RESET SYSTEM PARAMETERS** query menu, as shown at the right.

<RESET SYSTEM PARAMETERS?>

1. **NO**
2. **YES**

Number Select, **▲** Page, **RUN** or **MENU**

2. Press the **2** key to select **YES**. This will automatically reset the system to the factory and return the screen to the **RESET TO DEFAULTS** display.

2. RESET ALL SCHEDULES

1. Press the **2** key. This will automatically reset all weld schedule parameters to the factory defaults and return the screen to the **RESET TO DEFAULTS** display.
2. Press the **MENU** key to return to the **MAIN MENU** screen.

<RESET ALL SCHEDULES?>

1. NO
2. YES

Number Select, **▲** Page, **RUN** or **MENU**

3. RESET SCHEDULE LIMITS

1. The last **SCHEDULE** you used will appear as **highlighted**. You may change this to any **SCHEDULE** number you want to reset using the numeric keypad.
2. Press the **▼** key to reset the limits of the schedule you highlighted.

<RESET SCHEDULE LIMITS>

SCHEDULE : **01**

PUSH ▼ TO RESET THIS SCHEDULE'S LIMIT VALUES

Number Select an item, **▲▼** Page, **RUN** or **MENU**

3. Press the **MENU** key to return to the **MAIN MENU** screen.

9. CHAIN SCHEDULES

This feature allows you to automatically change from any weld schedule to any other schedule after a preset count, creating a "chain" of schedules that can accommodate a variety of welding needs. For example:

- A single work piece requires four welds, two weld points require the same weld schedule, each of the other two points require different weld schedules.

In this case you would program a sequence, or "chain," that looks like this: **Schedule 01** [2 times] - **Schedule 02** [1 time] - **Schedule 03** [1 time] - **Schedule 01**. This sequence will repeat, or "loop," until you turn **Chain Schedules OFF**.

- Some applications require a lower current for a number of welds after the electrodes have been replaced or resurfaced. Once the electrodes have been "seasoned", the current can be increased as required. If the electrodes require 100 welds to "season", Schedule 01 can be programmed with a lower current and Schedule 02 can be programmed with a higher current. The chain would look like this: **Schedule 01** [100 times] - **Schedule 02** [1 time] - **Schedule 02** [1 time].

In this chain, **Schedule 02** will just keep repeating *after* the 100 welds made using **Schedule 01**. When the electrodes are replaced or resurfaced, you can manually switch back to **Schedule 01** to restart the sequence.

CHAPTER 3: SYSTEM CONFIGURATION

You can program any of the Power Supplies 99 stored schedules to chain to any other schedule, or back to itself as in the second example above. The chain code becomes part of each weld schedule. You can turn the **Chain Schedules** feature **ON** or **OFF**, or re-program chains, any time you want.

- 1 From the **MAIN MENU**, press the **9** key to go to the **CHAIN SCHEDULES** menu.

NOTE: You should program, or "setup," the chain of schedules you want *before* you turn this feature **ON**.

CHAIN SCHEDULES
1. CHAIN SCHEDULE :OFF
2. SETUP CHAIN SCHEDULES

Number Select an item, RUN or MENU

- 2 Press the **1** key to toggle **CHAIN SCHEDULES ON** or **OFF**.
- 3 From the **CHAIN SCHEDULES** menu, press the **2** key to go to the **CHAIN SCHEDULE SETUP** menu.

CHAIN SCHEDULE SETUP

SCHEDULE NUMBER	WELD COUNT	NEXT
01	0001	01
02	0001	02
03	0001	03
04	0001	04

▲▼ Scroll, SCHEDULE Select, MENU

- 4 Use the ▲▼ (Up/Down) keys on the front panel to scroll vertically through the schedules to **highlight** the weld count for the schedule you want to chain.

CHAIN SCHEDULE SETUP

SCHEDULE NUMBER	WELD COUNT	NEXT
04	0001	04
05	0001	05
06	0001	06
07	0001	07

▲▼ Scroll, SCHEDULE Select, MENU

- 5 Use the numeric keypad to enter the number of times you want this schedule to weld before going to the next schedule.
- 6 Use the **SCHEDULE** key to move the highlight horizontally to select **NEXT**.

CHAIN SCHEDULE SETUP

SCHEDULE NUMBER	WELD COUNT	NEXT
04	0001	04
05	0002	05
06	0001	06
07	0001	07

▲▼ Scroll, SCHEDULE Select, MENU

- 7 Use the numeric keypad to enter the number of the next schedule in the chain.
- 8 Use the **SCHEDULE** key to move the highlight horizontally back to the **WELD COUNT** column. Repeat Steps 4 through 8 to program the rest of the chain.

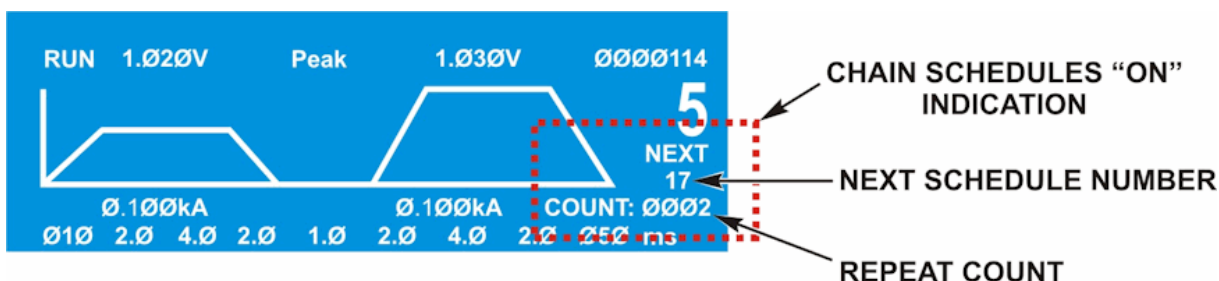
CHAIN SCHEDULE SETUP

SCHEDULE NUMBER	WELD COUNT	NEXT
04	0001	04
05	0002	05
06	0001	06
07	0001	07

▲▼ Scroll, SCHEDULE Select, MENU

- 9 When you finish programming the chain, press the **MENU** key to return to the **CHAIN SCHEDULES** menu.
- 10 Press the **1** key to toggle between **ON** or **OFF**.
- 11 Press the **RUN** key on the front panel, then use the **▲▼** keys to select the first weld schedule in the chain you want to use. The Power Supply will now weld in the "chain" mode until you turn the **Chain Schedules** feature **OFF**.

NOTE: When **Chain Schedules** is turned **ON**, the LCD screen changes to show the chain information on the right side of the screen.



Below the current schedule number, you can see the number of times the current schedule will be repeated, and the number of the next schedule in the chain.

Setup 1

1. Footswitch Weld Abort

From the **SETUP 1** screen, press the **1** key to toggle between **ON** and **OFF**. This function controls how the Power Supply interfaces with a foot switch, a force firing switch, or a programmable logic control (PLC). Any of these switches could be the weld initiation switch in your system setup.

ON means that the welding process is initiated by closure of the initiation switch and continues to its conclusion while the initiation switch remains closed. If the initiation switch opens during the welding process, the welding process will terminate. The **ON** state is preferred for human operated welding stations since it allows you to abort the weld process by releasing the foot switch (or the foot pedal in the case of a manually actuated weld head).

OFF is preferred for computer or PLC controlled welding stations since a single start pulse can be used to initiate the welding process. To select the **ON/OFF** states, press the **1** key. The **FOOTSWITCH WELD ABORT** line will now reflect your selection.

2. Switch Debounce Time

The contacts of single pole mechanical firing switches “bounce” when they close. The switch de-bounce time function allows you to specify that the initiation switch contacts must remain closed for 10, 20, or 30 milliseconds before the weld period can be initiated, thereby avoiding false starts caused by the switch contact bouncing.

CHAPTER 3: SYSTEM CONFIGURATION

1. From the **SETUP 1** screen, press the **2** key to go to the **SWITCH DE-BOUNCE TIME** menu screen.
2. Select the required debounce time by pressing the **1**, **2**, **3** or **4** key. **NONE** represents a debounce time of 0 ms.

<SWITCH DEBOUNCE TIME>

- 1. NONE
- 2. **10 ms**
- 3. 20 ms
- 4. 30 ms

Number Select, ▲ Page, RUN or MENU

Use **NONE** for interfacing with the AMADA WELD TECH SL-320A Electronic Weld Force Control.

3. The **SWITCH DEBOUNCE TIME** line will now reflect your switch debounce time selection.

3. Firing Switch

With the **SETUP 1** screen displayed, press the **3** key to select this function. The firing switch input, in conjunction with or without inputs from the foot switch input, initiates the weld energy sequence. Select the required switch type by pressing the **1**, **2**, or **3** key. Pressing the numeric keys automatically returns the display to the **SETUP 1** screen.

1. Auto

The Power Supply accepts a single pole, double pole or optical firing switch input from an AMADA WELD TECH weld head. Firing switch activation indicates that the weld head has reached the set weld force, thus permitting the weld energy sequence to start.

<FIRING SWITCH>

- 1. **AUTO**
- 2. NONE
- 3. REMOTE

Number Select, ▲ Page, RUN or MENU

2. None

When using a non-force fired weld head, weld energy initiation must be supplied with the foot switch input. Additionally, you must select sufficient squeeze time to permit the weld force to stabilize after contacting the weld pieces.

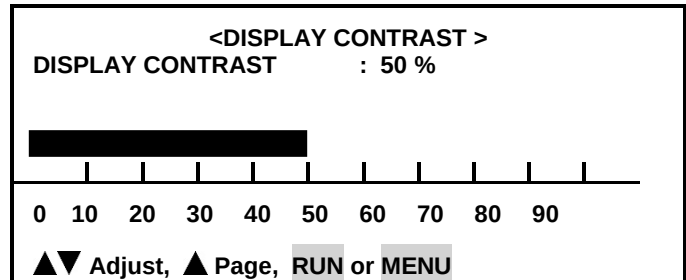
3. Remote

Use this setting in an automation application or when using PLC control. The BCD input lines, via the **CONTROL SIGNALS** connector (see *Appendix B. Electrical and Data Connections*), select weld energy schedules and initiate the weld energy sequence.

Setup 2

1. Display Contrast

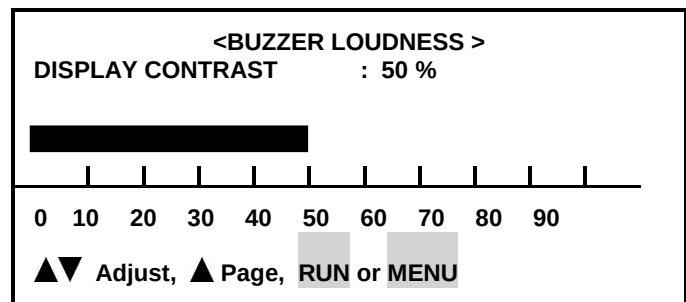
1. From the **SETUP 2** screen, press the **1** key to go to the **DISPLAY CONTRAST** adjustment screen.
2. Use the **▲** and **▼** keys to adjust the screen contrast for comfortable viewing in the shop environment.



3. Press the **▲** key to return to the **SETUP, PAGE 2** (of 3) screen.

2. Buzzer Loudness

1. From the **SETUP 1** screen, press the **2** key to go to the **BUZZER LOUDNESS** adjustment screen.
2. Use the **▲** and **▼** keys to adjust the buzzer tone so that it can be heard against shop background noise.



3. Press the **▲** key to return to the **SETUP, PAGE 2** (of 3) screen.

3. End Of Cycle Buzzer

1. With the **SETUP 2** screen displayed, press the **3** key to toggle the end of cycle buzzer **ON** or **OFF**. This function is normally used with manually actuated weld heads. **ON** means that an audible signal will be given at the end of each weld process to signal you to release the foot pedal.
2. To select the **ON/OFF** states, toggle the **3** key. The **END OF CYCLE BUZZER** line will now reflect your state selection.

4. Update Graph After Weld

From the **SETUP 2** screen, press the **4** key to toggle the update graph after weld **ON** or **OFF** function. The **UPDATE GRAPH AFTER WELD** line will now reflect your state selection.

ON means that the actual weld energy profile will overlay the programmed weld profile after each weld is made. The weld graph is useful for detecting weld splash, which is indicated by vertical gaps in the overlap. You can reduce weld splash, and eliminate it in some cases, by using the upslope weld energy profile.

5. Language

Press the **5** key to toggle between English and German. All menu items and instructions on the screen will be in the language selected.

Setup 3

1. DO TEST WELD

In voltage mode, the unit will do a test weld to optimize response to varying weld conditions. Press **1** to bring up the following choices:

1) ALWAYS

A test weld will be done if:

- The voltage level changes
- The time in any element of the schedule changes
- If the weld energy field is highlighted and the **V** key is pressed.

2) ASK

The user will be prompted to choose if a test weld is done or not upon the following conditions:

- The voltage level changes
- The time in any element of the schedule changes
- If the weld energy field is highlighted and the **V** key is pressed.

Section III. Operational States

The Power Supply has seven operational states:

NO WELD	WELD	MENU	MONITOR
TEST	ALARM	RUN	

You go to the **NO WELD**, **MENU**, **TEST**, **RUN** and **MONITOR** states through the control panel. The **WELD** and **ALARM** states are functions of the force firing switch and foot switch input states.

No Weld State

Setting the **WELD/NO WELD** switch on the control panel to the **NO WELD** position inhibits the delivery of weld energy if a weld is initiated, and will display a **WELD SWITCH IN NO WELD POSITION** alarm on the screen. But the Power Supply will still go through its electronic weld cycles as programmed into the selected weld schedule. Use the no weld state when adjusting the air regulators on air actuated weld heads.

Menu State

Pressing the **MENU** key puts the Power Supply in the menu state. It brings up menu screens that enable you to select various options common to all weld schedules, such as how the Power Supply interfaces with the force firing switch, foot switch and weld head.

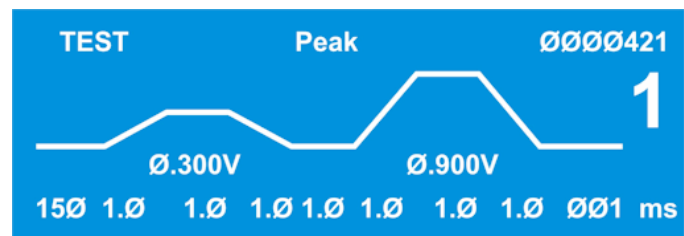
<MAIN MENU>

1. SETUP	6. COMMUNICATIONS
2. WELD COUNTERS	7. RELAY
3. COPY A SCHEDULE	8. RESET DEFAULTS
4. CALIBRATION	9. CHAIN SCHEDULES
5. SYSTEM SECURITY	

Number Select an item

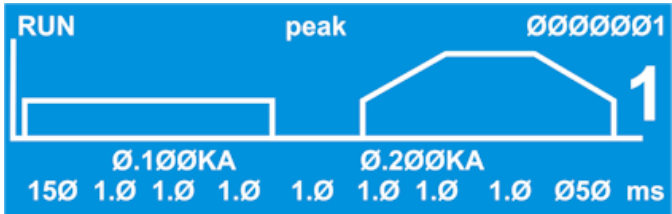
Test State

Programming a schedule for a voltage feedback welding mode, or changing the voltage or time settings while in the voltage feedback welding mode, puts the Power Supply in the **TEST** state. After making one weld, the Power Supply internally optimizes the feedback control loop to produce the fastest rise time, minimum overshoot weld pulse. The **TEST** state is automatically replaced by the run state for subsequent welds.

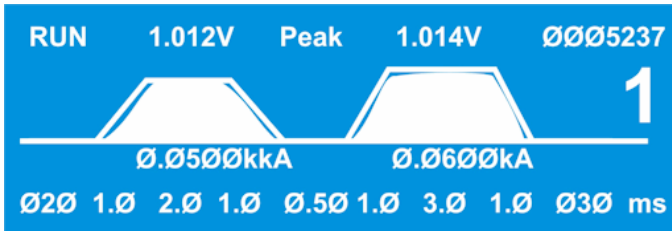


Run State

Pressing the **RUN** key puts the Power Supply in the run state. In the run state, the screen shows a trace that represents your programmed parameters for a given weld schedule. You may select a different weld schedule to be programmed with the **SCHEDULE** key and keypad, or with the up and down arrows. Then, you may program squeeze time, up slope, weld time, weld energy, down slope and cool time with the trace segment selector keys.



In the example on the right, the top line of the screen shows that the Power Supply is in the **RUN** state, the voltage at the voltage sense lead connections for the **PULSE 1** weld period was **1.012** volts, the monitor is set for displaying peak voltage (rather than average voltage), the voltage at the voltage sense input connection for the **PULSE 2** weld period was **1.014** volts, and the total weld count since the weld counter was last reset is **5,237**.



The weld profile trace is an analog display of the electrical parameters programmed with the weld period selector keys. When the weld is initiated, a profile of the actual weld energy delivered during the weld cycle, or both weld cycles, will be overlaid on the trace.

The large-type number **1** is the selected weld schedule.

The values **0.050 kA** and **0.060 kA** below the trace are respectively the weld current values programmed for **PULSE 1** and **PULSE 2** weld periods. You may optionally program weld energy in volts or kilowatts with the energy units selection keys.

Use the time/energy selector keys to toggle between the weld energy value field and the bottom line of text, which is the weld period time selection field. Use the weld period selector keys to enable the weld periods for programming, and use the numeric pad keys for entering time values in milliseconds.

See *Chapter 5, Operating Instructions* for application-related descriptions of the weld schedule profile.

Weld State

Once weld current is flowing, the Power Supply is in the **WELD** state. You can terminate weld current in five ways:

- Remove the first level of a single-level foot switch, assuming weld abort is ON.
- Remove the second-level of a two-level foot switch, assuming weld abort is ON.
- Input the process stop signal (refer to *Appendix B, Electrical and Data Connections*).
- Open the normally closed switch across the operator emergency stop switch cable.

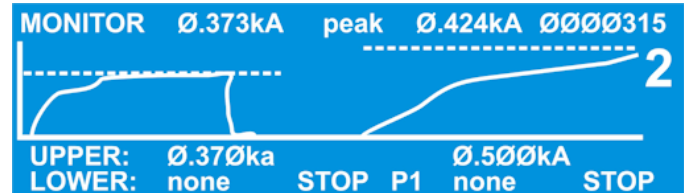
NOTE: This action removes all power from the Power Supply.

- Through the action of the monitor settings.

Completion of the firing state is indicated by a profile of actual delivered weld energy superimposed on the programmed weld energy trace, as shown in the example above.

Monitor State

From the **MONITOR** keys section on the front panel, press the **kA**, **V**, **kW** or **Ω** key to go to the monitor state. In this state, when the Power Supply detects an out of limits condition, it will take one of four actions for **PULSE 1**, and one of two actions for **PULSE 2** depending on the selection made with the **MONITOR** display as



shown at the right. Also, an alarm message will be displayed and any relay set for **ALARM** or **OUT OF LIMITS** will be energized.

The selections for **PULSE 1** are:

- **NONE:** The weld cycle will continue.
- **STOP WELD:** The weld cycle will stop immediately. Pulse 2 (if applicable) will not fire.
- **INHIBIT PULSE 2:** During the **COOL** time, the Power Supply calculates the average of the Weld1 pulse (including upslope, weld and downslope). If the average of the Weld1 pulse is out of limits, the weld cycle will stop and the Weld2 pulse will be inhibited.
- **PART CONDITIONER (Stop Pulse 1)** stops Pulse 1 immediately after upper or lower energy limits are exceeded, but allows Pulse 2 to fire.

The selections for **PULSE 2** are:

- **NONE:** The weld cycle will continue.
- **STOP WELD:** The weld cycle will stop immediately.

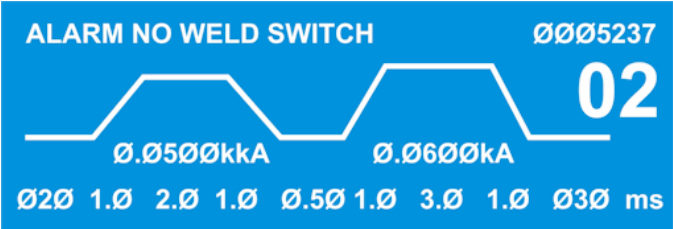
The display shows the actual trace of the weld current, voltage or power, and either the peak or the average value for each weld pulse as selected by pressing the **PEAK/AVERAGE** key.

CHAPTER 3: SYSTEM CONFIGURATION

See *Chapter 4, Using Feedback Modes and Weld Monitoring* for a detailed description of monitor and energy limits operation.

Alarm State

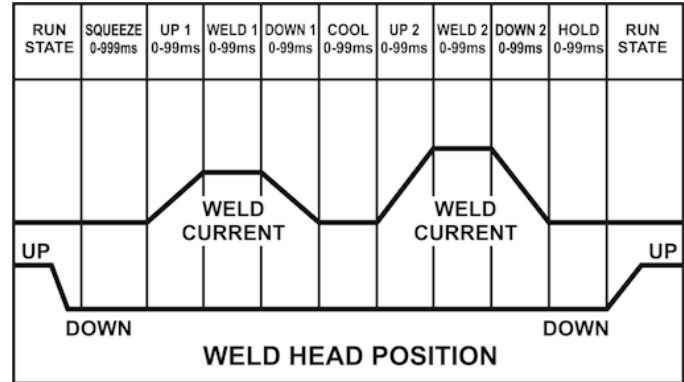
The Power Supply automatically recognizes many alarm conditions. The example **WELD SWITCH IN NO WELD POSITION** alarm screen shown at the right is displayed when you attempt to initiate a weld with the **WELD/ NO WELD** switch in the **NO WELD** position.



Section IV. Weld Functions

Welding Applications

Some welding applications require the use of specialized weld functions. A weld function is a unique heat profile created by weld current, voltage, or power that is applied over a fixed time period, to resistance weld different parts. An example of a fully programmed weld profile is shown at the right.



Applications include parts that:

- Are plated with cadmium, tin, zinc, or nickel
- Have heavy oxide coatings such as aluminum
- Are round or not flat

By programming the appropriate weld period time and weld energy amplitudes for the weld period segments, you can program an appropriate weld schedule profile to perform the above applications. Typical applications and recommended weld schedule profiles are defined in the table below. For more information about resistance welding, see *Appendix F, The Basics Of Resistance Welding* and *Appendix G, Quality Resistance Welding Solutions, Defining The Optimum Process*

Welding Applications

Weld Function	Typical Application
Single Pulse	Make single spot welds on simple flat parts without plating, or on conductive parts such as those made of copper or brass.
Up/Downslope	Weld round parts, parts that are not flat, spring steel parts, or heavily plated or oxidized parts such as aluminum.
Dual Pulse	Use for best control of miniature and small parts spot welding with or without plating.

Weld Head Applicability

The weld functions can be used with AMADA WELD TECH force fired, manual weld heads; air actuated weld heads; or SL-300A Weld Heads. **SQUEEZE TIME** is used to allow sufficient time for the electrodes to close and apply the required weld force to the parts before the weld current begins. Weld current begins when the squeeze period ends.

When the weld functions are used with any type of air actuated weld head, the hold period can be used to automatically keep the electrodes closed on the parts after weld current has terminated to provide additional heat sinking or parts cooling.

NOTES:

- **AMADA WELD TECH - SL-300A Electronic Force Controlled Weld Heads:** The **SQUEEZE TIME** is controlled by the weld head, *not* the Power Supply. **SQUEEZE TIME** begins when the force-firing switch closes, therefore you will set the Power Supply **SQUEEZE TIME** to zero and set the **DEBOUNCE TIME** to zero.
- **Air-Actuated Weld Heads:** For force fired, air actuated weld heads, **SQUEEZE TIME** begins when both levels of a two-level foot switch are closed and the force firing switch in the air actuated weld head closes.
- **Manual Weld Heads:** For manually actuated weld heads, **SQUEEZE TIME** begins when the force-firing switch closes. Using **SQUEEZE TIME** is optional, depending on the welding process you have developed.

When To Use Functions

To ensure accurate, consistent welds, the Power Supply delivers extremely precise pulses of energy to the weld head. Each pulse is comprised of weld-time and weld-energy (**voltage**, **current**, or **power**) values pre-programmed by the user. The Power Supply is a closed-loop welding control using internal and external sensors to measure the weld-energy delivered to the weld head. Weld-energy feedback instantly goes to the Power Supplies logic circuits that actively correct the pulse to compensate for any variation in part resistance. The Power Supply also has several monitor functions that give you remarkable control over the welding and production process. Together, these features ensure precise, consistent welds, higher productivity, a lower rejection rate, and longer electrode life.

Before operating the Power Supply, it is important to know how to match the Power Supplies capabilities to specific weld applications. This section provides **Weld** details in the following order:

- **Weld Schedules**
 - **Single-Pulse**
 - **Upslope/Downslope**
 - **Dual-Pulse**

Chapter 5, Operating Instructions, contains the step-by-step instructions on how to program each of the functions above.

Weld Schedule Definition

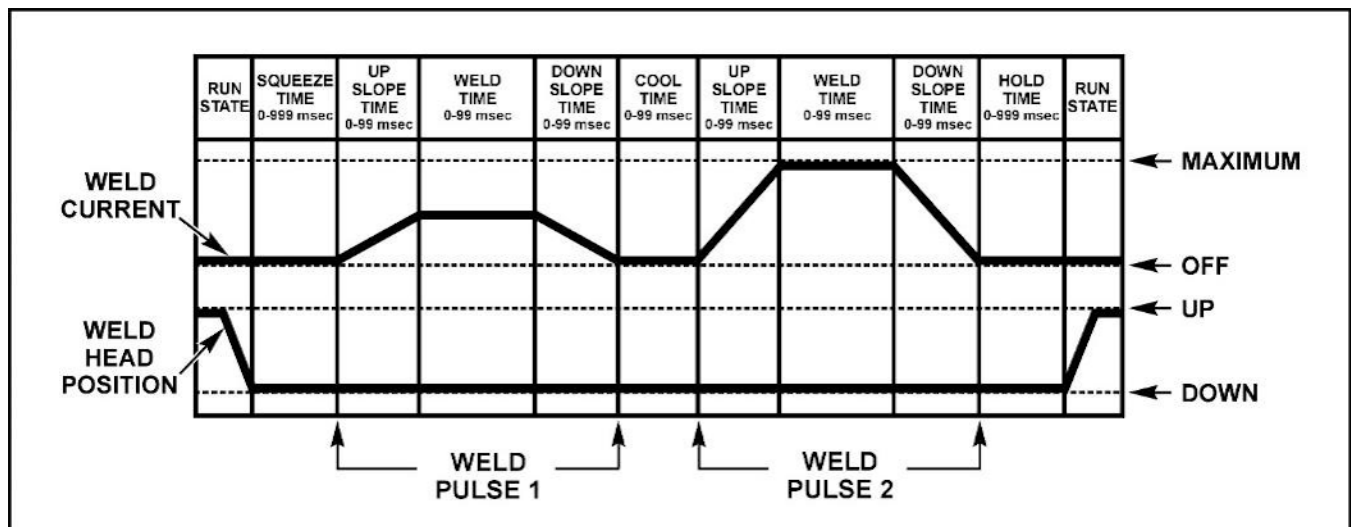
Weld Schedule is the name given to each of 99 separate *weld profiles* stored in the Power Supply, numbered from **01** to **99**. A weld profile is the graphic representation [or *waveform*] of the numeric weld-time and weld-energy values. **NOTE:** There is an additional weld schedule numbered **00**, which can be used as a "scratch pad" to develop new weld schedules.

When time and energy values are entered using the numeric keypad, the Power Supply displays a line-graph of the weld profile on the LCD screen. You can see the graph change as you enter new time and energy values.

Weld profiles may be programmed for **single-pulse**, **upslope/downslope**, or **dual-pulse** operation. Weld schedules may also use special monitoring features of the Power Supply such as **Energy Limit**, **Active Part Conditioner**, and **Pre-Weld Check**. These features are described later in this chapter.

Weld Sequence Timing

A weld schedule is a unique heat profile programmed in constant **current**, **voltage**, or **power** that is applied over a fixed time period, to resistance weld different parts. The entire weld can include all of the following time periods: Squeeze Time, Upslope 1, Weld Pulse 1, Downslope 1, Cool Time, Upslope 2, Weld Pulse 2, Downslope 2, and Hold Time. The sample dual-pulse profile [or *waveform*] below shows the weld current and the corresponding position of the weld head. The graph labeled **WELD CURRENT** is what displays on the LCD when you schedule a weld profile.



Sample Weld Sequence (Dual-Pulse)

Welding Applications

Weld Pulse Profile		Typical Application
Single-Pulse		Can be used for many of spot-welding applications. Use on flat parts without plating, or on conductive parts such as those made of copper or brass.
Upslope/Downslope		Upslope/Downslope should be used for the majority of spot welding applications. Weld round parts, parts that are not flat, spring steel parts, or heavily plated or oxidized parts.
Dual-Pulse		Use for spot welding parts with plating. First pulse can be used to displace plating or oxides and the second pulse to achieve the weld.

For a detailed coverage of resistance welding theory, please refer to *Appendix D, The Basics of Resistance Welding*.

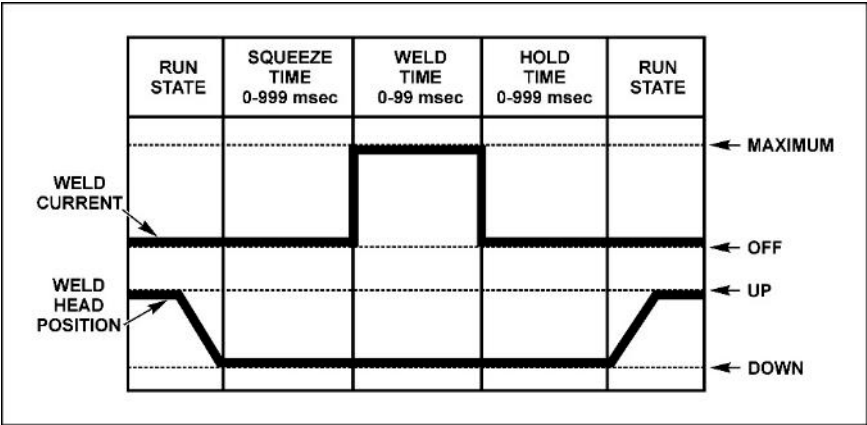
Single-Pulse Weld Profile

Applications

- Flat parts that do not have any plating or heavy oxides. Conductive parts made of copper or brass.

Description

Single-Pulse is a term used by the industry to describe the simplest heat profile used for many resistance spot-welding applications.



Single-Pulse Weld Profile

Upslope/Downslope Weld Profile

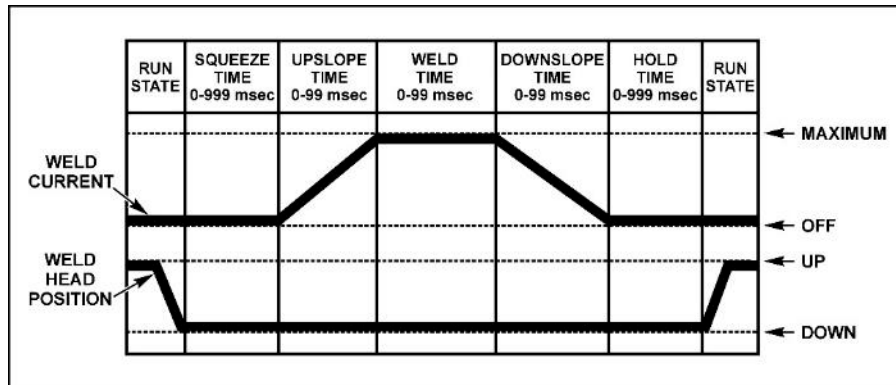
Applications

- Round or non-flat parts and most resistive materials.

