

Motoman XRC 2001 Controller

**Robotic Arc
Welding Manual
for Fronius Power Sources**

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Chapter 1

Introduction

The Fronius TS (synergic, non-pulse) and TPS (synergic, pulse) power sources represent state-of-the-art technology in welding today. An interactive power source manager is coupled with a digital signal processor to control and regulate the entire welding process. Weld data is measured continuously, allowing the power source to respond immediately to any changes.

1.1 About This Document

This manual provides information about Motoman's robotic arc welding system using the Fronius TS and TPS power sources. It is intended for welding personnel who have received operator training from Motoman, and are familiar with the operation of their Motoman robot model. For more detailed information, refer to the manuals listed in Section 1.3. This manual contains the following sections:

SECTION 1 - INTRODUCTION

This section provides general information about the Fronius power sources and their components, technical specifications, a list of reference documents, and customer service information.

SECTION 2 - SAFETY

This section describes the conventions used to identify precautionary text throughout this manual. This section also contains a list of general cautions and warnings that apply to many of the procedures described in this manual.

SECTION 3 - INSTALLATION

This section provides instructions for basic setup and integration of the Fronius arc welding system. This section also provides procedures for start-up and calibration.

SECTION 4 - THEORY OF OPERATION

This section describes general arc welding principles, how the welding system works, and identifies specific welding problems and requirements.

SECTION 5 - OPERATION

This section provides instructions for basic operation of the Fronius arc welding system. This section also provides procedures for start-up. Sample robot programs are also included in this section.

SECTION 6 - TROUBLESHOOTING

This section provides help for the user to identify alarms and errors and remedy problems found during operation and welding. Included are tips and techniques for using the Fronius power sources.

1.2 System Configuration

The Fronius welding system is an integrated package of tools and components designed for specific welding requirements. A typical system includes the following components and optional equipment.

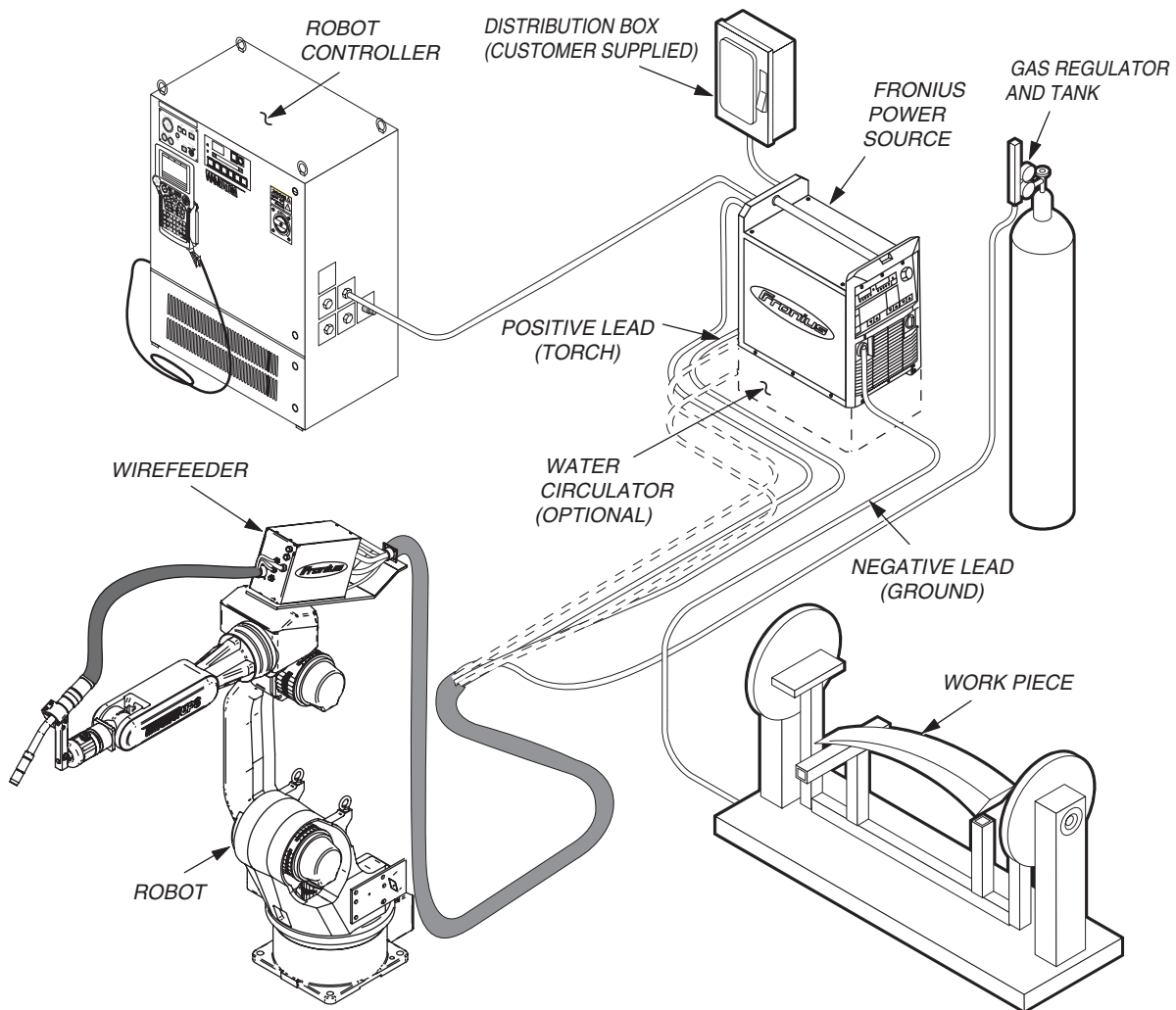


Figure 1 Typical Fronius Welding System

1.2.1 Major Components

A typical system includes the following major components:

- Motoman manipulator and XRC 2001 controller
- Welding equipment, including the following:
 - Fronius TS or TPS power source
 - Fronius VR1500 wirefeeder
 - ROB 5000 robotic interface
 - Welding torch
- Optional welding equipment including:
 - Water circulator
 - Program devices - RS232 adaptor for PC communication.
 - RCU-5000 programming pendant
 - Ethernet IP communication board
 - Computer software for weld management.
 - Robacta Drive feeder/torch - push-pull torch provides a highly integrated system for aluminium welding.
 - Nozzle cleaner
 - Bulk wire delivery package

1.3 Reference to Other Documentation

For additional information refer to the following:

- Motoman Manipulator Manual
- Motoman Operator's Manual for Arc Welding (P/N 142098-1)
- Motoman Concurrent I/O Parameter Manual (P/N 142102-1)
- Fronius manuals
- Vendor manuals for system components not manufactured by Motoman

1.4 Customer Service Information

If you are in need of technical assistance, contact the Motoman service staff at (937) 847-3200. Please have the following information ready before you call:

- Robot Type (UP6 or UP20)
- Application Type (welding)
- Power Supply Type (TS, TPS 4000)
- System Type (Robotic Arc Welding)
- Software Version (3.74A)
- Robot Serial Number (located on back side of robot arm)
- Robot Sales Order Number (located on front door of XRC 2001 controller)

Chapter 2

Safety

2.1 Introduction

It is the purchaser's responsibility to ensure that all local, county, state, and national codes, regulations, rules, or laws relating to safety and safe operating conditions for each installation are met and followed.

