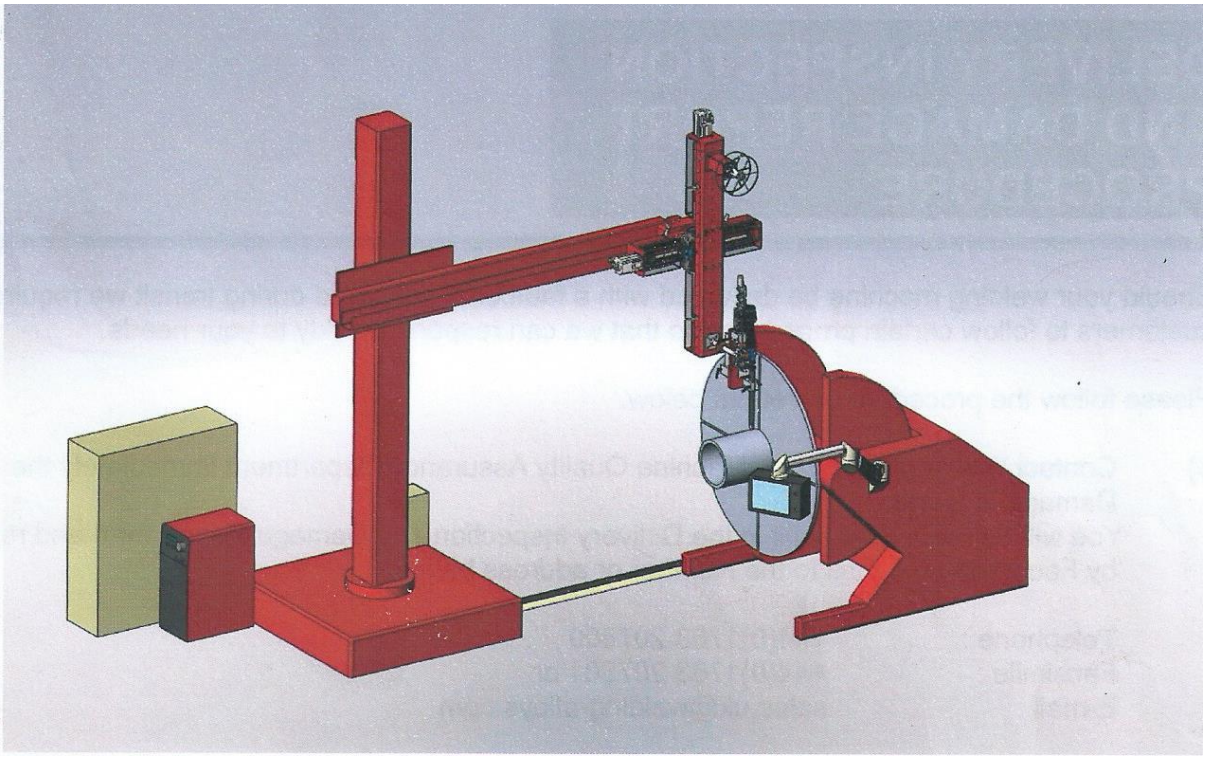
Orbital Welding System
Software User Manual



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Contents

Revision History

Revision History

Revision	Date	Description
0v0	10/3/2019	First release
0v1	07/6/2020	Step count increased to 50. Screen layout update. AVC modified for extra steps when stepping over from one row to the next
0v2	07/7/2021	AVC control in 4 directions added. Mechanical axis rotation added. AVC axis height can adjust the diameter on cylinder welding Working diameter displayed on main page

Safety Instructions

General safety information

The following safety instructions apply to the Orbital Welding System.

The product-specific safety and application notes given in this documentation must be observed

The Orbital Welding System:

- Must only be used for the intended purpose
- Must never be operated if damaged
- Must never be subject to technical modifications
- Must never be operated unless completely assembled

Only qualified skilled personnel are permitted to work with this product.

According to IEC 60364 or CENELEC HD 384, these are persons:

- Who are familiar with the installation, assembly, commissioning and operation of this product.
- Possess the appropriate qualifications for this work
- Are acquainted with and can apply all the accident prevention regulations, directives and laws at the place of use.

Application as directed

- The product must only be operated under the operating conditions prescribed in this documentation.
- The product is not a household appliance and is only designed as component for commercial or professional use in terms of EN 61000−3−2.

Refer to the original Welding Alloys documentation for

- Maintenance
- Additional manuals for ancillary equipment
- Additional safety notifications
- Electrical drawings

