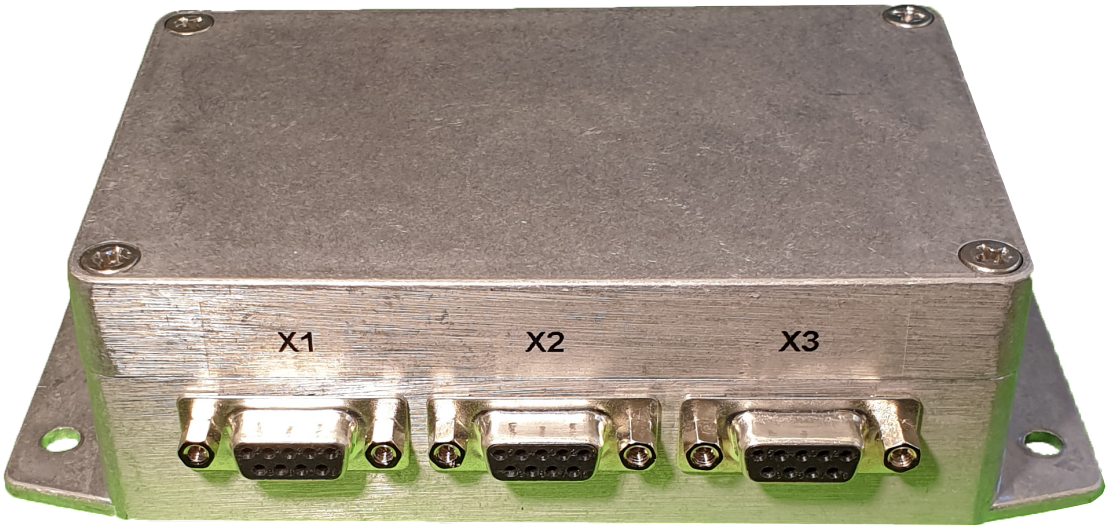
C-arc controller manual



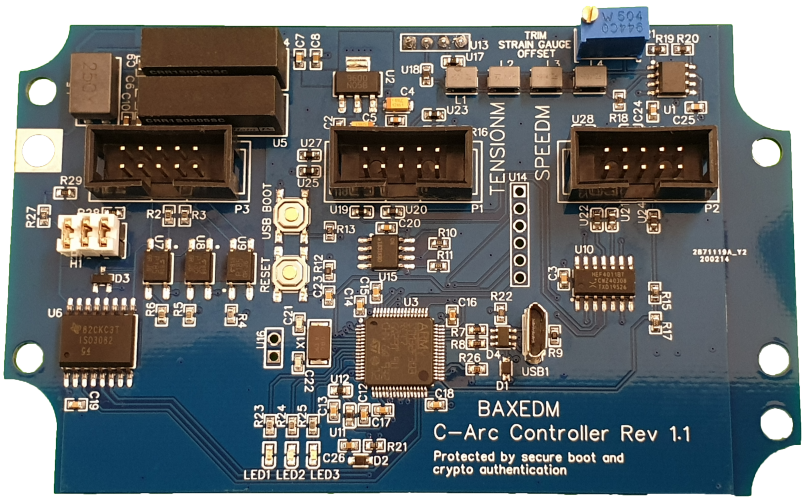


Table of Contents

1 Document Revision History

Revision number	Date	State	Change notes
0.1	11-Mar-2020	Draft	Initial Version
0.2	22-Mar-2020	Draft	Updated SW update procedure to latest ST toolset
0.3	28-Mar-2020	Draft	Added pin numbers for the P1-P3 board connectors and a note to reverse the sensor wires if applying a positive sensor load causes a decrease in the sensor readout instead of an increase.

Table 1: Document revision

2 References

#	Document title	Author / Published by
[1]		
[2]		
[3]		
[4]		

Table 2: References

3 Welcome note

Thank you for purchasing the BaxEDM C-Arc Controller! With the help of this manual and the C-arc controller you should be able to have your EDM wire handling hardware running at the right tension and at the right speed in no-time. BaxEDM is using this C-arc controller in every day use and we are continuously striving for improvements however small they may be. Any feedback is highly appreciated and will help to improve the product even more.