We suggest that you obtain and review a copy of the ANSI/RIA National Safety Standard for Industrial Robots and Robot Systems. This information can be obtained from the Robotic Industries Association by requesting ANSI/RIA R15.06. The address is as follows:

Robotic Industries Association

900 Victors Way

P.O. Box 3724

Ann Arbor, Michigan 48106

TEL: (734) 994-6088

FAX: (734) 994-3338

Ultimately, the best safeguard is trained personnel. The user is responsible for providing personnel who are adequately trained to operate, program, and maintain the robot cell. **The robot must not be operated by personnel who have not been trained!**

We recommend that all personnel who intend to operate, program, repair, or use the robot system be trained in an approved Motoman training course and become familiar with the proper operation of the system.

This safety section addresses the following:

- Standard Conventions (Section 2.2)
- General Safeguarding Tips (Section 2.3)
- Mechanical Safety Devices (Section 2.4)
- Installation Safety (Section 2.5)
- Programming Safety (Section 2.6)
- Operation Safety (Section 2.7)
- Maintenance Safety (Section 2.8)

2.2 Standard Conventions

This manual includes information essential to the safety of personnel and equipment. As you read through this manual, be alert to the four signal words:

DANGER!

WARNING!

CAUTION!

NOTE:

Pay particular attention to the information provided under these headings which are defined below (in descending order of severity).



DANGER!

Information appearing under the **DANGER** caption concerns the protection of personnel from the immediate and imminent hazards that, if not avoided, will result in immediate, serious personal injury or loss of life in addition to equipment damage.



WARNING!

Information appearing under the **WARNING** caption concerns the protection of personnel and equipment from potential hazards that can result in personal injury or loss of life in addition to equipment damage.



CAUTION!

Information appearing under the **CAUTION** caption concerns the protection of personnel and equipment, software, and data from hazards that can result in minor personal injury or equipment damage.



Note: Information appearing in a Note caption provides additional information which is helpful in understanding the item being explained.

2.3 General Safeguarding Tips

All operators, programmers, plant and tooling engineers, maintenance personnel, supervisors, and anyone working near the robot must become familiar with the operation of this equipment. All personnel involved with the operation of the equipment must understand potential dangers of operation. General safeguarding tips are as follows:

- Improper operation can result in personal injury and/or damage to the equipment. Only trained personnel familiar with the operation of this robot, the operator's manuals, the system equipment, and options and accessories should be permitted to operate this robot system.
- Do not enter the robot cell while it is in automatic operation. Programmers must have the teach pendant when they enter the robot cell.
- Improper connections can damage the robot. All connections must be made within the standard voltage and current ratings of the robot I/O (Inputs and Outputs).
- The robot must be placed in Emergency Stop (E-STOP) mode whenever it is not in use.
- In accordance with ANSI/RIA R15.06, section 6.13.4 and 6.13.5, use lockout/tagout procedures during equipment maintenance. Refer also to Section 1910.147 (29CFR, Part 1910), Occupational Safety and Health Standards for General Industry (OSHA).

2.4 Mechanical Safety Devices

The safe operation of the robot, positioner, auxiliary equipment, and system is ultimately the user's responsibility. The conditions under which the equipment will be operated safely should be reviewed by the user. The user must be aware of the various national codes, ANSI/RIA R15.06 safety standards, and other local codes that may pertain to the installation and use of industrial equipment. Additional safety measures for personnel and equipment may be required depending on system installation, operation, and/or location. The following safety measures are available:

- Safety fences and barriers
- Light curtains
- Door interlocks
- Safety mats
- Floor markings
- Warning lights

Check all safety equipment frequently for proper operation. Repair or replace any non-functioning safety equipment immediately.

2.5 Installation Safety

Safe installation is essential for protection of people and equipment. The following suggestions are intended to supplement, but not replace, existing federal, local, and state laws and regulations. Additional safety measures for personnel and equipment may be required depending on system installation, operation, and/or location. Installation tips are as follows:

- Be sure that only qualified personnel familiar with national codes, local codes, and ANSI/RIA R15.06 safety standards are permitted to install the equipment.
- Identify the work envelope of each robot with floor markings, signs, and barriers.
- Position all controllers outside the robot work envelope.
- Whenever possible, install safety fences to protect against unauthorized entry into the work envelope.
- Eliminate areas where personnel might get trapped between a moving robot and other equipment (pinch points).
- Provide sufficient room inside the workcell to permit safe teaching and maintenance procedures.

2.6 Programming Safety

All operators, programmers, plant and tooling engineers, maintenance personnel, supervisors, and anyone working near the robot must become familiar with the operation of this equipment. All personnel involved with the operation of the equipment must understand potential dangers of operation. Programming tips are as follows:

Any modifications to PART 1 of the XRC controller PLC can cause severe personal injury or death, as well as damage to the robot! Do not make any modifications to PART 1. Making any changes without the written permission of Motoman will VOID YOUR WARRANTY!

Some operations require standard passwords and some require special passwords. Special passwords are for Motoman use only. YOUR WARRANTY WILL BE VOID if you use these special passwords.

Back up all programs and jobs onto a floppy disk whenever program changes are made. To avoid loss of information, programs, or jobs, a backup must always be made before any service procedures are done and before any changes are made to options, accessories, or equipment.

The concurrent I/O (Input and Output) function allows the customer to modify the internal ladder inputs and outputs for maximum robot performance. Great care must be taken when making these modifications. Double-check all modifications under every mode of robot operation to ensure that you have not created hazards or dangerous situations that may damage the robot or other parts of the system.

- Improper operation can result in personal injury and/or damage to the equipment. Only trained personnel familiar with the operation, manuals, electrical design, and equipment interconnections of this robot should be permitted to operate the system.
- Inspect the robot and work envelope to be sure no potentially hazardous conditions exist. Be sure the area is clean and free of water, oil, debris, etc.
- Be sure that all safeguards are in place.
- Check the E-STOP button on the teach pendant for proper operation before programming.
- Carry the teach pendant with you when you enter the workcell.
- Be sure that only the person holding the teach pendant enters the workcell.
- Test any new or modified program at low speed for at least one full cycle.