Product Description

Product description

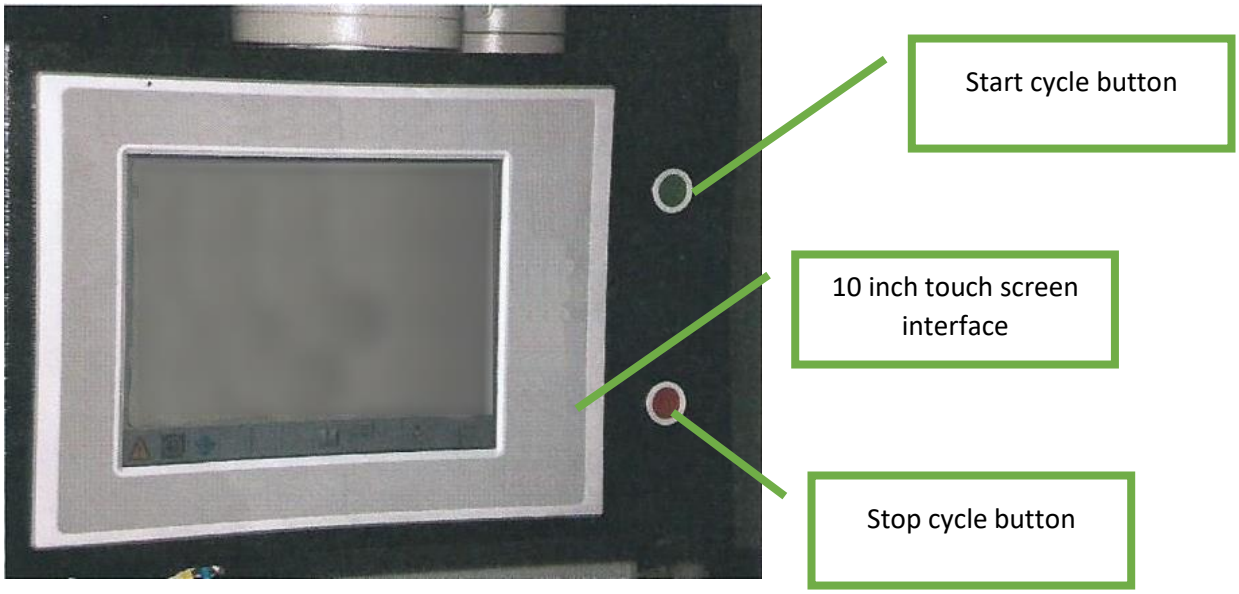


Figure 1 operators console front view

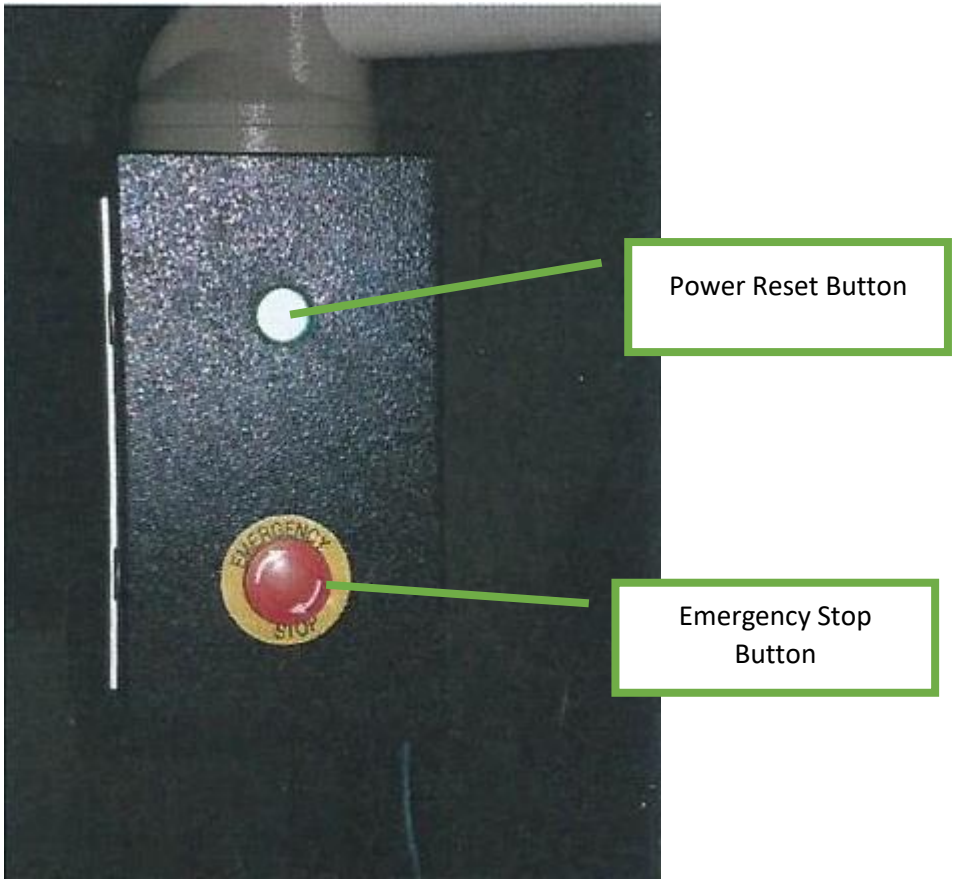


Figure 2 Operators console side view

Operation

Operation

Introduction

The orbital welding system software has been designed to control the path of a TIG welding torch on a rotating table. There are three axes of motion:

- The turntable
- X axis, moving the torch horizontally
- Y axis, moving the torch vertically

Additionally, the welding plant current and pulse frequency are controlled, the welding wire feed rate, the hot wire current and welding gas on/off are also controlled.

The system is configured with a series of parameters and positions entered on a touch screen. Sets of data can be saved as files for later retrieval.

Two modes of operation are possible:

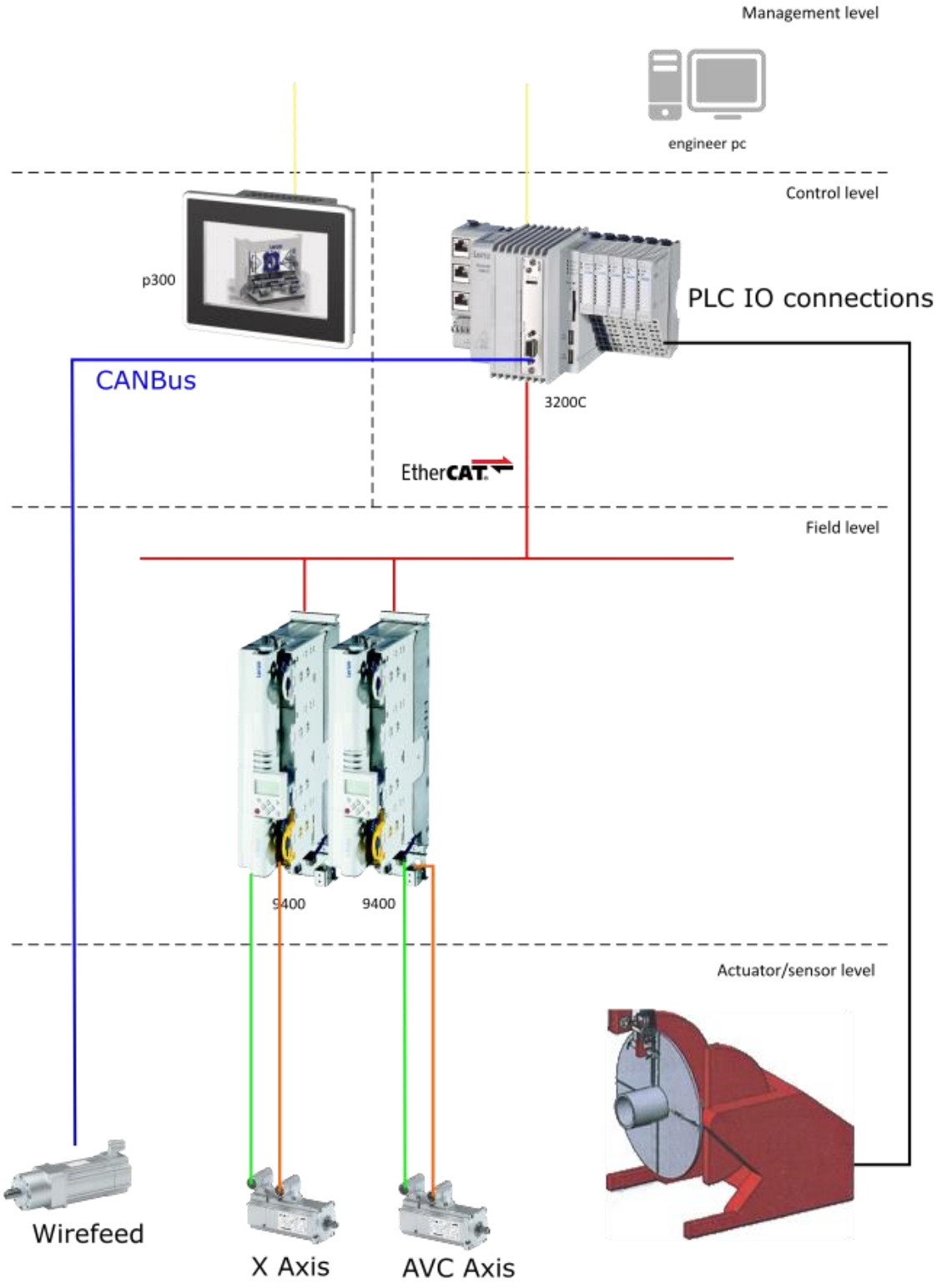
- Flat welding, for cladding the surface of a disk or filling a ring groove with the table set horizontally.
- Cylinder welding, for cladding the surface of a cylinder with the table tilted vertically.