Description

Upslope allows a gradual application of weld energy which permits the parts to come into better contact with each other reducing the electrode to part contact resistances. Upslope can allow a smaller electrode force to be used, resulting in a cleaner appearance by reducing electrode indentation, material pickup and electrode deformation. It can also be used to displace plating and/or oxides, reduce flashing and spitting, or reduce thermal shock when welding parts containing glass-to-metal seals.

Downslope (annealing) assists in the grain refinement of certain heat-treatable steels, and prevents cracking in aluminum and other materials by reducing the cooling rate. Annealing is not typically used for welding small parts.



Upslope / Downslope Weld Profile

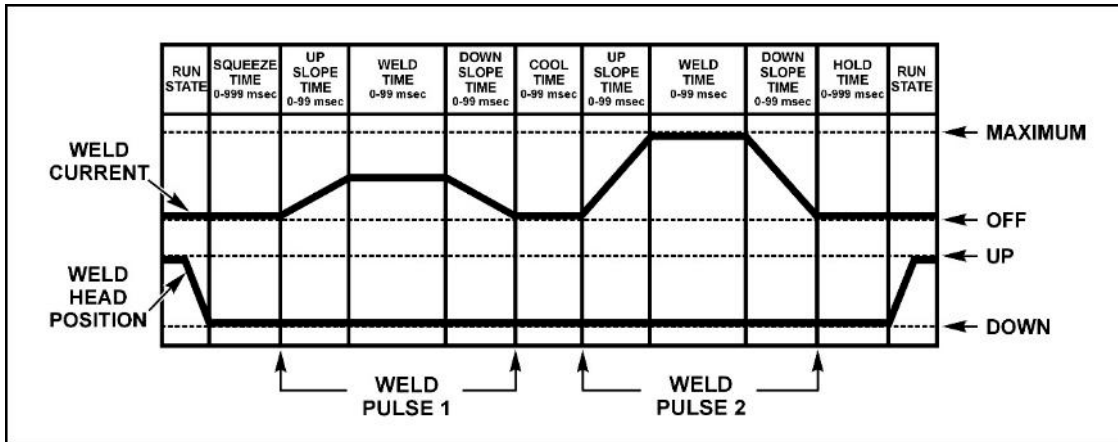
Dual-Pulse Weld Profile

Applications

- Flat-to-flat parts.
- Round-to-round parts.
- Round-to-flat small parts that may or may not be plated.

Description

Adding upslope to the front of both weld periods allows a reduction in electrode force, this results in a cleaner appearance by reducing electrode indentation, material pickup and electrode deformation.



Upslope will also help to displace plating and/or oxides, reduce flashing and spitting, or reduce thermal shock when welding parts containing glass-to-metal seals. In the normal application of dual-pulse, the Pulse 1 weld period provides sufficient heat to displace the plating or oxides, seat the electrodes against the base metals, and force the parts into intimate contact. The cool period allows time to dissipate the heat generated during Pulse 1.

The Pulse 2 weld period completes the structural weld. The Pulse 2 weld current is typically greater than the Pulse 1 weld current by a factor of 3 as the first pulse significantly reduces the resistance of the interface between the parts. The only use for the downslope period following the Pulse 1 or Pulse 2 weld period is to control grain refinement in brittle parts by slowly reducing the weld current to zero during the downslope period.

The dual-pulse weld profile is very valuable for pre-checking gross parts positioning problems and reducing parts scrap. Use the Pulse 1 weld at 0.050 kA [or less] and 2.0 ms as a pre-check pulse. Experiment with upper and lower limit values that you can use to inhibit the Pulse 2 weld if the test conditions measured by the Pulse 1 weld are out of limits.

NOTE: Upslope is required when a lower limit value is programmed.

CHAPTER 4

Introduction to Feedback Modes and Monitoring

Section 1. Programmable Feedback Modes

Introduction

The feedback mode (**current, voltage, or power**) is one of the selections entered when programming a weld schedule. Programming weld schedules is explained in *Chapter 5, Operating Instructions*.

Current Mode

Application

- Flat parts where the part-to-part and electrode-to-part contact is controlled and consistent

Description

This mode delivers the programmed current regardless of work piece resistance changes. This compensates for slight changes in part thickness without affecting weld quality. Set monitoring limits on voltage.

Voltage Mode

Application

- Ideal for welding round or non-flat parts

Description

This mode controls the voltage across the work piece during welding. It helps to compensate for part misplacement and force problems and automatically reduces weld splash, which is often associated with non-flat parts and wire welds. Set monitoring limits on current.

Power Mode

Application

- Breaking through surface oxides and plating
- Automated applications where part or electrode surface conditions can vary over time.

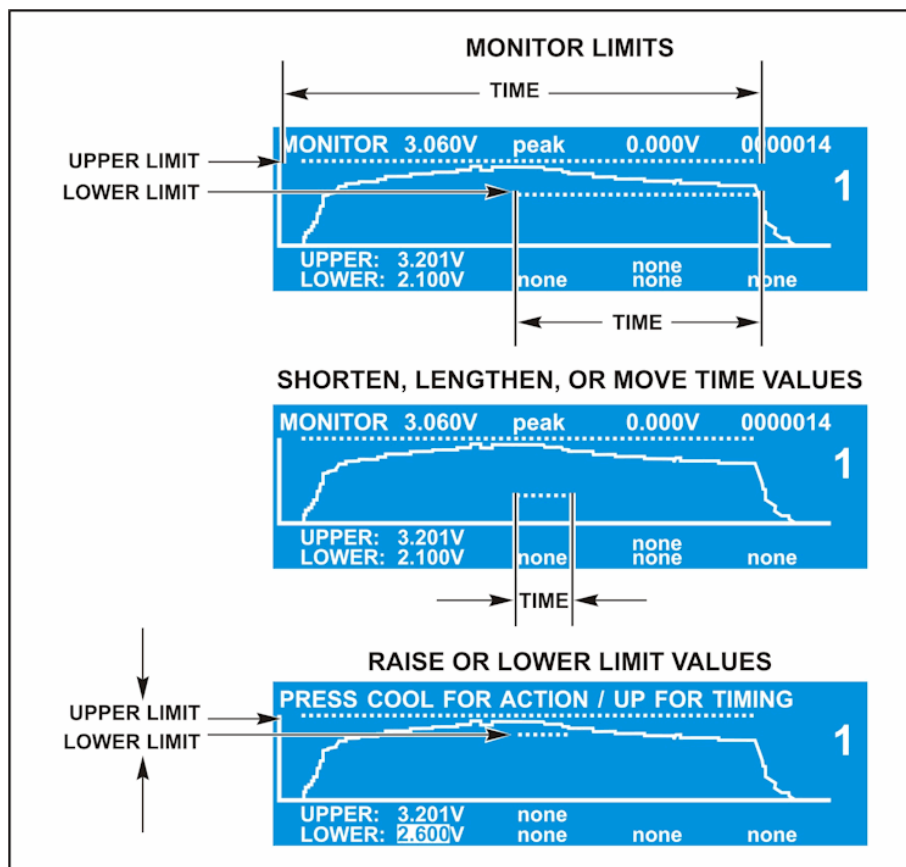
Description

This mode precisely varies the weld current and voltage to supply consistent weld energy to the parts. The power mode has been shown to extend electrode life in automated applications. Set monitoring limits on current or voltage.

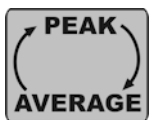
Section II. Weld Monitoring

Introduction

The Power Supplies feedback sensors not only control weld energy output, but they can also be used to monitor each weld. The Power Supplies **MONITOR** features allow you to view graphic representations of welds, visually compare programmed welds to actual welds, look at peak or average energy values, set upper and lower limits for welds, and vary the time periods for these limits during the weld pulse. These limits can be used for several purposes. Common uses for **out-of-limits** welds are to stop a weld, or to trigger a relay to remove parts with bad welds from the production line. These functions are accessed using the **MONITOR** buttons on the front panel. To use these functions, see *Chapter 5, Operating Instructions*.



PEAK and AVERAGE MONITORING



The Power Supply is *always* monitoring both the **PEAK** and **AVERAGE** of current, voltage, power, and resistance at the same time. When you press the **PEAK ↔ AVERAGE** key, the top line in the LCD simply toggles back and forth so you can *view* either **PEAK** or **AVERAGE** values whenever you choose.

Current, Voltage, Power, and Resistance Limits

With the **RUN** screen selected, you can select what you want to monitor by pressing the following **MONITOR** keys above: **kA** = **current**, **V** = **voltage**, and **kW** = **power**, and Ω = **resistance**. These monitors allow you to program upper and lower limits for **PULSE 1** and for **PULSE 2**. These limits will display as dotted lines on the LCD screen. Pushing either **PULSE** button will toggle between upper and lower limits. **PULSE 1** and for **PULSE 2** can be programmed to monitor the same units or monitor separate units. For example, **PULSE 1** can monitor **kA** and **PULSE 2** can monitor **V**.

NOTE: Whichever unit you select, the upper and lower limits for a single pulse must be in the *same* units, such as **kW**.

Process Tools

These “tools” are proven *methods* to use the monitor and limit functions described above in order to achieve specific results. There are five commonly defined *Process Tools*.

1. **Active Part Conditioner (APC)**
2. **Resistance Set**
3. **Pre-Weld Check**
4. **Weld To A Limit**
5. **Weld Stop**

1. **Active Part Conditioner (APC)**

Application

- Displace surface oxides and contamination
- Reduce contact resistances before delivering the main weld energy.

Description

In the production environment, it is common to see large variations in:

- Oxide and contamination
- Plating thickness and consistency
- Shape and fit up
- Contact resistances due to varying part fit up

In order for a weld to occur, the surface oxides and contamination must be displaced to allow proper current flow through the parts. Levels of oxide and contamination vary from part to part over time, which can have an adverse effect on the consistency of the welding process.

CHAPTER 4: INTRODUCTION TO FEEDBACK MODES AND MONITORING

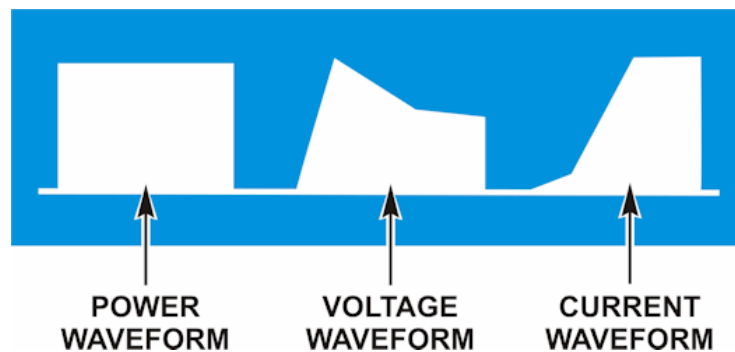
If production parts are plated, there can also be a plating process variation over time resulting in inconsistent welds. These minor material variations are a major cause of process instability, and it is best welding practice to seek to minimize their effect.

Active Part Conditioner is designed to cope with material contamination, variation and can be programmed to apply the exact power to the parts required to displace oxide or contaminants. In addition, the “Part Conditioner” pulse will terminate at a precise current flow preventing the sudden high flow, which occurs when the oxide is displaced. This prevents weld splash and material expulsion, which occurs as a result of an excessively fast heating rate. Part conditioning can help to reduce variations in contact resistance from part to part caused by different fit up of parts. It will stabilize the contact resistances before the main welding pulse, therefore reducing variation from weld to weld.

How It Works

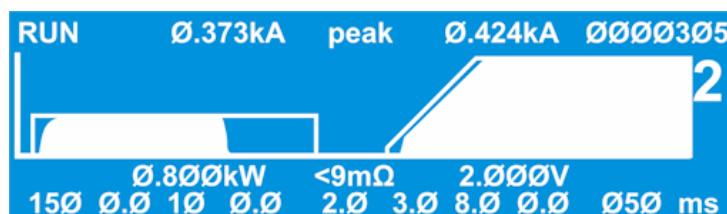
Both **constant current** feedback and **constant voltage** feedback modes are limited in their ability to deal with varying levels of part contamination and oxide. If **constant current** feedback were used, the power supply would ramp the voltage to very high levels in order to achieve current flow through the oxide. This rapid input of current is likely to cause splash, especially with round parts. **Constant voltage** mode is not ideal for this purpose either, as the voltage will be restricted from reaching sufficient levels to break down the oxide.

Constant power is ideal for this purpose. As the power supply tries to achieve constant power to the weld, it raises the voltage to high levels early in the output waveform, since current cannot flow due to the oxide. As the high voltage breaks down the oxide layer, more current flows to the weld and the voltage and resistance drop. It will achieve this in a controlled fashion to maintain constant power to the weld.



Constant Power Waveform with Corresponding Voltage and Current Waveforms

Active Part Conditioning uses a dual-pulse output. The first pulse is programmed for **constant power**, and the second for either **constant current**, **constant voltage**, or **constant power**. (**Constant voltage** is used if there is still a chance of weld splash). The purpose of a dual-pulse operation is to enable the first pulse to target displacement of oxides and good fit up; the second pulse achieves the weld.



Active Part Conditioning Waveform

The use of a current limit monitor for the first pulse enables the pulse to be terminated when a predetermined amount of current flow is achieved. The rise of the current waveform is proof positive that the oxide is breaking down and the parts are fitting up together, ready to weld. The first pulse, therefore, should be programmed to be much longer than generally required. The power supply will terminate the pulse based on the reading of current in the power supply's monitor.

2. Resistance Set

Application

- Reduce variations in Resistance prior to the weld
- Reduce contact resistances before delivering the main weld energy.

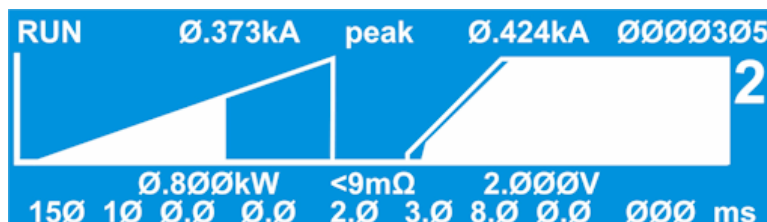
Description

Resistance Set is used when parts vary in initial resistance due to:

- Shape and part fit up
- Very small parts

Resistance Set is very similar to **APC** except that there are applications where you do not want a high voltage at the beginning of the pulse. Instead, you want to start both voltage and current low and build on an upslope. This would be used primarily where resistance would vary from weld to weld, coping with material contamination, and variation due to part fit up problems. It can be programmed to apply the exact power to the parts required to reduce the resistance to a consistent level for every weld.

Resistance Set uses a dual-pulse output. The first pulse is programmed for **upslope power**, and the second for either **constant current**, **constant voltage**, or **constant power**. (**Constant voltage** is used if there is still a chance of weld splash). The purpose of a dual-pulse operation is to enable the first pulse to target variations in resistance; the second pulse achieves the weld.



Resistance Set Waveform

CHAPTER 4: INTRODUCTION TO FEEDBACK MODES AND MONITORING

The use of a current limit monitor for the first pulse enables the pulse to be terminated when a predetermined amount of current flow is achieved. The rise of the current to a consistent level ensures a consistent resistance at the beginning of the second pulse. Depending on the initial resistance, the amount of time required to bring the resistance down will vary from weld to weld. The first pulse, therefore, should be programmed to be much longer than generally required to ensure that the current limit is always reached. The power supply will terminate the pulse based on the reading of current in the power supply's monitor.

3. Pre-Weld Check

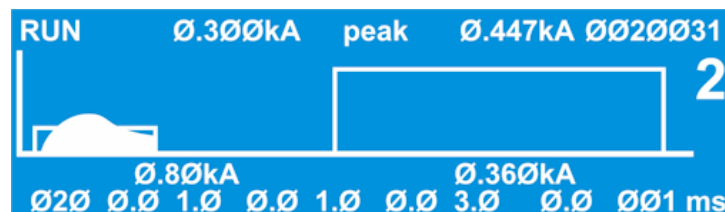
Application

- Detect Misaligned or Missing parts.

Function

This is used to see if parts are misaligned or missing **before** a welding pulse is delivered to the weld head. If a part is missing or misaligned, you do **not** want the machine to weld because the result would be an unacceptable weld and/or damaged electrodes.

When using a **Pre-Weld Check**, Pulse 1 should be very **short** (1-2 milliseconds), and the current should be **low**, about 10% of the Pulse 2 current. Pulse 1 should be used as a measurement pulse and should **not** perform a weld.



Pre-Weld Check Waveform

Example: To detect misaligned parts, use constant current and set upper and lower voltage limits for Pulse 1. If parts are **misaligned**, the work piece resistance will be higher, so the voltage will be higher. If parts are **missing**, voltage will be lower. In either case, the Pulse 1 upper or lower limits will be exceeded, and Pulse 1 can be inhibited.

NOTE: You **must** have **upslope** programmed into the pulse in order to set a lower limit.

In addition to inhibiting the weld, the Power Supply has four programmable relay outputs, which can be used to trigger alarms to signal operators of weld faults or signal automation equipment to perform pre-programmed actions, such as stopping the assembly line so the faulty weld piece can be removed.

4. Weld To A Limit

Applications

- Parts with narrow weld window
- Part-to-part positioning problems
- Electrode-to-part positioning problems

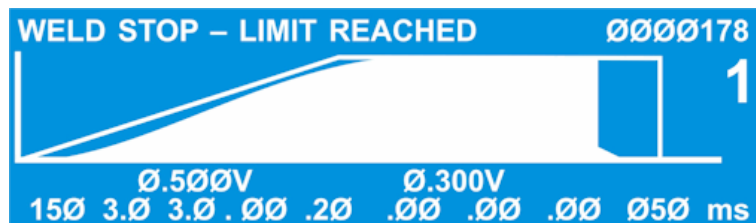
Function

To stop the weld when a sufficient **current**, **voltage**, or **power** level is reached. Using limits in this way ensures a more consistent input of energy, which produces consistently good welds.

Description

This function terminates the weld energy during the welding process if pre-set weld **current**, **voltage**, or **power** limits are exceeded. In addition to inhibiting the weld, the Power Supply has four programmable relay outputs which can be used to trigger alarms to signal operators of weld faults, or signal automation equipment to perform pre-programmed actions, such as stopping the production line so the faulty weld piece can be removed.

The monitor measures the weld energy parameters during the weld period and compares the measurements against the programmed limits. If any of the programmed limits are exceeded, the energy limits monitor sets the Power Supply to a state selected from the **OUT OF LIMITS ACTION** menu. In addition, the Power Supplies relays can be programmed to trigger alarms, or trigger an action in an automated welding system.



In the profile above, the weld current limit is at a sufficient level to get a good weld. In this case, the operator has selected the option to terminate the weld energy under this condition, so the energy limits monitor terminates the Pulse 1 weld and inhibits the Pulse 2 weld if it had been programmed.

NOTE: When using the energy limits monitor, always select a monitor mode that is *different* from the feedback mode. For example:

- If you are welding in constant current, monitor voltage.
- If you are welding in constant voltage, monitor current.
- If you are welding in constant power, monitor current or voltage.

5. Weld Stop

Applications

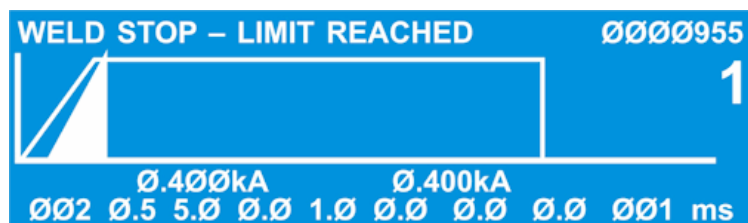
- Part-to-part positioning problems
- Electrode-to-part positioning problems

Function

To detect work piece resistance changes that occur when parts are positioned incorrectly at the weld head. In this case, the energy limits will prevent blowouts, parts damage, and electrode damage. Limits can be set to terminate the weld if this occurs.

Description

This function terminates the weld energy during the welding process if pre-set weld **current**, **voltage**, or **power** limits are exceeded. In addition to inhibiting the weld, the Power supply has four programmable relay outputs which can be used to trigger alarms to signal operators of weld faults, or signal automation equipment to perform pre-programmed actions, such as stopping the production line so the faulty weld piece can be removed.



In the profile above, the weld current is exceeding the selected upper limit before the end of the welding cycle. The spike in the current waveform indicates that parts were misplaced. In this case, the operator has selected the option to terminate the weld energy under this condition, so the energy limits monitor terminates the Pulse 1 weld and inhibits the Pulse 2 weld if it had been programmed.

The monitor measures the weld energy parameters during the weld period and compares the measurements against the programmed limits.

NOTE: When using the energy limits monitor, always select a monitor mode that is *different* from the feedback mode. For example:

- If you are welding in constant current, monitor voltage.
- If you are welding in constant voltage, monitor current.
- If you are welding in constant power, monitor current or voltage.

CHAPTER 5

Operating Instructions

Section I: Introduction

Before You Start

Before operating the Power Supply, you must be familiar with the following:

- The **location** and **function** of Controls and Indicators. For more information, see *Chapter 1* of this manual.
- How to **select** and **use** the Power Supply functions for your specific welding applications. For more information, see *Chapter 3, System Configuration*.
- The principles of resistance welding and the use of programmed weld schedules. For more information, see *Appendix E, The Basics of Resistance Welding*. For additional information on the welding process, see *Appendix F, Quality Resistance Welding Solutions, Defining the Optimum Process*.

Pre-Operational Checks

Always perform these checks **before** attempting to operate the Power Supply.

Connections

Verify that the Power Supply has been connected to a manual or air-actuated weld head as described in *Chapter 2* of this manual. Verify that the Emergency Stop Switch shorting wires are connected **or** verify that an Emergency Stop Switch is connected properly.

Power

Verify that power is connected as described in *Chapter 2* of this manual.

Compressed Air

If you are using an air-actuated weld head, verify that compressed air is connected as described in the appropriate sections of your weld head manual. Turn the compressed air ON, and adjust it according to the instructions in your weld head manual.

Initial Setup

1. Adjust the weld head force adjustment knob for a force appropriate for your welding application. A good starting point is the mid-point in the range of the weld head force.
2. Set the **WELD/NO WELD** switch on the Power Supply front panel to the **NO WELD** position. In this position, the Power Supply will operate the weld head *without* producing weld energy.

NOTE: When you are ready to perform a weld, be sure to set this switch back to the **WELD** position.

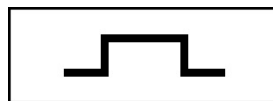
3. Turn the **ON/OFF** switch on the rear panel of the Power Supply to the **ON** position. The default **RUN** screen will be displayed. You will use this screen to enter welding parameters.



Default RUN Screen

Section II. Operation

Single-Pulse Weld Schedule



1.  Press the **SCHEDULE** key, then select a Weld Schedule using **either** the ▲ ▼ arrows **or** the numeric keypad.
2.  Press the **SQUEEZE** key to enter the squeeze time before the weld. Use the numeric keypad to enter the time or use the ▲ ▼ arrows. Enter a time between **0** and **999** milliseconds.
3.  Press the **PULSE 1 UPSLOPE** key to enter the amount of time for the Weld Pulse 1 **upslope**. Use the numeric keypad to enter the time or use the ▲ ▼ arrows. Enter **0** milliseconds.
4.  Press the **PULSE 1 WELD** key to **highlight** the **bottom line** of the LCD to enter the weld time. Use the numeric keypad to enter the time or use the ▲ ▼ arrows. Enter a time between **0** and **99** milliseconds.
5.  Press the **PULSE 1 WELD** key again to **highlight** the **middle line** of the LCD to enter **weld energy**. Use the numeric keypad to enter the **energy level** or use the ▲ ▼ arrows. The Power Supply output ranges are:
 - **Current:** from 0.1 → 2.4 kA
 - **Voltage:** 0.2 → 9.999 V
 - **Power:** 0.05 → 9.999 kW
6. Perform **one** of the following:
 -  From the **CONTROL** keys section on the front panel, press the **kA** key to program **current** as the feedback mode.
 -  From the **CONTROL** keys section on the front panel, press the **V** key to program **voltage** as the feedback mode.
 -  From the **CONTROL** keys section on the front panel, press the **kW** key to program **power** as the feedback mode.
7.  Press the **PULSE 1 DOWNSLOPE** key to enter the amount of time for the Weld Pulse 1 **downslope**. Use the numeric keypad or the ▲ ▼ arrows. Enter **0** milliseconds. Note that in combo mode when the unit reaches a constant current, any time programmed in this segment will be added to the weld at the constant current level.

CHAPTER 5. OPERATING INSTRUCTIONS

8.  Press the **COOL** key to enter the amount of time for the cool period after Pulse 1. Use the numeric keypad to enter the time or use the ▲ ▼ arrows. Enter **0.5** milliseconds.
9. Program Pulse 2 by repeating Steps 3 through 7 above using the keys for Pulse 2, entering the value **0** in each step.
10.  Press the **HOLD** key to enter the amount of time for the hold period after the weld. Use the numeric keypad or the ▲ ▼ arrows. Enter a time between **0** and **999** milliseconds. We recommend at least **50** milliseconds as weld strength is formed in the hold time.

Upslope/Downslope Weld Schedule



1.  Press the **SCHEDULE** key, then select a Weld Schedule using **either** the ▲ ▼ arrows **or** the numeric keypad.
2.  Press the **SQUEEZE** key to enter the squeeze time before the weld. Use the numeric keypad to enter the time or use the ▲ ▼ arrows. Enter a time between **0** and **999** milliseconds.
3.  Press the **PULSE 1 UPSLOPE** key to enter the amount of time for the Weld Pulse 1 **upslope**. Use the numeric keypad or the ▲ ▼ arrows to enter the time. Enter a time between **0** and **99** milliseconds. A good starting point is **5** milliseconds.
4.  Press the **PULSE 1 WELD** key to **highlight** the **bottom line** of the LCD to enter the weld time. Use the numeric keypad to enter the time or use the ▲ ▼ arrows. Enter a time between **0** and **99** milliseconds.
5.  Press the **PULSE 1 WELD** key again to **highlight** the **middle line** of the LCD to enter **weld energy**. Use the numeric keypad to enter the **energy level** or use the ▲ ▼ arrows. The Power Supply output ranges are:
 - **Current:** from 0.1 → 2.4 kA
 - **Voltage:** 0.2 → 9.999 V
 - **Power:** 0.05 → 9.999 kW
6. Perform **one** of the following:
 -  From the **CONTROL** keys section on the front panel, press the **kA** key to program **current** as the feedback mode.
 -  From the **CONTROL** keys section on the front panel, press the **V** key to program **voltage** as the feedback mode.
 -  From the **CONTROL** keys section on the front panel, press the **kW** key to program **power** as the feedback mode.
7.  Press the **PULSE 1 DOWNSLOPE** key to enter the amount of time for the Weld Pulse 1 **downslope**. Use the numeric keypad or the ▲ ▼ arrows to enter the time. Enter a time between **0** and **99** milliseconds. A good starting point is **5** milliseconds. Note that in combo mode when the unit reaches a constant current, any time programmed in this segment will be added to the weld at the constant current level.

CHAPTER 5. OPERATING INSTRUCTIONS

8.  Press the **COOL** key to enter the amount of time for the cool period after Pulse 1. Use the numeric keypad to enter the time or use the arrows. Enter **0.5** milliseconds.
9. Program Pulse 2 by repeating Steps 3 through 7 above using the keys for Pulse 2, entering the value **0** in each step.
10.  Press the **HOLD** key to enter the amount of time for the hold period after the weld. Use the numeric keypad or the arrows. Enter a time between **0** and **999** milliseconds. We recommend at least **50** milliseconds as weld strength is formed in the hold time.

Dual-Pulse Weld Schedule



1.  Press the **SCHEDULE** key, then select a Weld Schedule using **either** the ▲ ▼ arrows **or** the numeric keypad.
2.  Press the **SQUEEZE** key to enter the squeeze time before the weld. Use the numeric keypad to enter the time or use the ▲ ▼ arrows. Enter a time between **0** and **999** milliseconds.
3.  Press the **PULSE 1 UPSLOPE** key to enter the amount of time for the Weld Pulse 1 **upslope**. Use the numeric keypad to enter the time or use the ▲ ▼ arrows. Enter a time between **0** and **99** milliseconds.
4.  Press the **PULSE 1 WELD** key to **highlight** the **bottom line** of the LCD to enter the weld time. Use the numeric keypad to enter the time or use the ▲ ▼ arrows. Enter a time between **0** and **99** milliseconds.
5.  Press the **PULSE 1 WELD** key again to **highlight** the **middle line** of the LCD to enter **weld energy**. Use the numeric keypad to enter the **energy level** or use the ▲ ▼ arrows. The Power Supply output ranges are:
 - **Current:** from 0.1 → 2.4 kA
 - **Voltage:** 0.2 → 9.999 V
 - **Power:** 0.05 → 9.999 kW
6. Perform **one** of the following to program the Pulse 1 feedback mode:
 -  From the **CONTROL** keys section on the front panel, press the **kA** key to program **current** as the feedback mode.
 -  From the **CONTROL** keys section on the front panel, press the **V** key to program **voltage** as the feedback mode.
 -  From the **CONTROL** keys section on the front panel, press the **kW** key to program **power** as the feedback mode.
7.  Press the **PULSE 1 DOWNSLOPE** key to enter the amount of time for the Weld Pulse 1 **downslope**. Use the numeric keypad to enter the time or use the ▲ ▼ arrows. Enter a time between **0** and **99** milliseconds. Note that in combo mode when the unit reaches a constant current, any time programmed in this segment will be added to the weld at the constant current level.