2.7 Operation Safety

All operators, programmers, plant and tooling engineers, maintenance personnel, supervisors, and anyone working near the robot must become familiar with the operation of this equipment. All personnel involved with the operation of the equipment must understand potential dangers of operation. Operation tips are as follows:

- Be sure that only trained personnel familiar with the operation of this robot, the operator's manuals, the system equipment, and options and accessories are permitted to operate this robot system.
- Check all safety equipment for proper operation. Repair or replace any non-functioning safety equipment immediately.
- Inspect the robot and work envelope to ensure no potentially hazardous conditions exist. Be sure the area is clean and free of water, oil, debris, etc.
- Ensure that all safeguards are in place.
- Improper operation can result in personal injury and/or damage to the equipment. Only trained personnel familiar with the operation, manuals, electrical design, and equipment interconnections of this robot should be permitted to operate the system.
- Do not enter the robot cell while it is in automatic operation. Programmers must have the teach pendant when they enter the cell.
- The robot must be placed in Emergency Stop (E-STOP) mode whenever it is not in use.
- This equipment has multiple sources of electrical supply. Electrical interconnections are made between the controller, external servo box, and other equipment. Disconnect and lockout/tagout all electrical circuits before making any modifications or connections.

- All modifications made to the controller will change the way the robot operates and can cause severe personal injury or death, as well as damage the robot. This includes controller parameters, ladder parts 1 and 2, and I/O (Input and Output) modifications. Check and test all changes at slow speed.

2.8 Maintenance Safety

All operators, programmers, plant and tooling engineers, maintenance personnel, supervisors, and anyone working near the robot must become familiar with the operation of this equipment. All personnel involved with the operation of the equipment must understand potential dangers of operation. Maintenance tips are as follows:

- Do not perform any maintenance procedures before reading and understanding the proper procedures in the appropriate manual.
- Check all safety equipment for proper operation. Repair or replace any non-functioning safety equipment immediately.
- Improper operation can result in personal injury and/or damage to the equipment. Only trained personnel familiar with the operation, manuals, electrical design, and equipment interconnections of this robot should be permitted to operate the system.
- Back up all your programs and jobs onto a floppy disk whenever program changes are made. A backup must always be made before any servicing or changes are made to options, accessories, or equipment to avoid loss of information, programs, or jobs.
- Do not enter the robot cell while it is in automatic operation. Programmers must have the teach pendant when they enter the cell.
- The robot must be placed in Emergency Stop (E-STOP) mode whenever it is not in use.
- Be sure all safeguards are in place.
- Use proper replacement parts.
- This equipment has multiple sources of electrical supply. Electrical interconnections are made between the controller, external servo box, and other equipment. Disconnect and lockout/tagout all electrical circuits before making any modifications or connections.
- All modifications made to the controller will change the way the robot operates and can cause severe personal injury or death, as well as damage the robot. This includes controller parameters, ladder parts 1 and 2, and I/O (Input and Output) modifications. Check and test all changes at slow speed.
- Improper connections can damage the robot. All connections must be made within the standard voltage and current ratings of the robot I/O (Inputs and Outputs).

Chapter 3

Equipment Description

This section contains brief descriptions of Fronius welding system components.

3.1 Robot and Controller

The robot controller coordinates the operation of the various welding system components. The controller executes instruction sequences provided in a robot job file. As the controller steps through the series of instructions, it directs the movement of the torch, and operates the welding power supply. The robot moves the welding torch and supply lines through a series of programmed steps. The controller controls the speed, direction, and position of the robot as it moves from point to point. The controller communicates weld signals through an interface board mounted in the controller cabinet. The controller sends analog voltages for wire feed speed, voltage/voltage trim, and inductance/arc dynamic, along with a signal to energize the contactor to weld. The Fronius power source communicates to the controller when the arc is established, when there is a fault condition, or when the wire is stuck to the puddle.

3.2 Fronius Power Supplies

The Fronius TS (non-pulsed) and TPS (non-pulsed, pulsed) power sources are totally digitized, microprocessor-controlled inverter power sources. An interactive power source manager is coupled with a digital signal processor to control and regulate the welding arc. The weld data is measured continuously, and the machine responds to any changes. The control algorithms developed by Fronius ensure that the specified target status is maintained. All Fronius power sources are multi process-capable and fully synergic, and their programmable output slope characteristics are from flat to drooping. All power sources are rated for 230/440 VAC, 50/60 Hertz, and have S, CE, CSA approval markings. Additional features include:

3.2.1 Welding Circuit Resistance Measurement

The Fronius power supply can be setup to compensate for voltage drops caused by welding circuit resistance. During setup, the welding circuit resistance is measured and stored by the power supply. The power supply then uses this value to compensate for voltage drops. For example, long electrode leads may produce a 2 volts drop between the power supply and the workpiece. Once this value is measured and stored, the power supply is able to compensate for this loss so that when the robot Job requests 22V, the power supply produces 24V to compensate for the 2 volt drop ($24V - 2V = 22V$). If the length of the electrode lead changes, the welding circuit resistance should be remeasured and the output of the power supply adjusted for the new welding circuit resistance.

3.2.2 Robacta Torch

The Robacta Drive is a torch with an integral wire drive for robot welding. It is mounted directly on the front axis of the welding robot. This ensures uniform wire travel and the highest precision in the welding process. The Robacta robot welding torch also features forced contacting. This ensures a defined, reliable current transfer, as the welding wire is guided through the contact tip at an exactly defined angle. This eliminates punctual current transfers resulting in consistently high welding quality.

The electrode is “pushed” by the VR1500 wire feeder and “pulled” by the Robacta Drive torch. Fronius uses this fine control of the electrode to achieve near spatter-free arc starts. During arc starting, the wire is fed until contact is made with the workpiece. At this point low current / voltage is applied as the wire feed speed is reversed. A gap is formed between the electrode tip and the workpiece as the electrode is retracted. After sufficient energy has been applied and a welding arc has been initiated, the electrode is fed towards the workpiece and full current/voltage is applied. Welding commences.

3.2.3 Job Mode

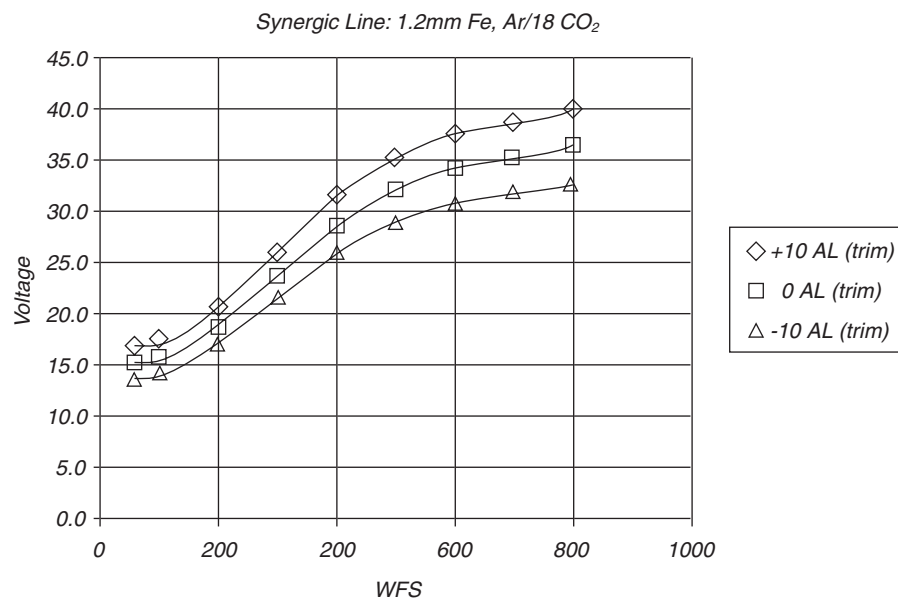
The power supply has the ability to store and control all welding parameters (including wire feed speed and voltage/voltage trim) from the power supply; using robot communication to select job number and control weld timing. Welding parameters including; starting and ending power levels, shielding gas flow timing, run-in speed, voltage trim, and WFS are contained in jobs stored in the power supply memory. These jobs are selectable using outputs from the robot or PLC. Windows of adjustability (for wire feed speed and voltage) can be set so that the robot operator has some limited control of the welding process from the robot teach pendant. One of the advantages of Job Mode is that all welding parameters (except for travel speed and torch angles) are controlled from one source. Using PC software, these parameters provide data for Process Control.