The electronics hardware:

- Lenz C3200 PLC/Motion controller
- Lenze P300 10” touch screen
- Lenze 9400 servo controllers and motors
- Lenze 940 Fluxx Torque motor for the wire feed.
- The rotator has its own control for rotation and tilt. The C3200 outputs signals to control rotation but not tilt which is controlled with its own independent pendant.
- The column and boom is a self-contained system with its own pendant for positioning.

Operation

System hardware layout



Operation

Operating Screen

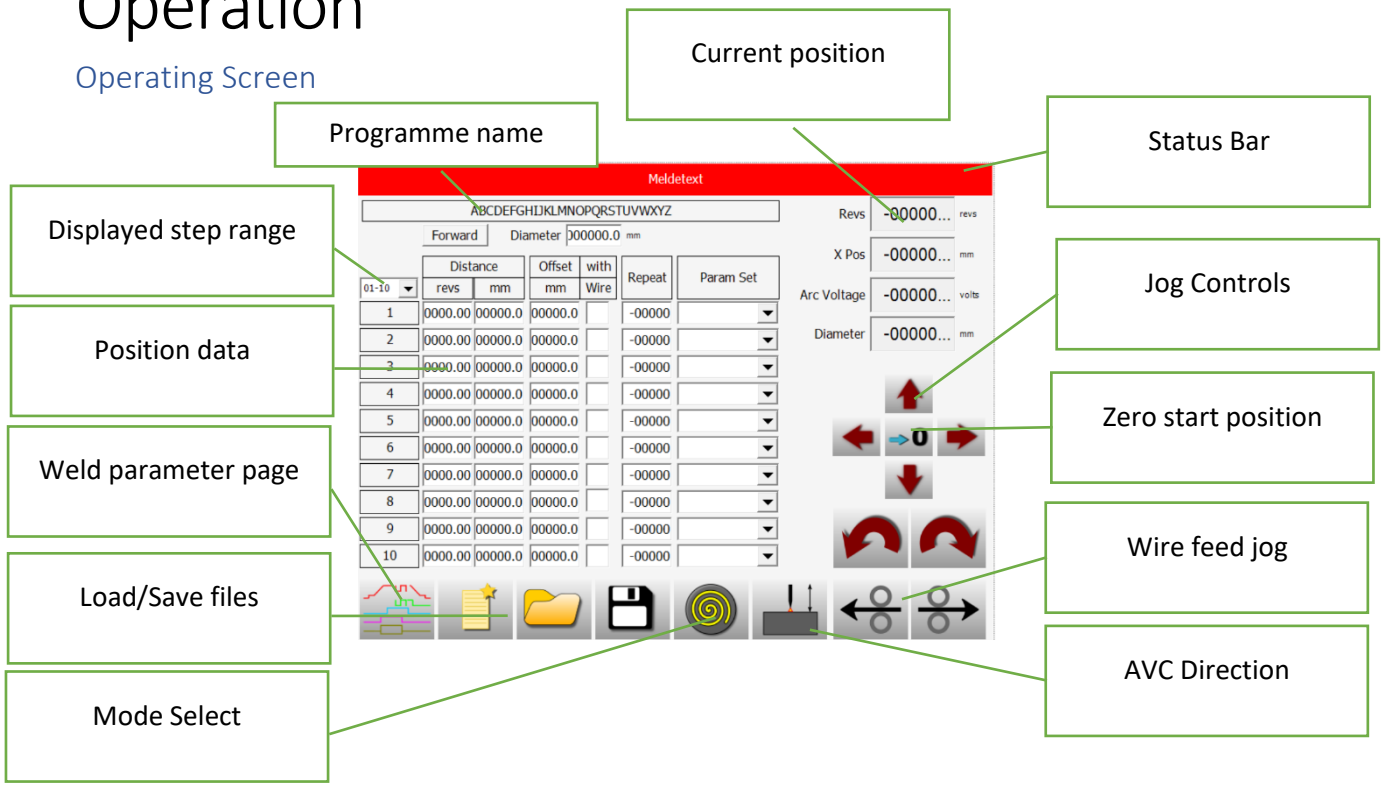
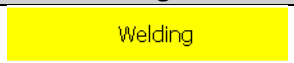
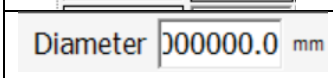
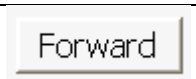
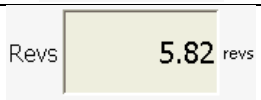
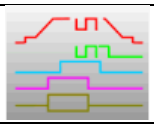
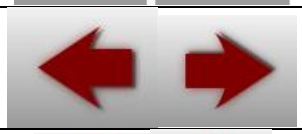
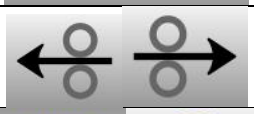
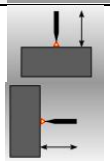
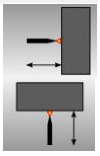


Image	Description
	The status bar shows any alarms (in red) or whether the weld is in cycle or not. If multiple errors occur the status will cycle through each in turn. Touching the status bar will open the alarm window where all current alarms can be viewed at once.
	The screen size limits the number of steps that can be displayed at one time. The programme can consist of up to 50 steps which can be displayed ten at a time by picking the range from the drop down list
	Entering the diameter calibrates the rotation speed and distance. The initial diameter at the start position is entered. The diameter will be internally recalculated as the cycle proceeds and the torch moves away from the centre of rotation (flat welding)
	Direction of rotation of the turntable
	Current distance travelled by the system. The weld cycle can be stopped and restarted without losing position. Press zero to clear.
	Current position of the X axis in millimetres from the last time the zero button was pressed. In flat welding, a negative value is a move closer to the centre of rotation. This is so the calculated diameter decreases as the torch move nearer to the centre of rotation. In cylinder welding the positive/negative direction is unimportant and can be mechanically aligned either way.
	The arc voltage represents the height of the torch from the workpiece during welding. It is only sampled during the high current weld time (ti5)
	Opens the weld parameters page

Operation

Image	Description
	Load and save position data and welding parameters to file
	Jog the X axis left and right at a fixed speed. Jogging to the left should move the torch closer to the centre of the table (flat welding)
	Lower and raise the welding torch manually.
	Reset the position to zero.
	Jog turntable counter clockwise and clockwise.
	Manual wire feed controls.
	Operation mode, cylinder welding or flat welding
1.  2. 3.  4.	Selects the direction of the AVC height control of the torch. Because the axis control is modified by this control it is only active when the emergency stop has been pressed. 1. Torch welding on a horizontal surface with a vertical height control 2. Torch welding on a vertical surface with horizontal height control, the voltage/height increasing if the torch moves +X 3. Torch welding on a vertical surface with horizontal height control, the voltage/height increasing if the torch moves -X 4. Torch welding on a horizontal surface with a vertical height control, the voltage/height increasing if the torch moves -Y