4 Intended use

This product is designed only for inclusion by professional installers within other equipment; it must not be operated as a stand alone product.

5 Functional description of the C-Arc controller

The BaxEDM C-arc controller is a digital control solution for controlling the speed and tension of the EDM wire in a wire-EDM machine, with the help of two servo motors and a load cell. The C-arc controller integrates a load cell amplifier, a digital closed loop controller for the tension servo, a setpoint generator for the speed servo and digital optically isolated data interfaces all into a single solution.

6 Enclosure interfaces

6.1 X1 – Power, communication and digital IO

Pin Number	Function
1	Isolated wire break signal output: opto coupler emitter
2	Isolated +5V signal input #2
3	Isolated +5V signal input #1 : Wire tension and speed control ON/OFF
4	RS-485 B = FTDI cable yellow wire
5	+5V power input
6	Isolated wire break signal output: opto coupler collector
7	Isolated ground
8	RS-485 A = FTDI cable orange wire
9	Power ground

Table 3: X1 - pinout

The C-Arc controller power supply input is not protected against reversed power supply polarity. Reversing the power supply input will lead to damage.

6.2 X2 – Tension motor interface

Pin number	Function
1	Not Connected
2	Not connected
3	Tension motor feedback 5V input
4	Tension motor 5V PWM setpoint output
5	Enable tension motor 5V output
6	Not connected
7	+5V out
8	GND
9	GND

Table 4: X2 - Pinout

6.3 X3 – Speed motor interface

Pin number	Function
1	Not connected
2	Not connected
3	Speed motor feedback 5V input
4	Speed motor 5V PWM setpoint output
5	Enable speed motor 5V output
6	Not connected
7	+5V out
8	GND
9	GND

Table 5: X3 - Pinout

6.4 X4 – Load cell interface

See section 7.4

6.5 Enclosure to circuit board cabling

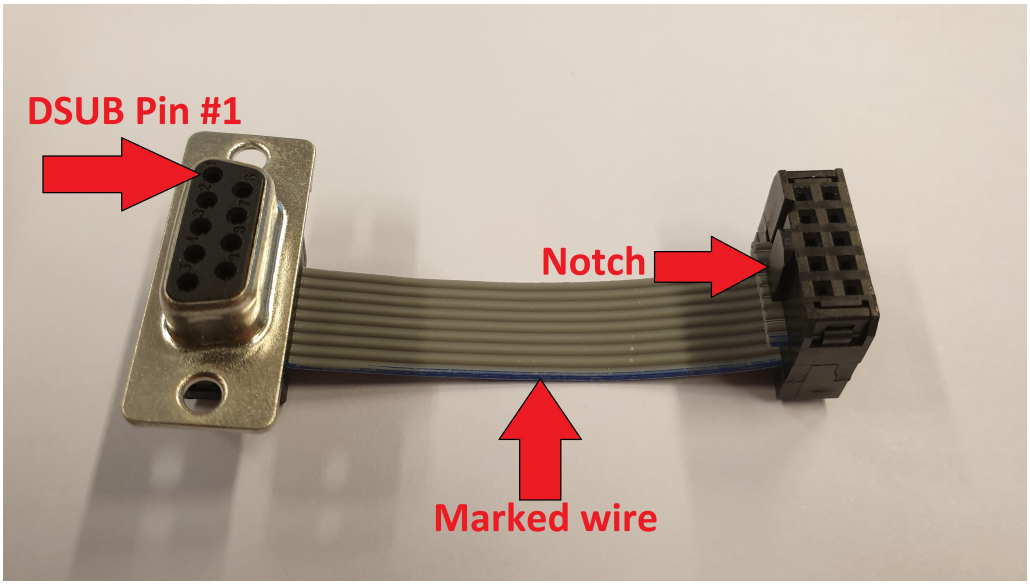


Illustration 1: Enclosure to circuit board cable

The circuit board must be connected to the enclosure DSUB-9 connectors by 3 identical short flabcables with 9 conductors.