3.2.4 PC Software

PC-based, Fronius-developed software is available that provides an array of functionality. The applications include: OPC Server (user friendly interface provides real-time process control data / weld data / peripheral timing via the OPC protocol), Lookout (graphical presentation of system timing and weld process data), JobExplorer (maintenance of power supply Job data), and WinRCU (remote control of the power supply using a model of the front panel of the unit), among others.

3.2.5 Synergic Control

Also known as “unified” or “one-knob-control,” the power supply automatically adjusts the voltage and pulse-waveform parameters as the wire feed speed is changed by the operator. For example, simply changing the wire feed speed from 200 in/min. to 300 in/min. while maintaining a 0 Arc Length trim yields a change in voltage from perhaps 18.5V to 24.0V. For any wire feed speed level, the power supply automatically sets the voltage output to the “ideal” voltage setting.



If the operator would like to change the voltage output of the power supply from the “ideal” value, a “trim” adjustment can be made. The reference value for the “ideal” Arc Length Trim is 0 (AL = 0). Arc Length Trim can be adjusted from +30 to -30.

3.3 Fronius VR1500 Wire Feeder

The VR1500 wire feeder is equipped with a 42-volt motor which drives four drive rolls. Pressure is controlled by dual manual adjustments. Feeding speeds range from 20 ipm (inches per minute) to 866 ipm. A solid-state motor located in the feeder enclosure controls the feeding speed. The feeder and all other welding system components communicate via the Local-Net Bus network. The VR1500 has a large, insulated mounting base, which also holds a cable and hose strain relief. The feeder can be fitted to accept either a Miller-style power pin, or the Fronius Robacta torch. The VR1500 has internal hoses for liquid cooling, internal cable routing for shock sensor, torch, and blow-off air, and standard couplings. The unit weighs 7.0 Kg.

3.4 ROB 5000 Interface

The ROB 5000 power source-to-XRC interface is designed for DIN rail mounting inside the robot controller cabinet and converts controller analog signals to Local-Net digital format for the welding system components. The signal identifications for all wires are clearly labeled throughout the length of each wire, making connections much easier. Molex type plugs make separating the wiring harness from the interface easy and saves time when trouble shooting a malfunction.

3.5 Water Circulator

The water circulator supplies cooling water to the welding torch. It can be programmed to either run continuously or automatically when a temperature threshold is reached. An internal flow sensor ensures safe conditions are maintained for the welding torch.

Chapter 4

Theory of Operation

This section covers the theory of operation of the welding system and specifically discusses the following items:

- Gas Metal Welding (GMAW)
- Pulsed Gas Metal Welding (GMAW-P)

4.1 Gas Metal Arc Welding

The Fronius TS and TPS units are Gas Metal Arc Welding power supplies capable of non-pulsed (GMAW), and in the case of the TPS, pulsed (GMAW-P) modes of operation. GMA welding is typically a fusion welding process in which high temperatures provide for local melting and mixing of a filler metal with the base metal, followed by solidification to a welded structure. GMA welding adds material to the weld joint by continuously fed filler metal. The filler metal is typically supplied in the form of a spool or large drum of wire. The filler metal is often referred to as a consumable electrode or simply electrode, as the filler metal provides the electrical circuit for the welding current. The consumable electrode (e.g. steel, aluminium, copper, etc.) is fed from the spool or drum through a contact tube (or contact “tip”) by a wire feed system. The tip of the contact tube is typically placed between 12mm (1/2 in.) and 25mm from the base metal or workpiece.

Welding voltage (typically between 14 to 40 volts) is then transferred to the contact tip while the workpiece is kept at a reference voltage (typically 0 volts). This difference in voltage causes an arc to occur between the end of the electrode and the base metal. As wire is fed, the power supply produces current that is proportional to the wire feed rate (or wire feed speed / WFS) but is also based on the resistance between the contact tip and the workpiece. As the WFS is increased, current is automatically increased as well.

To prevent the molten weld metal from absorbing undesirable elements from the atmosphere, and to improve electrical conductivity of the welding arc, shielding gas (typically argon with additions of oxygen or carbon dioxide) is fed through a gas nozzle to the contact tip and workpiece. As current flows between the electrode and workpiece, melting of the electrode takes place at the electrode/workpiece interface, transferring liquid metal either to the workpiece and/or to the air (causing spatter). The applied voltage produces a gap, or arc, between the un-melted electrode and the workpiece. As this occurs, the voltage between the electrode and the grounded (0 volts) workpiece causes the shielding gas to become ionized. When the gas becomes ionized, the ability of the gas to conduct electricity improves, and current flow is maintained. This process produces high temperatures in the arc causing melting of the workpiece. The liquid metal at the end of the electrode transfers and combines with the liquid metal of the workpiece to form the weld pool.

A basic GMAW power supply controls two basic process parameters - wire feed speed and voltage. Voltage determines the length of the arc, or distance between the end of the electrode and the weld pool. Wire feed speed controls the amount of wire that is fed in a given time. Typically, voltage remains fixed while current is free to change (termed CV, or constant voltage). For the arc length to maintain an approximately fixed length, the burn-off rate of the electrode must match the wire feed speed. The burn-off rate (e.g. inches/minute) is a function of melting rate (e.g. grams/minute), and melting rate is a function of current. Low wire feed speeds require low burn-off rates, and thus lower current levels. Conversely, high wire feed speeds require high currents. Because current is allowed to vary with a CV power supply, the power supply provides just the right amount of current to maintain a defined arc length.

4.1.1 Short-Circuit Transfer

At low wire feed speeds the welding current is too low to maintain an arc. As the wire is fed, the arc length decreases until a short occurs. When the electrode is in contact with the workpiece, the electrical resistance decreases, allowing the current to increase enough to break the short. This high current rapidly melts the electrode, which in turn allows an arc to be established and the arc length to increase. Once the arc is re-established, the current is again at a level too low to maintain an arc, and the process repeats. This cyclical process is called Short-Circuit Transfer, or GMAW-S. As wire feed speed is increased, the frequency of short circuits increases causing the average current to increase.