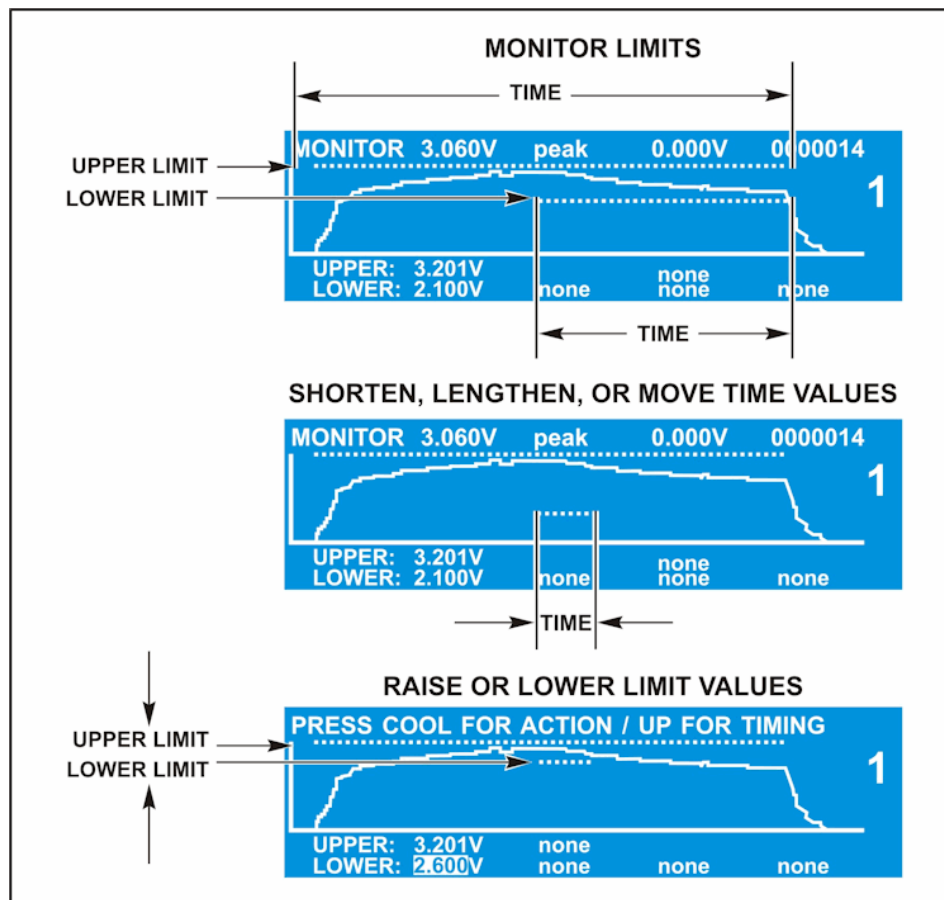
CHAPTER 5. OPERATING INSTRUCTIONS

8.  Press the **COOL** key to enter the amount of time between Pulse 1 and Pulse 2. Use the numeric keypad to enter the time or use the ▲ ▼ arrows. Enter a time between **0** and **99** milliseconds. We recommend at least 2 milliseconds.
9. Program Pulse 2 by repeating Steps 3 through 7 above using the keys for Pulse 2, entering appropriate values for Pulse 2.
10.  Press the **HOLD** key to enter the amount of time for the hold period after the weld. Use the numeric keypad to enter the time or use the ▲ ▼ arrows. Enter a time between **0** and **999** milliseconds. We recommend at least **50** milliseconds.

Section III. Using the Weld Monitor

The Power Supply allows you to adjust extremely precise limits for the amount of energy and weld time. Like all welding process development, you'll need to make several test welds, and view the waveforms and limits of actual welds in order to "fine tune" the limits to your needs.

The energy limits appear as horizontal dotted lines on the LCD screen. The **UPPER LIMIT** line is longer than the lower limit line because it includes the **UPSLOPE**, **WELD**, and **DOWNSLOPE** portions of the actual weld waveform. The **LOWER LIMIT** line is shorter because it only includes the **WELD** portion of the waveform. If the line of either limit crosses the weld energy waveform, the Power Supply can trigger an alarm, inhibit the second pulse, or stop the weld energy. See *Chapter 4, Using Feedback Modes and Weld Monitoring* for more details.



As you can see by the LCD screens above, you can shorten the length of the time of the **LOWER LIMIT** so it will not cross the weld waveform. This allows you to raise or lower the **LOWER LIMIT** closer to the peak of the actual waveform **without** crossing the weld waveform. For some welds it may be very important to get up to the peak voltage or current to get the right melting and get there at the right time during the pulse. Every millisecond could be very important.

CHAPTER 5. OPERATING INSTRUCTIONS

1.  Press the **SCHEDULE** key, then select a Weld Schedule using **either** the ▲ ▼ arrows **or** the numeric keypad. Fire the welder and view the output waveform (shaded graph) on the display.
2. From the **MONITOR** keys section on the front panel, press the , , , or  key to view the desired waveform. Note that the other monitor keys do not have graphical waveforms.
3.  Toggle the Pulse 1 weld time/energy selector key to select the **upper** limit field for the weld period. Use the numeric keypad or the ▲ ▼ arrows to enter the **upper limit** value for the Pulse 1 weld period.
4. Perform **one** of the following to program the Pulse 1 monitor limit mode:
 -  Press the **kA** key to program **current** as the limit mode.
 -  Press the **V** key to program **voltage** as the limit mode.
 -  Press the **kW** key to program **power** as the limit mode.
 -  Press the **Ω** key to program **resistance** as the limit mode.
5.  Toggle the Pulse 1 weld time/energy selector key to select the **lower limit** field for the weld period. Enter the lower limit value for the Pulse 1 weld period.

NOTE: In order for a Pulse 1 **lower limit** to be programmed, you must **first** program a Pulse 1 upslope in the weld schedule.

The lower limit mode (current, voltage, or power) will automatically be the same as the upper limit mode programmed in Step 4.
6.  Press the **COOL** weld period key. This will bring up the **PULSE 1 OUT OF LIMITS ACTION** screen. This screen allows you to select the action that the Power Supply will take if the Pulse 1 upper or lower limits are exceeded. You have **four** choices:

PULSE 1 OUT OF LIMITS ACTION

 1. none
 2. STOP WELD
 3. INHIBIT PULSE 2
 4. PART CONDITIONER (Stop Pulse1)

NUMBER Select, ▲ Page, RUN or MENU

 - **NONE** takes no action if upper or lower energy limits are exceeded.
 - **STOP WELD** stops the weld immediately during Pulse 1, and prevents Pulse 2 from firing (if applicable).
 - **INHIBIT PULSE 2** stops the weld at the end of Pulse 1, and prevents Pulse 2 from firing. This function will not operate if both pulses are joined **without** a cool time.

- **PART CONDITIONER (Stop PULSE1)** stops Pulse 1 immediately after upper or lower energy limits are exceeded, but allows Pulse 2 to fire. This function will not operate if both pulses are joined **without** a cool time.

NOTE: See Section IV, *Programming For Active Part Conditioning*.

- After making your selection the display will automatically return to the monitor screen.
- Program the upper and lower limits for Pulse 2 by repeating Steps 4 through 6 above using the keys for Pulse 2, entering appropriate values for Pulse 2.

NOTES:

- The monitor limit mode (current, voltage, power or resistance) for Pulse 2 can be different than the monitor limit mode for Pulse 1.
- To “fine tune” the monitor limits to very precise values, see *Chapter 4, Introduction to Feedback Modes and Monitoring*.

-  Press the **HOLD** period key. This will bring up the **PULSE 2 OUT OF LIMITS ACTION** screen. This screen allows you to select the action that the Power Supply will take if the Pulse 2 upper or lower limits are exceeded. You have **two** choices:

PULSE 2 OUT OF LIMITS ACTION

1. none
2. STOP WELD

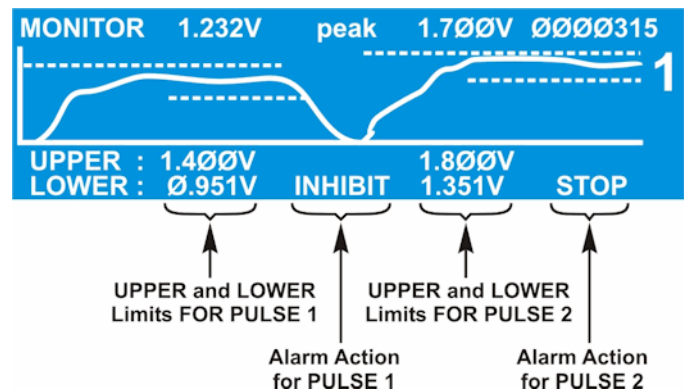
NUMBER Select, ▲ Page, RUN or MENU

- **NONE** takes no action if upper or lower energy limits are exceeded.
- **STOP WELD** stops **PULSE 2** immediately after upper or lower energy limits are exceeded.

- After you have made your selection the display will automatically return to the **MONITOR** screen.

NOTE: The Power Supply adds dotted lines to the appropriate graph to show the **programmed limits**.

The screen on the right shows how the **Limits** and **Alarm** actions appear when an actual weld trace is displayed on the LCD.



- After entering or changing monitor limits, you must press either the appropriate **MONITOR** or **RUN** buttons to save the changes. If this is not done, the last input field will remain highlighted, and the changes will not be saved to memory. Any welds done in this condition will use the older, unedited values still stored in the memory.

CHAPTER 5. OPERATING INSTRUCTIONS

NOTE: All lower limits apply only to the Pulse 1 and Pulse 2 **WELD** periods. Lower limits do **not** cover any upslope or downslope periods. All upper limits apply to the entire Pulse 1 and Pulse 2 periods, including their upslope and downslope periods.

12. Set an **UPPER LIMIT** and **LOWER LIMIT** using the procedures in *Chapter 4, Using Feedback Modes and Weld Monitoring*. Perform a weld to see how the limits (dotted lines) appear compared to the weld graph.
13. Raise or lower the **UPPER LIMIT** and **LOWER LIMIT** as necessary using the procedures in *Chapter 4, Using Feedback Modes and Weld Monitoring*.
14. To lengthen or shorten the time periods, go to the **MONITOR** screen.
15. Press the **UPSLOPE** key for **PULSE 1** or **PULSE 2** to get the **MONITOR LIMITS** screen.

NOTE: **IGNORE 1st** deletes time from the beginning of the limit, **IGNORE LAST** deletes time from the end of the limit. This will not only shorten the limit time, but depending on the amount of time deleted on each end of the limit, the limit will appear to move horizontally across the screen. This allows

you to fit the **LOWER LIMIT** precisely into the waveform graph.

< PULSE 1 MONITOR LIMITS >		
1. LOWER LIMIT	IGNORE 1ST :	0.0 ms
2. LOWER LIMIT	IGNORE LAST :	2.5 ms
3. UPPER LIMIT	IGNORE 1ST :	0.0 ms
4. UPPER LIMIT	IGNORE LAST :	0.0 ms

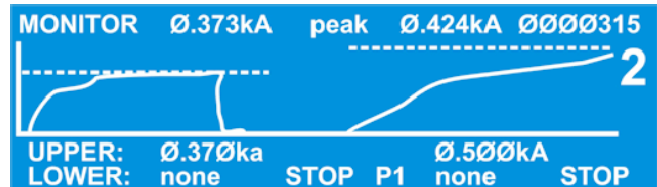
NUMBER Select an item, **RUN** or **MENU**

16. Use the numerical keypad to select the number of the limit you want to change.
17. When the value is highlighted (Example: **2.5 ms**), use the numerical keypad to type in a new value. You must leave a minimum time of 0.5 ms in order for the changes to be saved in memory.
18. Press the **RUN** or **monitor** key when you have finished entering new values.
19. Raise or lower the **UPPER LIMIT** and **LOWER LIMIT** as necessary using the procedures in *Section III, Programming the Weld Monitor*.
20. Return to the **RUN** screen and make a test weld in order to view the waveform to see where the new limits appear compared to the waveform graph.
21. Repeat steps 1 → 10 until the limits are where you want them.

NOTE: Lower limits apply to the programmed weld time **only**. Programming a longer upslope extends the time before a lower limit applies in the monitoring screen.

Section IV. Active Part Conditioning

1.  Press the **SCHEDULE** key, then select a Weld Schedule using **either** the ▲ ▼ arrows **or** the numeric keypad.
2. Program a single pulse for **Constant Power** operation. Program the power level and weld time to cause slight sticking between the two parts. Make a few welds and pull them apart. Increase or decrease the power setting until a light tack weld is achieved.
3.  From the **MONITOR** keys section on the front panel, press the voltage **V** key and observe the high peak of the voltage waveform.
4.  From the **MONITOR** keys section on the front panel, press the **Ω** (resistance) key and observe the resistance waveform. This should appear to begin high, then start to drop as a tack weld is made and oxides are removed.
5.  From the **MONITOR** keys section on the front panel, press the **kA** (current) key and observe the current waveform starting to rise as the oxidization breaks down. If the current waveform starts to flatten, this is an indication that the resistance has stabilized and the parts have come into closer contact.
6.  Push **RUN** and optimize the energy and time setting of Pulse 1 (constant power) to provide an adequate tack weld and also a current waveform (view in the monitor screen) that has started to flatten out, but is still rising. This indicates that a full melt has not yet occurred.
7.  From the **MONITOR** keys section on the front panel, press the **kA** key to program an upper current limit on the **MONITOR** screen.



NOTE: You can toggle between **PEAK** and **AVERAGE** readings by pressing the **PEAK/AVERAGE** key.

8.  Press the **COOL** weld period key. This will bring up the **PULSE 1 OUT OF LIMITS ACTION** screen.
9. Select **4. PART CONDITIONER (Stop Pulse1)**

PULSE 1 OUT OF LIMITS ACTION

1. none
2. STOP WELD
3. INHIBIT PULSE 2
4. PART CONDITIONER (Stop Pulse1)

NUMBER Select, ▲ Page, RUN or MENU

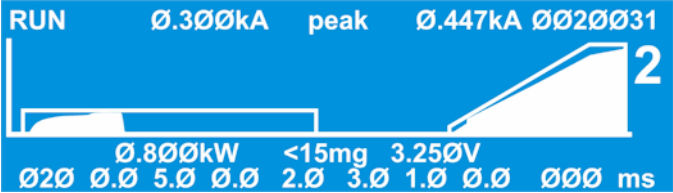
NOTE: For more details on this process, see **Active Part Conditioner** in *Chapter 4, Using Feedback Modes and Weld Monitoring*.

10.  Since different levels of oxide require different amounts of time to reach the current limit, return to the **RUN** screen and extend the programmed weld time (usually double the time works). This will ensure that there will be enough time for the current to rise and reach the limit, even with heavily oxidized parts.

CHAPTER 5. OPERATING INSTRUCTIONS

11. Try welds with varying oxide (clean and dirty). The power supply terminates the first pulse when your programmed current is reached. A clean part will reach the current limit sooner and the pulse will terminate early. A dirty part will require more time before the oxide is broken down and current can flow.

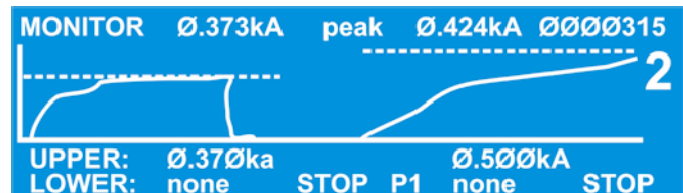
12. Program your second welding pulse as normal to achieve a strong weld. Constant voltage is recommended for round parts and constant current for flat parts. An upslope may be required to restrict the current flow early in the second pulse and avoid weld splash.



Section V. Resistance Set

NOTE: The **Resistance Set** tool is very similar to the **Active Part Conditioning** tool. The difference is that the first pulse is programmed as all Upslope for Resistance Set, where it is programmed as all Weld Time (Square Wave) for Active Part Conditioning. The Resistance Set pulse is programmed as all Upslope to keep both the Voltage and Current low at the beginning of the pulse.

1.  Press the **SCHEDULE** key, then select a Weld Schedule using **either** the **▲ ▼** arrows **or** the numeric keypad.
2. Program a single pulse for **Constant Power** operation, but program the time in the Upslope portion of Pulse 1. Program the Weld Time and Downslope of Pulse 1 to 0.0 ms. Program the power level and Upslope time to cause slight sticking between the two parts. Make a few welds and pull them apart. Increase or decrease the power setting until a light tack weld is achieved.
3.  From the **MONITOR** keys section on the front panel, press the voltage **V** key and observe gradual rise of the voltage waveform.
4.  From the **MONITOR** keys section on the front panel, press the **Ω** (resistance) key and observe the resistance waveform. This should appear to begin high, then start to drop as a tack weld is made and the resistance decreases.
5.  From the **MONITOR** keys section on the front panel, press the **kA** (current) key and observe the current waveform starting to rise as the resistance decreases. If the current waveform starts to flatten, this is an indication that the resistance has stabilized and the parts have come into closer contact.
6.  Push **RUN** and optimize the energy and time setting of Pulse 1 to provide an adequate tack weld and also a current waveform (view in the monitor screen) that has started to flatten out, but is still rising. This indicates that a full melt has not yet occurred.
7.  From the **MONITOR** keys section on the front panel, press the **kA** key to program an upper current limit on the **MONITOR** screen.



NOTE: You can toggle between **PEAK** and **AVERAGE** readings by pressing the **PEAK/AVERAGE** key.

8.  Press the **COOL** weld period key. This will bring up the **PULSE 1 OUT OF LIMITS ACTION** screen.
9. Select **4. PART CONDITIONER (Stop PULSE1)**.

- PULSE 1 OUT OF LIMITS ACTION**
1. none
 2. STOP WELD
 3. INHIBIT PULSE 2
 4. PART CONDITIONER (Stop Pulse1)

NUMBER Select, **▲** Page, **RUN** or **MENU**

CHAPTER 5. OPERATING INSTRUCTIONS

NOTE: For more details on this process, see **Resistance Set** in *Chapter 4, Using Feedback Modes and Weld Monitoring*.

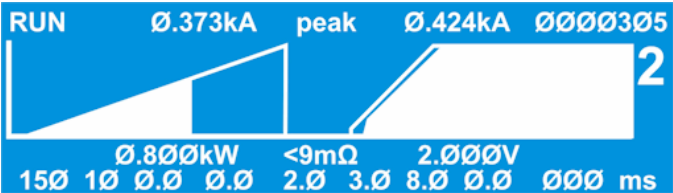
10.



Since different levels of resistance require different amounts of time to reach the current limit, return to the **RUN** screen and extend the programmed weld time (usually double the time works). This will ensure that there will be enough time for the current to rise and reach the limit, even with wide variations in initial resistance.
11.

The power supply terminates the first pulse when your programmed current is reached. A low resistance part will reach the current limit sooner and the pulse will terminate early. A highly resistive part will require more time before the resistance decreases and current can flow.
12.

Program your second welding pulse as normal to achieve a strong weld. Constant voltage is recommended for round parts and constant current for flat parts. An upslope may be required to restrict the current flow early in the second pulse and avoid weld splash.



Section VI. Pre-Weld Check

Note: The **Pre-Weld Check** function is used to detect misaligned or missing parts before the weld is performed. Therefore, the Pre-Weld Check function should only be programmed after the welding schedule has been developed. The welding schedule includes the time and energy settings as well as the electrode force required to produce strong, consistent welds.

1.  Press the **SCHEDULE** key, then select a Weld Schedule using **either** the **▲ ▼** arrows **or** the numeric keypad.
2. Program the second pulse as required to produce strong, consistent welds. Then, program the first pulse for **Constant Current** operation. Program the first pulse current level to approximately 10% of the second pulse current. Program the first pulse upslope time to 1 ms and first pulse weld time to 2 ms. Program 2 ms of cool time between the pulses. Make a few welds and verify that the welds are strong and consistent.
3.  From the **MONITOR** keys section on the front panel, press the voltage **V** key and observe the peak voltage reading of the first pulse. Make several more welds and observe the range of first pulse peak voltage readings from weld to weld.
4.  Press the Pulse 1 weld key to highlight the **upper** limit field for the weld period. Use the numeric keypad to enter the **upper limit** value for the Pulse 1 weld period. Program a voltage level that is slightly higher than the voltages observed in step 3 above.
5.  Press the voltage **V** key to save the setting as an upper voltage limit.
6.  Press the **COOL** weld period key. This will bring up the **PULSE 1 OUT OF LIMITS ACTION** screen.

PULSE 1 OUT OF LIMITS ACTION

 1. none
 2. STOP WELD
 3. INHIBIT PULSE 2
 4. PART CONDITIONER (Stop Pulse1)

NUMBER Select, **▲** Page, **RUN** or **MENU**
7. Select **2. STOP WELD**
8.  Toggle the Pulse 1 weld key to highlight the **lower** limit field for the Pulse 1 weld period. Use the numeric keypad to enter a **lower limit** value with a voltage level that is slightly lower than the voltages observed in step 3 above.
9.  Press the voltage **V** key to save the setting as a lower voltage limit.
10. Make several more welds and verify that under normal circumstances, the limits are not reached and the welds are not aborted. If the limits are reached under normal welding conditions, adjust the levels and times of the upper and lower voltage limits accordingly.
11.  Return to the **RUN** screen and make several welds. Observe that under normal conditions, the welds are not aborted, and that consistent, strong welds can be produced.

CHAPTER 5. OPERATING INSTRUCTIONS

12. Try making welds with only one part present. Also try making welds with misaligned parts. Observe that the power supply terminates the weld during the first pulse as soon as the voltage limits are reached. If the voltage limits are not being reached with these conditions present, return to the voltage monitor screen and adjust the limits accordingly. You may also have to adjust the Pulse 1 current from the RUN screen if needed to optimize the Pre-Weld Check settings.
13. The Pre-Weld Check function can now be used to detect misaligned or missing parts before the Pulse 2 welding current is delivered to the parts.



Pre-Weld Check Waveform

Section VII. Weld To A Limit

NOTE: The **Weld to a Limit** function is used to stop the weld when a specific **current, voltage, or power** level, sufficient to produce good welds, is reached. Using limits in this way ensures a more consistent input of energy, which produces consistently good welds for some applications. The Weld to a Limit function should only be programmed after a welding schedule, which produces acceptable results, has been developed. The welding schedule includes the time and energy settings as well as the electrode force setting. In the following steps, a **Constant Voltage** weld is used as an example to show how the Weld to a Limit function is programmed.

1.  Press the **SCHEDULE** key, then select a Weld Schedule using **either** the **▲ ▼** arrows **or** the numeric keypad.
2. Program a single pulse for **Constant Voltage** operation as required to make strong welds. Make a few welds and verify that the welds are acceptable.
3.     From the **MONITOR** keys section on the front panel, press the **kA** (current), **V** (voltage), **kW** (power), and **Ω** (resistance) keys and observe the resulting waveforms.

NOTE: You can toggle between **PEAK** and **AVERAGE** readings by pressing the **PEAK/AVERAGE** key.

4.  Press the **kA** (current) key and observe the current waveform. If the current waveform is still rising at the end of the pulse, the Weld to a Limit function may work well for the application. If the current waveform quickly rises and flattens out early in the pulse, the Weld to a Limit function is not appropriate for the application.
5. Observe the peak current reading on the current monitor screen. Make several more welds and observe the range of peak current readings from weld to weld.
6.  Press the Pulse 1 weld key to highlight the **upper** limit field for the weld period. Use the numeric keypad to enter the **upper limit** value for the Pulse 1 weld period. Program a current level that is the same as the peak current readings observed in step 5 above.
7.  Press the current **kA** key to save the setting as an upper current limit.
8.  Press the **COOL** weld period key. This will bring up the **PULSE 1 OUT OF LIMITS ACTION** screen.
9. Select 2. **STOP WELD**

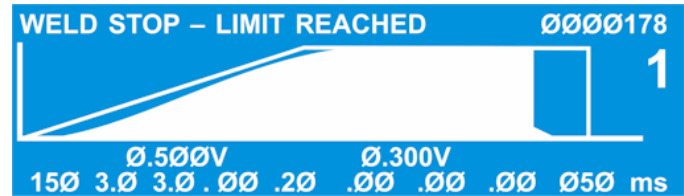
PULSE 1 OUT OF LIMITS ACTION

1. **none**
2. **STOP WELD**
3. **INHIBIT PULSE 2**
4. **PART CONDITIONER (Stop Pulse1)**

NUMBER Select, **▲** Page, RUN or MENU

CHAPTER 5. OPERATING INSTRUCTIONS

10.  Return to the **RUN** screen and increase the weld time by 1-2 ms. Make several welds and verify that the upper voltage limit is reached for every weld, and the weld pulse stops before the end of the programmed weld time.



Weld to a Limit Waveform

11. Make several more welds and inspect them for consistency of weld quality and/or weld strength.

NOTE: When using the Weld to a Limit function, always select a monitor mode that is *different* from the feedback mode. For example:

- If you are welding in constant current, put limits on voltage.
- If you are welding in constant voltage, put limits on current.
- If you are welding in constant power, put limits on current or voltage.

Section VIII. Weld Stop

NOTE: The **Weld Stop** function is similar to the **Pre-Weld Check** function, as both are used to detect missing or misaligned parts. Both functions are used to stop the weld when a specific **current**, **voltage**, or **power** level is reached. The Weld Stop function stops the weld in the actual welding pulse; the Pre-Weld Check uses a small pre-pulse to stop the weld. The Weld Stop function should only be programmed after a welding schedule, which produces acceptable results, has been developed. The welding schedule includes the time and energy settings as well as the electrode force setting. In the following steps, a **Constant Current** weld is used as an example to show how the Weld Stop function is programmed.

1.  Press the **SCHEDULE** key, then select a Weld Schedule using **either** the **▲ ▼** arrows **or** the numeric keypad.
2. Program a single pulse for **Constant Current** operation as required to make strong, consistent welds. Make a few welds and verify that the welds are acceptable.
3.     From the **MONITOR** keys section on the front panel, press the **kA** (current), **V** (voltage), **kW** (power), and **Ω** (resistance) keys and observe the resulting waveforms.

NOTE: You can toggle between **PEAK** and **AVERAGE** readings by pressing the **PEAK/AVERAGE** key.

4.  Press the **V** (voltage) key and observe the voltage waveform.
5. Observe the peak and average readings on the voltage monitor screen. Make several more welds and observe the range of voltage readings from weld to weld.
6.  Press the Pulse 1 weld key to highlight the **upper** limit field for the weld period. Use the numeric keypad to enter the **upper limit** value for the Pulse 1 weld period. Program an upper voltage limit that is slightly above the peak voltage readings observed in step 5 above.
7.  Press the voltage **V** key to save the setting as an upper voltage limit.
8.  Press the **COOL** weld period key. This will bring up the **PULSE 1 OUT OF LIMITS ACTION** screen.

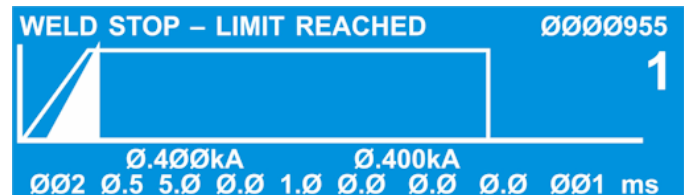
PULSE 1 OUT OF LIMITS ACTION

 1. none
 2. STOP WELD
 3. INHIBIT PULSE 2
 4. PART CONDITIONER (Stop Pulse 1)

NUMBER Select, ▲ Page, RUN or MENU
9. Select **2. STOP WELD**
10.  Toggle the Pulse 1 weld key to highlight the **lower** limit field for the Pulse 1 weld period. Use the numeric keypad to enter a **lower limit** value with a voltage level that is slightly lower than the voltages observed in step 3 above.

CHAPTER 5. OPERATING INSTRUCTIONS

11.  Press the voltage **V** key to save the setting as a lower voltage limit.
12. Make several more welds and verify that under normal circumstances, the limits are not reached and the welds are not aborted. If the limits are reached under normal welding conditions, adjust the levels and times of the upper and lower voltage limits accordingly.
13.  Return to the **RUN** screen and make several welds. Observe that under normal conditions, the welds are not aborted, and that consistent, strong welds can be produced.
14. Try making welds with only one part present. Also try making welds with misaligned parts. Observe that the power supply terminates the weld as soon as the voltage limits are reached. If the voltage limits are not being reached with these conditions present, return to the voltage monitor screen and adjust the limits accordingly.
15.  Return to the **RUN** screen and make several welds. Verify that the Weld Stop function detects missing and misaligned parts.



Weld Stop Waveform

NOTE: When using the Weld Stop function, always select a monitor mode that is *different* from the feedback mode. For example:

- If you are welding in constant current, put limits on voltage.
- If you are welding in constant voltage, put limits on current.
- If you are welding in constant power, put limits on current or voltage.

Section IX. Programming Relays

- From the **MAIN MENU**, press the **7** key to go to the **RELAY** output state selection menu, shown at the right. The Power Supply has four relays that can provide dry-contact signal outputs under many different conditions.

```

                                <RELAY>
1. RELAY1:ON    ALARM
2. RELAY2:ON    ALARM
3. RELAY3:ON    ALARM
4. RELAY4:ON    ALARM

Number Select an item, RUN or MENU
    
```

See *Appendix C, System Timing* for the timing diagrams for the four relays.

- From the **RELAY** menu, press the **1** key to go to **RELAY 1** shown at the right.
- Press the **1** key to toggle the relay contact signal state: **ON** (closed) or **OFF** (open).

```

                                <RELAY 1>
1. SET RELAY TO    : ON
2. WHEN            : ALARM

Number Select, ▲ Page, RUN or MENU
    
```

- Press the **2** key to select the **WHEN** menu, shown at the right.

```

                                <WHEN>
1. ALARM
2. OUT OF LIMITS
3. WELD
4. END OF WELD
5. P1HIGH
6. P1LOW
7. P2HIGH
8. P2LOW
9. MG3 SYNC

Number Select, ▲ Page, RUN or MENU
    
```

- Press the **2** key to select **OUT OF LIMITS** as the condition for initiating the **Relay 1** output signal. This will bring up the **RELAY 1** menu screen, where the **WHEN** line will now reflect **OUT OF LIMITS**.

```

                                <RELAY 1>
1. SET RELAY TO    : ON
2. WHEN            : OUT OF LIMITS

Number Select, ▲ Page, RUN or MENU
    
```

- Choosing **WHEN** options **1 - 4** or **9** will complete the relay programming process. Choosing options **5 - 8** or **0** will bring up the **RELAY (1, 2, 3, or 4)** screen with a **new** option, number **3**. Press **3** to access the next level menus which are shown on the next page.

```

                                <RELAY 1>
1. SET RELAY TO    : ON
2. WHEN            : OUT OF LIMITS

Number Select, ▲ Page, RUN or MENU
    
```


CHAPTER 6

Maintenance

Section I. Introduction

General Kinds of Problems

It has been our experience that most resistance welding power supply ‘problems’ are caused by lack of material control, process control and electrode tip surface maintenance. The problems that you might encounter fall into two groups:

- **Soft** — The problem is transient, and you can correct it by resetting the system or parameter limits. For example, you should ensure that:
 - Correct force is set at the weld head
 - Correct weld energy and time is set at the Power Supply
 - The equipment is set up properly
 - All electrical connections are tight
 - Electrode alignment allows flush contact with the weld pieces
 - Electrodes are properly dressed
- **Hard** — The problem is embedded in the system and some form of repair will be needed. For example, repair might include replacing a broken weld head flexure.

Alarm Messages

Built-in automatic self-test and self-calibration routines will bring up alarm messages on the display screens. These messages will usually let you know what action is required of you to correct the reason for the alarm. For a complete listing of the alarm messages, what they mean, and corrective actions, see *Section II, Troubleshooting*.