The cable should have one DSUB-9 connector on one side of the cable and one 2x5 IDC connector with 2.54mm pitch on the other side. As the IDC connector has 10 pins, one pin should not be connected, see Illustration 2.

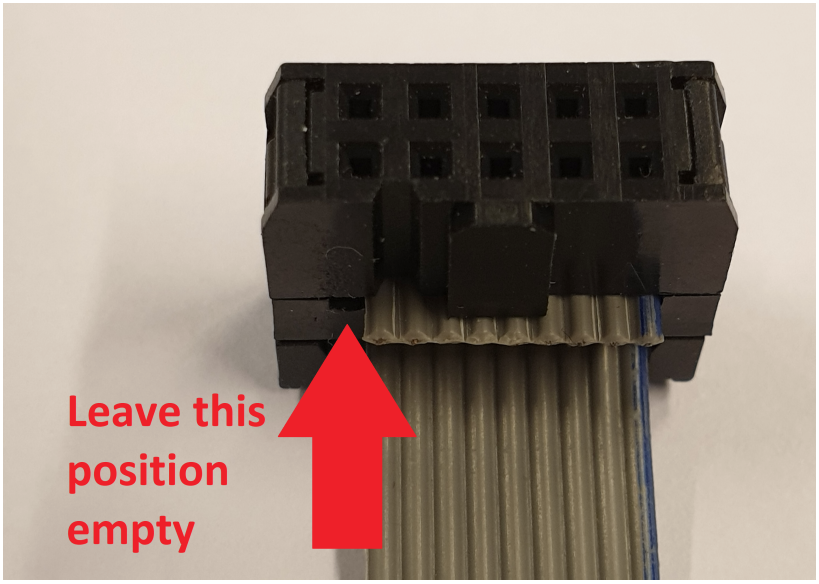


Illustration 2: IDC cable connection

7 Circuit board interfaces

The C-arc controller board contains 4 interfaces. Interface P1, P2 and P3 use the pin numbering described in Illustration 3. Note the orientation of the notch in the header.

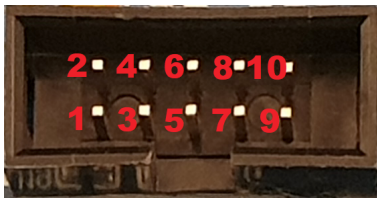


Illustration 3: Pin mumbering of the P1, P2 and P3 interfaces

7.1 P3 – Power, communication and digital IO

Pin Number	Function
1	+5V power input
2	Power ground
3	RS-485 B = FTDI cable orange wire
4	RS-485 A = FTDI cable orange wire
5	Isolated +5V signal input #1 : Wire tension and speed control ON/OFF
6	Isolated ground
7	Isolated +5V signal input #2
8	Isolated wire break signal output: Opto coupler collector
9	Isolated wire break signal output: Opto coupler emitter
10	Not connected

Table 6: P3 - Pinout

The C-Arc controller power supply input is not protected against reversed power supply polarity. Reversing the power supply input will lead to damage.

7.2 P1 – Tension motor interface

Pin number	Function
1	Enable tension motor 5V output
2	Ground
3	Tension motor 5V PWM setpoint output
4	Ground
5	Tension motor 5V feedback input
6	+5V out
7	Not connected
8	Not connected
9	Not connected
10	Not connected

Table 7: P1 - Pinout

7.3 P2 – Speed motor interface

Pin number	Function
1	Enable speed motor 5V output
2	Ground
3	Speed motor 5V PWM setpoint output
4	Ground
5	Speed motor 5V feedback input
6	+5V out
7	Not connected
8	Not connected
9	Not connected
10	Not connected

Table 8: P3 – Pinout

7.4 U13 – Load cell interface

Pin number	Function
1	Ground
2	Bridge voltage 1
3	Bridge voltage 2
4	Load cell supply voltage

Table 9: Load cell connection pinout

NOTE:
During the load cell offset adjust ment, given in section 13.1, you can check if your load cell is connected correctly by applying a slight pressure on the sensor in the direction that the EDM wire normally applies pressure. The sensor readout should then show a positive increase. If the value decreases, then reverse the sensor pin 2 and pin 3.