4.1.2 Globular Transfer

Intermediate wire feed speeds produce a mode of metal transfer in which an arc is continuously established and electrode shorting does not necessarily occur. At current levels just above those for short circuit transfer, forces involved around the arc/electrode cause large metal droplets to form at the tip of the electrode. Once the metal droplet is of sufficient size, gravity, and to a lesser extent, magnetic fields, pull the droplet across the arc gap to the weld pool. This mode of transfer is called globular transfer. These large droplets are very unstable as they take flight through the arc. As they fall, they typically break apart and spray metal droplets out of the arc as spatter. When the metal finally contacts the weld pool, the large droplet size causes violent puddle agitation, which can also lead to the production of spatter. A warning light on the power supply lights when globular transfer conditions are selected.

4.1.3 Spray Transfer

At higher wire feed speeds and current levels, arc forces promote smaller, but more frequent droplets to form at the electrode tip. These droplets (less than 1.5 times the diameter of the electrode) stream across the arc reducing spatter production. This mode of transfer is called spray transfer. The transition from globular transfer to spray transfer occurs rather quickly, and at a specific current level. This current level is a function of the shielding gas composition, electrode composition, and electrode diameter. For a 0.045-inch mild steel electrode, with a 90%Ar/10%CO₂ gas mixture, the transition current to spray occurs at about 245A. This mode of transfer typically extends for hundreds of amperes until the electrode reaches current carrying capacity.

Of these three modes of metal transfer, only globular transfer is seldom (should never be?) used due to excessive spatter production and poor arc stability.

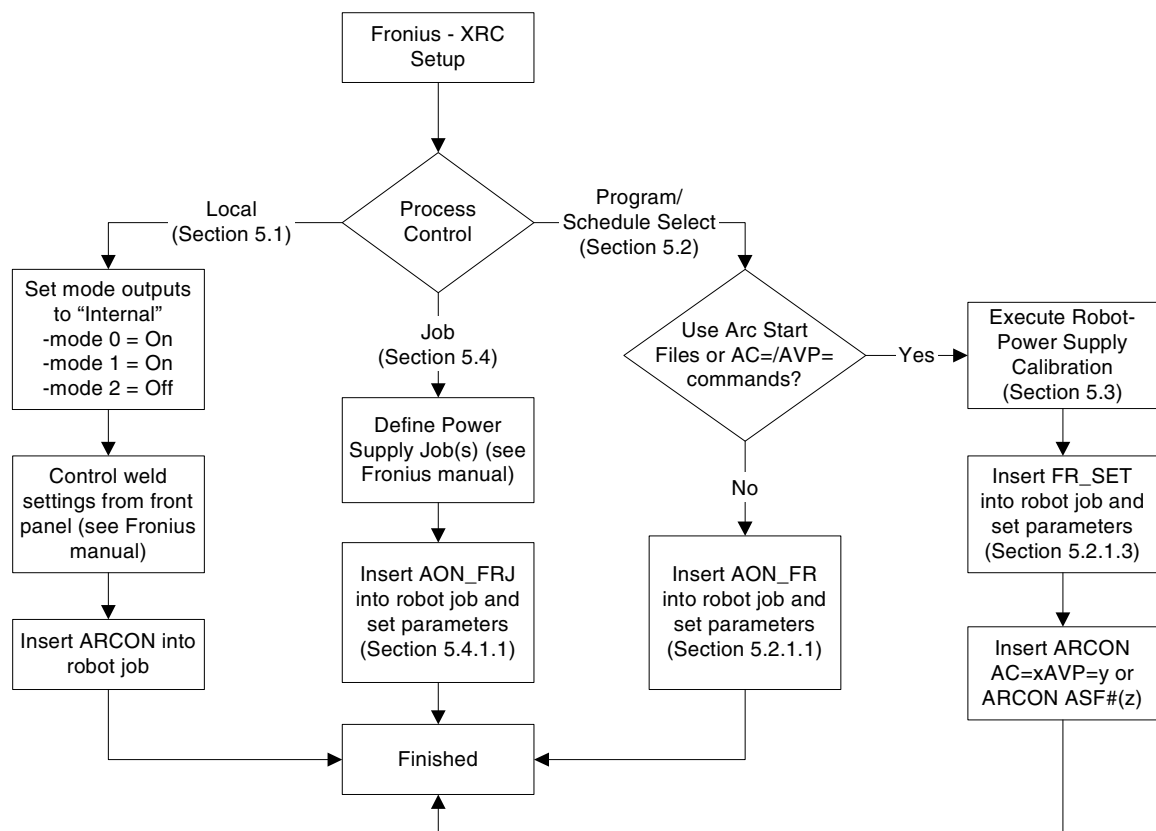
4.2 Pulsed Gas Metal Arc Welding

Pulse welding, or GMAW-P is similar to non-pulsed welding as defined above except that spray current, hence low/no-spatter, can be achieved for virtually the entire range of wire feed speeds. Spray transfer is accomplished by elevating the current above that required for globular transfer, holding the current while a droplet(s) is formed and detached from the electrode, and then dropping the current to a low background level (typically between 20 and 100 Amps). The amount of time at this background level is often based (inversely) on the wire feed speed – higher wire feed speeds require more droplets per second and so shorter background times (higher frequencies) are often used. Pulse mode is recommended for welding conditions (wire feed speeds) where globular transfer would be achieved in non-pulsed mode. Pulse mode is typically used for all wire feeds speeds for aluminium GMA welding. Pulse welding is often a more complex process to control as the process has numerous variables that must be balanced.

The Fronius TPS power supply automatically associates specific pulse parameter variable values with specific wire feed speed levels. As the wire feed speed is changed, these pulse parameters are automatically changed as well. This is the definition of a synergic power supply.

Notes

Chapter 5 Operation



5.1 Local Control

With local control, the welding process is controlled from the front panel of the power supply. Program/Job number I/O are ignored as well as the AWELD and VWELD analog signals. The following variable parameters must be adjusted from the power supply:

- Output mode (pulse synergic, synergic, standard, Job mode, etc.)
- Wire Feed Speed (WFS)
- Voltage trim / voltage
- Arc-force (dynamic) correction

For detailed information on controlling the welding process locally from the power supply, refer to the Fronius vendor manuals that shipped with your system.

To operate your system via local control, set mode outputs as follows:

```
mode 0 = ON  
mode 1 = ON  
mode 2 = OFF
```

Refer to your system documentation to determine the specific Universal Outputs used to control operation mode for your specific system.

5.2 Program (Schedule Select) Control

Various schedules (Programs) have been defined inside the Fronius power supply. Each program is set up for a specific wire diameter, wire type (mild steel, 4043 aluminium, etc.), and shielding gas type (CO₂, Argon, etc.). For example: schedule 2 is developed for Synergic Mode welding of mild steel with a 1.2mm diameter steel electrode and CO₂ shielding gas, schedule 17 has been developed for Synergic or Pulse Synergic Mode welding of aluminium with a 1.2mm (3/64") 4043 aluminium electrode and Argon shielding gas. The schedules are listed in the Fronius Operations Manual.