Section II. Troubleshooting

Troubleshooting

Problem	Cause (in order of probability)	Problem	Cause (in order of probability)
Electrode Damage	1. Excessive current/energy set at HF-2500A 1. Excessive or insufficient weld head force 1. Wrong electrode tip shape 2. Excessive weld time set at HF-2500A 2. Contaminated weld piece surface/ plating 2. Wrong electrode material 2. Contaminated electrode surface	Electrode Sparking	1. Excessive current/energy set at HF-2500A 1. Insufficient weld head force 1. Slow weld head follow-up 1. Incompatible weld piece projection design 1. Contaminated weld piece surface/ plating 1. Wrong electrode tip shape 2. Wrong electrode material 2. Contaminated electrode surface
Electrode Sticking	1. Contaminated weld piece surface/ plating 1. Wrong electrode material/ tip shape 1. Insufficient weld head force 2. Excessive current/energy set at HF-2500A 2. Excessive weld time set at HF-2500A 2. Contaminated electrode surface 3. Slow weld head follow-up	Weld Piece Warping	1. Excessive weld time set at HF-2500A 1. Excessive weld head force 1. Incompatible weld piece projection design 2. Incompatible weld piece materials 2. Wrong electrode tip shape 3. Excessive current/energy set at HF-2500A
Insufficient Weld Nugget	1. Insufficient current/ energy set at HF-2500A 1. Wrong electrode material/ tip shape 1. Worn/mushroomed electrodes 2. Insufficient weld time set at HF-2500A 2. Incorrect weld head polarity 2. Contaminated weld piece surface/ plating 2. Excessive weld head force 3. Insufficient weld head force 3. Contaminated electrode surface 3. Incompatible weld piece projection design 3. Slow weld head follow-up 4. Incompatible weld piece materials 4. No cover gas on weld piece	Metal Expulsion	1. Excessive current/energy set at HF-2500A 1. Insufficient weld head force 1. Slow weld head follow-up 1. Incompatible weld piece projection design 2. Contaminated weld piece surface/ plating 2. Incompatible weld piece materials 2. Contaminated electrode surface 2. Wrong electrode tip shape 3. No cover gas on weld piece 4. Excessive weld time set at HF-2500A

Problem	Cause (in order of probability)	Problem	Cause (in order of probability)
Weld Piece Over-heating	- Excessive weld time set at HF-2500A - Excessive current/energy set at HF-2500A - Insufficient weld head force - Incompatible weld piece materials - Wrong electrode material/tip shape - Contaminated electrode surface	Weld Piece Discoloration	- Excessive weld time set at HF-2500A - No cover gas on weld piece - Excessive current/energy set at HF-2500A - Insufficient weld head force - Contaminated weld piece surface/plating - Wrong electrode material/tip shape - Contaminated electrode surface

Alarm Messages

Alarm Message	Description	Corrective Action
ACCESS DENIED! SYSTEM SECURITY ON	Operator tried to change a weld schedule number, individual weld schedule parameters, I/O switch functions, and calibration parameters.	Press MENU, select System Security, then enter the correct access code to turn off the System or Calibration Lock protection features. NOTE: Entering a security code of 280 will always unlock the system.
ACCESS DENIED! SCHEDULE LOCK ON	Operator tried to change a weld schedule or individual weld parameters.	Press MENU, select System Security, then enter your access code to turn off System Security. NOTE: Entering a security code of 280 will always unlock the system.
CALIBRATION RESET TO DEFAULT	User entered calibration values reset to factory default values.	Execute the built-in calibration procedure to get the correct setting.
CHECK CONTROL SIGNALS INPUT STATUS	One or more of the I/O input control signals is preventing the HF-2500A from continuing to operate.	Remove the I/O input control signal condition preventing further HF-2500A operation. NOTE: The correct removal action depends on how the control signal select in the Setup 1 menu was programmed by the user.
CHECK INPUT SWITCH STATUS	One or more of the Firing or Foot Switch input signals is preventing the HF-2500A from continuing to operate.	Remove the I/O input control signal condition preventing further HF-2500A operation. NOTE: The correct removal action depends on how the INPUT SWITCH SELECT in the Setup 1 menu was programmed by the user.
CHECK VOLTAGE CABLE	No electrode voltage measurement was made.	Verify that the Voltage Sense Cable is properly connected to the electrodes or electrode holder. NOTE: Polarity is not important for the cable connection.
CURRENT 1 GREATER THAN UPPER LIMIT	Actual weld current is greater than the user set Upper Limit value for Weld1.	Reset the Upper Limit for Weld1 to a larger value.

CHAPTER 6: MAINTENANCE

Alarm Message	Description	Corrective Action
CURRENT 2 GREATER THAN UPPER LIMIT	Actual weld current is greater than the user set Upper Limit value for Weld2.	Reset the Upper Limit for Weld2 to a larger value.
CURRENT 1 LOWER THAN LOWER LIMIT	Actual weld current is less than the user set Lower Limit value for Weld1.	Weld splash can cause the actual weld current to drop below the user set Lower Limit for Weld1. Add upslope to reduce weld splash. Reset the lower Limit for Weld1 to a smaller value.
CURRENT 2 LOWER THAN LOWER LIMIT	Actual weld current is less than the user set Lower Limit value for Weld2.	Weld splash can cause the actual weld current to drop below the user set Lower Limit for Weld2. Add upslope to reduce weld splash. Reset the lower Limit for Weld2 to a smaller value.
EMERGENCY STOP - OPERATOR ACTIVATED	The Operator Emergency Stop switch has been activated. All power to the HF-2500A is immediately terminated.	Remove any unsafe operating conditions at the welding electrodes. Reset the Operator Emergency Stop switch. Recycle power on the HF-2500A.
CHECK VOLTAGE CABLE	No electrode voltage measurement was made.	Verify that the Voltage Sense Cable is properly connected to the electrodes or electrode holder. NOTE: Polarity is not important for the cable connection.
CURRENT 1 GREATER THAN UPPER LIMIT	Actual weld current is greater than the user set Upper Limit value for Weld1.	Reset the Upper Limit for Weld1 to a larger value.
ENERGY SETTING TOO SMALL	While in the voltage or power feedback mode, the HF-2500A could not control the energy setting because the required current was smaller than the minimum current specified.	Increase the energy setting.
FIRING SWITCH BEFORE FOOT SWITCH	The Firing Switch input has been activated before the Foot Switch has been activated, preventing weld current from flowing.	Check the weld head for an improperly adjusted firing switch. Automation Only - Check the timing on the PLC control lines to the Firing Switch and Foot Switch inputs.
FIRING DIDN'T CLOSE IN 10 SECONDS	The Firing Switch on an AMADA WELD TECH air actuated weld head did not activate within 10 seconds after the Foot Switch was initially activated.	Press RUN and readjust the air pressure to the AMADA WELD TECH air actuated weld head.
ILLEGAL SECURITY CODE ENTERED	The wrong security code was entered to de-activate the System, Schedule, or Calibration Lock protection features.	Press MENU, select System Security, then enter the correct access code to turn off System, Schedule, or Calibration Lock protection features. NOTE: Entering a security code of 280 will always unlock the system.

Alarm Message	Description	Corrective Action
INHIBIT CONTROL SIGNALS ACTIVATED	The Inhibit input control signal is activated, preventing the HF-2500A from continuing to operate. NOTE: Activating the Inhibit input terminates only future operations. It does NOT terminate any present HF-2500A operation.	Remove the Inhibit signal condition preventing further HF-2500A operation. NOTE: The correct removal action depends on how the control signal I/O logic was programmed by the user.
INPUT TOO LARGE	The user has attempted to program a weld energy or time that exceeds the capability of the HF-2500A.	Re-program welding parameters to be within the capability of the HF-2500A.
INPUT TOO SMALL	The user has attempted to program a weld energy or time that is below the capability of the HF-2500A.	Re-program welding parameters to be within the capability of the HF-2500A.
LOAD RESISTANCE TOO HIGH	The total electrical resistance, comprised of the weld cables, weld head, and parts to be welded, has exceeded the drive capability of the HF-2500A. The HF-2500A will not be able to maintain the user set weld parameters.	Reduce the total electrical resistance by reducing the weld cable length. Reduce the total electrical resistance by increasing the weld cable diameter. Check cable and weld head connections. Verify that all three phases from the input power lines are functioning
LOW BATTERY	The battery supplying backup power to the HF-2500A internal memory is out of energy.	Replace the memory battery on the Main Control PCB. CAUTION: Replace the battery while power is ON, otherwise all memory contents will be lost.
LOWER LIMIT GREATER THAN UPPER LIMIT	The user has tried to program a Lower Limit value that is greater than the Upper Limit value for Weld1 or Weld2 time periods.	Re-program the invalid Lower Limit value.
NO WELD TRANSFORMER DETECTED	Cable connecting the Control and Power PCB's is open. Cable connecting the Power PCB to the Weld Transformer is open.	Verify installation of the welding transformer/rectifier module connections.
POWER 1 GREATER THAN UPPER LIMIT	Actual weld power is greater than the user set Upper Limit value for Weld1.	Weld splash can cause the actual weld power to exceed the user set Upper Limit for Weld1. Add upslope to reduce weld splash. Reset the Upper Limit for Weld1 to a larger value.
POWER 2 GREATER THAN UPPER LIMIT	Actual weld power is greater than the user set Upper Limit value for Weld2.	Weld splash can cause the actual weld power to exceed the user set Upper Limit for Weld2. Add upslope to reduce weld splash. Reset the Upper Limit for Weld2 to a larger value.

CHAPTER 6: MAINTENANCE

Alarm Message	Description	Corrective Action
POWER 1 LOWER THAN LOWER LIMIT	Actual weld power is less than the user set Lower Limit value for Weld1.	Weld splash can cause the actual weld power to drop below the user set Lower Limit for Weld1. Add upslope to reduce weld splash. Reset the Lower Limit for Weld1 to a smaller value.
POWER 2 LOWER THAN LOWER LIMIT	Actual weld power is less than the user set Lower Limit value for Weld2.	Weld splash can cause the actual weld power to drop below the user set Lower Limit for Weld2. Add upslope to reduce weld splash. Reset the Lower Limit for Weld2 to a smaller value.
POWER TRANSISTOR OVERHEATED	The power dissipated by the power transistors has exceeded the HF-2500A specified capability.	Reduce duty cycle. Reduce weld time.
PROCESS STOP ON CONTROL SIGNALS INPUT	The Process Stop signal on the CONTROL SIGNALS connector has been activated, immediately terminating weld current.	Remove the Process Stop activating signal from the CONTROL SIGNALS connector.
SAFE ENERGY LIMIT REACHED	The HF-2500A internal power dissipation has exceeded the HF-2500A specified capability.	Reduce duty cycle. Reduce weld time.
SCHEDULES ARE RESET	User programmed the HF-2500A to automatically reset all 100 weld schedules to their factory set default values.	CAUTION: Be careful when using the MENU default features. There is no way to restore a default action.
SYSTEM PARAMETERS ARE RESET	User programmed the HF-2500A to automatically reset all I/O and other system parameters to their factory set default values.	CAUTION: Be careful when using the MENU default features. There is no way to restore a default action.
SYSTEM & SCHEDULE RESET TO DEFAULTS	User programmed the HF-2500A to automatically reset all 100 weld schedules, I/O and other system parameters to their factory set default values.	CAUTION: Be careful when using the MENU default features. There is no way to restore a default action.
UPSLOPE REQUIRED FOR LOWER LIMIT	User has programmed a Lower Limit value for Weld1 or Weld2 periods without using an upslope period. The HF-2500A will automatically stop when activated because the starting weld energy will always be lower than the Lower Limit.	Delete the Weld1 or Weld2 Lower Limit value. Add an upslope period before Weld1 or Weld2 if a Lower Limit value is desired.
VOLTAGE 1 GREATER THAN UPPER LIMIT	Actual weld voltage is greater than the user set Upper Limit value for Weld1.	Weld splash can cause the actual weld voltage to exceed the user set Upper Limit for Weld1. Add upslope to reduce weld splash. Reset the Upper Limit for Weld1 to a larger value.

Alarm Message	Description	Corrective Action
VOLTAGE 2 GREATER THAN UPPER LIMIT	Actual weld voltage is greater than the user set Upper Limit value for Weld2.	Weld splash can cause the actual weld voltage to exceed the user set Upper Limit for Weld2. Add upslope to reduce weld splash. Reset the Upper Limit for Weld2 to a larger value.
VOLTAGE 1 LOWER THAN LOWER LIMIT	Actual weld voltage current is less than the user set Lower Limit value for Weld1.	Reduce the weld cable length or increase the diameter of the weld cables. Reset the Lower Limit for Weld1 to a smaller value.
VOLTAGE 2 LOWER THAN LOWER LIMIT	Actual weld voltage current is less than the user set Lower Limit value for Weld2.	Reduce the weld cable length or increase the diameter of the weld cables. Reset the Lower Limit for Weld2 to a smaller value.
VOLTAGE SELECTION PLUG IS MISSING	The Voltage Selection Plug on the Weld Transformer is missing or improperly connected.	Verify the Voltage Selection Plug connection on the Weld Transformer.
WELD STOP - LIMIT REACHED	The user set Upper Limit value has been exceeded and automatically terminated the weld energy.	This is a MONITOR LIMITS feature activated by the selecting the ENERGY key, then programming the Upper Limit values for Weld1 and Weld2. If the terminated weld energy is not adequate for the weld, re-set the Upper Limit values for Weld1 and Weld2.
WELD SWITCH IN NO WELD POSITION	User has tried to activate the HF-2500A with the Weld/No Weld Switch in the No Weld Position. No weld current will flow.	Set the Weld/No Weld switch to the Weld position.
WELD TIME TOO SMALL	The user has attempted to program zero for all upslope, weld, and downslope time periods.	Re-program the welding parameters to be within the capability of the HF-2500A.

Section III. Maintenance

Electrode Maintenance

When a welding schedule has been suitable for a particular welding application over many welds, but poor quality welds are now resulting, electrode deterioration could be the problem. If you need to increase welding current to maintain the same weld heat, the electrode tip has probably increased in surface area (mushroomed), effectively increasing weld current density, thus cooling the weld. Try replacing the electrodes.

The rough surface of a worn electrode tip tends to stick to the work pieces. So, periodic tip resurfacing (dressing) is required to remove pitting, oxides and welding debris from the electrode. You should limit cleaning of an electrode on the production line to using a # 400-600 grit electrode polishing disk. If you must clean a badly damaged tip with a file, you must use a polishing disk after filing to ensure the electrode faces are smooth.

The best method of preventing electrode problems is to regularly re-grind electrode tip surfaces and shapes in a certified machine shop.

Parts Replacement

Below is a list of the replacement parts for the Power Supply. All items listed are a quantity of 1 each.

WARNING: Only qualified technicians should perform internal adjustments or replace parts. Removal of the unit cover could expose personnel to high voltage and may void the warranty.

Part Description	AMADA WELD TECH Pt #	Location
Input Power Line Protection Fuses F1 and F2: HF-2500A/240 HF-2500A/400 HF-2500A/480	330-071 330-092 330-092	Rear Panel
Power Supply Power Protection Fuse F1	330-078	Power PCB
Input Power Selection Plug Set: 240 Volts 400 Volts 480 Volts	4-34314-01 4-34315-01 4-34316-01	Welding Transformer Chassis

Section IV. Repair Service

If you have problems with your Power Supply that you cannot resolve, please contact our service department at the address, phone number, or e-mail address indicated in **CONTACT US** in the front of this manual.

APPENDIX A

Technical Specifications

NOTE: The specifications listed in this appendix may be changed without notice.

Power

Input Power Line 50-60 Hz, 3 phase

Input Voltage Range at Maximum Output Current

HF-2500A/240 192-264 VAC at 25 A

HF-2500A/400 320-440 VAC at 20 A

HF-2500A/480 384-528 VAC at 13 A

Input kVA (Demand) 30 kVA max at 3% duty cycle

Output Power at 12% Duty Cycle and a

Combined PULSE 1 and PULSE 2 Pulse Width of 50 ms 6.0 kW max

Maximum Output Current 2400 A

Max Peak Output Voltage at Max Peak Output Current..... 5.2 V

Duty Cycle at Max Peak Output Current..... 3%

Max Load Resistance for Max Output Current..... 2.1 mΩ

Output Adjustment Range, Resolution and Accuracy

NOTE: Actual maximum and minimum current, voltage or power achievable depends on transformer and load resistance.

Parameter	Adjustment Range	Resolution (Steps)	Accuracy
Current	100 – 2400 A	0.001 kA	± (2% of setting +2 A)
Voltage	0.2 - 9.99 V	0.001 V	± (2% of setting +0.02 V)
Power	0.05 - 9.99 kW	0.001 kW	± (5% of setting +10 W)
Weld Periods	0.0 - 9.9 ms	0.1 ms	± 20 μs
	10 – 99 ms	1.0 ms	

APPENDIX A: TECHNICAL SPECIFICATIONS

Performance Capabilities

Number of Weld Schedules100

Programmable Weld Periods:

Squeeze	0 – 999 ms
Upslope 1	0 – 99 ms
Weld 1	0 – 99 ms
Downslope 1	0 – 99 ms
Cool	0 – 99 ms
Upslope 2	0 – 99 ms
Weld 2	0 – 99 ms
Downslope 2	0 – 99 ms
Hold	0 – 999 ms

Weld Head System Compatibility

Force Fired, Foot Actuated
Force Fired, Single Valve Air Actuated
Non Force-Fired, Single Valve Air or Cam Actuated
Force Fired, EZ Air Kit
Plug-and-Play 24VDC EZ-AIR weld head
SL-300A/320A Electronic Weldheads

Weld Energy Limits Monitoring

Weld Pre-Check Mode: Inhibit second weld pulse when first test pulse exceeds programmed limits.

Measurement Parameters: Current, voltage and power.

Measurement Selection: Peak or average.

Measurement Range and Accuracy:

Parameter	Range	Accuracy
Current	0.1 - 2.4 kA	± (2% of setting +2 A)
Voltage	0.2 - 9.999 V	± (2% of setting +0.02 V)
Power	0.05 - 9.999 kW	± (5% of setting +10 W)

Limit Ranges: Same as the measurement ranges

Alarms: Display alert and four programmable AC/DC relay contact outputs.

Input Signals

NOTE: Except where parenthetically noted below, all input signals accept 5 to 24 VDC, normally open or normally closed, positive or negative logic. Inputs are optically isolated.

Firing Switch Initiation: 1-level foot switch, 2-level foot switch or opto firing switch.

Remote Control Barrier Strip: Remote weld schedule select, process inhibit, emergency stop

RS-232: Change weld schedules and individual weld parameters.

RS-485: Change weld schedules and individual weld parameters. “Daisy chain” RS-485 input with RS-485 output from other HF-2500A Power Supplies and host computer.

Voltage: Weld voltage signal for voltage feedback operation (0 to 10 volt peak).

Weld Head: Plug-and-play connector with Firing and Foot switch inputs, Voltage Sense input and 24VDC Air Valve Driver output.

Output Signals

Monitor: Internal analog voltage signals representing secondary current feedback (0 - 5 VDC), primary current (0 - 4 VDC), or weld voltage (0 - 5VDC).

Air Valve Driver: 24 VAC, 1 amp; timing controlled by the HF-2500A. No weld over-force protection.

Alarm Relay: Four programmable mechanical relays: 24 VAC/VDC at 1 amp.

RS-232: Monitor weld parameter data. Download and upload schedules.

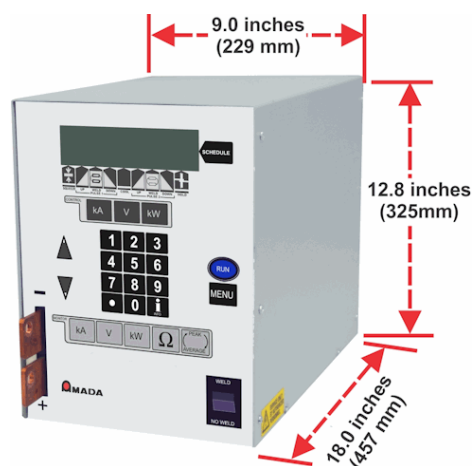
RS-485: Monitor weld parameter data. “Daisy chain” RS-485 input with RS-485 output from other HF-2500A Power Supplies and host computer. Download and upload schedules.

24V_OUT: 24 VDC power supply, polyfused at 1 amp

Physical Specifications

Size: (see illustration)

Weight: 62 lb. (28 kg)



APPENDIX B

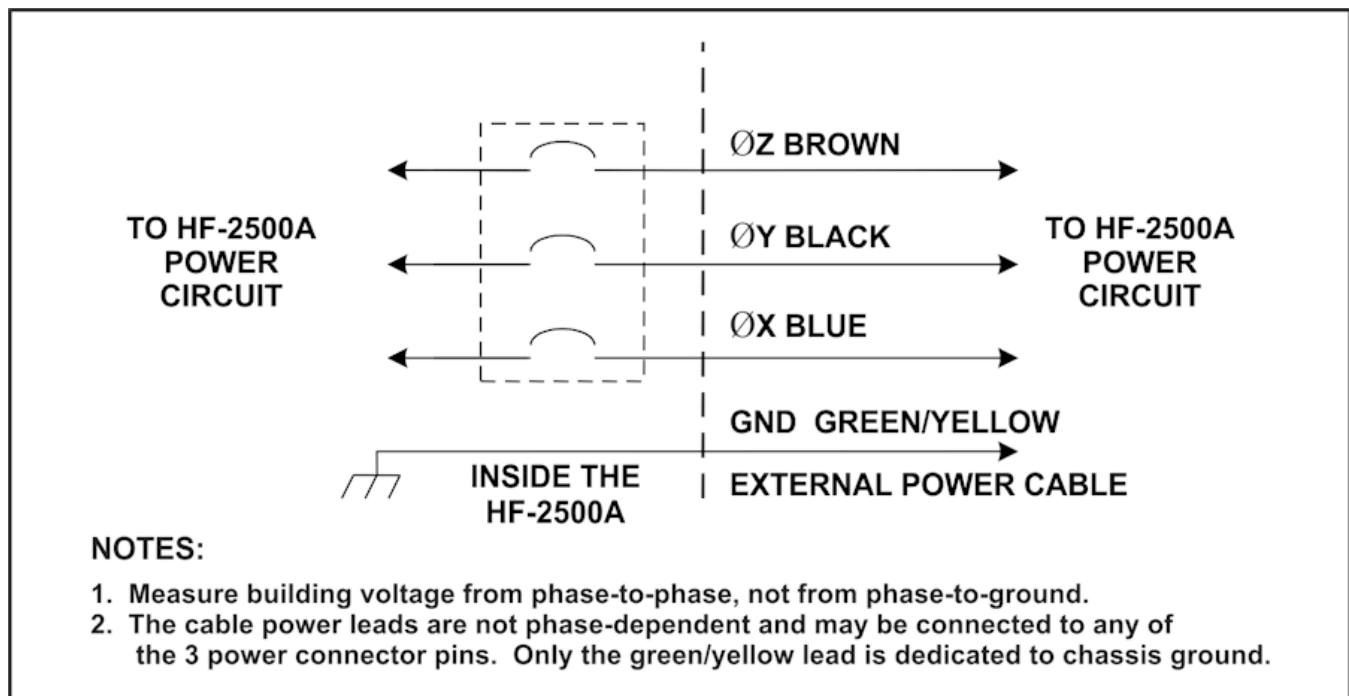
Electrical and Data Connections

Section I. Electrical Connection

As described in *Chapter 2*, you need to supply a connector for the Power Supply input power cable (see diagram below).

Connect the Power Supply power cable to a 3-phase, 50/60 Hz power source. The voltage range for each model is set at the factory by a set of two jumper plugs. One jumper plug is installed on power connector J23, located on the center chassis plate. The other jumper plug, P22, plugs into welding transformer cable connector J22. The jumper plug set determines the power wiring configuration between the power board and the welding transformer.

Input Power Wiring Diagram



CAUTIONS:

- Be sure that the shop source power is appropriate for your Power Supply model.
- If the blue phase wire is **not** connected, **no** alarm will occur and the weld control will produce more than 20% ripple in the weld output waveform.

Section II. I/O Connectors

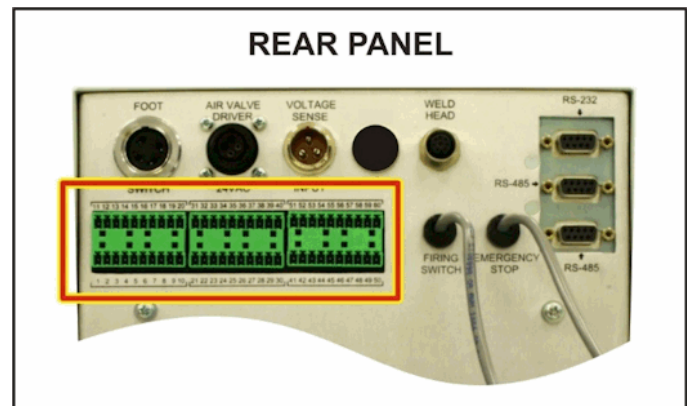
Overview

The control can be configured several different ways in order to match your welding needs. Configuration is achieved by using the pre-wired **Configuration Plug** and by fabricating your own I/O cables using three un-wired plugs. All of these connectors are supplied in the Ship Kit. Complete connection information is in *Section III, I/O Configuration*.

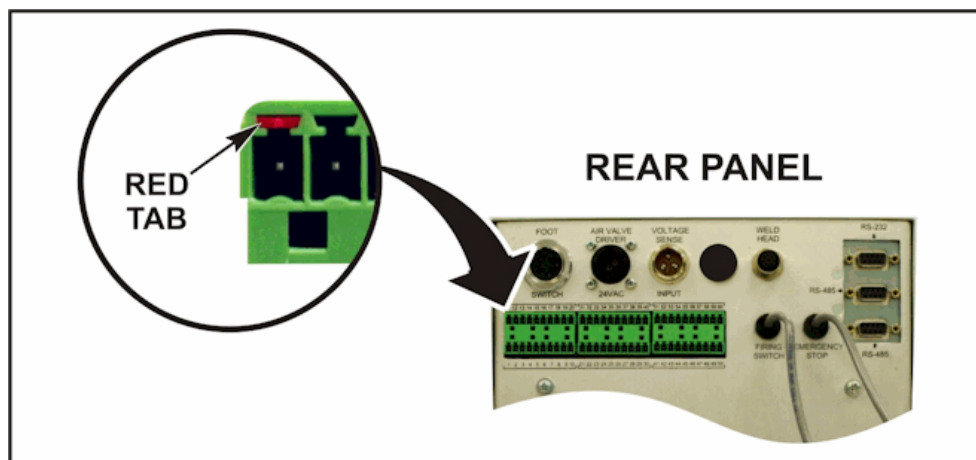
Before fabricating I/O cables, you should be familiar with the physical characteristics of the Power Supplies I/O connectors.

60-Pin Connector

The 60-pin I/O connector is located on the Power Supplies rear panel as shown on the right. This connector can accommodate six 10-pin plugs, including the factory-supplied **Configuration Plug**.

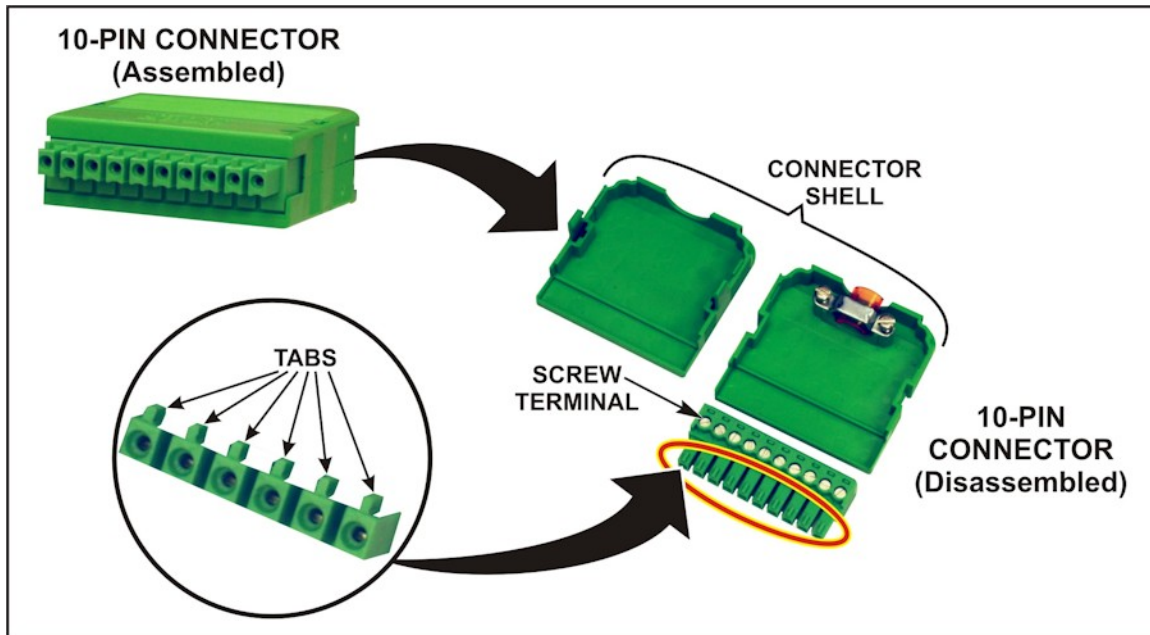


Selected pins contain red inserts as shown below. These inserts prevent properly configured 10-pin plugs from being plugged into the wrong sections of the 60-pin connector.

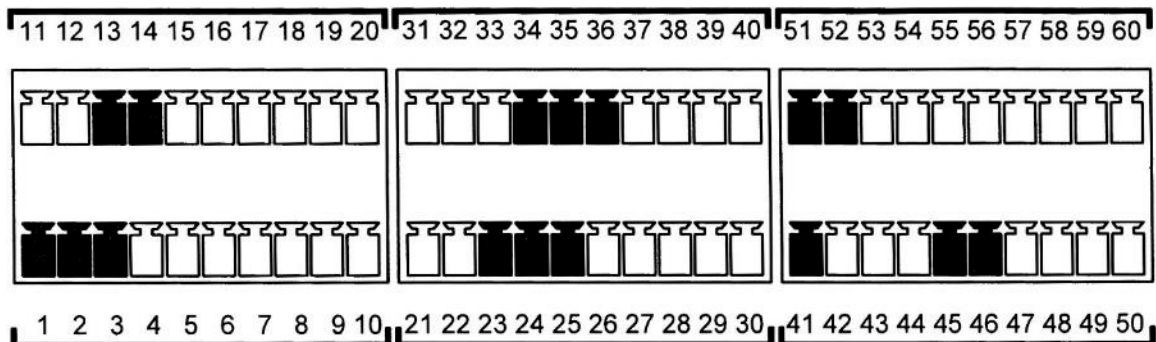


10-Pin Connectors

Three un-wired, “blank” 10-pin connectors are supplied in the Ship Kit. These connectors are used for the configurations described in *Section III, I/O Configuration*. These connectors easily snap apart and use screw-terminal wire connections so no soldering is required. Each pin of this connector has a tab on top as shown below.



When you fabricate I/O cables according to the configuration instructions, ***you must also cut off the tabs on the top of specific pins as indicated by the black shading below.***



Example: To fabricate a connector for pins **31 - 40**, you must remove the tabs for pins **34, 35, and 36**. If you do not remove the appropriate tabs, you will ***not*** be able to insert the plug into the Power Supply.

Section III. I/O Configuration

Basic I/O Configuration:

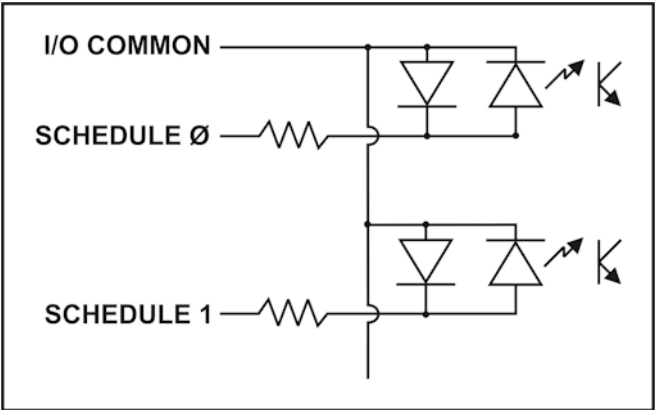
The unit requires configuration of the I/O's to accept any inputs. A pre-wired configuration plug is provided which has to be plugged into connector labeled 11 through 20. It allows the use of standard AMADA WELD TECH foot switches and weld heads without further configuration.

For other configuration methods please refer to *Modification of I/O Configuration* on page B-6.