Mode selection

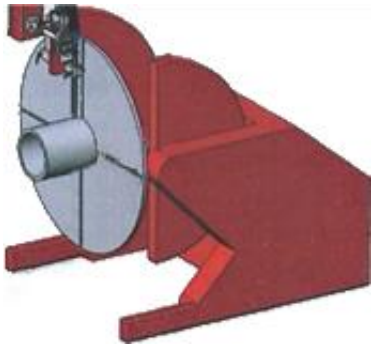
Two modes of operation are available:

- Cylinder welding
- Flat welding

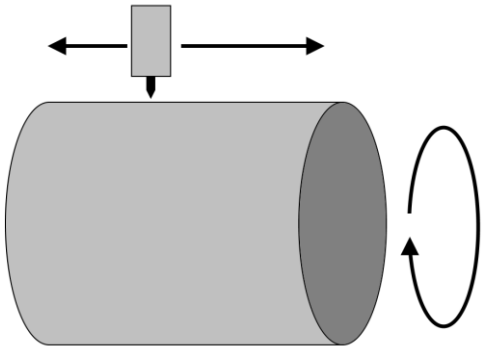
Cylinder Welding

The turntable is tilted so the surface plate is vertical and the cylinder rotates about a horizontal axis.

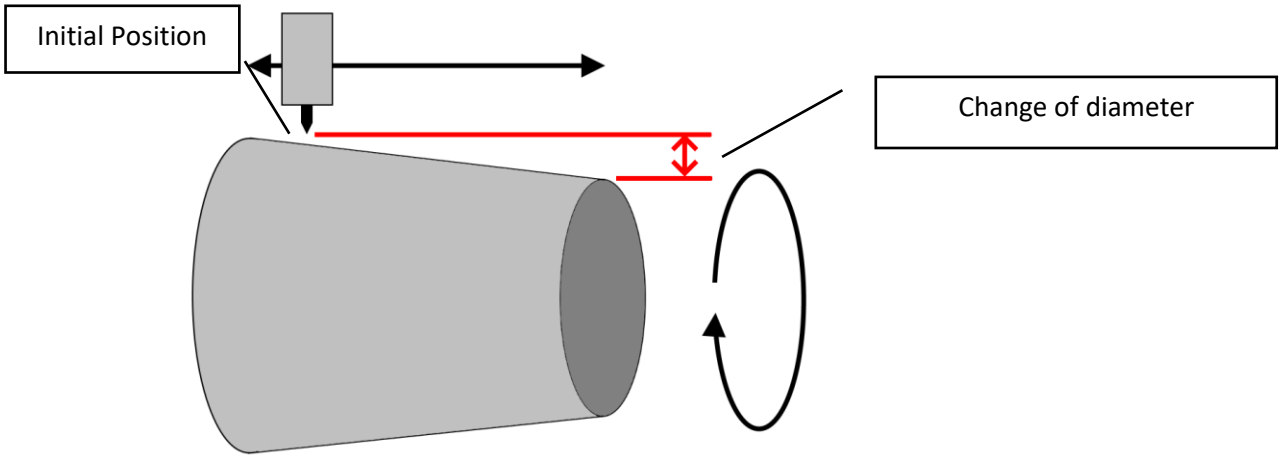
Operation



During welding the turntable rotates and the X axis moves along the length of the cylinder at each offset.



On initial start up of the weld the position of the AVC axis (in millimetres) is measured. Subsequent changes in the position of the AVC axis result in a recalculation of the work piece diameter. This allows for the changes in diameter due to layering or tapered work pieces.



Flat Welding

The turntable is tilted so the surface plate is horizontal and the workpiece rotates around a vertical axis.

During welding the turntable rotates and the X Axis moves perpendicular to the centre of rotation. As the X axis moves away from the centre of rotation, during the offset, the diameter will be re-calculated and the rotation will slow down automatically. The weld parameters do not need to compensate for the change of diameter.

Operation

Position data

01-10	Distance revs	Distance mm	Offset mm	with Wire	Repeat	Param Set
1	0000.00	00000.0	00000.0		-00000	
2	0000.00	00000.0	00000.0		-00000	
3	0000.00	00000.0	00000.0		-00000	
4	0000.00	00000.0	00000.0		-00000	
5	0000.00	00000.0	00000.0		-00000	
6	0000.00	00000.0	00000.0		-00000	
7	0000.00	00000.0	00000.0		-00000	
8	0000.00	00000.0	00000.0		-00000	
9	0000.00	00000.0	00000.0		-00000	
10	0000.00	00000.0	00000.0		-00000	

The position data table sets up the position sequence during welding. It is based on a rotation distance of the turntable followed by an index of the x axis (Offset).

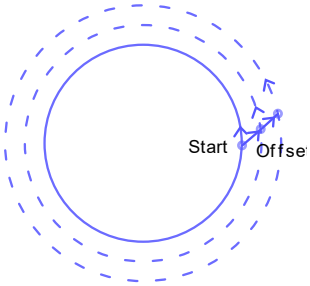


Figure 3 Flat Weld

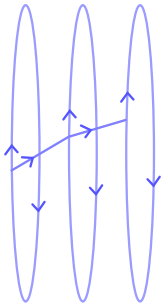


Figure 4 Cylinder Weld

Each step can be repeated multiple times before moving on to the next. The system will stop when a step is reached which has no distance or when the last has completed.

The turntable does not stop when the X axis offset move is applied resulting in a diagonal move.

The rotation distance is measured in two types of units, revs and millimetres. This is just to make calculating the overall distance simpler for the operator. The two values are added together to make an overall distance. If an overlap is required on the weld then the distance in revs can be set to 1rev, then the overlap measured in millimetres added on, say 10mm. If the whole move was measured in revs then the overlap would vary as the diameter changes, if the whole move was measured in millimetres then the single rev would need to be recalculated for each diameter change. The distance can be negative so the total move could be 1rev minus 10mm.

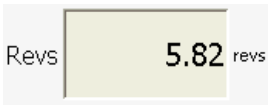
Each step has an associated set of welding parameters. This allows the system to change the welding system voltages, currents etc. for different stages of the process. Perhaps the root pass,

Operation

intermediate passes and final capping pass all require slightly different settings then these can be changed by using a different step for each pass.

A step can be carried out without using wire, this overrides the settings configured on the settings page.

The step label on the side of the table highlights the active step in yellow depending on the revolutions made by the turntable. The example shows 5.82 revs completed. Step one is repeated twice, step two three times so step 3 (highlighted) is the sixth rev.