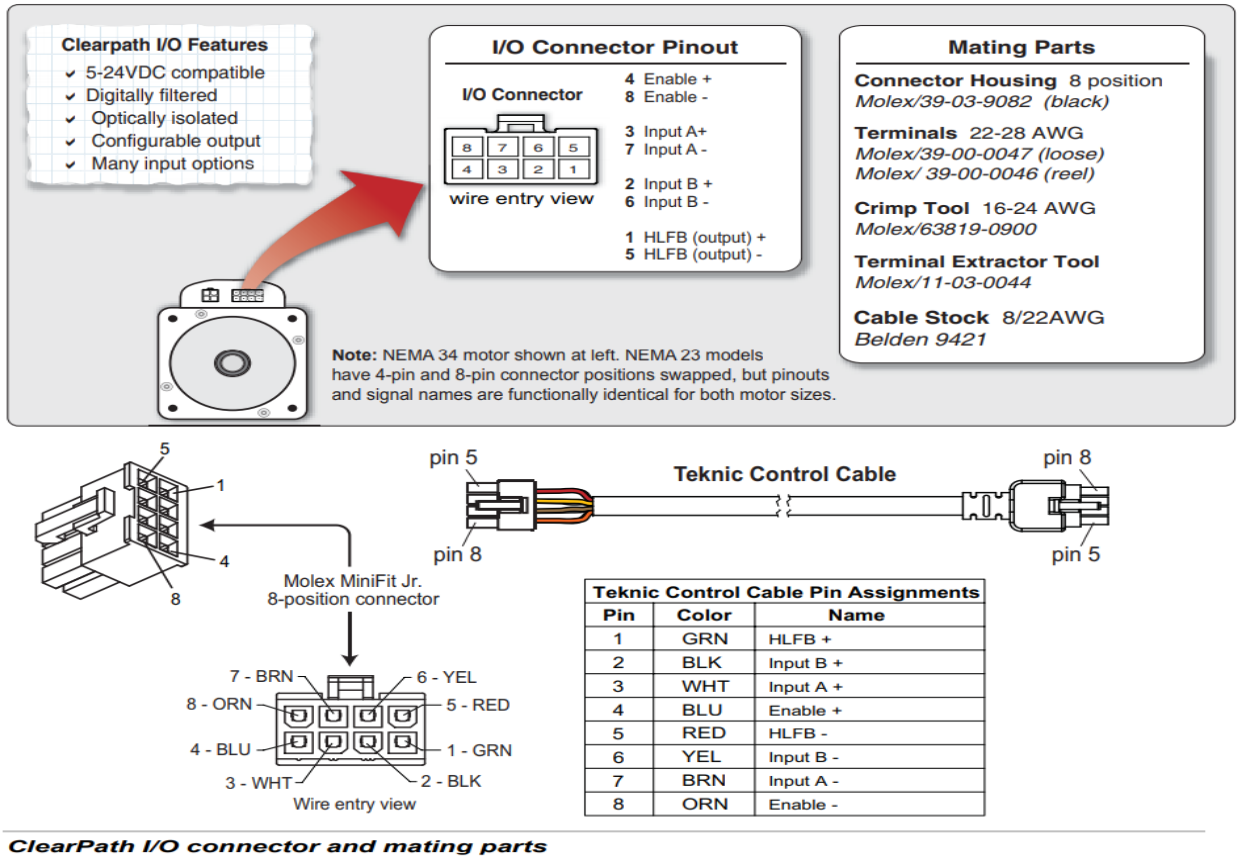
8 Clearpath servo connections

For your convenience, the C-arc controller connections to Teknic clearpath servos are given in Table 10 and Illustration 4, which are identical for the speed and tension servos.