Input Section Example

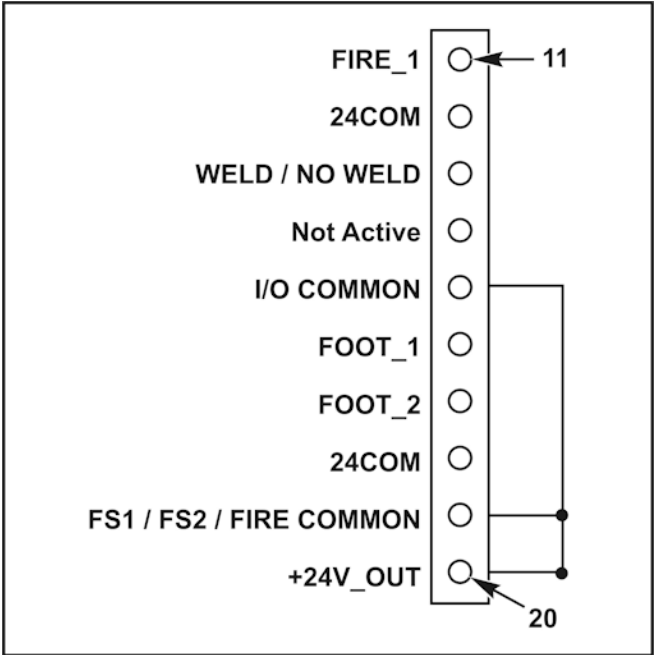
This unit employs bi-directional opto-isolators which allow the user to configure the inputs to sink current, i.e. +24 VDC active, or source current, i.e. 0 VDC active. A typical input section is shown on the right.

See *Modification of I/O Configuration* on page B-6 for both complete input sections.

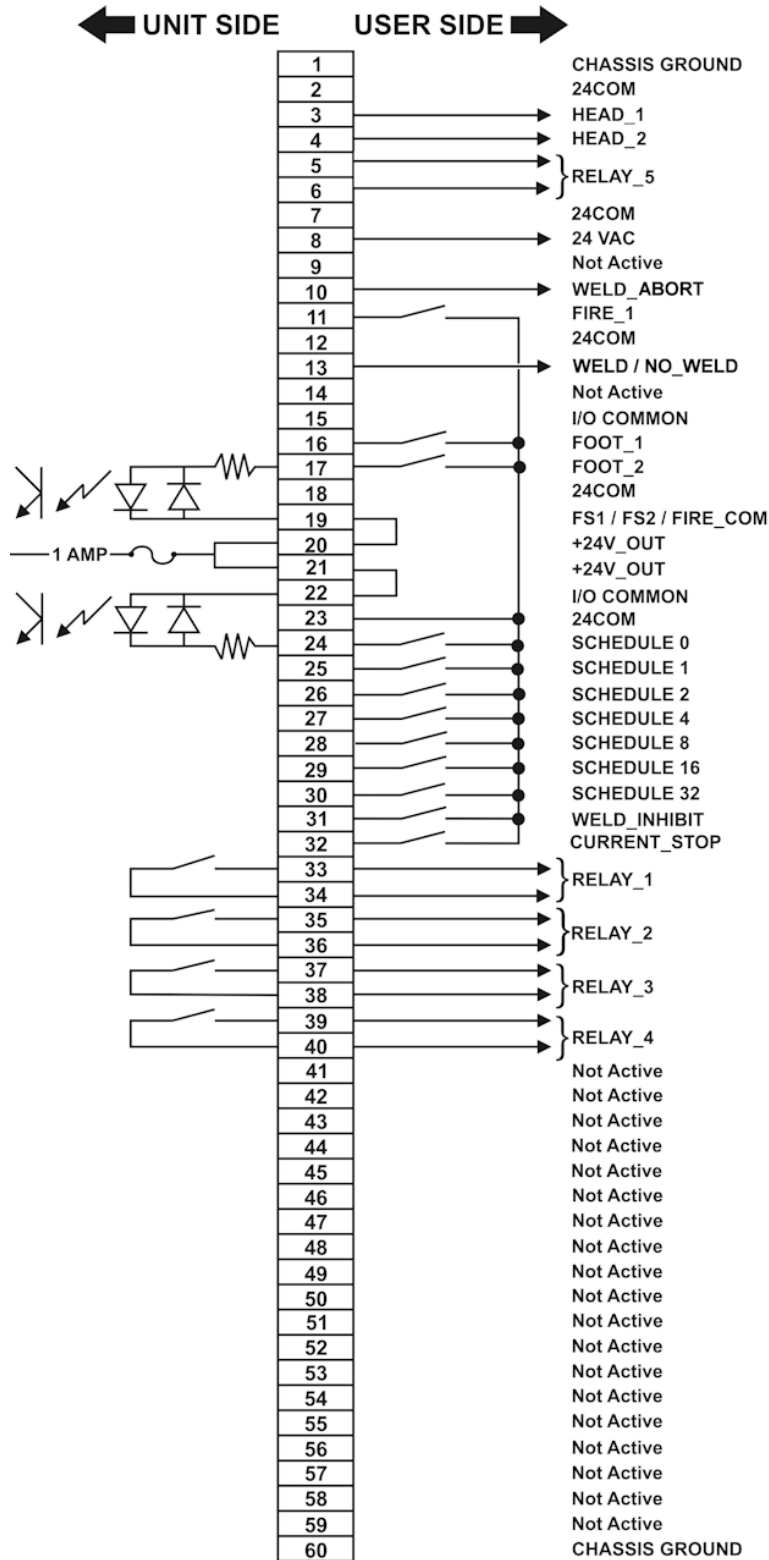


Factory Configuration Plug

The factory default setting is 0 VDC active and is set by connecting the **CONFIGURATION** plug into I/O connector labeled 11 through 20. The plug's internal wiring is shown on the right.



I/O Signal Interface General Description



APPENDIX B: ELECTRICAL AND DATA CONNECTIONS

Input / Output Signals

Pin	Signal Name	Description
1	CHASSIS GROUND	Chassis Ground
2	24COM	NEGATIVE of internal 24 VDC power supply
3	HEAD_1	COMMON for air valve solenoid, switched For 24 VDC operation: Connect other end of solenoid to +24V_OUT For 24 VAC operation: Connect other end of solenoid to 24 VAC
4	HEAD_2	
5	RELAY_5	Relay 5 output, dry contact, programmable Contact rating: 24 VDC/AC, 1 amp
6	RELAY_5R	
7	24COM	NEGATIVE of internal 24 VDC power supply
8	24VAC	24 VAC power supply
9	Not active	Not active
10	WELD_ABORT	Weld Abort Input
11	FIRE 1	Fires unit
12	24COM	NEGATIVE of internal 24 VDC power supply
13	WELD / NO_WELD	Weld / No Weld Input. Functions as a weld enable.
14	Not active	Not active
15	I/O COMMON	COMMON terminal for pins 10, 13, 24 - 31
16	FOOT 1	Activates foot level stage 1
17	FOOT 2	Activates foot level stage 2
18	24COM	NEGATIVE of internal 24 VDC power supply
19	FS1/FS2/FIRE_COM	COMMON terminal for pins 11, 16, 17
20-21	+24V_OUT	+24 VDC output of internal power supply, polyfused at 1 amp
22	I/O COMMON	COMMON terminal for pins 10, 13, 24 - 31
23	24COM	NEGATIVE of internal 24 VDC power supply
24	SCHEDULE 0	Binary Schedule input terminals, used for schedule selection
25	SCHEDULE 1	
26	SCHEDULE 2	
27	SCHEDULE 4	
28	SCHEDULE 8	
29	SCHEDULE 16	
30	SCHEDULE 32	
31	WELD_INHIBIT	Inhibits weld

APPENDIX B: ELECTRICAL AND DATA CONNECTIONS

Pin	Signal Name	Description
32	CURRENT_STOP	Interrupts weld current (< 100 μ s from current_stop trigger to end-of-weld current with debounce set to 0)
33	RELAY_1	Relay 1 output, dry contact, programmable Contact rating: 24 VDC/AC, 1 amp
34	RELAY_1R	
35	RELAY_2	Relay 2 output, dry contact, programmable Contact rating: 24 VDC/AC, 1 amp
36	RELAY_2R	
37	RELAY_3	Relay 3 output, dry contact, programmable Contact rating: 24 VDC/AC, 1 amp
38	RELAY_3R	
39	RELAY_4	Relay 4 output, dry contact, programmable Contact rating: 24 VDC/AC, 1 amp
40	RELAY_4R	
41-59	Not Active	Not active
60	CHASSIS GROUND	Chassis ground

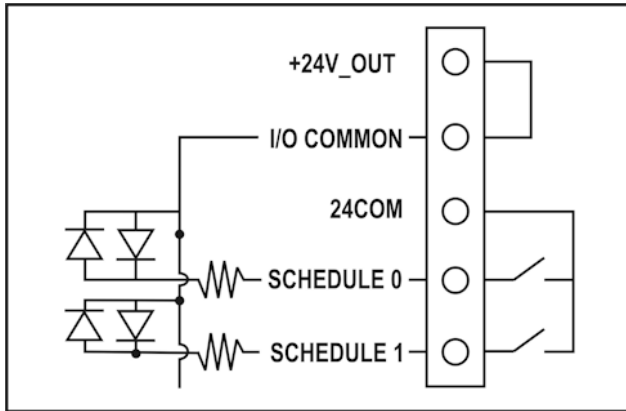
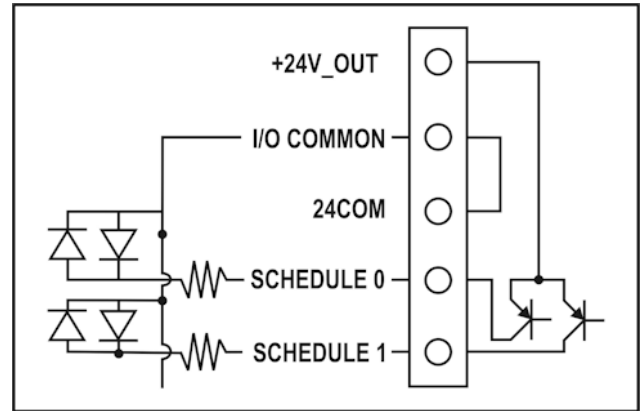
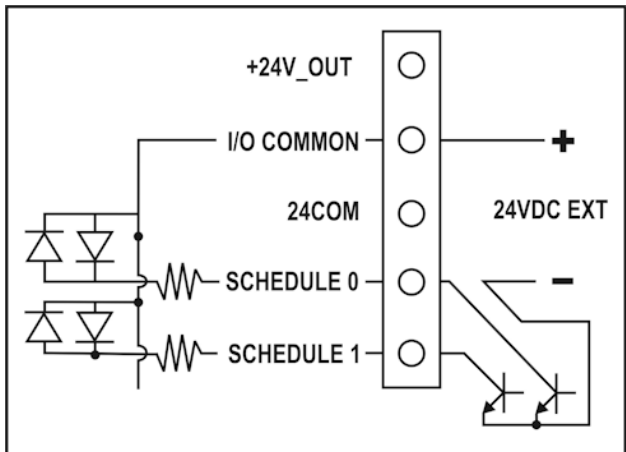
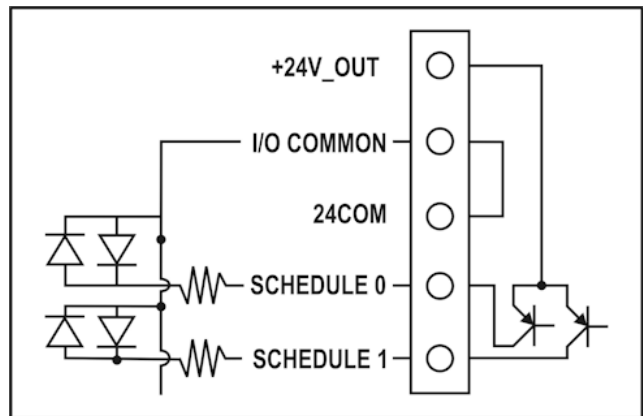
APPENDIX B: ELECTRICAL AND DATA CONNECTIONS

Modification of I/O Configuration:

The inputs of this unit are grouped into two major blocks, which can be independently configured.

SCHEDULE INPUTS		
Common	Input	Pin Number
I/O COMMON	WELD ABORT	10
	WELD / NO WELD	13
	SCHEDULE 0 (2^0)	24
	SCHEDULE 1 (2^1)	25
	SCHEDULE 2 (2^2)	26
	SCHEDULE 4 (2^3)	27
	SCHEDULE 8 (2^4)	28
	SCHEDULE 16 (2^5)	29
	SCHEDULE 32 (2^6)	30
	WELD INHIBIT	31

FOOT SWITCH / FIRE SWITCH INPUTS		
Common	Inputs	Pin Number
FS1/FS2/FIRE_COM	FIRE_1	11
	FOOT_1	16
	FOOT_2	17
	CURRENT STOP	32

Configuration for Common Input Connections:**Dry Contact Input****Common Positive Input
(External Power)****Common Negative Input
(External Power)****Common Positive Input
(Internal Power)**

NOTE: The preceding configuration methods can be used for both input blocks.

Two-Level Foot Switch Connector

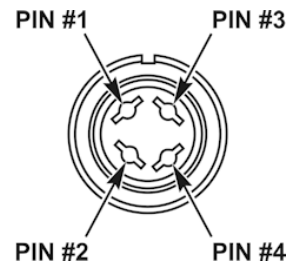
When you press the foot switch to the first level, the Power Supply energizes the air actuated weld head. This causes the upper electrode to descend and apply force to the weld pieces. If you release the foot switch before pressing it to the second level, the Power Supply will automatically return the upper electrode to its UP position so that you may re-position the weld pieces.

If you do not release the foot switch at the first level and proceed to the second level, the force-firing switch in the weld head will close. Weld current will flow, and the Power Supply will automatically return the upper electrode to its UP position.

Using the supplied Configuration plug on Pins 11 – 20 allows the use of the AMADA WELD TECH 2-level footswitch directly. If a PLC or other means of trigger is used, refer to the *I/O Signal Interface General Description* on page B-3.

Foot Switch Connector

Pin	Description
1	Chassis Ground
2	Foot_1 (Connect to pin 4 to activate)
3	Foot_2 (Connect to pin 4 to activate)
4	24COM



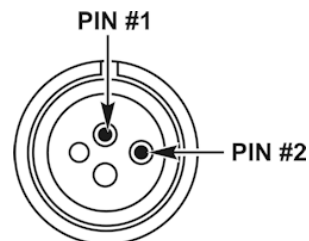
Standard Air Valve Driver Output Connector

The air valve driver output (24 VAC) is initiated when Foot Switch Level 1 is initiated.

Using the supplied Configuration plug on Pins 11 – 20 allows the use of the AMADA WELD TECH 2-level footswitch directly. If a PLC or other means of trigger is used, refer to the *I/O Signal Interface General Description* on page B-3. The mating connector is a TE Connectivity # 206429-1 (Pt # 520-107), using cable clamp TE Connectivity # 206358-5 (Pt # 245-084). The two male pins used are TE Connectivity # 66361-2 for 14-18awg wire (Pt # 253-055).

Air Valve Driver 24 VAC Connector

Pin	Description
1	24VAC (for solenoid)
2	HEAD_1 (Switched 24V common)

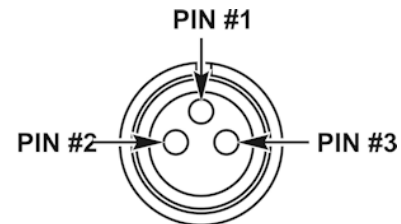


Voltage Sense Input Connector

The voltage leads are connected to the electrode holders to sense weld voltage.

Voltage Sense Input Connector

Pin	Description
1	Not Used
2	VOLT_IN
3	VOLT_COM



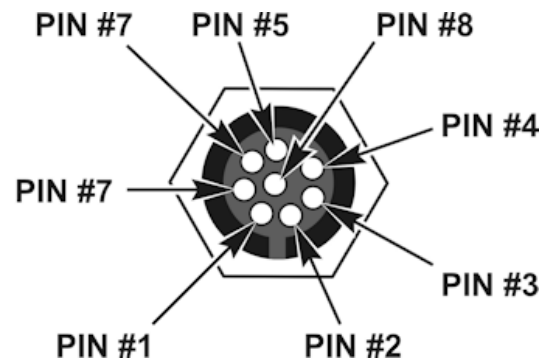
Weld Head Connector

The Weld Head Connector combines all the inputs and outputs necessary to connect a plug-and-play EZ-AIR AMADA WELD TECH weld head.

Using the supplied Configuration plug on Pins 11 – 20 allows the use of the AMADA WELD TECH 2-level footswitch directly. If PLC or other means of trigger is used, refer to the *I/O Signal Interface General Description* on page B-3.

Weld Head Connector

Pin	Description
1	HEAD_1 switched 24 V common
2	24V_OUT 24 VDC for solenoid
3	24COM
4	FIRE_1
5	VOLT_IN
6	VOLT_COM
7	AIRHEAD
8	Not used



Force Firing Switch Cable Input

Function

The force-firing switch input to the Power Supply from the weld head signals that the selected pressure has been applied to the weld pieces. Note that a mechanical firing switch is subject to contact bounce, which can cause false weld starts. The effects of switch bounce can be avoided at low weld speeds by using the switch debounce function on the Power Supply main menu. If welding speeds are to exceed 1.5 welds per second, use an optical firing switch.

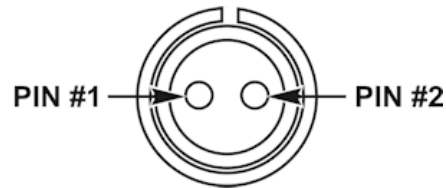
Connections

The firing switch cable is 5 feet long, Type 2/C, 600 volt cable containing two shielded, twisted pair 22 AWG stranded leads.

The firing switch cable connector is a 2-pin Amphenol # 80-MC2F1 (Pt # 520-008). It mates with the weld head firing switch connector, which is a 2-Pin Amphenol # 80-MC2M (Pt # 520-001) connector.

Firing Switch Connector

Pin	Description
1	FIRE_1
2	24COM



Operator Emergency Stop Cable Switch Input

Function

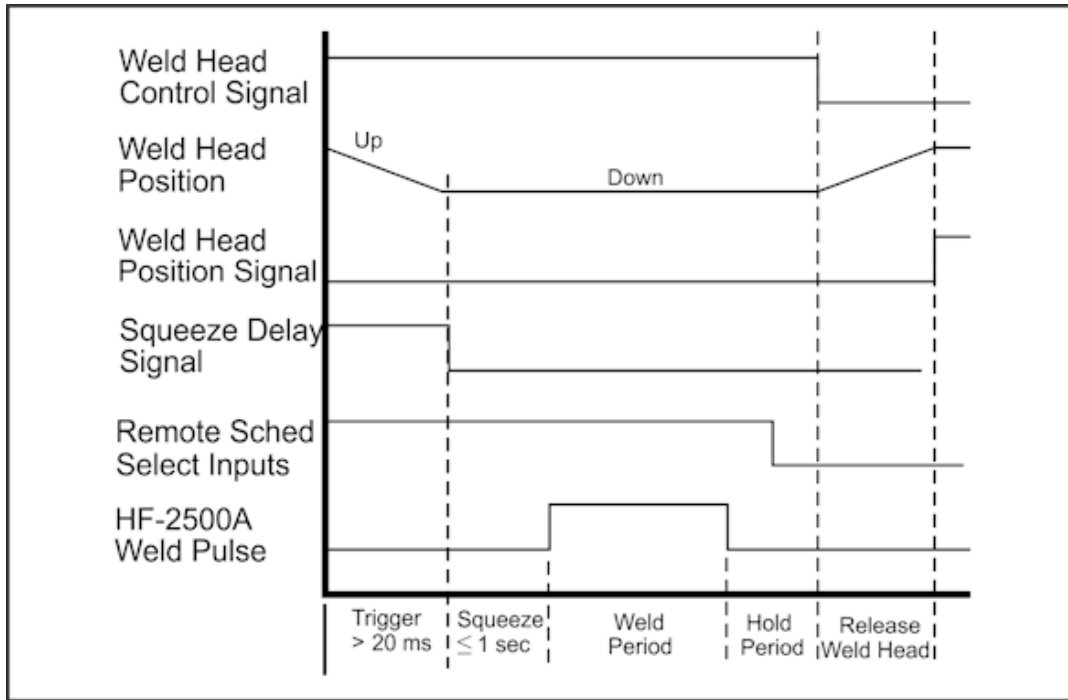
You must connect a normally closed, single-pole switch across both cable leads, otherwise the Power Supply cannot be turned ON. Use the switch during Power Supply operation as an emergency stop switch. When operated (opened), it will immediately halt the weld process.

NOTE: You must press the **RUN** key on the front panel to reset the Power Supply following an emergency stop operation.

Connections

Connect an approved, normally closed emergency stop switch across the 2 foot (61 cm) operator emergency stop switch cable. When the switch is operated (opened), it de-energizes the main power contactor, removing three-phase input power to the Power Supply.

PLC Timing Diagram



BCD Welding Schedule Selection Scheme

Weld Schedule No.	Bit 2 ⁰ Sch 0	Bit 2 ¹ Sch 1	Bit 2 ² Sch 2	Bit 2 ³ Sch 4	Bit 2 ⁴ Sch 8	Bit 2 ⁵ Sch 16	Bit 2 ⁶ Sch 32
0	0	0	0	0	0	0	0
1	1	0	0	0	0	0	0
2	0	1	0	0	0	0	0
3	1	1	0	0	0	0	0
4	0	0	1	0	0	0	0
5-98	BCD progression from 5 to 98						
99	1	1	0	0	0	1	1

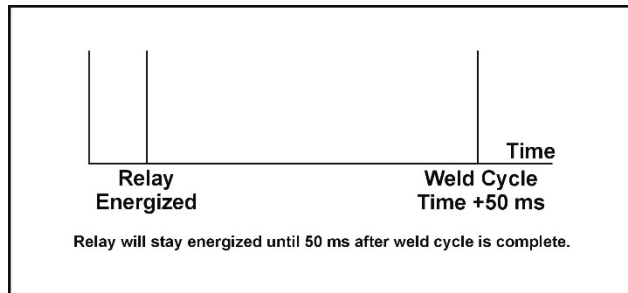
Relay Outputs

Function

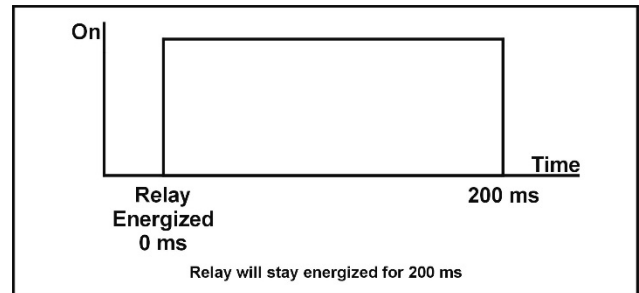
Four mechanical relays on the control board can be independently programmed to supply alarm or weld status contact signal outputs. You can access the programming function through the main menu, as described in *Chapter 3*. The events that you can program for each relay and their timing diagrams are as follows:

Relay contacts closed or open in the energized state. Relays are energized when:

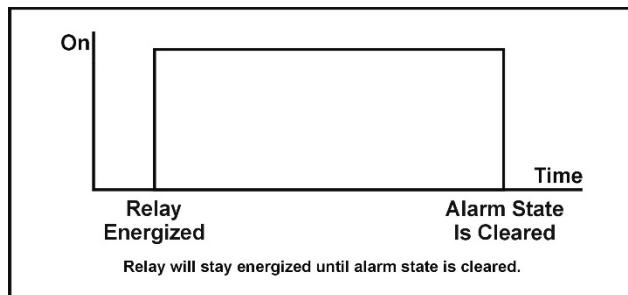
1. Weld cycle starts.



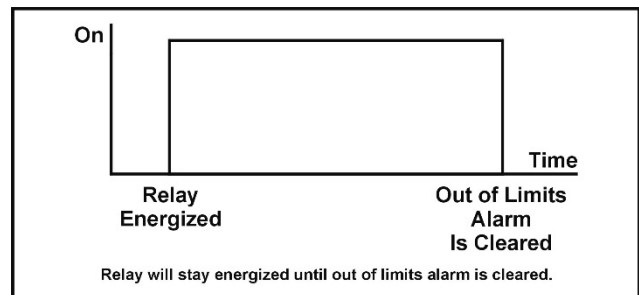
2. Weld cycle ends.



3. Alarm state is detected.



4. Weld is out of programmed limits.



APPENDIX C

Calibration

Section I. Calibrating the Power Supply

Overview

The Power Supply is calibrated by the software, using inputs from a calibration setup during a weld process. Following a few calibration inputs, the Power Supply will adjust itself and store the calibration values in RAM, where they will be used as standards for the operational welding parameters.

CAUTION: Only authorized personnel should perform this procedure.

Calibration Equipment Required

The required equipment for the setup is as follows:

- 2 weld cables, No. 2/0, 1ft (30 cm) long, Pt # 2/0 BB11
- 1000 $\mu\Omega$ coaxial shunt resistor accurate to $\pm 0.2\%$.

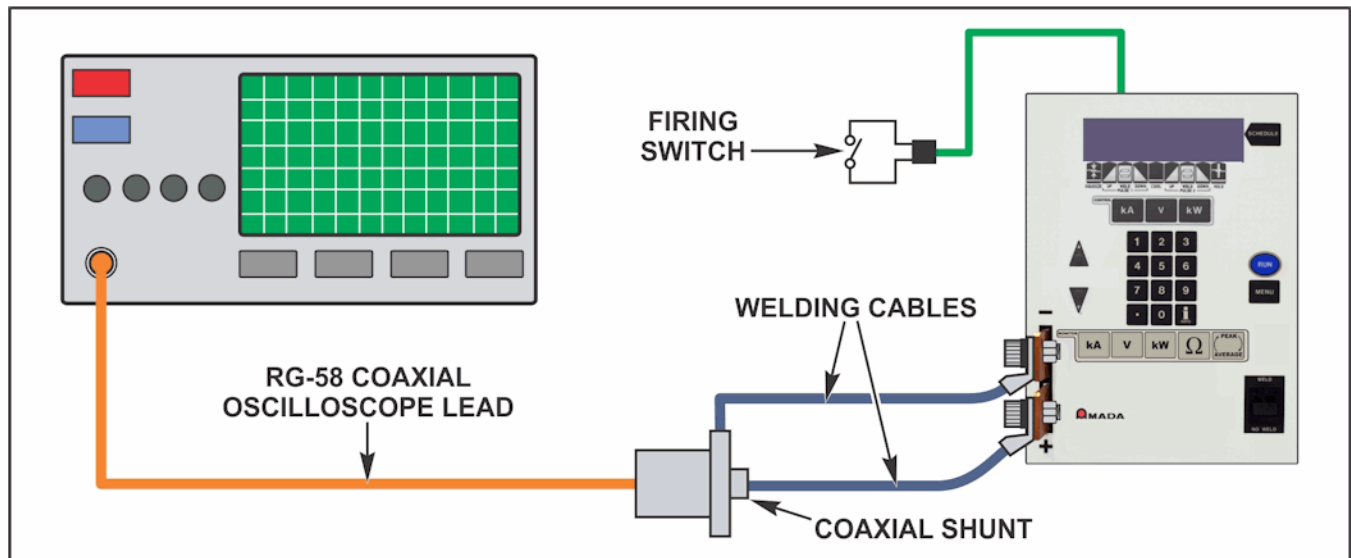
Source for shunt resistor: Model R7500-8

T & M Research Products, Inc.
139 Rhode Island Street NE
Albuquerque, NM 87108
Telephone: (505) 268-0316

- Shielded voltage sense cable, Pt # 4-32998-01
- Digital oscilloscope, Tektronix 724C or equivalent
- Male BNC to dual binding post
- 2-wire, normally open switch for weld initiation, mating connector Pt # 520-001
- Coaxial BNC-to-BNC cable

APPENDIX C: CALIBRATION

Calibration Procedure



Initial Calibration Setup

1. Connect the calibration setup to the Power Supply as shown.
2. Turn the Power Supply ON.
3. In the **MAIN MENU** press 4 to enter the calibration screen.
4. Press **1** for **HF-2500A CALIBRATION** which will bring up the **CAUTION** screen on the right. Press the ▼ arrow.
5. Press **2** to calibrate the HF-2500A.

<MAIN MENU>

- | | |
|--------------------|--------------------|
| 1. SETUP | 6. COMMUNICATIONS |
| 2. WELD COUNTERS | 7. RELAY |
| 3. COPY A SCHEDULE | 8. RESET DEFAULTS |
| 4. CALIBRATION | 9. CHAIN SCHEDULES |
| 5. SYSTEM SECURITY | |

Number Select an item

CAUTION

CALIBRATION SHOULD BE PERFORMED BY A QUALIFIED TECHNICIAN ONLY.
REFER TO MANUAL FOR CALIBRATION SETUP.

▼ next, MENU

<PRE-CALIBRATION>

1. TEST HF25 (T-232 REQUIRED)
2. CALIBRATE HF25
3. RESET CALIBRATION
4. SET CURRENT SHUNT VALUE
5. TEST SERIAL PORT

Menu

6. The first calibration screen is the **CAUTION** screen. If you are qualified to proceed with the calibration press ▼ to continue.
7. **The next page is for the CALIBRATION SHUNT.** This screen asks for the actual value of the 1000 micro-ohm shunt.

<CALIBRATION SHUNT>

Shunt value : 0987.6 $\mu\Omega$

Number change ▼ Proceed

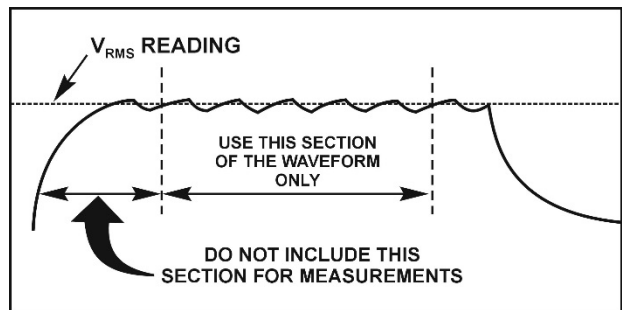
The actual value is printed on the exterior of the R7500-8 shunt. Enter this value using the number keys, and press ▼ to continue.

NOTE: The next calibration screen is the **CURRENT SHUNT**. It is not necessary to change the current shunt value unless the internal welding transformer was changed. If it was changed, remove the top cover and enter the shunt value, which is stamped on the copper conductor connected to the transformer. Press ▼ to continue.

8. The next two screens are **1. CALIBRATE D/A HIGH** and **2. CALIBRATE D/A LOW**. Following the screen instructions, adjust the energy output using the measuring parameter feature of the oscilloscope.