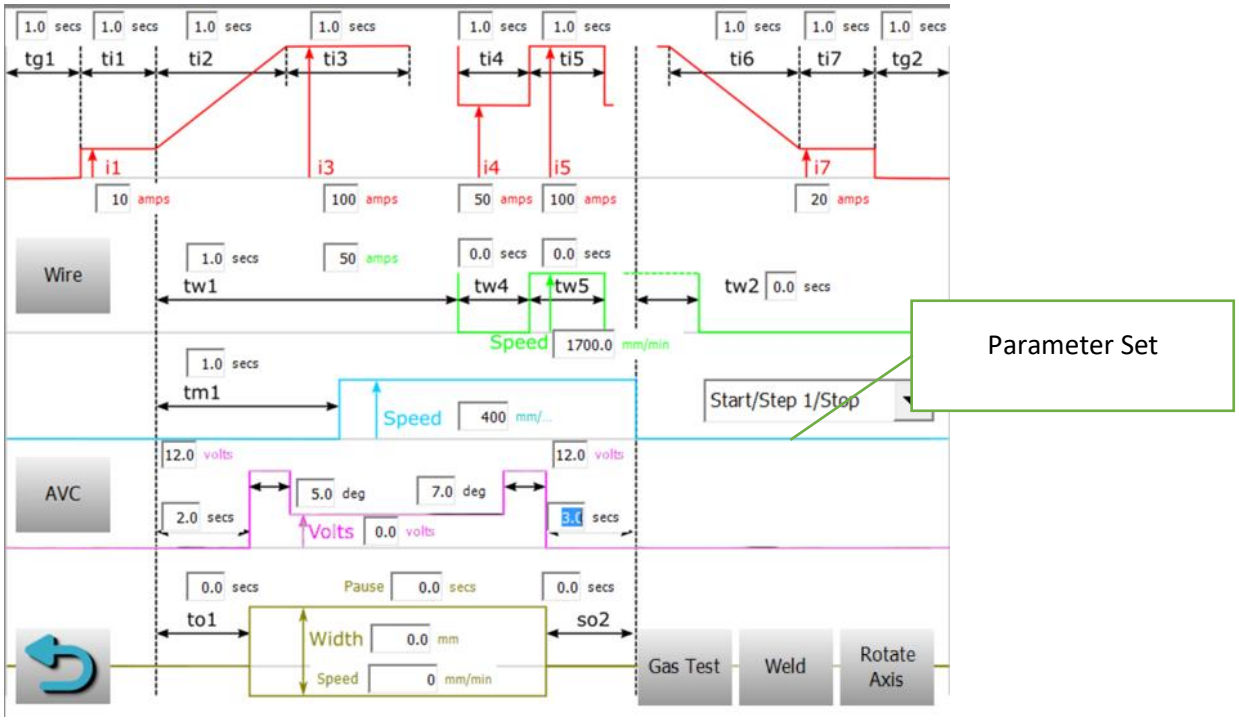


Operation

Weld Parameter Screen

Welding Parameters

Pressing the  opens the welding parameters page.



Ten sets of parameters can be configured. When parameter set 1 is displayed then weld start and stop parameters are also displayed.

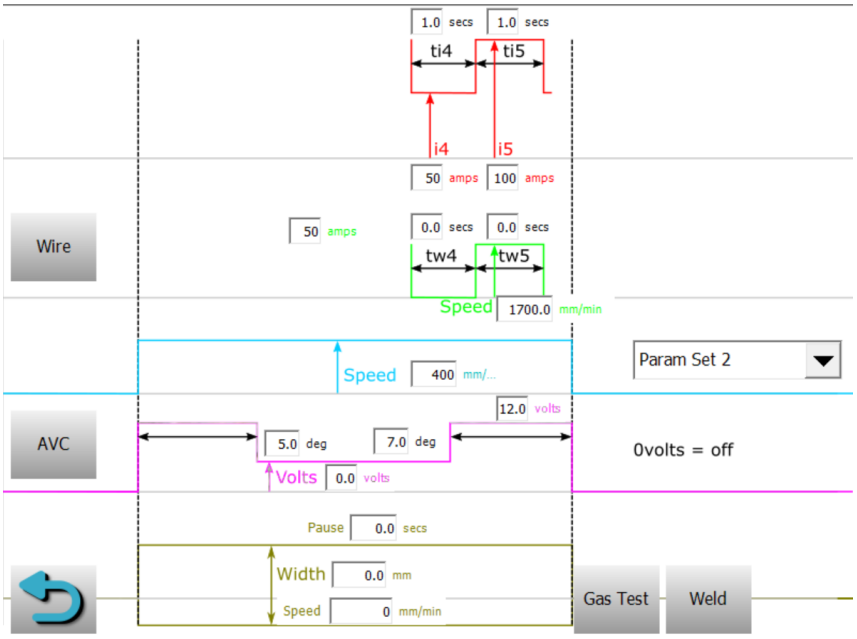
Weld start parameters take the system from initialisation, to establishing the arc and stabilising the weld pool.

Weld stop parameters ramp down the arc, stop movement and wire, switch off the arc and post flow the gas.

The rotate axis button 

rotates the XY axis on the machine. This should be used in conjunction with the manual gearbox on the rear of the XY slide which attaches the unit to the boom. After the XY slide has been physically rotated 90 degrees from its normal position the button should be activated. The jog controls on the main screen should then work as normal.

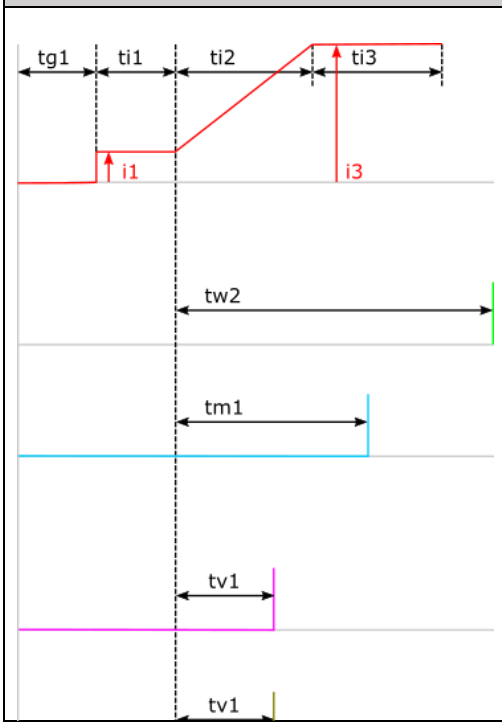
Operation



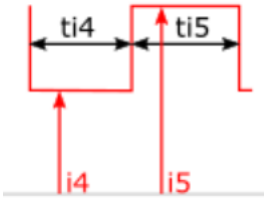
When parameter sets 2 to 10 are displayed the start/stop parameters are hidden.