DSUB connector pin # (for X2/X3 enclosure interface	General Function	Clearpath I/O connector pin #	Clearpath control cable wire color
1	Not Connected	N/A	N/A
2	Not connected	N/A	N/A
3	Servo motor feedback 5V input	5	Red
4	Servo motor 5V PWM setpoint output	3	Black
5	Enable servo motor 5V output	4	Blue
6	Not connected	N/A	N/A
7	+5V out	1	Green
8	GND	7	Yellow
9	GND	6	Orange

Table 10: Clearpath servo connections

I/O Connector Parts and Pinout



Teknic Control Cable Pin Assignments		
Pin	Color	Name
1	GRN	HLFB +
2	BLK	Input B +
3	WHT	Input A +
4	BLU	Enable +
5	RED	HLFB -
6	YEL	Input B -
7	BRN	Input A -
8	ORN	Enable -

ClearPath I/O connector and mating parts

Illustration 4: Clearpath servo pinouts

9 The importance of proper grounding and shielding

The EMC environment of an EDM machine is very noisy due to the arcing process which radiates broadband electromagnetic disturbances. For proper operation of the C-arc controller measures to protect from this radiation are required. Practically this means that the C-arc controller must be enclosed in a shielded box and the wires between the load cell and C-arc controller must be shielded. Next to that, the enclosure must be properly grounded and the load cell and load cell wire shielding must be grounded too.