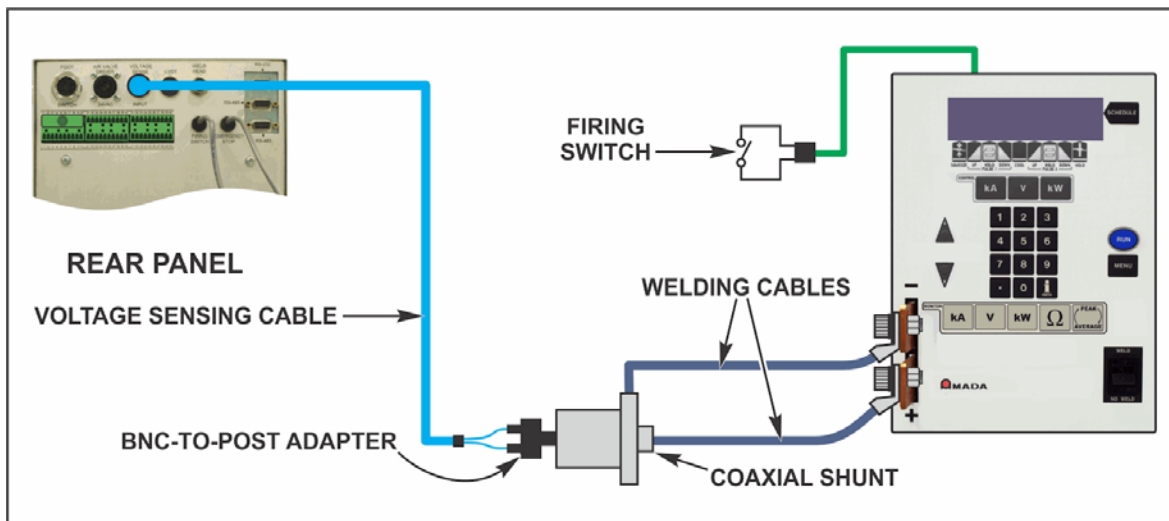
NOTE: Do *not* use a visual assessment.

Press the period [.] key to advance to the next step.



Calibration Signal

9. The next calibration screen is **CALIBRATE HIGH**. Disconnect the oscilloscope from the shunt resistor and connect the output of the shunt resistor to the **VOLTAGE SENSE INPUT** connector using the male BNC to binding post adapter and voltage sense cable. Follow the screen instructions for this step and the next step, **4. CALIBRATION LOW**.



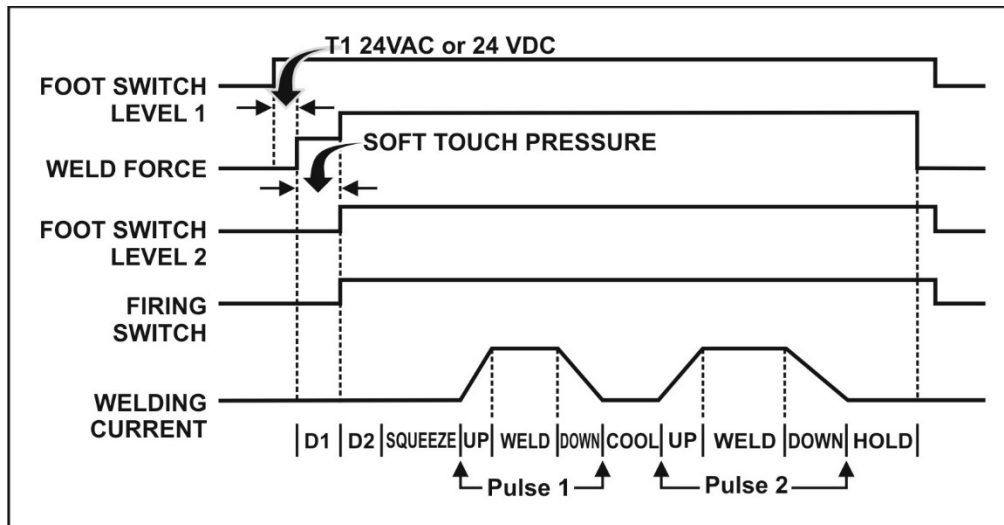
Final Calibration Setup

10. The last calibration screen is **5. END OF CALIBRATION**. Press the **MENU** key. HF-2500A calibration is now complete.

APPENDIX D

System Timing

Basic Weld Operation: Air Head System with Two-Level Foot Switch



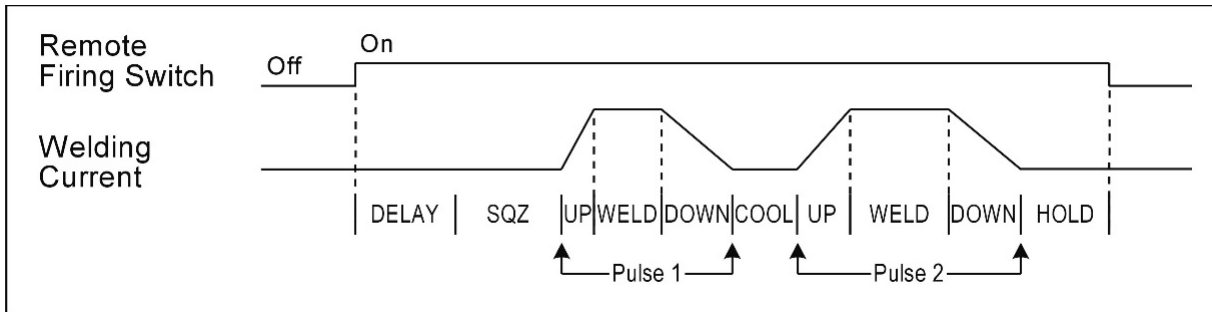
NOTE: The **SOFT TOUCH PRESSURE** feature is **not** available on the HF-2500A Power Supply, it is **only** available on HF-2700A Power Supply.

Definitions

- T1** Delay time from Foot Switch Level 1 closure to Weld Force start. Maximum delay time is 1 ms plus switch debounce time. Switch debounce time can be set to none, 10, 20, or 30 ms with the **SETUP 1** menu screen.
- D1** Delay time from Weld Force start to Firing Switch closure. Maximum D1 time is 10 seconds. If the firing switch does not close within 10 seconds, the message **FIRING SWITCH DIDN'T CLOSE IN 10 SECONDS** will be displayed.
- D2** Delay time from Firing Switch closure and Foot Switch Level 2 closure to squeeze time (SQZ). Maximum D2 time is 2 ms plus switch debounce time.
- SQZ** Squeeze time. Selectable range is 0 to 999 ms.
- UP** Up slope time. Selectable range is 0.0 to 99.0 ms.
- WELD** Weld time. Selectable range is 0.0 to 99.0 ms.
- DOWN** Down slope time. Selectable range is 0.0 to 99.0 ms.
- COOL** Cool time: Selectable range is 0.0 to 99.0 ms.
- HOLD** Hold time. Selectable range is 0 to 999 ms.

APPENDIX D: SYSTEM TIMING

Basic Weld Operation: Manual Head System with Firing Switch Operation

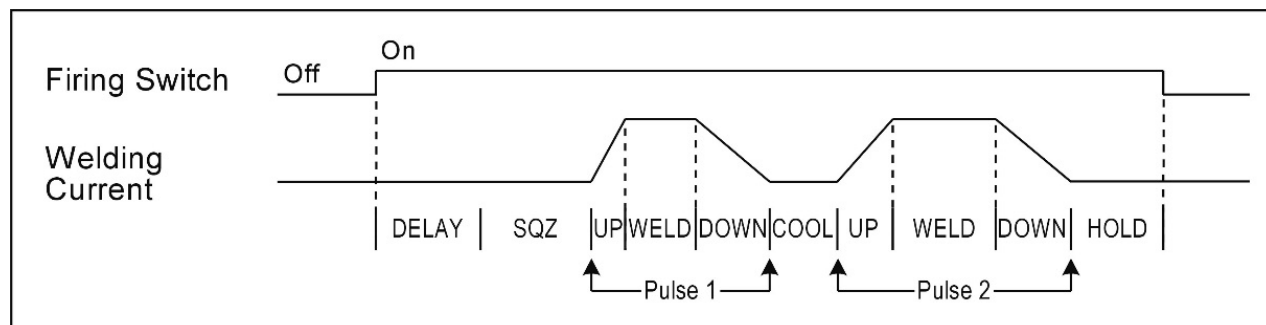


Definitions

DELAY	Delay time from firing switch closure to the start of the weld sequence (that is, start of SQZ). Maximum DELAY time is 2 ms, plus switch debounce time.
SQZ	Squeeze time. Selectable range is 0 to 999 ms.
UP	Up slope time. Selectable range is 0.0 to 99.0 ms.
WELD	Weld time. Selectable range is 0.0 to 99.0 ms.
DOWN	Down slope time. Selectable range is 0.0 to 99.0 ms.
COOL	Cool time. Selectable range is 0.0 to 99.0 ms.
HOLD	Hold time. Selectable range is 0 to 999 ms.

Basic Weld Operation: System with Remote Firing Switch

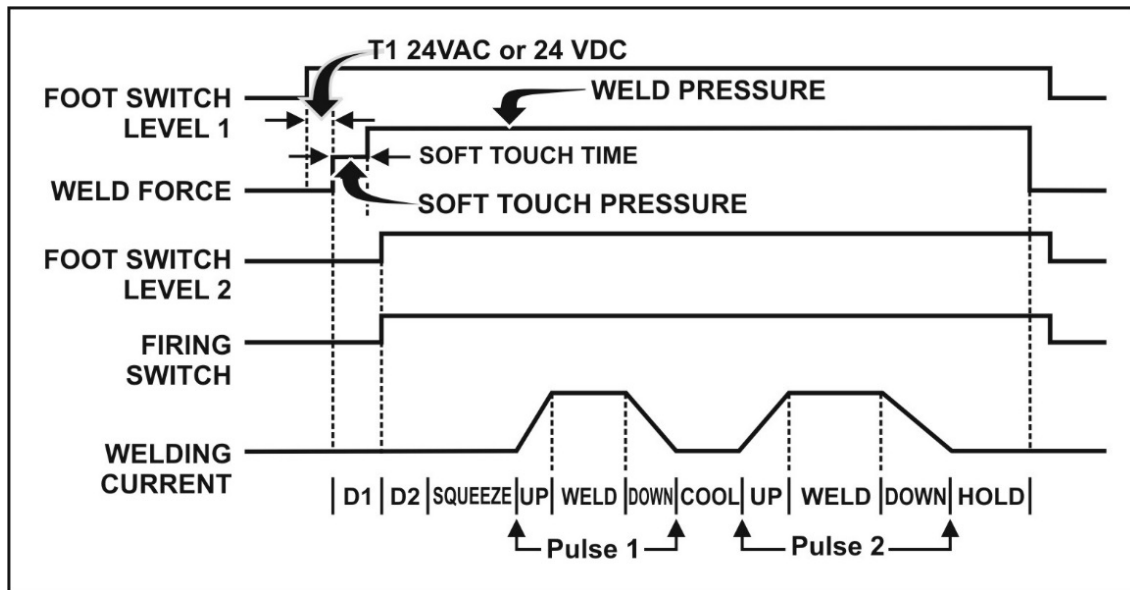
NOTE: The firing switch mode is selected under the Setup 1 menu.



Definitions

DELAY	Delay time from Remote Schedule Select Signal ON to the start of the weld sequence (that is, start of SQZ). DELAY time is 23 ms.
SQZ	Squeeze time. Selectable range is 0 to 999 ms.
UP	Up slope time. Selectable range is 0.0 to 99.0 ms.
WELD	Weld time. Selectable range is 0.0 to 99.0 ms.
DOWN	Down slope time. Selectable range is 0.0 to 99.0 ms.
COOL	Cool time. Selectable range is 0.0 to 99.0 ms.
HOLD	Hold time. Selectable range is 0 to 999 ms.

Basic Weld Operation: Air Head System with Two-Level Foot Switch



NOTE: The **SOFT TOUCH PRESSURE** feature is **not** available on the HF-2500A Power Supply, it is **only** available on HF-2700A Power Supply.

Definitions

- T1** Delay time from Foot Switch Level 1 closure to Weld Force start. Maximum delay time is 1 ms plus switch debounce time. Switch debounce time can be set to none, 10, 20, or 30 ms with the **SETUP 1** menu screen.
- T2** Soft touch time.
- D1** Delay time from Foot Switch Level 2 to Firing Switch closure. Maximum D1 time is 10 seconds. If the firing switch does not close within 10 seconds, the message **FIRING SWITCH DIDN'T CLOSE IN 10 SECONDS** will be displayed.
- D2** Delay time from Firing Switch closure and Foot Switch Level 2 closure to squeeze time (SQZ). Maximum D2 time is 2 ms plus switch debounce time.
- SQZ** Squeeze time. Selectable range is 0 to 999 ms. Note that for SQZ to start, Foot Switch level 2 must be ON, Soft touch time must be complete and the firing switch must be closed.
- UP** Up slope time. Selectable range is 0.0 to 99.0 ms.
- WELD** Weld time. Selectable range is 0.0 to 99.0 ms.
- DOWN** Down slope time. Selectable range is 0.0 to 99.0 ms.
- COOL** Cool time: Selectable range is 0.0 to 99.0 ms.
- HOLD** Hold time. Selectable range is 0 to 999 ms.

APPENDIX E

Communications

Overview

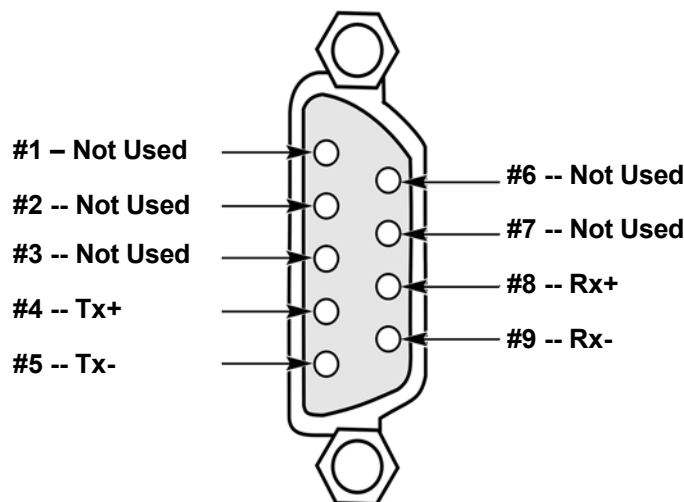
The Power Supply has the ability to communicate with a host computer or with an automation control system. The communications option uses either RS-232 to connect one Power Supply to one host, or RS-485 multi-drop architecture to connect up to 30 Power Supplies to one host on a single channel.

Remote Programming

The codes needed to perform remote programming are listed in *Section II. Communications Protocol and Commands*. Using these codes, users can write customized software for controlling all functions of the welding power supply and interfacing the unit to automation control systems.

RS-485 Connectors

The unit has two DB-9 (female) connectors wired as follows:

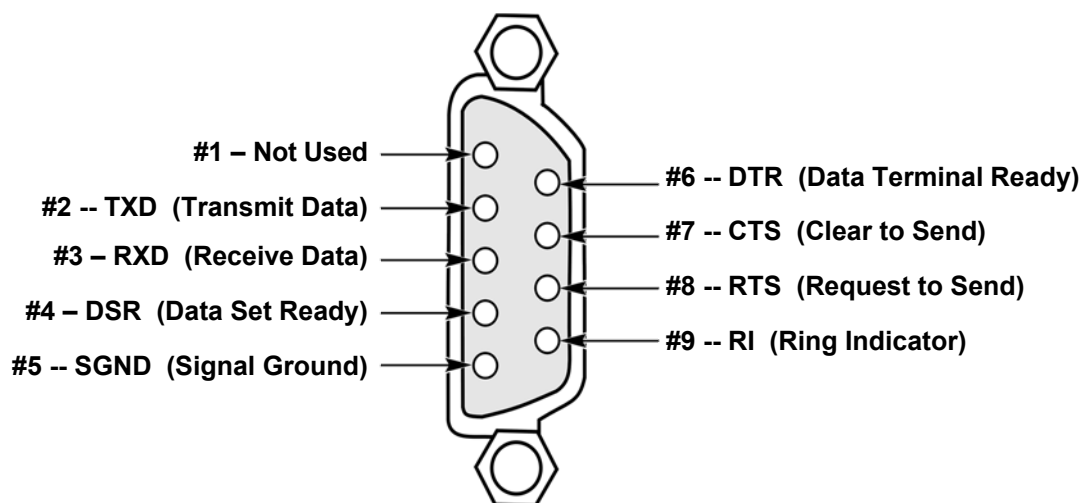


A terminating resistor assembly is supplied with the unit. If only one unit is connected to the host, the terminating resistor assembly must be installed in that unit. If multiple units are connected to the host, only one unit (the unit furthest from the host) must have the terminating resistor assembly installed.

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RS-232 Serial Connector Information

The serial port pin assignment is as follows:



Host settings

Baud Rate	1.2k, 2.4k, 4.8k, 9.6k, 14.4k, 19.2k, 28.8k, 38.4k (set on the unit)
Data bits	8
Stop bit	1
Parity	None

NOTES:

- The host must be set to the same baud rate as the unit. The computer hardware and operating system needed to support communication depends upon the RS-485 adapter (or converter box) used.
- For a microprocessor-based conversion (such as the Edgeport USB converter from Inside Outside Networks), the host computer should be at least a Pentium II-233 running Windows 98, Windows ME, Windows 2000, Windows XP or Windows NT 4.0. For a hardware-based converter without an internal microprocessor (such as the Telebyte model 285), the host computer should be at least a Pentium III-550 running Windows 98, Windows ME, Windows 2000, Windows XP or Windows NT 4.0.

For RS-485 communication, do **not** exceed the capacity of each channel. The product of:

(total number welds per second on all welders on that channel)

times

(total number of bytes exchanged per weld)

times

(8 bits per byte)

must in all cases remain **less** than the theoretical maximum capacity of the channel – the baud rate selected on the unit. This capacity is not an issue on RS-232 channels.

A good guideline is that on a line free of electrical noise, the number calculated above must remain less than 70% of the theoretical maximum capacity. Electrical noise on the communications lines will further reduce this capacity. Shielded cables are recommended.

Several commands require the unit to be in **HOST** mode for the unit to accept them. Those commands include the **REPORT** command and all **SET** commands. See the **HOST CNTL** command in *Chapter 3* and the **REMOTE** command below for more information.

Section II. Communications Protocol and Commands

Command Format

#ID **KEYWORD** *parameters* <crLf><lF>

UNIT IDENTIFICATION: *#ID* (*ID* is any number from “00” to “30”, must be a two digit number).

COMMAND KEYWORDS: **BOLD.**

VARIABLE: *italics.*

REQUIRED PARAMETERS: {enclosed in braces} (one required and only one parameter allowed).

CHOICE OF PARAMETERS: separated by vertical bar "|" indicates one *OR* another of choices presented.

REQUIRED/OPTIONAL PARAMETERS: [enclosed in brackets] (one or more allowed, used in the **SET** parameter)(zero allowed in the **READ** parameter).

RANGE OF PARAMETERS: *low_end - high_end* (separated by hyphen).

END OF PARAMETER TERMINATOR: <crLf> (carriage return followed by linefeed).

TERMINATION OF COMMAND: <lF> (linefeed - must be preceded by the end of line terminator <crLf>).

Each unit identifier, command keyword, and parameters must be separated by one or more spaces except the termination of command <lF> must follow the end of parameter terminator<crLf> immediately. I. E. “<crLf><lF>”

Computer Originated Commands

These are the commands sent by the host computer, via RS-485 or RS-232 to a Power Supply.

Command	STATUS <crLf><lF>
Control State	Any
Description	Requests the Power Supply to report the status of the weld data buffer. Power Supply returns STATUS with either “OK” or “OVERRUN.”
Command	TYPE <crLf><lF>
Control State	Any
Description	Requests the Power Supply to return the type of welder, release number, and revision letters.
Command	COUNT <crLf><lF>
Control State	Any
Description	Requests the Power Supply to report the number of weld data accumulated since the last data collection. Power Supply returns the COUNT even if there is no weld data available.
Command	ERASE <crLf><lF>
Control State	Any
Description	Requests the Power Supply to erase all the weld reports.
Command	SYNC <crLf><lF>
Control State	Any
Description	Provides synchronization of the commands. The Power Supply returns SYNC command back to the host computer.
Command	CURRENT <crLf><lF>
Control State	Any
Description	Requests the Power Supply to report the sampled Current data of the last weld. Power Supply shall return with CURRENT report. See CURRENT command under Power Supply Originating Commands section.
Command	VOLTAGE <crLf><lF>
Control State	Any
Description	Requests the Power Supply to report the sampled Voltage data of the last weld. Power Supply shall return with a VOLTAGE report. See VOLTAGE command under Power Supply Originating Commands section.
Command	POWER <crLf><lF>
Control State	Any
Description	Requests the Power Supply to report the sampled Power data of the last weld. Power Supply shall return with POWER report. See POWER command under Power Supply Originating Commands section.

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Command	OHMS <crLf><lF>
Control State	Any
Description	Requests the Power Supply to report the sampled resistance data of the last weld. Power Supply shall return with OHMS report. See OHMS command under Power Supply Originating Commands section.
Command	STATE { READ RUN MENU } <crLf><lF>
Control State	Any
Description	Commands the Power Supply to identify its current state ("READ" keyword, see STATE command under Power Supply Originating Commands section) or go to either RUN state or PROGRAM state.
Command	LOAD { <i>schedule_number</i> } <crLf><lF>
Control State	RUN state
Description	Selects the <i>schedule_number</i> as the currently loaded schedule. <i>schedule_number</i> may be any number from 0 to 99. There must be a space between LOAD and <i>schedule_number</i> .
Command	COUNTERS { READ SET } { TOTAL HIGH LOW GOOD } <crLf><lF>
Control State	Any
Description	Requests the Power Supply to return the Power Supply weld counter contents. TOTAL: Returns the total number of weld counter. HIGH: Returns the out of limits high counter. LOW: Returns the out of limits low counter. GOOD: Returns the within limits counter.
Command	REPORT { OLD ERASE } <i>number</i> <crLf><lF>
Control State	Any
Description	Requests the Power Supply to send the weld report. OLD: requests to send the number of oldest weld reports since the last data collection. The reported weld data will be erased. ERASE: a request to erase the number of oldest welds. <i>number:</i> the number of weld data to be sent. If the number is greater than the number of weld data in the buffer, less than the number of weld data will be sent. NOTE: There must be at least one space between each of the three field.

Command **COPY** {*from_schedule_number*} {*to_schedule_number*}<crLf><lF>
Control State Any
Description Allows one schedule to be copied to another schedule number. From_schedule_number and to_schedule_number may be any number from 0 to 99. Copying a schedule to itself has no effect other than to invoke a schedule printout when "PRINT SCHEDULES/PROGRAMS" is enabled.

Command **SCHEDULE**<crLf><lF>
Control State Any state *except* while welding.
Description Requests the Power Supply to return the currently selected schedule number.

Command **SCHEDULE {READ | SET}** <crLf>
 [*parameter_name value*<crLf>]
 <lF>
Control State RUN state.
Description Provides control over the Power Supply schedule parameters. When used with the "READ" keyword, all parameters pertaining to the currently loaded schedule are returned (see SCHEDULE under Power Supply Originated Commands). When the "SET" keyword is used, the host may set (change) the value of one or more of the parameters pertaining to the currently loaded schedule. The following is a list of valid literal substitutions for the parameter_name and value variables:

ENG1	{ <i>weld_energy</i> }	energy amount for pulse 1
FEEDBACK1	{ KA V KW }	feedback type for pulse 1
ENG2	{ <i>weld_energy</i> }	energy amount for pulse 2
FEEDBACK 2	{ KA V KW }	feedback type for pulse 2
SQUEEZE	{ <i>squeeze_time</i> }	squeeze time
UP1	{ <i>weld_time</i> }	up slope time of pulse 1
WELD1	{ <i>weld_time</i> }	weld time of pulse 1
DOWN1	{ <i>weld_time</i> }	down slope time of pulse 1
COOL	{ <i>weld_time</i> }	cool time
UP2	{ <i>weld_time</i> }	up slope time of pulse 2
WELD2	{ <i>weld_time</i> }	weld time of pulse 2
DOWN2	{ <i>weld_time</i> }	down slope time of pulse 2
HOLD	{ <i>hold_time</i> }	hold time
RINDEX1	{ <i>resistance index</i> }	index value into PID resistance table for pulse 1
RINDEX2	{ <i>resistance index</i> }	index value into PID resistance table for pulse 2
EINDEX1	{ <i>energy index</i> }	index value into PID energy table for pulse 1
EINDEX2	{ <i>energy index</i> }	index value into PID energy table for pulse 2

NOTES:

squeeze_time and *hold_time* are the parameter that defines the time for the given period in 1 msec. Valid range is from 0 to 999.

weld_time is the parameter that defines the time for the given period. . Each count of *weld_time* is equivalent to 0.01 for increments from 0.1 to 0.99 ms and increments of 0.1 ms for 1.0 to 9.9 ms and increments of 1.0 ms for 10.0 to 99.0 ms. (see table next page)

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HOST		POWER SUPPLY	
Increments	Range	Time Range	Increments
0.01	0.1 - 0.99	0.1 - 0.99 ms	0.01 ms
0.1	1.00 - 9.90	1.0 - 9.9 ms	0.1 ms
1.0	10.00 - 99.0	10.0 - 99.0 ms	1 ms

weld_energy is the parameter that specifies the amount of weld energy. In the current feedback mode, **weld_energy** is in unit of 0.001 kA. In the voltage feedback mode, **weld_energy** is in units of 0.001 V. In the power feedback mode, **weld_energy** is in units of 0.001 kW.

volt multiplier is an index value for a table of resistance vs. a PID multiplier for voltage mode. Note: Not used in versions where **RINDEXx** and **EINDEXx** are present.

resistance index is an index value into a table of resistance vs. energy PID tables. If 0, then a test pulse will occur on the next weld to determine the actual resistance (Note: customer control of this value is not recommended)

energy index is an index value into a PID energy vs. PID values table. (Note: customer control of this value is not recommended)

Command **MONITOR {READ | SET}<crLf>**
 [parameter_name value<crLf>]
 <lF>

Control State Any except while welding

Description Provides control over the basic weld monitor settings of the Power Supply schedule. When used with the "READ" keyword, the basic weld monitor settings of the currently loaded schedule are returned (see MONITOR under Power Supply Originated Commands). When the "SET" keyword is used, the host may set (change) the value of one or more of the parameters of the basic weld monitor settings pertaining to the currently loaded schedule. The following is a list of valid literal substitutions for the parameter_name and value variables:

MONTYPE1	{ KA V KW R }	Monitor Type for pulse 1
UPPER1	{ limit_value }	Upper Limit for pulse 1
LOWER1	{ limit_value }	Lower Limit for pulse 1
ACTION1	{ none STOP INHIBIT APC }	Out of Limit Action for pulse 1
MONTYPE2	{ KA V KW R }	Monitor Type for pulse 2
UPPER2	{ limit_value }	Upper Limit for pulse 2
LOWER2	{ limit_value }	Lower Limit for pulse 2
ACTION2	{ none STOP }	Out of Limit Action for pulse 2
P1LDLY1	{ delay_value }	Pulse 1 Lower Delay Start Time For Lower Limit
P1LDLY2	{ delay_value }	Pulse 1 Lower Delay End Time For Lower Limit
P1UDLY1	{ delay_value }	Pulse 1 Upper Delay Start Time For Upper Limit
P1UDLY2	{ delay_value }	Pulse 1 Upper Delay End Time For Upper Limit

P2LDLY1	{delay_value}	Pulse 2 Lower Delay Start Time For Lower Limit
P2LDLY2	{delay_value}	Pulse 2 Lower Delay End Time For Lower Limit
P2UDLY1	{delay_value}	Pulse 2 Upper Delay Start Time For Upper Limit
P2UDLY2	{delay_value}	Pulse 2 Upper Delay End Time For Upper Limit

limit_value is the parameter that specifies the range of the valid readings. If the reading was within the range of the *limit_value*, no alarm will occur. If the reading was out of the valid range, an alarm will occur. If the monitor type is KA, the *limit_value* is in unit of 1 A. If the monitor type is V, the *limit_value* is in unit of 1 mV. If the monitor type is kW, the *limit_value* is in unit of 1 W. The valid number for *limit_value* is 1 through 9999 and 0 is for none.

The **delay_value** is the parameter that defines the time for the given period in 0.1 ms. Valid range is from 0 to 99. Lower delay value is only valid during WELD time. Upper delay value is valid during UP time, WELD time, and DOWN time.

Command **RELAY {READ | SET} <crLf>**
 [*parameter_name value*<crLf>]
 <lF>

Control State Any except while welding

Description Provides control over the Power Supply schedule parameters for relay settings. When used with the "READ" keyword, the relay settings of the currently loaded schedule are returned (see **RELAY** under Power Supply Originated Commands). When the "SET" keyword is used, the host may set (change) the value of one or more of the relay settings of the currently loaded schedule. The following is a list of valid literal substitutions for the *parameter_name* and *value* variables:

ACTIVE1	{ HIGH LOW }	Relay 1 Active High or Active Low
CONDITION1	<i>condition_value</i>	Relay 1 Active Conditions
SUBCOND1	<i>extended_condition_value</i>	Relay 1 Extended Conditions.
ACTIVE2	{ HIGH LOW }	Relay 2 Active High or Active Low
CONDITION2	<i>condition_value</i>	Relay 2 Active Conditions
SUBCOND2	<i>extended_condition_value</i>	Relay 2 Extended Conditions.
ACTIVE3	{ HIGH LOW }	Relay 3 Active High or Active Low
CONDITION3	<i>condition_value</i>	Relay 3 Active Conditions
SUBCOND3	<i>extended_condition_value</i>	Relay 3 Extended Conditions.
ACTIVE4	{ HIGH LOW }	Relay 4 Active High or Active Low
CONDITION4	<i>condition_value</i>	Relay 4 Active Conditions
SUBCOND4	<i>extended_condition_value</i>	Relay 4 Extended Conditions.

condition_value: { **ALARM** | **LIMITS** | **WELD** | **END** | **P1HI** | **P1LOW** | **P2HI**
 | **P2LOW** | **MG3** }

NOTE: *extended_condition_value*:

P1HI, P1LOW: Pulse 1 hi/low limit reached.

P2HI, P2LOW: Pulse 2 hi/low limit reached.

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Command	SYSTEM {READ SET}<crLf> [<i>parameter_name value</i> <crLf>] <lf>
Control State	Any
Description	Provides control over the Power Supplies system parameters. When used with the "READ" keyword, all system parameters are returned (see SYSTEM under Power Supply Originated Commands). When used with the "SET" keyword, the host may set (change) the value of one or more of the system parameters.

The following is a list of valid literal substitutions for the *parameter_name* and *value* variables:

LIGHT	{ <i>light_value</i> }	LCD contrast
LOUDNESS	{ <i>loudness_value</i> }	Buzzer Loudness
BUZZER	{ OFF ON }	end of cycle buzzer
DISPLAY	{ PEAK AVG }	Display mode
SWSTATE	{ <i>switch_state</i> }	Input Switch Type
CTSTATE	{ <i>switch_state</i> }	Control Signals Type
FIRESW	{ AUTO REMOTE NONE }	Firing Switch Type
GRAPH	{ OFF ON }	Update Graph
WELDABORT	{ OFF ON }	Footswitch weld abort
DEBOUNCE	{ NONE 10 20 30 }	Switch debounce time in msec

These parameters pertain to the settings of the option menus available via the front panel user interface.

light_value is a number 0 to 100 for brightness of the LCD. 0 is dark and 100 is the brightest.

loudness_value is a number 0 to 100 for buzzer loudness. 0 is off and 100 is the loudest.

switch_state: { MECHOPEN | MECHCLOSED | OPTOOPEN | OPTOCLOSED
| PLC0V | PLC24V }

Command	ALARM {READ CLEAR SET <i>error_number</i> DISPLAY <i>alarm_message_string</i>} <crLf><lF>
Control State	Any
Description	Provides access to the Power Supply alarm logic. When used with the "READ" keyword, the current error condition value is returned. See Appendix A. for list of alarm messages. When the "CLEAR" keyword is used, all alarm conditions are canceled. When the "SET" keyword is used, the host may invoke an error identified by <i>error_number</i> . When the "DISPLAY" keyword is used, an error condition can be created with any message desired. The length of the error message must be limited to 40 characters or less. No help message will be available in connection with this created error message.
Command	SECURITY {OFF SCHEDULE SYSTEM CALIBRATION} <crLf><lF>
Control State	Any
Description	Allows control of the system security mode. “OFF” sets all security status Power Supply to “OFF.” “SCHEDULE” sets the schedule lock to “ON.” “SYSTEM” sets the system lock to “ON.” “CALIBRATION” sets the calibration lock to “ON.”