5.2.1 Robot Job Commands for Program Mode

5.2.1.1 AON_FR

The AON_FR command sets the power supply to Pulse or Synergic mode; selects the program or schedule to be used; sets Arc Dynamic, Wire Feed Speed, and Voltage Trim; and issues the ARCON command, and sets a robot pause time.

Table 4 AON_FR Parameters

Parameter	Value
Wire Feed Speed	Inches per minute
Voltage Trim	-30 to +30
Timer	seconds
Mode	0= Synergic, 1= Pulse
Program Number	0 to 99
Arc Dynamic	-5.0 to +5.0

Sample Robot Job:

```
0000  NOP
0001  MOVJ  VJ=100.0
0002  MOVJ  VJ=100.0
0003  AON_FR  WFS=200  V=4  T=0.5
0004  MOVL  V=100
0005  ARCOF
0006  MOVJ  VJ=100.0
0007  END
```

To change AON_FR parameters, proceed as follows:

1. Select the AON_FR command from the instruction side of the job line.
2. Press [SELECT]. The AON_FR command appears in the input buffer line.

JOB	EDIT	DISPLAY	UTILITY
JOB CONTENT			
J:WORK	S:002	R1	TOOL:*
0000 NOP			
0001 MOVJ VJ=100.0			
0002 MOVJ VJ=100.0			
0003 AON_FR WFS=200 V=4 T=0.5			
0004 MOVL V=100			
0005 ARCOF			
0006 MOVJ VJ=100.0			
=>AON_FR WFS=200 V=4 T=0.5			
!			

3. Press [SELECT]. The Detail Edit screen appears.

JOB	EDIT	DISPLAY	UTILITY
DETAIL EDIT			
AON_FR			TOOL:*
Wire Feed Speed		200	in/min
Voltage Trim		4	-30:30
Timer		0.5	sec
mode: Pls=1, Syn=0		0	0/1
Program Number		0	0:99
Arc Dynamic		0	-5.0:5.0
=>AON_FR WFS=200 V=4 T=0.5			
!			

4. Cursor to the parameters you wish to change and press [SELECT].
5. Enter correct data using the number keypad and press [ENTER]. The new data is displayed in the Input Buffer line.
6. Press [ENTER] once more to register the data in the job or press [CANCEL] if you do not wish to register the data.

5.2.1.2 ASET_FR

The ASET_FR command is used to modify the weld parameters or operating mode during a weld. The output mode can be changed for Pulse or Synergic mode and Arc Dynamic, WFS, and Voltage Trim can be adjusted as well.

Table 5 ASET_FR Parameters

Parameter	Value
Wire Feed Speed	inches per minute
Voltage Trim	-30 to +30
Mode	0=Synergic, 1=Pulse
Arc Dynamic	-5.0 to +5.0

Sample Robot Job:

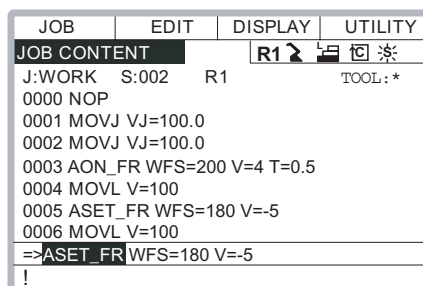
```

0000  NOP
0001  MOVJ VJ=100.0
0002  MOVJ VJ=100.0
0003  AON_FR WFS=200 V=4 T=0.5
0004  MOVL V=100
0005  ASET_FR WFS=180 V=-5
0006  MOVL V=100
0007  ARCOF
0008  MOVJ VJ=100.0
0009  END

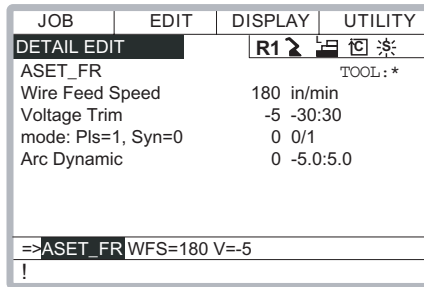
```

To set ASET_FR parameters, proceed as follows:

1. Select the ASET_FR command from the instruction side of the job line.
2. Press [SELECT]. The ASET_FR command appears in the input buffer line.



3. Press [SELECT]. The Detail Edit screen appears.



4. Cursor to the parameters you wish to change and press [SELECT].
5. Enter correct data using the number keypad and press [ENTER]. The new data is displayed in the Input Buffer line.
6. Press [ENTER] once more to register the data in the job or press [CANCEL] if you do not wish to register the data.

5.2.1.3 FR_SET

The FR_SET command is used in conjunction with the ARCON and ARCOF commands. It sets the power supply to either Pulse Synergic or Synergic mode, and selects the program or schedule to be used.



Note: Before using Arc Start/Arc End files, or the ARCSET/ARCON/ARCOF commands with AC= and AV= or AVP= arguments, the AWELD signal must be defined (see Section 5.3 AWELD Calibration).

Table 6 FR_SET Parameters

Parameter	Value
Mode	0 = Synergic, 1 = Pulse
Program Number	0 to 99
Arc Dynamic	-5.0 to +5.0

Sample Robot Job:

```

0000  NOP
0001  MOVJ VJ=100.0
0002  MOVJ VJ=100.0
0003  FR_SET Mode=1 P=18
0004  MOVL V=100
0005  ARCON ASF#(1)
0006  MOVL V=100
0007  FR_SET Mode=1 P=18
0008  ARCSET AC=200 AVP=98
0009  MOVL V=100
0010  ARCOF ASF#(2)
0011  MOVJ VJ=100.0
0012  END

```

To set FR_SET parameters, proceed as follows:

1. Select the FR_SET command from the instruction side of the job line.
2. Press [SELECT]. The FR_SET command appears in the input buffer line.

JOB	EDIT	DISPLAY	UTILITY
JOB CONTENT			
J:WORK	S:002	R1	TOOL:*
0000 NOP			
0001 MOVJ VJ=100.0			
0002 MOVJ VJ=100.0			
0003 FR_SET Mode=1 P=18			
0004 MOVL V=100			
0005 ARCON ASF# (1)			
0006 MOVL V=100			
=>FR_SET Mode=1 P=18			
!			

3. Press [SELECT]. The Detail Edit screen appears.

JOB	EDIT	DISPLAY	UTILITY
DETAIL EDIT			
FR_SET			TOOL:*
mode: Pls=1, Syn=0		0	0/1
Program Number		6	0:99
Arc Dynamic		0	-5.0:5.0
=>FR_SET Mode=0 P=6			
!			

4. Cursor to the parameters you wish to change and press [SELECT].
5. Enter correct data using the number keypad and press [ENTER]. The new data is displayed in the Input Buffer line.
6. Press [ENTER] once more to register the data in the job or press [CANCEL] if you do not wish to register the data.