Operation

Weld Start up parameters

	Parameter	Description
	tg1	Pre-flow gas time
	ti1	Arc stabilisation time, allows the arc to settle after ignition
	I1	Initial arc current
	ti2	Arc ramp up time
	I3	Arc current to establish weld pool
	ti3	Time at i3 current before pulsing arc and starting the main parameter set
	tw2	Delay after establishing arc before wire feed begins
	tm1	Delay after establishing arc before turntable motion begins
	tv1	Delay after establishing arc before arc voltage height control begins
	to1	Delay after establishing arc before X axis oscillation begins

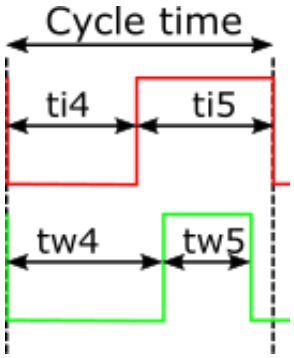
Parameter set

	Parameter	Description
	ti4	Time at background current i4
	ti5	Time at foreground current i5
	I4	Weld background current
	I5	Weld foreground current
	Wire Current	Set current of hot wire system
	Wire Speed	Hot wire feed rate mm/min during tw5 time
	tw4	Wire pause time
	tw5	Wire feed time
		Rotation speed in mm/min. the speed of the rotator is automatically scaled by the diameter value on the main page. On a flat weld the diameter is automatically re-calculated as the X axis move towards/away from the centre of rotation.
	Volts	Set arc voltage, controls the height of the torch from the workpiece. The control only measures the actual voltage during ti5. The step is split into 3 parts, an initial voltage v1 for lt1 degrees, then the main part of the step at voltage v2,

Operation

	Parameter	Description
		then at a distance lt3 before the end of the step the voltage setting changes to v3. V2 can be set to 0 volts which switches off the AVC control, the torch height can be initially set using v1, then the AVC is switched off for the remainder of the step. V3 is used to enable the AVC when the weld may overlap the beginning. V1 is only used when the arc is first initialised, on subsequent steps the voltage level v3 continues on for a distance of lt1 into the next step.
	Width	Width of the X axis oscillation during welding. The torch moves left and right symmetrically around the set position.
	Oscillation Speed	The speed in mm/min of the X axis during oscillation and during the X offset move described in the position data table.
	Pause	At each end of the oscillation move the X axis pauses before returning in the opposite direction. This pause will transform the overall move from a zig zag to a squarer move.

The current pulse and wire pulse are synchronised at the falling edge of the peak current (tw5).

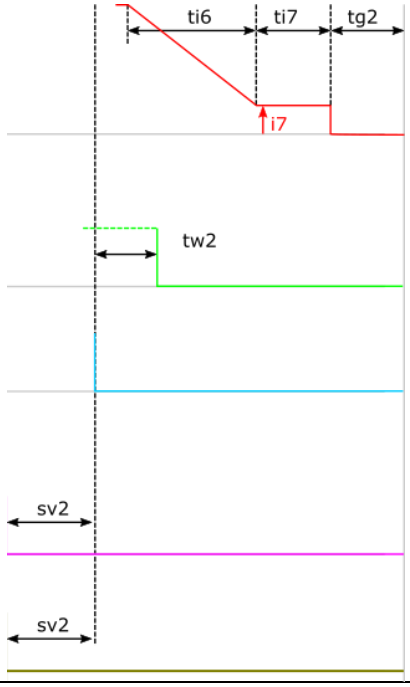


This allows the wire to be started and stopped earlier or later than the peak welding current to optimise the wire feed.

Weld Stop Parameters

	Parameter	Description
	ti6	Weld current ramp down time
	ti7	Weld pool cooling time. Allows the final weld pool to settle before switching of the arc
	I7	final arc current

Operation



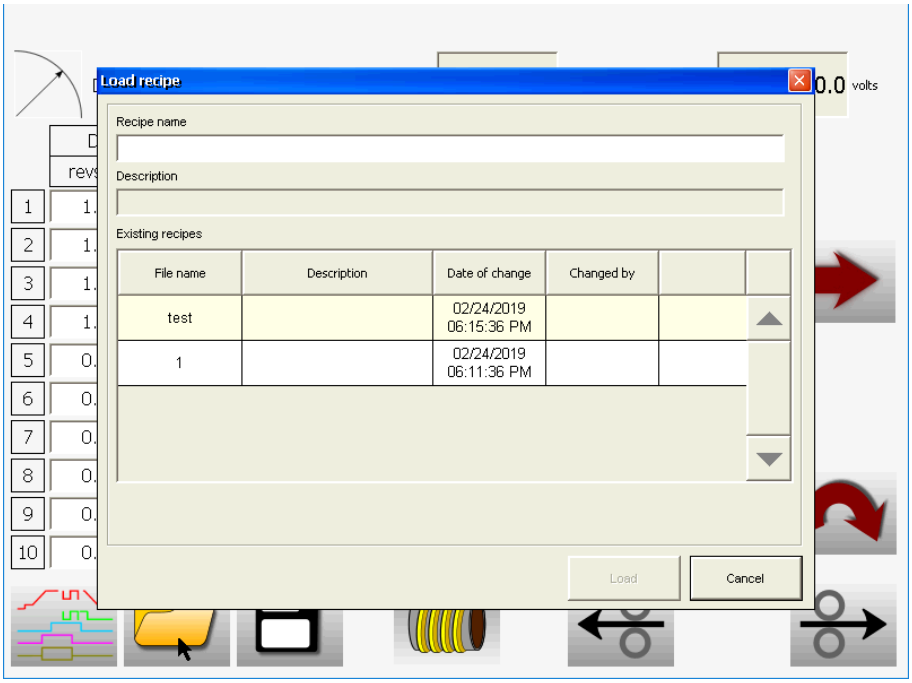
tg2	Post flow gas time. Gas continues to flow after the arc has extinguished
tw2	Time before turntable stops that the hot wire is switched off and no longer fed
tv2	Time before turntable stops that the arc voltage control is switched off
to2	Time before turntable stops that the oscillation is stopped.

Operation

Loading and saving parameters

Loading

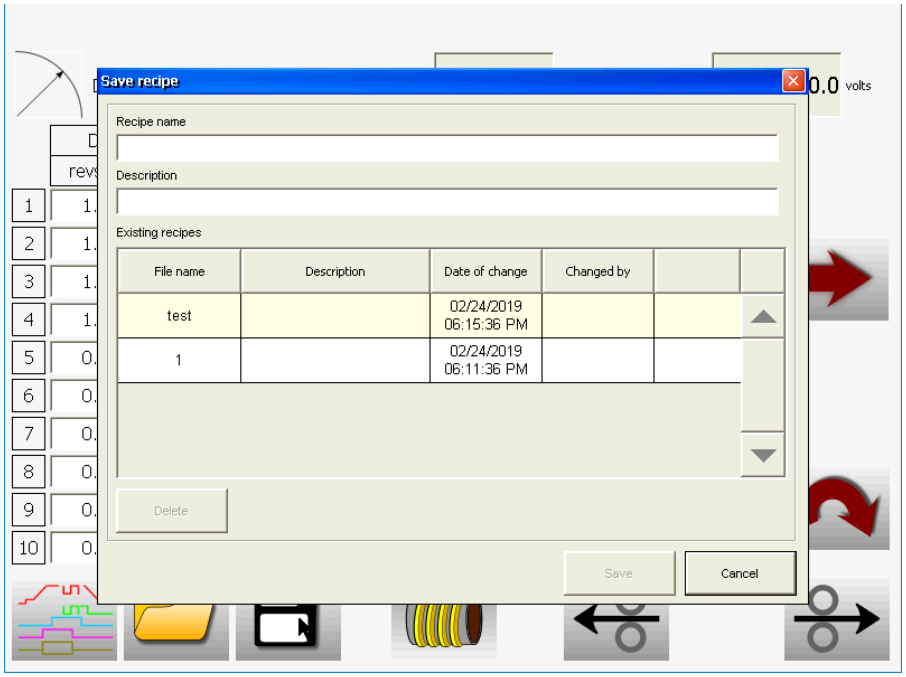
Press  on the operating screen to open the file load dialog.