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Power Supply Originated Commands

These are the commands sent from a Power Supply to a host computer.

Command	STATUS <i>state_name</i> <crLf><lF>
Control State	Any
Description	Identifies the current status of the weld data buffer. May be in response with “OK” or “OVERRUN.” “OK” means that the Power Supply weld buffer did not over-run since the last data collection and all the data are intact. “OVERRUN” means that the Power Supply weld buffer did over-run since the last data collection and only the latest 900 weld data are available to report.
Command	TYPE <i>type, release numbers, revision letters</i> <crLf><lF>
Control State	Any
Description	Returns “HF25 1.00 A 37250” for the first release of an HF-2500A.
Command	COUNT <i>number</i> <crLf><lF>
Control State	Any
Description	Returns the number of weld data available in Power Supply. The total number of weld data that the Power Supply holds in the buffer is 900.
Command	NAME <i>schedule_name</i> <crLf><lF>
Control State	Any
Description	Returns the current schedule’s name up to a maximum of 20 characters.
Command	STATE <i>state_name</i> <crLf><lF>
Control State	Any
Description	Identifies the current state of operation of the Power Supply. May be in response to the STATE READ Command sent by the host, or may be sent as a result of a state change from the Power Supply front panel. <i>state_name</i> may be “RUN”, “MENU”, “MONITOR”, “RUN <NO WELD>”, “MENU <NO WELD>”, or “MONITOR <NO WELD>”
Command	COUNTERS <crLf> TOTAL <i>number</i> <crLf> HIGH <i>number</i> <crLf> LOW <i>number</i> <crLf> GOOD <i>number</i> <crLf> <lF>
Control State	Any
Description	Returns the requested current Power Supply weld counter values.

Command	ALARM <i>error_message</i> <crLf><lF>
Control State	Any
Description	Identifies the current error condition of operation of the Power Supply. May be in response to the ALARM READ command sent by the host, or may be sent as a result of an error condition occurring in the Power Supply. error_message is a text string describing the error message, which is the same error message that is displayed to the screen.
Command	CURRENT <i>number_of_data</i> <crLf> data <crLf> data <crLf> data <crLf><lF>
Control State	Any
Description	Returns the Current waveform data of the last weld. First field is the number of data to be sent. Then follows the packets of data. Each data is separated by <crLf> and this command ends with <crLf><lF>. number_of_data: This is the number of data that shall be included in this command. The Power Supply samples current every 40 μs. For a weld less than 80 ms weld time, the number of data will be approximately: $total\ weld\ time \div 40\ \mu s$. This number will always be less than 2000. data: an integer number in unit of A.
Command	VOLTAGE <i>number_of_data</i> <crLf> data <crLf> data <crLf> data <crLf><lF>
Control State	Any
Description	Returns the Voltage waveform data of the last weld. First field is the number of data to be sent. Then follows the packets of data. Each data is separated by <crLf> and this command ends with <crLf><lF>. number_of_data: This is the number of data that shall be included in this command. The Power Supply samples Voltage every 40 μs. For a weld less than 80 ms weld time, the number of data will be approximately: $total\ weld\ time \div 40\ \mu s$. This number will always be less than 2000. data: An integer number in unit of mV.
Command	POWER <i>number_of_data</i> <crLf> data <crLf> data <crLf> data <crLf><lF>
Control State	Any
Description	Returns the Power waveform data of the last weld. First field is the number of data to be sent. Then follows the packets of data. Each data is separated by <crLf> and this command ends with <crLf><lF>. number_of_data: This is the number of data that shall be included in this Command. The Power Supply samples Current and Voltage every 40 μs. For a weld less than 80 ms weld time, the number of data will be approximately: $total\ weld\ time \div 40\ \mu s$. This number will be always less than 2000. data: An integer number in unit of W.

APPENDIX E. COMMUNICATIONS

Command	OHMS <i>number_of_data</i> <crLf> data <crLf> data <crLf> data <crLf><lf>
Control State	Any
Description	Returns the Resistance waveform data of the last weld. First field is the number of data to be sent. Then follows the packets of data. Each data is separated by <crLf> and this command ends with <crLf><lf>. <i>number_of_data:</i> This is the number of data that shall be included in this Command. The Power Supply samples Current and Voltage every 40 μ s. For a weld less than 80 ms weld time, the number of data will be approximately: <i>total weld time</i> $\div$ 40 μ s. This number will be always less than 2000. <i>data:</i> An integer number in unit of mOhms.
Command	SYNC <crLf><lf>
Control State	Any
Description	The Power Supply return SYNC command back to the host computer when the SYNC command is received from the host computer.
Command	SYSTEM <crLf> LIGHT { <i>light_value</i> }<crLf> BUZZER { OFF ON }<crLf> LOUDNESS { <i>loudness_value</i> }<crLf> DISPLAY { PEAK AVG }<crLf> SWSTATE { <i>switch_state</i> }<crLf> CTSTATE { <i>switch_state</i> }<crLf> FIRESW { AUTO REMOTE NONE } <crLf> FIRESW { AUTO OPTO NONE } <crLf> GRAPH { OFF ON } <crLf> WELDABORT { OFF ON } <crLf> DEBOUNCE { NONE 10 20 30 } <crLf> <lf>
Control State	Any
Description	Reports the current settings of the Power Supply system parameters. <i>light_value</i> is a number 0 to 99 for brightness of the LCD. 0 is dark and 100 is the brightest. <i>loudness_value</i> is a number 0 to 99 for buzzer loudness. 0 is off and 100 is the loudest. <i>switch_state:</i> { MECHOPEN MECHCLOSED OPTOOPEN OPTOCLOSED PLC0V PLC24V }

Command	REPORT <i>type_of_report</i> <i>number_of_reports</i> <crLf> <i>report</i> <crLf> <i>report</i> <crLf> <i>report</i> <crLf><lf>																																																
Control State	Any																																																
Description	Returns the requested number of weld reports. First field is the type of reports to be sent. The second field is the number of reports sent. Then follows the packets of report. One report pack holds the information about the weld requested. Each report packet is separated by <crLf> and this Command ends with <crLf><lf>. Type_of_report: This field defines the type of report that was requested by the host computer. The fields in the report packet are separated with a comma and all fields are in integer format. There are always 24,027 fields in a report packet. OLD: Number_of_reports: This is the number of reports that shall be included in this command. If the host computer requests more weld data than is available in the weld data buffer, the Power Supply sends only the weld reports in the weld buffer and the <i>number_of_reports</i> is the number of weld reports available in the weld data buffer. After the report is sent to the host computer, the Power Supply does not erase the weld data sent to the host from the weld data buffer. You must use the REPORT ERASE # command to erase weld data from the weld buffer. <table> <tr> <td><i>unit_number:</i></td><td>The unit number assigned to the unit.</td></tr> <tr> <td><i>Schedule_number:</i></td><td>The schedule number of the weld.</td></tr> <tr> <td><i>weld_status:</i></td><td>The status of the weld.</td></tr> <tr> <td><i>Average_current_1:</i></td><td>The average current of pulse 1 (in A).</td></tr> <tr> <td><i>Average_voltage_1:</i></td><td>The average voltage of pulse 1(in mV).</td></tr> <tr> <td><i>peak_current_1:</i></td><td>The peak current of pulse 1 (in A).</td></tr> <tr> <td><i>peak_voltage_1:</i></td><td>The peak voltage of pulse 1 (in mV).</td></tr> <tr> <td><i>average_power_1:</i></td><td>The average power of pulse 1 (in W).</td></tr> <tr> <td><i>peak_power_1:</i></td><td>The peak power of pulse 1 (in W).</td></tr> <tr> <td><i>average_resistance_1:</i></td><td>The average resistance of pulse 1 (in 10⁻⁵ Ω).</td></tr> <tr> <td><i>peak_resistance_1:</i></td><td>The peak resistance of pulse 1 (in 10⁻⁵ Ω).</td></tr> <tr> <td><i>null_1:</i></td><td>Always zero</td></tr> <tr> <td><i>null_2:</i></td><td>Always zero</td></tr> <tr> <td><i>average_current_2:</i></td><td>The average current of pulse 2 (in A).</td></tr> <tr> <td><i>average_voltage_2:</i></td><td>The average voltage of pulse 2(in mV).</td></tr> <tr> <td><i>peak_current_2:</i></td><td>The peak current of pulse 2 (in A).</td></tr> <tr> <td><i>peak_voltage_2:</i></td><td>The peak voltage of pulse 2 (in mV).</td></tr> <tr> <td><i>average_power_2:</i></td><td>The average power of pulse 2 (in W).</td></tr> <tr> <td><i>peak_power_2:</i></td><td>The peak power of pulse 2 (in W).</td></tr> <tr> <td><i>average_resistance_2:</i></td><td>The average resistance of pulse 2 (in 10⁻⁵ Ω).</td></tr> <tr> <td><i>peak_resistance_2:</i></td><td>The peak resistance of pulse 2 (in 10⁻⁵ Ω).</td></tr> <tr> <td><i>null_3:</i></td><td>Always zero</td></tr> <tr> <td><i>null_4:</i></td><td>Always zero</td></tr> <tr> <td><i>Weld_count:</i></td><td>The number of this weld assigned by the unit</td></tr> </table>	<i>unit_number:</i>	The unit number assigned to the unit.	<i>Schedule_number:</i>	The schedule number of the weld.	<i>weld_status:</i>	The status of the weld.	<i>Average_current_1:</i>	The average current of pulse 1 (in A).	<i>Average_voltage_1:</i>	The average voltage of pulse 1(in mV).	<i>peak_current_1:</i>	The peak current of pulse 1 (in A).	<i>peak_voltage_1:</i>	The peak voltage of pulse 1 (in mV).	<i>average_power_1:</i>	The average power of pulse 1 (in W).	<i>peak_power_1:</i>	The peak power of pulse 1 (in W).	<i>average_resistance_1:</i>	The average resistance of pulse 1 (in 10 ⁻⁵ Ω).	<i>peak_resistance_1:</i>	The peak resistance of pulse 1 (in 10 ⁻⁵ Ω).	<i>null_1:</i>	Always zero	<i>null_2:</i>	Always zero	<i>average_current_2:</i>	The average current of pulse 2 (in A).	<i>average_voltage_2:</i>	The average voltage of pulse 2(in mV).	<i>peak_current_2:</i>	The peak current of pulse 2 (in A).	<i>peak_voltage_2:</i>	The peak voltage of pulse 2 (in mV).	<i>average_power_2:</i>	The average power of pulse 2 (in W).	<i>peak_power_2:</i>	The peak power of pulse 2 (in W).	<i>average_resistance_2:</i>	The average resistance of pulse 2 (in 10 ⁻⁵ Ω).	<i>peak_resistance_2:</i>	The peak resistance of pulse 2 (in 10 ⁻⁵ Ω).	<i>null_3:</i>	Always zero	<i>null_4:</i>	Always zero	<i>Weld_count:</i>	The number of this weld assigned by the unit
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APPENDIX E. COMMUNICATIONS

WELD STATUS CODES

Number	Status Message
0	GOOD
1	CHECK CONTROL SIGNALS INPUT STATUS
2	CHECK INPUT SWITCH STATUS
3	FIRING SWITCH BEFORE FOOT SWITCH
4	STOP ON CONTROL SIGNALS INPUT
5	POWER TRANSISTOR OVERHEATED
6	EMERGENCY STOP - OPERATOR ACTIVATED
7	FIRING SWITCH DIDN'T CLOSE IN 10 SECOND
8	WELD TRANSFORMER OVERHEATED
9	TEST WELD
10	VOLTAGE SELECTION PLUG IS MISSING
11	INHIBIT CONTROL SIGNALS ACTIVATED
12	LOW BATTERY
13	NO CURRENT READING
14	NO VOLTAGE READING
15	LOAD RESISTANCE TOO HIGH
16	NO WELD TRANSFORMER DETECTED
17	WELD SWITCH IN NO WELD POSITION
18	CHECK VOLTAGE CABLE & SECONDARY CIRCUIT
19	CALIBRATION RESET TO DEFAULT
20	LOWER LIMIT GREATER THAN UPPER LIMIT
21	COOL TIME ADDED FOR DIFFERENT FEEDBACK
22	ENERGY SETTING TOO SMALL
23	SYSTEM & SCHEDULE RESET TO DEFAULTS
24	LIMITS ROUND UP
25	CHAINED TO NEXT SCHEDULE
26	SAFE ENERGY LIMIT REACHED
27	P1 LOWER LIMIT DELAYS ADJUSTED
28	P1 UPPER LIMIT DELAYS ADJUSTED
29	P2 LOWER LIMIT DELAYS ADJUSTED
30	P2 UPPER LIMIT DELAYS ADJUSTED
31	UPSLOPE REQUIRED FOR LOWER LIMIT

APPENDIX E. COMMUNICATIONS

WELD STATUS CODES

Number	Status Message
32	INPUT TOO LARGE
33	INPUT TOO SMALL
34	PRESS RUN BEFORE WELDING
35	ERASE FAILED
36	PROGRAM FAILED
37	NO LOWER LIMIT WITH STOP P1 ACTION
38	LIMIT DELAYS RESET TO 0
39	ACCESS DENIED! SYSTEM SECURITY ON
40	ILLEGAL SECURITY CODE ENTERED
41	NOT USED
42	NOT USED
43	NOT USED
44	NOT USED
45	NOT USED
46	NOT USED
47	ACCESS DENIED! SCHEDULE LOCK ON
48	NOT USED
49	NOT USED
50	NOT USED
51	NOT USED
52	NOT USED
53	NOT USED
54	NOT USED
55	CURRENT1 > UPPER LIMIT
56	CURRENT1 < LOWER LIMIT
57	VOLTAGE1 > UPPER LIMIT
58	VOLTAGE1 < LOWER LIMIT
59	POWER1 > UPPER LIMIT
60	POWER1 < LOWER LIMIT
61	RESISTANCE1 > UPPER LIMIT
62	RESISTANCE1 < LOWER LIMIT
63	NOT USED
64	NOT USED

HF-2500A HIGH FREQUENCY WELD CONTROL

APPENDIX E. COMMUNICATIONS

WELD STATUS CODES

Number	Status Message
65	SCHEDULES ARE RESET
66	SYSTEM PARAMETERS ARE RESET
67	PULSE 1 LOWER LIMIT REACHED
68	PULSE 1 UPPER LIMIT REACHED
69	WELD TIME TOO SMALL
70	NOT USED
71	CURRENT2 > UPPER LIMIT
72	CURRENT2 < LOWER LIMIT
73	VOLTAGE2 > UPPER LIMIT
74	VOLTAGE2 < LOWER LIMIT
75	POWER2 > UPPER LIMIT
76	POWER2 < LOWER LIMIT
77	RESISTANCE2 > UPPER LIMIT
78	RESISTANCE2 < LOWER LIMIT
79	INHIBIT 2ND PULSE
80	WELD STOP - LIMIT REACHED
81	SYSTEM ERROR: BUS ERROR
82	SYSTEM ERROR: SOFTWARE INTERRUPT
83	SYSTEM ERROR: ILLEGAL INSTRUCTION
84	SYSTEM ERROR: DIVIDED BY ZERO
85	SYSTEM ERROR: SPURIOUS INTERRUPT
86	COOL TIME MINIMUM
87	TEST WELD? [MENU]=NO [RUN]=YES
88	NOT USED
89	NOT USED
90	NOT USED
91	NOT USED
92	NOT USED

Command SCHEDULE *schedule_number* <cr><lf>

Control State Any

Description Returns the current schedule number to the host. Schedule_number may be any number from 0 to 99.

Command	SCHEDULE	<i>schedule_number</i> <crLf>
	ENG1	<i>weld_energy</i> <crLf>
	FEEDBACK1	{ KA V KW } <crLf>
	ENG2	<i>weld_energy</i> <crLf>
	FEEDBACK2	{ KA V KW } <crLf>
	SQUEEZE	<i>squeeze_time</i> <crLf>
	UP1	<i>weld_time</i> <crLf>
	WELD1	<i>weld_time</i> <crLf>
	DOWN1	<i>weld_time</i> <crLf>
	COOL	<i>weld_time</i> <crLf>
	UP2	<i>weld_time</i> <crLf>
	WELD2	<i>weld_time</i> <crLf>
	DOWN2	<i>weld_time</i> <crLf>
	HOLD	<i>hold_time</i> <crLf>
	RINDEX1	<i>resistance_index</i> <crLf>
	RINDEX2	<i>resistance_index</i> <crLf>
	EINDEX1	<i>energy_index</i> <crLf>
	EINDEX2	<i>energy_index</i> <crLf>
	<lF>	

Control State Any

Description Reports the settings of the currently loaded Power Supply schedule parameters. The *schedule_number* variable identifies which schedule is currently loaded, and may be any value from 0 to 99.

squeeze_time and *hold_time* are the parameter that defines the time for the given period in 1 msec. Valid range is from 0 to 999.

weld_time is equivalent to 0.01 for Increments from 0.1 to 0.99 ms and increments of 0.1 ms for 1.0 to 9.9 ms and increments of 1.0 ms for 10.0 to 99.0 msec. (see table below)

HOST		POWER SUPPLY	
Increments	Range	Time Range	Increments
0.01	0.1 - 0.99	0.1 - 0.99 ms	0.01 ms
0.1	1.00 - 9.90	1.0 - 9.9 ms	0.1 ms
1.0	10.00 - 99.0	10.0 - 99.0 ms	1 ms

APPENDIX E. COMMUNICATIONS

weld_energy is the parameter that specifies the amount of weld energy.

- **Current Feedback** mode: the **weld_energy** range for the HF-2500A is from 10 to 2.400 A (10 to 2400).
- **Voltage Feedback** mode: **weld_energy** for the HF-2500A is in units of 0.001 V, and the range is from 0.200 to 9.9V (200 to 9900). (Note: Maximum attainable voltage is dependent on the HF-2500A model and the load resistance).
- **Power Feedback** mode: **weld_energy** for the HF-2500A is in units of 1 W, and the range is from 10 W to 9900 W (10 to 9900).

volt multiplier is the index value for a table of resistance vs. a PID multiplier for voltage mode (used for the last weld). Note: Not used in versions where **RINDEXx** and **EINDEXx** are present.

resistance index is the index value into a table of resistance vs. energy PID tables used for the last weld.

energy index is the index value into a PID energy vs. PID values table used for the last weld.

Command	MONITOR	<i>schedule_number</i> <crLf>
	MONTYPE1	{ KA V KW R }<crLf>
	UPPER1	{ limit_value }<crLf>
	LOWER1	{ limit_value }<crLf>
	ACTION1	{ none STOP INHIBIT APC }<crLf>
	MONTYPE2	{ KA V KW R }<crLf>
	UPPER2	{ limit_value }<crLf>
	LOWER2	{ limit_value }<crLf>
	ACTION2	{ none STOP }<crLf>
	P1LDLY1	{ delay_value }<crLf>
	P1LDLY2	{ delay_value }<crLf>
	P1UDLY1	{ delay_value }<crLf>
	P1UDLY2	{ delay_value }<crLf>
	P2LDLY1	{ delay_value }<crLf>
	P2LDLY2	{ delay_value }<crLf>
	P2UDLY1	{ delay_value }<crLf>
	P2UDLY2	{ delay_value }<crLf>
	<lF>	
Control State	Any	
Description	Reports the settings of the weld monitor of the currently loaded Power Supply schedule. The schedule_number variable identifies which schedule is currently loaded, and may be any value from 0 to 99. The possible value for all variables listed after their parameter name correspond to the values listed under MONITOR in <i>Host Originated Commands</i> of this manual.	

Command	RELAY <crLf> ACTIVE1 { HIGH LOW }<crLf> CONDITION1 {condition_value}<crLf> SUBCOND1 {extended_condition_value}<crLf> ACTIVE2 { HIGH LOW }<crLf> CONDITION2 {condition_value}<crLf> SUBCOND2 {extended_condition_value}<crLf> ACTIVE3 { HIGH LOW }<crLf> CONDITION3 {condition_value}<crLf> SUBCOND3 {extended_condition_value}<crLf> ACTIVE4 { HIGH LOW }<crLf> CONDITION4 {condition_value}<crLf> SUBCOND4 {extended_condition_value}<crLf> <lF> condition_value: { ALARM LIMITS WELD END P1HI P1LOW P2HI P2LOW} extended_condition_value: { P1HI P1LOW P2HI P2LOW} NOTES: P1HI, P1LOW: Pulse 1 low/hi limit reached. P2HI, P2LOW: Pulse 2 low/hi limit reached.	
Control State	Any	
Description	Reports the relay settings.	
Command	SECURITY<crLf> SCHEDULE { ON OFF }<crLf> SYSTEM { ON OFF }<crLf> CALIBRATION { ON OFF }<crLf><lF>	
Control State	Any	
Description	Returns the current status of the security settings.	

APPENDIX F

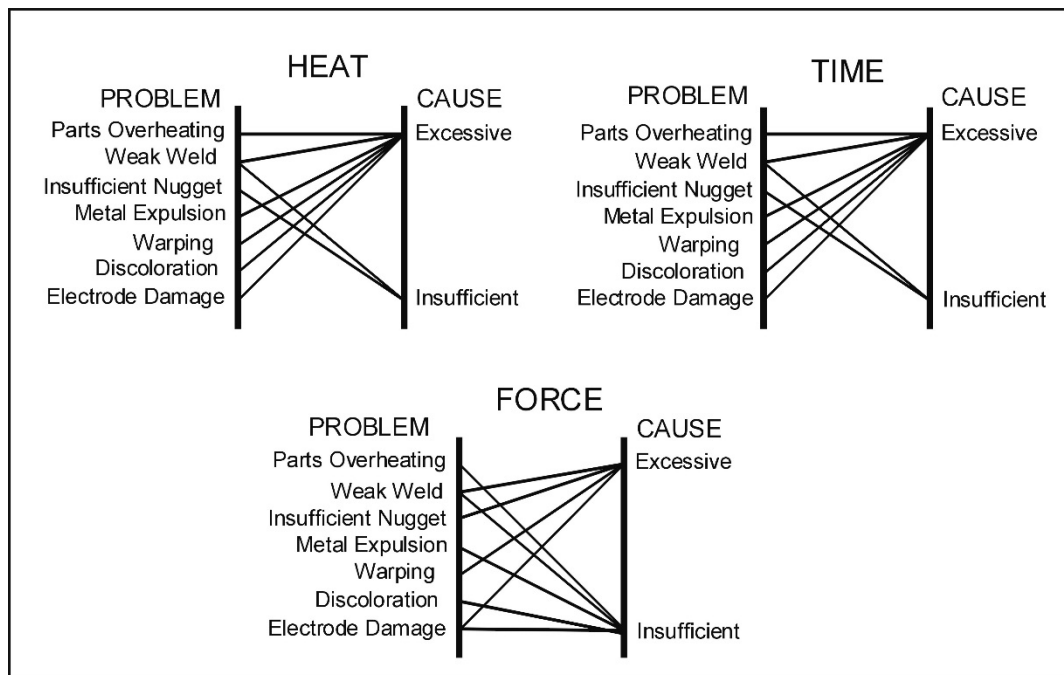
The Basics of Resistance Welding

Resistance Welding Parameters

Resistance welding heat is produced by passing electrical current through the parts for a fixed time period. The welding heat generated is a function of the magnitude of the weld current, the electrical resistance of the parts, the contact resistance between the parts, and the weld force applied to the parts. Sufficient weld force is required to contain the molten material produced during the weld. However, as the force is increased, the contact resistance decreases. Lower contact resistance requires additional weld current, voltage, or power to produce the heat required to form a weld.

The higher the weld force, the greater the weld **current**, **voltage**, **power**, or **time** required to produce a given weld. The formula for amount of heat generated is I^2RT -- the square of the weld current [**I**] times the workpiece resistance [**R**] times the weld time [**T**].

Welding Parameter Interaction



Interaction of Welding Parameters

APPENDIX F: THE BASICS OF RESISTANCE WELDING

Electrode Selection

Correct electrode selection strongly influences how weld heat is generated in the weld area. In general, use conductive electrodes such as a RWMA-2 (Copper alloy) when welding electrically resistive parts such as nickel or steel so that the weld heat is generated by the electrical resistance of the parts and the contact resistance between the parts. Use resistive electrodes such as RWMA-13 (Tungsten) and RWMA-14 (Molybdenum) to weld conductive parts such as copper and gold because conductive parts do not generate much internal heat so the electrodes must provide external heat. Use the following Electrode Selection Table for selecting the proper electrode materials.

MATERIAL	ELECT RWMA TYPE	MATERIAL	ELECT RWMA TYPE
Alumel	-2	Alumel	-2
Alumel	-2	Chromel	-2
Alumel	-2	Dumet	-2
Aluminum	-1	Aluminum	-1
Aluminum	-1	Aluminum Alloys	-1
Aluminum	-1	Cadmium Plating	-1
Aluminum	-1	Tinned Brass	-14
Aluminum	-1	Tinned Copper	-14
Aluminum	-1	Gold Plated Dumet	-2
Aluminum	-1	Gold Plated Kovar	-2
Aluminum	-1	Kovar	-2
Aluminum	-1	Magnesium	-1
Aluminum	-1	Cold Rolled Steel	-2
Aluminum	-1	Stainless Steel	-2
Beryllium Copper	-2	Beryllium Copper	-2
Beryllium Copper	-2	Brass	-2, -14
Beryllium Copper	-2	Copper	-14
Beryllium Copper	-2	Tinned Copper	-14
Beryllium Copper	-2	Nickel	-2

MATERIAL	ELECT RWMA TYPE	MATERIAL	ELECT RWMA TYPE
Beryllium Copper	-2	Cold Rolled Steel	-2
Beryllium Copper	-2	Stainless Steel	-2
Brass	-2, -14	Brass	-2, -14
Brass	-2, -14	Tinned Brass	-14
Brass	-2, -14	Consil	-2
Brass	-2, -14	Constantan	-2
Brass	-2, -14	Copper	-14
Brass	-2, -14	Tinned Copper	-14
Brass	-2, -14	Dumet	-2
Brass	-2, -14	Nichrome	-2
Brass	-2, -14	Nickel	-2
Brass	-2, -14	NiSpan C	-2
Brass	-2, -14	Paliney 7	-2
Brass	-2, -14	Silver	-11, -14
Brass	-2, -14	Cold Rolled Steel	-2
Brass	-2, -14	Stainless Steel	-2
Bronze	-2, -11	Bronze	-2, -11
Bronze	-2, -11	Tinned Copper	-14
Bronze	-2, -11	Iron	-2

APPENDIX F: THE BASICS OF RESISTANCE WELDING

MATERIAL	ELECT RWMA TYPE	MATERIAL	ELECT RWMA TYPE
Bronze	-2, -11	Nichrome	-2
Bronze	-2, -11	Nickel	-2
Chromel	-2	Chromel	-2
Chromel	-2	Constantan	-2
Chromel	-2	Copel	-2
Chromel	-2	Copper	-14
Chromel	-2	Tinned Copper	-14
Chromel	-2	Dumet	-2
Chromel	-2	Nichrome	-2
Chromel	-2	Cold Rolled Steel	-2
Consil	-2	Consil	-2
Consil	-2	Tinned Copper	-14
Consil	-2	Dumet	-2
Constantan	-2	Constantan	
Constantan	-2	Copper	-14
Constantan	-2	Tinned Copper	-14
Constantan	-2	Iron	-2
Constantan	-2	Nichrome	-2
Constantan	-2	Nickel	-2
Copper	-14	Copper	-14
Copper	-14	Dumet	-2
Copper	-14	Invar	-2
Copper	-14	Karme	-2
Copper	-14	Manganin	-2
Copper	-14	Nichrome	-2
Copper	-14	Nickel	-2
Copper	-14	Paliney 7	-2

MATERIAL	ELECT RWMA TYPE	MATERIAL	ELECT RWMA TYPE
Copper	-14	Silver	-11, -14
Copper	-14	Cold Rolled Steel	-2
Copper	-14	Stainless Steel	-2
Dumet	-2	Dumet	-2
Dumet	-2	Nichrome	-2
Dumet	-2	Nickel	-2
Dumet	-2	Platinum	-2
Dumet	-2	Cold Rolled Steel	-2
Evanohm	-14	Copper	-14
Gold	-14	Gold	-14
Gold	-14	Kovar	-2
Hastalloy	-2	Titanium	-2
Inconel	-2	Inconel	-2
Inconel	-2	Kulgrid	-2
Invar	-2	Invar	-2
Iridium	-2	Iridium	-2
Iridium	-2	Platinum	-2
Iron	-2	Iron	-2
Karma	-2	Karma	-2
Karma	-2	Nickel	-2
Karma	-2	Platinum	-2
Kovar, Gold Plate	-2	Kovar, Gold Plate	-2
Kovar, Gold Plate	-2	Kulgrid	-2
Kovar, Gold Plate	-2	Nickel	-2
Kovar, Gold Plate	-2	Silver	-11, -14
Kovar, Gold Plate	-2	Stainless Steel	-2
Magnesium	-1	Magnesium	-1

APPENDIX F: THE BASICS OF RESISTANCE WELDING

MATERIAL	ELECT RWMA TYPE	MATERIAL	ELECT RWMA TYPE
Molybdenum	-2	Nickel	-2
Molybdenum	-2	Tungsten	-2
Nichrome	-2	Nichrome	-2
Nichrome	-2	Nickel	-2
Nichrome	-2	Cold Rolled Steel	-2
Nichrome	-2	Stainless Steel	-2
Nickel	-2	Nickel	-2
Nickel	-2	Cold Rolled Steel	-2
Nickel	-2	Stainless Steel	-2
Nickel	-2	Tantalum	-2
Nickel	-2	Tungsten	-2
Nickel Alloy	-2	Nickel Alloy	-2
Nickel Alloy	-2	Tinned Brass	-14
Nickel Alloy	-2	Beryllium Copper	-2
Nickel Alloy	-2	Consil	-2
Nickel Alloy	-2	Tinned Copper	-14
Nickel Alloy	-2	Nichrome	-2
Nickel Alloy	-2	Nickel	-2
Nickel Alloy	-2	Cold Rolled Steel	-2

MATERIAL	ELECT RWMA TYPE	MATERIAL	ELECT RWMA TYPE
NiSpan C	-2	NiSpan C	-2
NiSpan C	-2	Cold Rolled Steel	-2
NiSpan C	-2	Stainless Steel	-2
Niobium	-2	Niobium	-2
Platinum	-2	Platinum	-2
Paliney 7	-2	Paliney 7	-2
Silver	-11, -14	Silver	-11, -14
Silver	-11, -14	Cadmium	-13
Cold Rolled Steel	-2	Cold Rolled Steel	-2
Cold Rolled Steel	-2	Stainless Steel	-2
Cold Rolled Steel	-2	Tantalum	-2
Stainless Steel	-2	Stainless Steel	-2
Stainless Steel	-2	Tungsten	-2
Tantalum	-2	Tantalum	-2
Titanium	-2	Titanium	-2
Tungsten	-2	Tungsten	-2
Tungsten	-2	henium	-2
Zinc	-14	Zinc	-14

Electrode Maintenance

Depending on use, periodic tip resurfacing is required to remove oxides and welding debris from electrodes. Cleaning of electrodes on production line should be limited to use of # 400 - 600 grit electrode polishing disks. For less critical applications, a file can be used to clean a badly damaged tip. However, after filing, polishing disks should then be used to ensure that the electrode faces are smooth. If this is not done, the rough surface of the electrode face will have a tendency to stick to the work piece.