5.3 Robot Controller-Power Supply Calibration

Although the AWELD signal always directly controls the wire feeding speed, the robot programming pendant can be calibrated to display one of two values for the AWELD signal: Wire Feed Speed (recommended) or Amperage. Power trim calibration is especially useful when operating with multiple wire types and/or wire diameters.

Before welding using Arc Start/Arc End files, or the ARCSET/ARCON/ARCOF commands with AC= and AV= or AVP= arguments, the AWELD/VWELD signals must be defined to determine what value will be displayed on the programming pendant. The AWELD signal value is determined by a table in the Welder Condition File.



Note: Regardless of calibration (wire feed speed, amperage, or power trim), it is not possible to modify the Arc Start and Arc End Files to display "in/min." on the programming pendant. The display will always show "(A)."



Note: The AON_FR and ASET_FR robot job commands do not require the following calibration procedures.

5.3.1 AWELD = Wire Feed Speed

To calibrate the AWELD signal to wire feed speed, proceed as follows:

1. Open Welder Condition File (TOP MENU > ARCWELDING > WELDER CONDITION).

DATA	EDIT	DISPLAY	UTILITY
WELDER CONDITION			
WELDER NO.	:	1	
SETTING	:	DONE	
WELDER NAME	:	FRONIUS	
COMM.:AWELD=WFS	:		
POWER SUPPLY	:	A/%	
SHIELDING GAS	:	CO2	
WIRE DIA.	:	1.2 mm	
WIRE EXT.	:	15 mm	
WIRE ANTI-STICKING	:	0.3 sec	
ARC SHORTAGE STOP	:	1.50 sec	
!			

2. Verify POWER SUPPLY is set to A/%, not A/V (used for Standard mode only).
3. Scroll down to Welding Current Output Characteristics.

DATA	EDIT	DISPLAY	UTILITY
WELDER CONDITION			
<WELDING CURRENT OUTPUT CHAR.>			
RANGE:+	:	ADJUST :1.00	
NO.	REF.(V)	MEASURE(A)	
01	0.00	60	
02	5.00	460	
03	10.00	860	
04	0.00	0	
05	0.00	0	
06	0.00	0	
07	0.00	0	
!			

4. Modify Welding Current Output Characteristics using appropriate values from the following table.

Table 7 Wire Feed Speed (WFS) Calibration

Ref. (V)	0.9 Steel Measured (A)	1.2 Steel Measured (A)	1.6 Steel Measured (A)	0.9 4043 Al Measured (A)	1.2 4043 Al Measured (A)	1.6 4043 Al Measured (A)
0.00	60	60	45	195	195	100
5.00	460	460	200	530	420	245
10.00	860	860	350	860	640	390

5. Scroll down to Welding Voltage Output Characteristics.

DATA	EDIT	DISPLAY	UTILITY
WELDER CONDITION R1			
<WELDING VOLTAGE OUTPUT CHAR.>			
RANGE:+		ADJUST :1.00	
NO.	REF.(V)	MEASURE(%)	
01	0.00	70	
02	5.00	100	
03	10.00	130	
04	0.00	0	
05	0.00	0	
06	0.00	0	
07	0.00	0	
!			

6. Verify values for Welding Voltage Output Characteristics as follows:

Table 8 Welding Voltage Output Characteristics

Ref. (V)	TRIM Measured (%)
0.00	70
5.00	100
10.00	130

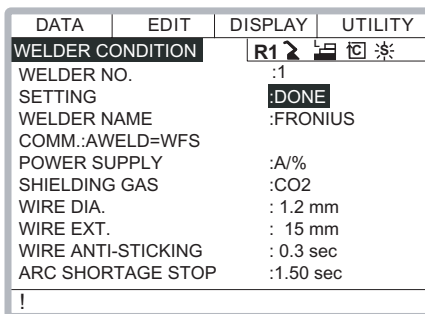
7. When you are finished modifying the Weld Condition values, be sure to change Setting value to "DONE".

DATA	EDIT	DISPLAY	UTILITY
WELDER CONDITION R1			
WELDER NO.		:1	
SETTING		:DONE	
WELDER NAME		:FRONIUS	
COMM.:AWELD=WFS			
POWER SUPPLY		:A/%	
SHIELDING GAS		:CO2	
WIRE DIA.		: 1.2 mm	
WIRE EXT.		: 15 mm	
WIRE ANTI-STICKING		: 0.3 sec	
ARC SHORTAGE STOP		:1.50 sec	
!			

5.3.2 AWELD = Amperage

To view the AWELD signal as amperage, proceed as follows:

1. Open Welder Condition File (TOP MENU > ARCWELDING > WELDER CONDITION).



2. Verify POWER SUPPLY is set to A/%, not A/V (used for Standard mode).
3. Set Welding Current Output Characteristics using appropriate values from the following table.

Table 9 Amperage Calibration

Ref. (V)	0.9 Steel Measured (A)	1.2 Steel Measured (A)	1.6 Steel Measured (A)	0.9 4043 Al Measured (A)	1.2 4043 Al Measured (A)	1.6 4043 Al Measured (A)
0.00	38	69	96	55	95	105
1.50	101	188	193	144	124	79
3.00	141	248	247	121	177	186
4.50	183	314	304	157	213	248
6.00	217	374	345	192	252	301
7.50	248	433	402	225	290	345
9.00	276	477	441	257	326	384
10.00	294	499	496	279	349	409

4. Scroll down to Welding Voltage Output Characteristics.

DATA	EDIT	DISPLAY	UTILITY
WELDER CONDITION		R1	⏪ ⏩ ⏴ ⏵
<WELDING VOLTAGE OUTPUT CHAR.>			
RANGE:+		ADJUST :1.00	
NO.	REF.(V)	MEASURE(%)	
01	0.00	70	
02	5.00	100	
03	10.00	130	
04	0.00	0	
05	0.00	0	
06	0.00	0	
07	0.00	0	
!			

5. Verify values for Welding Voltage Output Characteristics as follows:

Table 10 Welding Voltage Output Characteristics

Ref. (V)	TRIM Measured (%)
0.00	70
5.00	100
10.00	130

6. When you are finished modifying the Weld Condition values, be sure to change Setting value to “DONE”.

DATA	EDIT	DISPLAY	UTILITY
WELDER CONDITION		R1	⏪ ⏩ ⏴ ⏵
WELDER NO.		:1	
SETTING		:DONE	
WELDER NAME		:FRONIUS	
COMM.:AWELD=WFS			
POWER SUPPLY		:A%	
SHIELDING GAS		:CO2	
WIRE DIA.		: 1.2 mm	
WIRE EXT.		: 15 mm	
WIRE ANTI-STICKING		: 0.3 sec	
ARC SHORTAGE STOP		:1.50 sec	
!			

5.3.3 Verify Proper Calibration

It is important to verify that the AWELD values defined on the programming pendant match those displayed on the front of the power supply.