Select the required data set (recipe) from the list and press the “Load” button.

All the welding parameters on the parameter screen and the position data on the operating screen will be overwritten.

Saving



Operation

Tap the “Recipe Name” entry to bring up a QWERTY keypad and enter the filename to save the data set. Do not use dots, slashes, or any other special characters in the filename. Spaces can be used.

The “Description” field can be used to give more detail as to what the data set is for.

To overwrite an existing file, tap on a filename in the list. When pressing the “save” button an extra dialog will appear requesting confirmation of the overwrite.

Existing files can be deleted by tapping on a filename then pressing the “Delete” button. A dialog will appear requesting confirmation of the deletion. Only one file can be selected at a time.

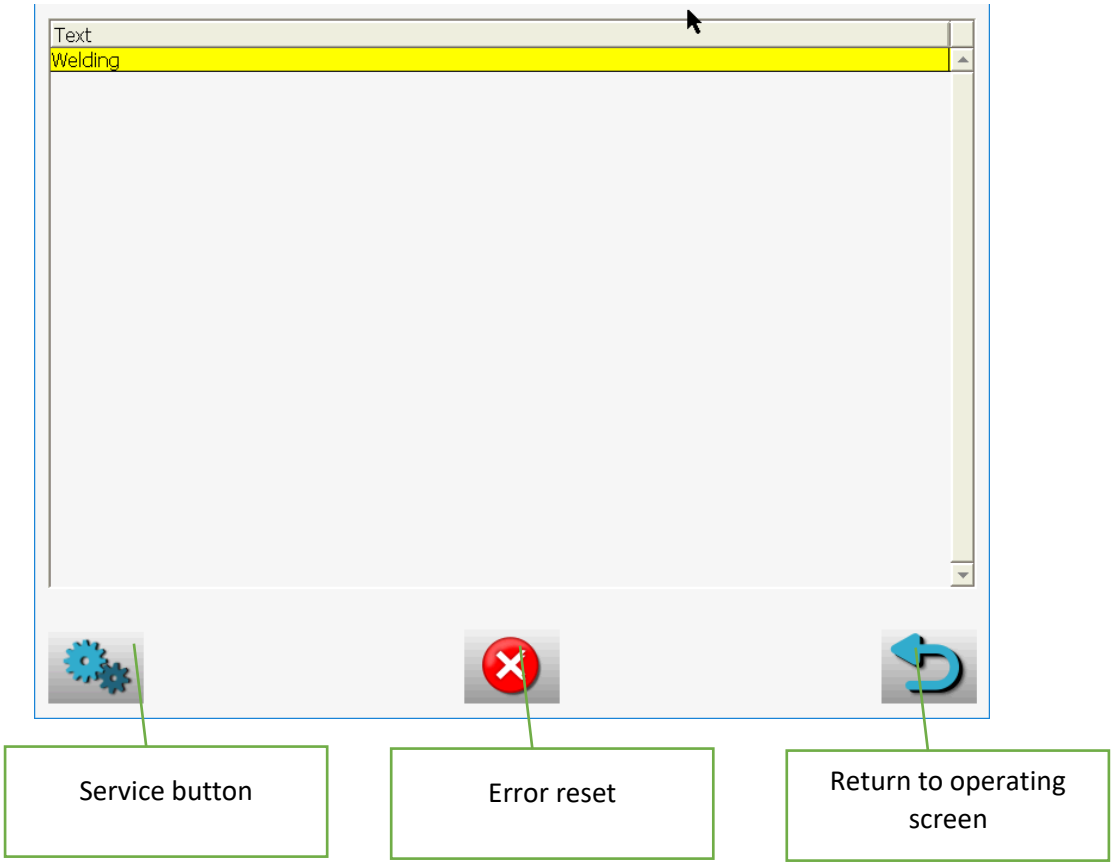
Status

The top of the operating screen displays the status of the system. It shows any faults in red and any status messages in yellow.

Any faults will prevent the system from running.

If multiple messages are available then the status bar will toggle through each one in turn.

Tapping on the status bar will open the status page.



Operation

The main table displays the current status messages.

Active alarms are shown with a red background and white text.

Alarms that aren't active but haven't been acknowledged appear with a red background with black text.

Alarms that have been acknowledged but are still active appear as black text on a cyan background.

Alarms can be acknowledged by tapping on them in the table. Once an alarm has de-activated and been acknowledged then it will disappear from the table.