Weld Schedule Development

Developing a weld schedule is a methodical procedure, which consists of making sample welds and evaluating the results. The first weld should be made at low energy settings. Adjustments are then made to each of the welding parameters **one at a time** until a successful weld is made.

- 1 Install the correct electrodes in the electrode holders on the Weld Head. See the preceding Table for electrode material recommendations.
- 2 Use a flat electrode face for most applications. Use a "domed" face if surface oxides are a problem. If either of the parts is a wire, the diameter of the electrode face should be equal to or greater than the diameter of the wire. If both parts are flat, the face should be at least one-half the diameter of the electrodes. Pencil point electrodes cause severe electrode sticking to the parts, unexplained explosions, and increase the weld heat substantially because of the reduced electrode-to-part contact area.
- 3 Use the Force Adjustment Knob on the Weld Head to set the Firing Force and adjust an Air Actuated Weld Head.
- 4 Program a weld schedule, then make your first weld. Always observe safety precautions when welding and wear safety glasses. For a complete procedure on making welds, refer to *Operating Instructions*.
- 5 Use pliers to peel the welded materials apart. A satisfactory weld will show residual material pulled from one material to the other. Tearing of base material around the weld nugget indicates a material failure NOT a weld failure. Excessive electrode sticking and/or "spitting" should define a weld as unsatisfactory and indicates that too much weld current, voltage, power, or time has been used.
- 6 If the parts pull apart easily or there is little or no residual material pulled, the weld is weak. Increase the weld time in 1ms increments. Increase weld current, voltage, or power if a satisfactory weld achieved using 10ms of weld time.

NOTE: Actual weld strength is a user-defined specification.

- 7 Polarity, as determined by the direction of weld current flow, can have a marked effect on the weld characteristics of some material combinations. This effect occurs when welding materials with large differences in resistivity, such as copper and nickel or when welding identical materials with thickness ratios greater than 4 to 1. The general rule is that the more resistive material or the thinner material should be placed against the negative (-) electrode. Polarity on the Power Supply can only be changed by reversing the Weld Cables.

Weld Strength Testing

Destructive tests should be performed on a random basis using actual manufacturing parts. Destructive tests made on spot welds include tension, tension-shear, peel, impact, twist, hardness, and macro-etch tests. Fatigue tests and radiography have also been used. Of these methods torsional shear is preferred for round wire and a 45-degree peel test for sheet stock.

APPENDIX F: THE BASICS OF RESISTANCE WELDING

Weld Strength Profiles

Creating a weld strength profile offers the user a scientific approach to determining the optimum set of welding parameters and then displaying these parameters in a graphical form.

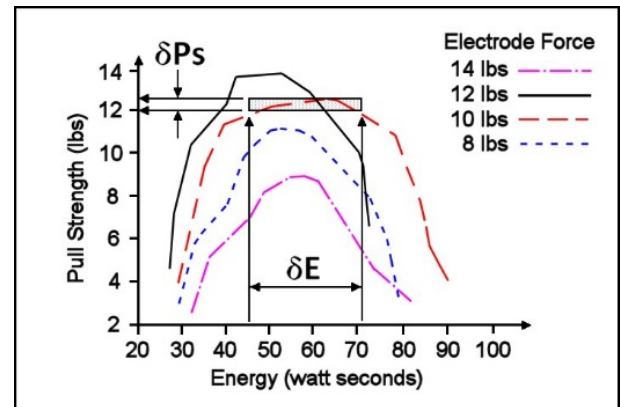
- 1 Start at a low weld current, voltage, or power, making five or more welds, then perform pull tests for each weld. Calculate the average pull strength. Increase weld current, voltage, or power and repeat this procedure. Do not change the weld time, weld force, or electrode area.
- 2 Continue increasing weld current, voltage, or power until any unfavorable characteristic occurs, such as sticking or spitting.
- 3 Repeat steps 1 through 3 for different weld forces, then create a plot of part pull strength versus weld current, voltage, or power for different weld forces as shown in the illustration below, *Typical Weld Strength Profile*.
- 4 Repeat steps 1 through 3 using a different but fixed weld time.

Typical Weld Strength Profile

The picture on the right illustrates a typical weld strength profile. The 14 lb electrode force curve shows the highest pull strengths but the lowest tolerance to changes in weld current, voltage, or power. The 12 lb electrode force curve shows a small reduction in pull strength, but considerably more tolerance to changes in weld energy. Weld heat will vary as a result of material variations and electrode wear.

The 12 lb electrode force curve is preferred. It shows more tolerance to changes in weld current, voltage, or power and has nearly the same bond strength as the 14 lb electrode force curve.

A comparison of weld schedules for several different applications might show that they could be consolidated into one or two weld schedules. This would have obvious manufacturing advantages.



Typical Weld Strength Profile

APPENDIX G

Quality Resistance Welding Solutions: Defining the Optimum Process

Introduction

A quality resistance welding solution both meets the application objectives and produces stable, repeatable results in a production environment. In defining the optimum process the user must approach the application methodically and consider many variables. In this article we will look at the following key stages and principles to be considered when defining the optimum resistance welding process:

- Materials and their properties
- Basic resistance welding
- principles
- Weld profiles
- Approach to development
- Common problems
- Use of screening DOE's
- Use of factorial DOE's

Resistance Welding -- A Material World

The first consideration in designing a quality welding solution is the properties of the materials to be joined and the quality requirements of the desired welded joint. At this stage, it is worthwhile to review the way the resistance welding process works and the likely outcome when the parts are resistance welded.

There are four main types of structural materials:

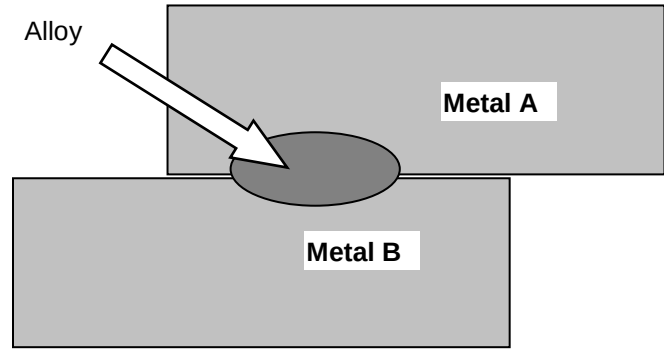
- Metals (silver, steel, platinum)
- Ceramic (alumina, sand)
- Plastics/polymers (PVC, teflon)
- Semiconductors (silicon, germanium)

Of these, only metals can be resistance welded because they are electrically conductive, soften on heating, and can be forged together without breaking.

APPENDIX G: DEFINING THE OPTIMUM PROCESS

Alloys are a mixture of two or more metals. An alloy is normally harder, less conductive, and more brittle than the parent metal which has bearing on the type of joint one can expect when resistance welding a combination of different metals.

Metals atoms are naturally attracted to other metal atoms even in different parent materials. Metals and alloys will bond together once surface contaminants such as dirt, grease, and oxides removed. Resistance welding generates heat at the material interface, which decomposes the dirt and grease and helps to break up the oxide film. The resultant heat softens or melts the metal and the applied force brings the atoms on either side into close contact to form the bond. The strength of the joint develops as it cools and a new structure is formed.



There are three main types of bonds that can be formed using the resistance welding process:

- **Solder or Braze Joint**

A filler material such as a solder or braze compound is either added during the process or present as a plating or coating. Soldered joints are typically achieved at temperatures less than 400 °C and brazed joints such as Sil-Phos materials melt at temperatures above 400 °C.

- **Solid-State Joint**

A solid state joint can be formed when the materials are heated to between 70 - 80% of their melting point.

- **Fusion Joint**

A fusion joint can be formed when both metals are heated to their melting point and their atoms mix.

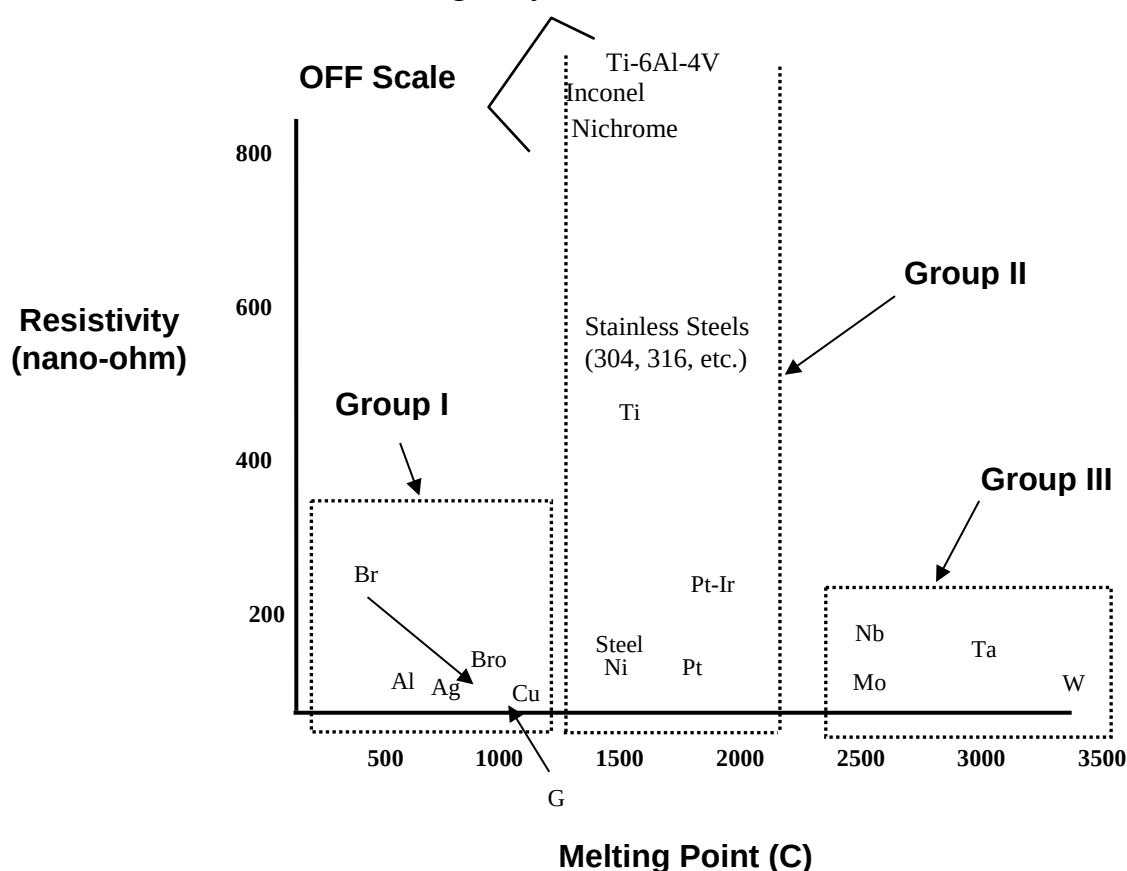
Many micro-resistance welding challenges involve joining dissimilar metals in terms of their melting points, electrical conductivity, and hardness. A solid-state joint can be an ideal solution for these difficult applications; there is no direct mixing of the two materials across the weld interface thus preventing the formation of harmful alloys that could form brittle compounds that are easily fractured. Remember that in a solid-state joint, the metals are only heated to 70 - 80% of their respective melting points, resulting in less thermal stress during heating and subsequent joint cooling in comparison to a fusion weld. As there is no real melting of the materials in a solid-state joint, there is less chance of weld splash or material expulsion. A weld nugget can still be achieved with a solid-state joint.

Consider the Material Properties

The important material properties to be considered in the resistance welding process are:

- *Electrical and thermal conductivity*
- *Plating and coating*
- *Hardness*
- *Melting point*
- *Oxides*

The figure below illustrates the variance in resistivity and melting points for some of the more common materials used in micro resistance welding today.



The materials can be grouped into three common categories. The types of joints achievable within each of the main groups are detailed below:

- **Group I – Conductive Metals**

Conductive metals dissipate heat and it can be difficult to focus heat at the interface. A solid-state joint is therefore preferred. Typically, resistive electrode materials are used to provide additional heating.

APPENDIX G: DEFINING THE OPTIMUM PROCESS

- Group II – Resistive Metals**

It is easier to generate and trap heat at the interface of resistive metals and therefore it is possible to form both solid state and fusion welds depending on time and temperature. Upslope can reduce contact resistances and provide heating in the bulk material resistance.

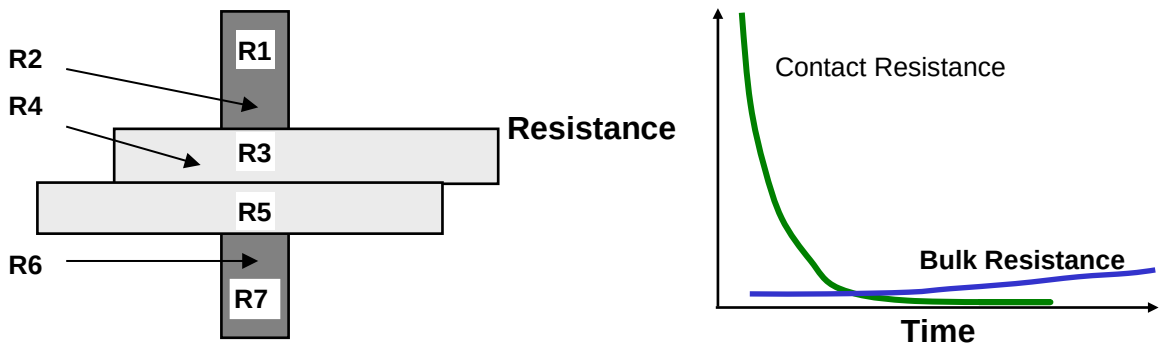
- Group III – Refractory Metals**

Refractory metals have very high melting points and excess heating can cause micro-structural damage. A solid-state joint is therefore preferred.

The chart below gives some guidance on the type of joint that can be expected and design considerations required when joining materials from the different groups.

	Group I	Group II	Group III
Group I (Copper)	• Solid-State • W/Mo electrodes	• Solid-State • Projection on Group I	• Solid-State • Fine projections on Group III
Group II (Steel)		• Solid-State or Fusion	• Solid-state or braze of II on III • Projection on III
Group III (Moly)			• Solid-State

Basic Principles



The figure above shows the key resistances in a typical opposed resistance weld and the relationship between contact resistances and bulk resistances over time, during a typical resistance weld:

APPENDIX G: DEFINING THE OPTIMUM PROCESS

R1 & R7 The electrode resistances affect the conduction of energy and weld heat to the parts and the rate of heat sinking from the parts at the end of the weld.

R2, R4 & R 6 The electrode-to-part and part-to-part “Contact Resistances” determine the amount of heat generation in these areas. The contact resistances decline over time as the parts achieve better fit up.

R3 & R5 The metal “Bulk Resistances” become higher during the weld as the parts are heated.

If a weld is initiated when the contact resistances are still high, the heat generated is in relation to the level and location of the contact resistances, as the materials have not had a chance to fit up correctly. It is common for the heat generated at the electrode-to-part and part-to-part resistances to cause multiple welding problems when welding resistive materials including:

- Part marking and surface heating
- Weld splash or expulsion
- Electrode sticking
- Weak welds

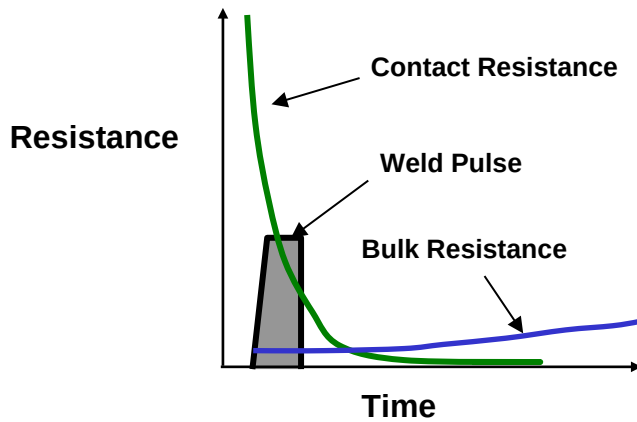
Alternately, conductive materials can be welded by using high contact resistance and fast heating because their bulk resistance is not high and cannot be relied upon for heat generation.

If a weld is initiated when both parts and electrodes are fitted up correctly, the contact resistance is lower and bulk resistance now controls the heat generation. This type of weld is achieved with a slower heating rate and normally longer time is preferred for welding resistive materials, which can generate heat through their bulk resistance.

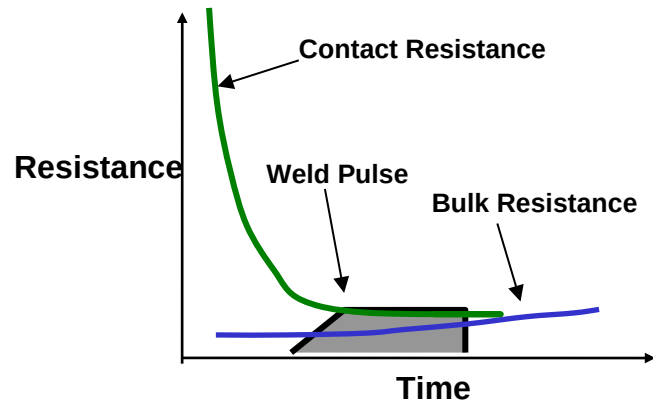
The contact resistances present at the weld when the power supply is fired have a great impact on the heat balance of a weld and, therefore, the heat affected zone.

APPENDIX G: DEFINING THE OPTIMUM PROCESS

The figure below shows a weld that is fired early on in the weld sequence when the contact resistance is still quite high.



The figure shows a weld that is initiated when the contact resistance is lower; in this example, we are using bulk resistance to generate our weld heat.

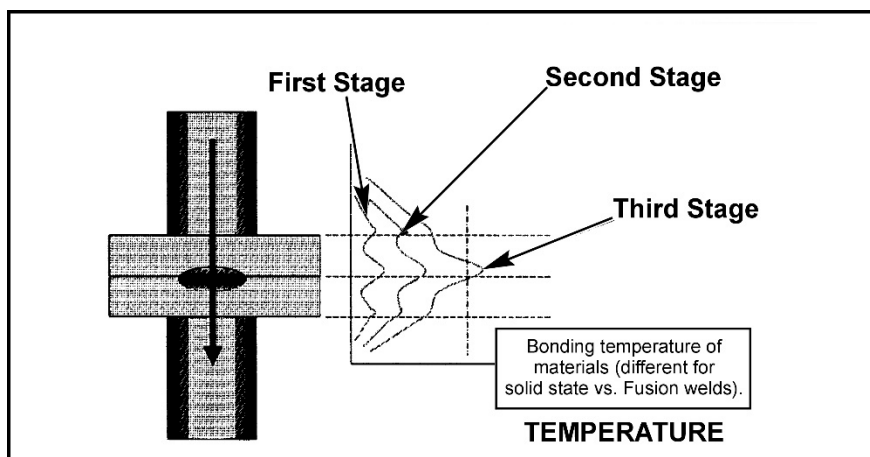


Heat Affected Zone

(NOTE: Larger nuggets are possible with longer weld times when using bulk resistance.)

In general, conductive materials benefit from a faster heating rate, as the higher contact resistances assist heat generation in the weld. Resistive materials benefit from slower heating rates which allow the contact resistances to reduce significantly. Bulk resistances, therefore, become the major source for heat generation. The heat-affected zone is also much smaller in this case producing a weld with less variation.

The following figure shows the three stages of heat generation for resistive materials in a fusion weld. In the first stage, the heat is focused in the part-to-part and electrode-to-part contact areas, since contact resistance is high relative to bulk resistance. In the second stage, contact resistance decreases as the electrodes seat better to the parts. Less heat is generated in the electrode-to-part contact areas, and a greater amount of heat is generated in the parts as the bulk resistance increases. In the third stage, the bulk resistance becomes the dominant heat-generating factor and the parts can reach their bonding temperature at the part-to-part interface. The stages of heat generation for conductive materials will be similar to that of resistive materials, but there will be less heat generated in the bulk resistance due to the conductivity of the materials.

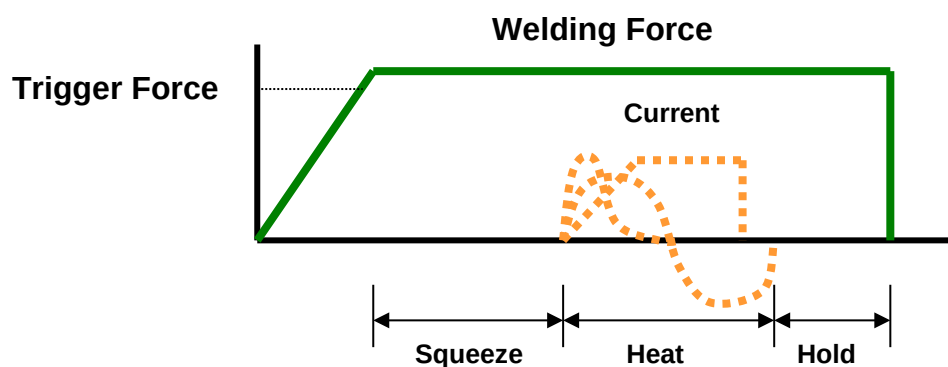


Weld Profiles

The basic welding profile (or schedule) consists of a controlled application of energy and force over time. Precision power supplies control the energy and time and therefore heating rate of the parts. The weld head applies force from the start to finish of the welding process.

The figure on the right shows a typical welding sequence where the force is applied to the parts; a squeeze time is initiated which allows the force to stabilize before the current is fired. Squeeze time also allows time for the contact resistances to reduce as the materials start to come into

closer contact at their interface. A hold time is initiated after current flows to allow the parts to cool under pressure before the electrodes are retracted from the parts. Hold time is important as weld strength develops in this period. This basic form of weld profile is sufficient for the majority of small part resistance welding applications.



Power supply technology selection is based on the requirements of both the application and process. In general, closed loop power supply technologies are the best choice for consistent, controlled output and fast response to changes in resistance during the weld.

Approach to Weld Development

The first stage in developing a quality welding process is to fix as many of the variables as possible in the welding equipment set up. The welding variables can be grouped in the following categories:

- **Material Variables**
 - Base material
 - Plating
 - Size
 - Shape
- **Weld Head & Mechanical Variables**
 - Force, squeeze, hold
 - Actuation method
 - Electrode material and shape
- **Power Supply Variables**
 - Energy
 - Time (squeeze, weld, hold)
- **Process Variables**
 - Tooling, level of automation
 - Repetition rate
 - Part positioning
 - Maintenance, electrode cleaning
- **Quality Requirements**
 - Pull strength
 - Visual criteria
 - Test method, other weld joint requirements

The first stage in developing a quality welding process is to fix as many of the variables as possible in the welding equipment set up. Welding variables can be grouped in the following categories:

Initial Welding Trials -- The “Look See” Tests

“Look see” welding tests are a series of mini welding experiments designed to provide a starting point for further statistical development of the welding parameters. The user should adjust the key welding variables (energy, force, time) in order to identify the likely good “weld window.” Close visual inspection of the weld parts will promote better understanding of the heating characteristics of the application.

The mini-experiments should also be used to understand the weld characteristics from both application and process perspective. Key factors in this understanding are as follows:

Application Perspective

- Materials: Resistivity, melting point, thermal mass, shape, hardness, surface properties.
- Heat balance: Electrode materials, shape, Polarity, heating rate (upslope).
- Observation: visual criteria, cross section, and impact of variables on heat balance.

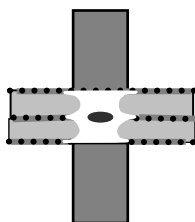
Process Perspective

- What are the likely variables in a production process?
- How will operators handle and align the parts?
- What tooling or automation will be required?
- How will operators maintain and change the electrodes?
- What other parameters will operators be able to adjust?
- What are the quality and inspection requirements?
- What are the relevant production testing methods and test equipment?
- Do we have adequate control over the quality of the materials?

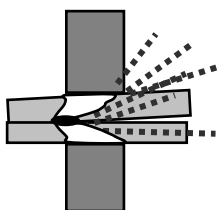
Common Problems

During this stage of process development, it is important to understand that the majority of process problems are related to either materials variation, or part-to-electrode positioning. Some examples are shown below.

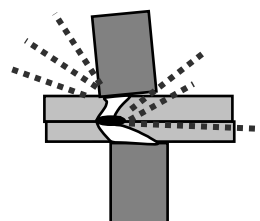
Material Control



Part-To-Part Positioning



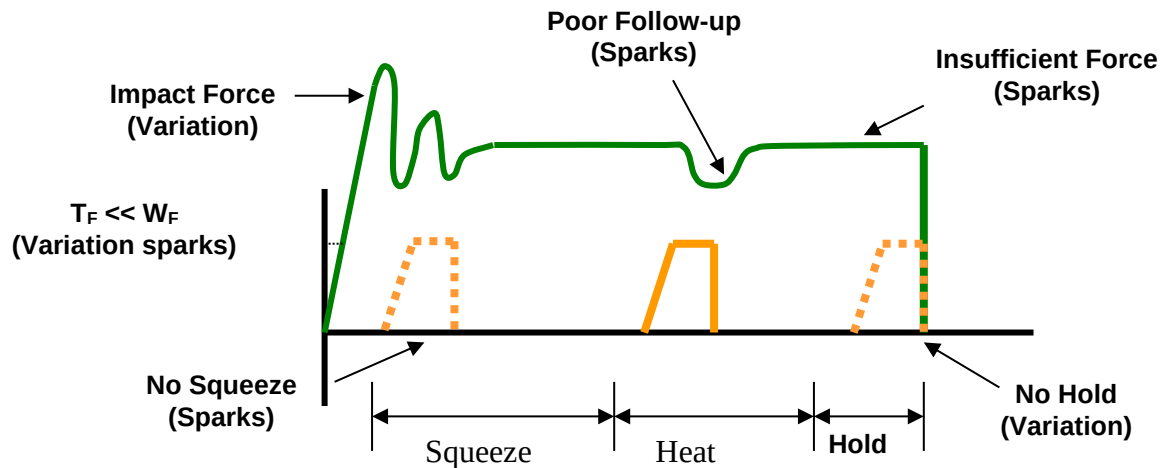
Electrode-To-Part Positioning



The changes detailed above generally result in a change in contact resistance and always affect the heat balance of the weld. During weld development these common problems must be carefully monitored so as not to mislead the course and productivity of the welding experiments.

In summary, the “look see” welding experiments should be used to fix further variables from an application and process perspective and also to establish a “weld window” for energy, time and force. This part of weld development is critical in order to proceed to a statistical method of evaluation (Design of Experiments or “DOEs”). Random explosions or unexpected variables will skew statistical data and waste valuable time.

APPENDIX G: DEFINING THE OPTIMUM PROCESS



Common welding problems can often be identified in the basic set up of the force, energy, and time welding profile shown above. These problems can lead to weld splash, inconsistency, and variation (contact AMADA WELD TECH for further information and support).

What are Screening DOE'S?

The purpose of a Screening DOE is to establish the impact that welding and process parameters have on the quality of the weld. Quality measurement criteria should be selected based on the requirements of the application. A Screening DOE will establish a relative quality measurement for the parameters tested and the variation in the welded result. This is important, as identifying variation in process is critical in establishing the best production settings. Typically, welded assemblies are assessed for strength of joint and variation in strength.

A Screening DOE tests the high, low settings of a parameter, and will help establish the impact of a parameter on the process. A Screening DOE is a tool that allows the user to establish the impact of a particular parameter by carrying out the minimum number of experiments to gain the information. A five-factor screening DOE can be accomplished in as few as 24 welds, with three welds completed for each of 8 tests. By comparison, it would take 96 welds to test every combination. The DOE promotes understanding of many variables in a single experiment and allows the user to interpret results, thus narrowing the variables for the next level of statistical analysis. If many variables are still not understood, multiple Screening DOE's may be required. AMADA WELD TECH provides a simple Screening DOE tool that is run in *Excel®* and is sufficient for the majority of possible applications (contact AMADA WELD TECH for details). Sophisticated software is also available from other vendors designed specifically for this purpose.

Criteria for Success

Before running the series of experiments, the user must establish an acceptable window for energy, time, and force, thus preventing voided results. It is common practice to include one or all of the above variables in a Screening DOE. This is only recommended if sufficient understanding has been established for the other application and process variables that can impact quality. Users should first try to screen out all common application and process variables that require further exploration from the results of the “look see” mini experiments and then include the three key welding variables (energy, force and time). Several Screening DOE’s may be required.

Results should be interpreted carefully. Typically, one would look for the highest result in terms of quality with the least variation. A Screening DOE provides only a measurement that indicates the relative importance of a parameter and not the ideal setting. Factorial DOE’s should be used to establish the correct or best setting for a parameter once many of the other variables have been screened and fixed. This is also the time to assess the measurement accuracy and consistency of the test method and procedure. Variation in test method can invalidate the test and lead to misinterpretation of results.

What are Factorial DOE’s?

The purpose of a Factorial DOE is too narrow in on the optimal setting for a particular parameter. This method is generally used when the critical or main key variables have been identified, and we need to establish the best settings for the process. A factorial DOE may also give an indication as to how wide the acceptable weld window is in relation to quality requirements. We recommend data be gathered from a monitoring perspective so that this can provide a starting point for establishing a relationship between quality and the monitored measurement parameter.

Criteria for Success

Critical parameters should be identified from the list of unfixed variables left from the Screening DOE’s. A mini-experiment may be required establishing reasonable bounds for the combination of parameters to be tested. This will prevent void data and wasted time. At this stage, it is useful to record multiple relevant quality measurement or inspection criteria so that a balanced decision can be reached. For example, if part marking and pull strength are the relevant criteria, a compromise in ideal setting may be required.

As with all experiments, the test method should be carefully assessed as a potential source of variation and inconsistency. Once the optimum parameters have been established in this series of experiments, a validation study can be run which looks at the consistency of results over time. It is good practice to build in variables such as electrode changes and cleaning, as well as equipment set up by different personnel. This will ensure that the solution is one that can run in a real production environment. Welded assemblies should be tested over time and under real use conditions to ensure that all functional criteria will be met. Validation testing is usually required to prove the robustness of the process under production conditions.

Conclusion

The resistance welding process can deliver a reliable and repeatable joining solution for a wide range of metal joining applications. Defining the optimum welding process and best production settings can be achieved through a methodical and statistical approach. Time spent up front in weld development will ensure a stable welding process and provide a substantial return in quality and long term consistency. Welding problems can more easily be identified and solved if sufficient experimental work is carried out to identify the impact of common variables on the quality and variation of the welded assembly. AMADA WELD TECH frequently uses the Screening DOE tool to establish the impact of key variables and to assist customers with troubleshooting. Often, the testing described above will provide the information and understanding to predict common failure modes and causes. A troubleshooting guide can be requested in the form of a slide rule, to assist users in identification of welding problems and likely causes.