1. Insert an ARCSET command into a robot Job using the FR_SET command.

```
0000  NOP
0001  FR_SET Mode=0 P=18
0002  ARCSET AC=200 AVP=98
0012  END
```

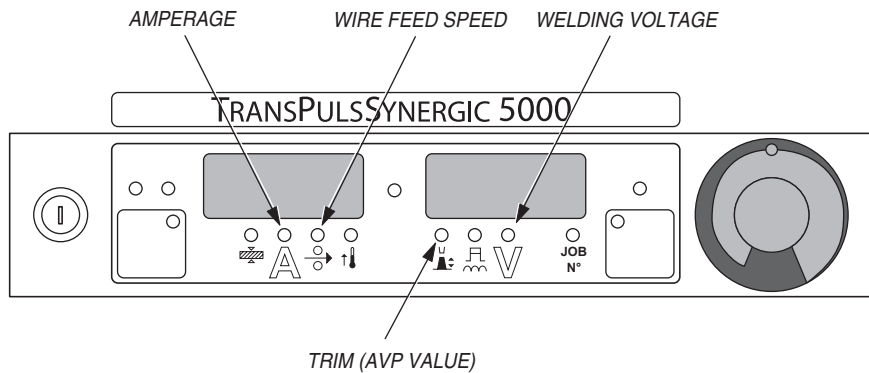
2. Click SELECT twice on the ARCSET command from the Instruction side. The Detail Edit screen appears.
3. Select AC and AV from the Detail Edit screen. The ARCSET command should appear in the robot job as follows:

```
ARCSET AC=xxx AVP=yyy
```

4. Place various values into the ARCSET command (e.g. AC=100 AVP=85; AC=300 AVP=100; AC=700 AVP=115; etc.).
5. Set the power supply to display the parameter that you calibrated the programming pendant to display for AWELD (Amperage or Wire Feed Speed).



Note: Power Trim value cannot be displayed on the power supply.



During day-to-day operation, the alpha-numeric displays of the power supply provides the following functions:

Table 11 Power Supply Displays

State	Left Display	Right Display
Not Welding	Wire Feed Speed	Arc Length Correction/Trim
	Anticipated Amperage	Arc Dynamic
	Recommended Thickness	Anticipated Welding Voltage
		Job Number
Welding	Actual Amperage	Actual Welding Voltage
1 Second After Welding	Actual Amperage	Actual Welding Voltage

- Execute the ARCSET command by holding down the INT LOCK key and pressing FWD. Each time a value is executed, look at the display on the power supply and verify the requested job value matches the value displayed on the power supply.

Table 12 AWELD = Amperage (Synergic modes)

AC (Job Value)	Amps (Fronius Display)	AVP (Job Value)	Trim (Fronius Display)
120A	120A	70%	-30%
200A	200A	100%	0
280A	280A	130%	30%

Table 13 AWELD = Wire Feed Speed(Synergic modes)

AC (Job Value)	WFS (Fronius Display)	AV (Job Value)	Trim (Fronius Display)
120A	120 in/min.	70%	-30%
200A	200 in/min.	100%	0
280A	280 in/min.	130%	30%

Table 14 AWELD = Power Trim (Synergic modes)

AC (Job Value)	Power Trim (Fronius Display)	AV (Job Value)	Trim (Fronius Display)
120A	12% of max WFS	70%	-30%
500A	50% of max WFS	100%	0
920A	92% of max WFS	130%	30%

Job Value is the value set in the ARCSET command of the robot job. Fronius Display is the value displayed on the power supply.

5.4 Job Mode

An alternate way to control the power supply is to use jobs stored in the power supply. Several welding parameters including; wire feed speed (termed “Power” by the power supply), and voltage trim are saved in jobs contained in the power supply memory. These jobs can be modified, copied, or deleted locally using the front panel of the power supply, or by remote PC software. There are typically 100 jobs available. These jobs are selected the same way (same I/O bits) as Program selections were made above. Each individual job can be set up for Synergic or Pulse Synergic operation, and contain parameters to adjust starting and ending parameters, gas flow timing, arc dynamic, and others. Each job is also set up for a material type, wire diameter, and gas type.

There are also job parameters that allow the user to control primary welding variables to a limited degree from the robot controller.

AL.c (Arc Length Correction) Allows VWELD to adjust voltage trim from the value stored in the Fronius job. Maximum correction boundary window is -30% to +30%

PcL (Power Control Low) Allows the AWELD channel to decrease the WFS by up to 20% of the value stored in the Fronius job.

PcH (Power Control High) Allows the AWELD channel to increase the WFS by up to 20% of the value stored in the Fronius job.

5.4.1 Robot Job Commands for Job Mode

5.4.1.1 AON_FRJ

The AON_FRJ command sets the power supply to Job mode; sets the Job number to be used; assigns values for Timer, WFS correction %, and Voltage trim correction; and issues the ARCON command.

Table 15 AON_FRJ Parameters

Parameter	Value
Job Number	0 to 99
Timer	seconds
WFS trim	-20 to +20
Voltage trim	-30 to +30

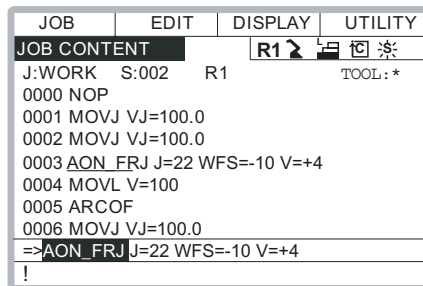
Sample Robot Job:

```

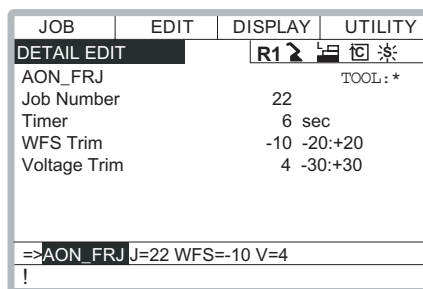
0000  NOP
0001  MOVJ  VJ=100.0
0002  MOVJ  VJ=100.0
0003  AON_FRJ  J=22  WFS=-10  V=4
0004  MOVL  V=100
0005  ARCOF
0006  MOVJ  VJ=100.0
0007  END
  
```

To change AON_FRJ parameters, proceed as follows:

1. Select the AON_FRJ command from the instruction side of the job line.
2. Press [SELECT]. The AON_FRJ command appears in the input buffer line.



3. Press [SELECT]. The Detail Edit screen appears.



4. Cursor to the parameters you wish to change and press [SELECT].
5. Enter correct data using the number keypad and press [ENTER]. The new data is displayed in the Input Buffer line.
6. Press [ENTER] once more to register the data in the job or press [CANCEL] if you do not wish to register the data.

Table 16

Reference Voltage	Voltage Trim	Wire Feed Speed (WFS)
0.0V	-AL.c value	WFS set value - PcL value
5.0V	V Trim value set in Job	WFS value set in Job
10.0V	+AL.c value	WFS set value +PcH value

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