Alarms

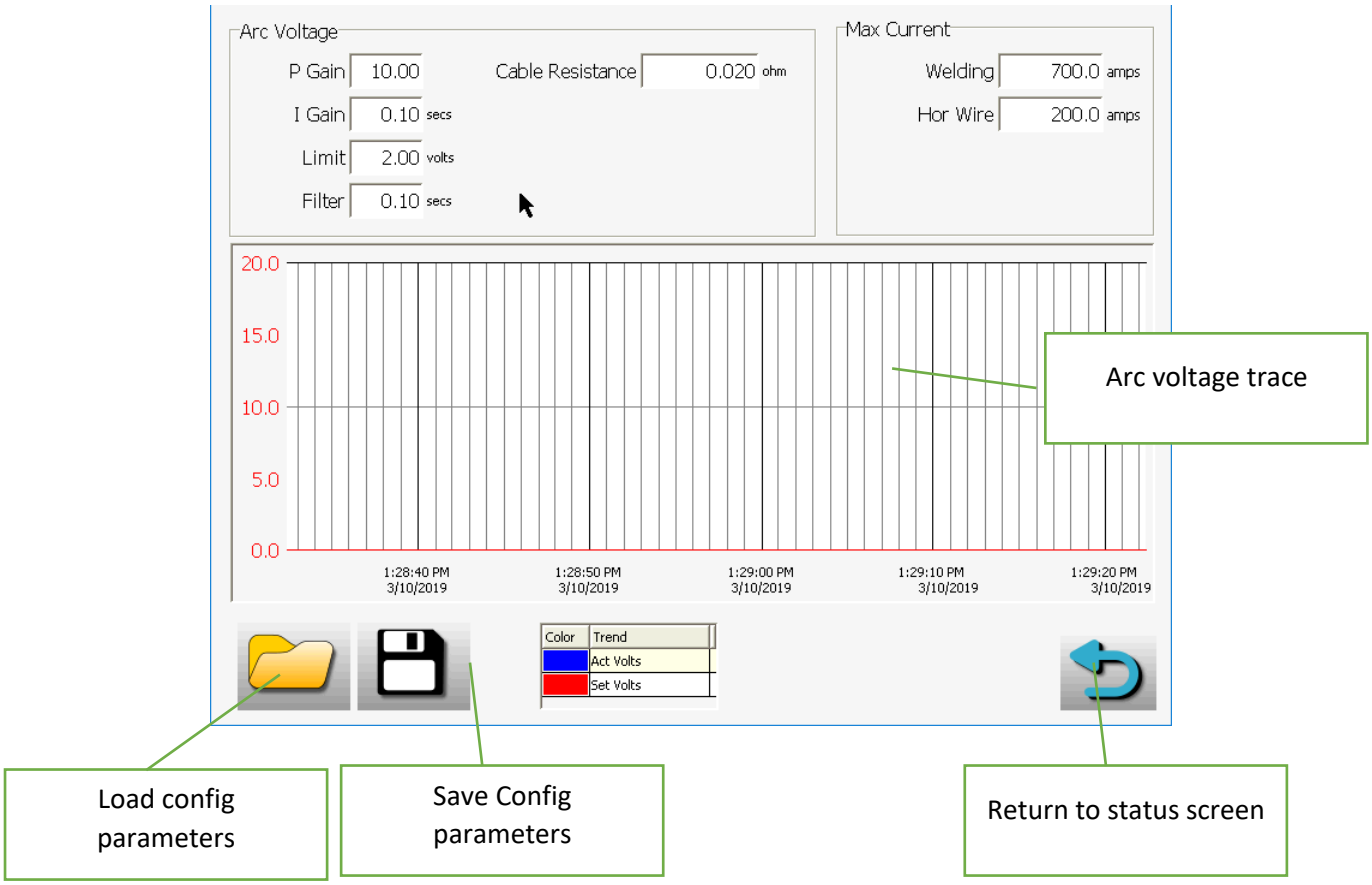
Message	Description
E-Stop Active	The emergency stop circuit has been tripped or not reset. Check the emergency stop switches on the side of the panel, the main panel and the Welding Alloys green remote pendant. If the switches are okay then the circuit should reset with the reset button on the side of the operators panel.
24V Touch and Retract PSU Tripped	Touch and retract system has not been implemented.
Low Gas Pressure	Gas pressure monitoring has not been implemented
Water Cooler Tripped	The motor overload trip inside the main panel has tripped.
Wire feed motor error	The wire feeder motor is reporting an error, check the 42 volt power supplies inside the main panel is okay and checked for damaged wiring to the wire feed motor.
Started	Start weld button has been pressed and the pre/post flow gas is on
Welding	The arc has been struck and the weld sequence is active
Low Water Pressure	A flow switch in the water cooler has detect an insufficient cooling water flow to the torch. Check the water level in the cooler and look for any kinked or trapped hoses.
Water flow switch stuck	The flow switch in the water cooler is still registering flow but the cooler pump is not running. The flow switch is probably faulty and needs to be replaced. This alarm will not stop the operation of the system.
AVC Axis Error ….	There is fault in the AVC axis, the exact fault will also be displayed as part of the message. Reference should be made to the Lenze 9400HL drive manual for full details
AVC Drive Error …	There is fault in the AVC axis, the exact fault will also be displayed as part of the message. Reference should be made to the Lenze 9400HL drive manual for full details
X Axis Error …	There is fault in the X axis, the exact fault will also be displayed as part of the message. Reference should be made to the Lenze 9400HL drive manual for full details
X Drive Error …	There is fault in the X axis, the exact fault will also be displayed as part of the message. Reference should be made to the Lenze 9400HL drive manual for full details

Commissioning

Commissioning

Some parameters are available for tuning and calibrating the arc voltage control system. They are accessed by pressing the service button  on the status page.

Configuration Screen



The configuration parameters can be saved to file as a backup and recalled later if the system is ever reset. In normal circumstances the parameters are stored to non-volatile ram and will not change.

The trace runs continuously and displays the set arc voltage and the actual arc voltage and can be used to see if the system is working correctly and stable.

Setting the cable resistance value

The arc voltage used by the system is measured at the welding power source. There is a voltage drop across the power cables between the torch and power source which causes an error in the measured values. The voltage drop can be calculated and compensated using Ohms law V=IR.

Procedure

1. Set i4 and i5 to the same current e.g. 100Amps so that the current is steady and not pulsing.
2. Set the torch height manually to approximately 3mm above the test piece and start the system.
3. Switch off the AVC system with the button on the parameters page.
4. With a voltmeter measure the voltage across the arc by measuring from the back of the torch to the workpiece. Normally it will be in the range of 10 to 15volts. Do not attach the voltmeter until the arc is established as the HF start will damage the meter.

5. At the same time observe the voltage displayed on the control system operating screen.
6. The voltage difference between the two readings is the voltage drop across the power cables.
7. The cable resistance can be calculated and entered.

$$V = IR$$

$$R = \frac{Voltage_{power\ source} - Voltage_{torch}}{Current}$$

Example:

- Voltage measured at torch = 15.6 volts
- Voltage observed on control system = 13.2 volts
- Current set on i4 and i5 = 100 amps

$$R = \frac{15.6 - 13.2}{100} = 0.024\ ohms$$

Arc Voltage Control

Four parameters are used to tune the system so that the actual arc voltage accurately follows the set voltage. If the system is under tuned then the actual voltage will never reach the set point, if the system is over tuned then the welding torch will oscillate up and down continuously and may even crash into the workpiece.

The system is tuned in a particular order:

- Filter, takes out the electrical noise and miss readings. Too much filtering and the system will be unresponsive, too little and the torch won't be stable. 0.1secs is a typical value
- Limit, limits how much the torch can try and correct the voltage in one t4/t5 current cycle. Sets this low to limit any big movements of the torch when first trying to tune the system.
- P Gain, this is a multiplier on the error voltage. If the difference between setpoint and actual voltage is 0.5volts then a gain of 10 tries to correct the position of the torch by 5 volts. (This would then be limited to 2 volts by the limit.
  When the error is very small then the correction is also very small and no change will be observed. A system with only P Gain will always suffer from a lag between the setpoint and actual voltages.
- To correct for the lag caused by the P Gain an integral error correction is also added. The I Gain is a time period in which the error is added to the correction in the torch height. Making the time shorter means the voltage error will be added more often to the height correction so reducing the value of I Gain makes the system more sensitive.

Tuning method

- Set the filter to 0.1sec and the Limit to 2 volts.
- Set the I Gain to 10 seconds to switch it off.
- Start the system welding with a pulsed arc with the workpiece on a slight uphill gradient.
- Observe the arc closely (with eye protection of course) and increase the P Gain so that a steady movement of the torch is observed without oscillation.

Commissioning

- The torch should maintain a settled height – not necessarily the correct voltage. Adjustment is only made on the peak current i5/t5 and not on the base current i4/t4.
- When the above step has been achieved reduce the I Gain until the actual arc voltage follows the set voltage. If the torch oscillates then the value has been set too low.

Max Currents

Different welding and hot wire power sources can be used with the system which may have different power ranges. Also, the outputs of the control system may not give an accurate enough current value.

The system can be adjust using the “Max Welding Current” and the Max Hot Wire Current”.

The value represents the current from the power source when a 10 volt reference signal is applied.