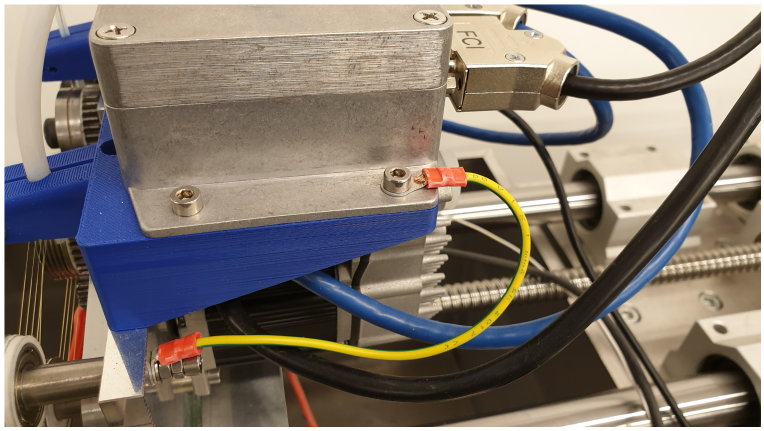


Illustration 5: Enclosure connected to ground

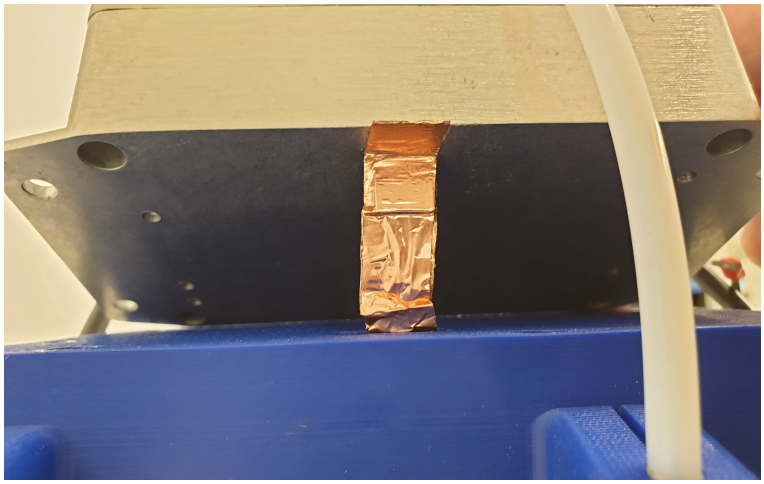


Illustration 6: Load cell connector shielded with copper tape

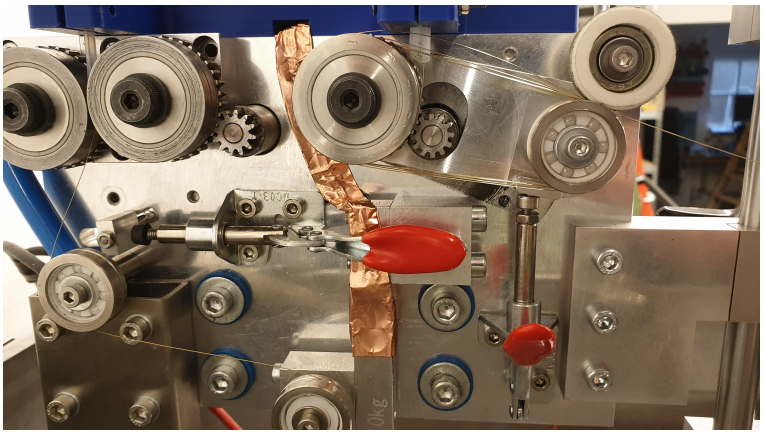


Illustration 7: Load cell wires shielded with copper tape

Inside the C-arc controller enclose, it is essential that the circuit board ground pad is connected to the enclosure by mounting a screw in the ground pad hole, see Illustration 8.

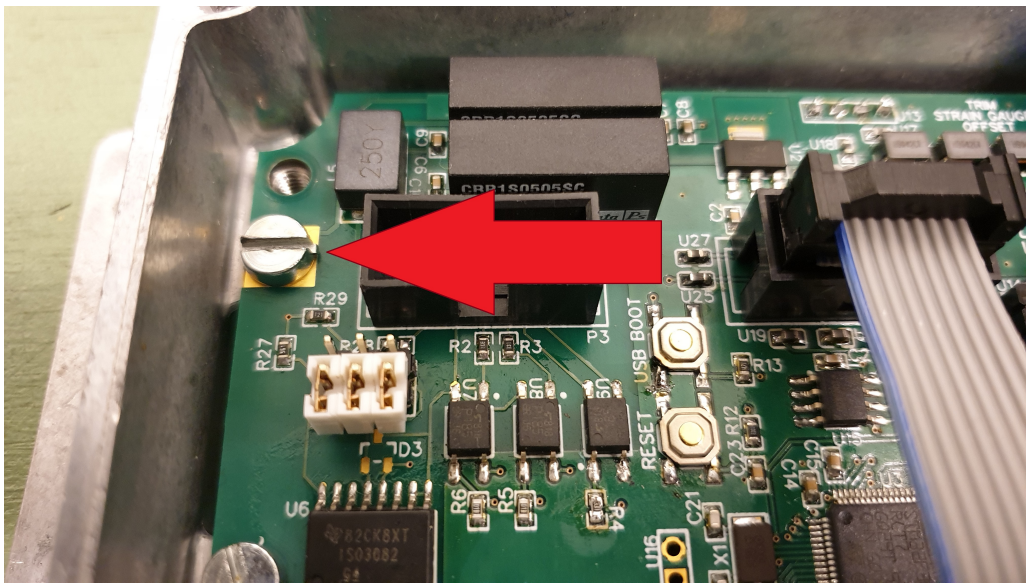


Illustration 8: Ground pad with mounted screw

10 ClearPath servo configuration

The C-arc controller has an internal control loop for the wire tension control that is tuned per default to the usage of clearpath servos. In order to simply use the default tuning the clearpath servos need to be configured as follows:

Speed motor:

- Servo mode – Follow Digital Velocity : Unipolar PWM Command

- Max speed – 1000 rpm
- Max Acceleration – 20 rmp/s
- RAS Setting – Auto-Ras, Auto-med, Conversion = 779 ms

Tension motor:

- Servo Mode – Follow Digital Velcocity: Bipolar PWM Command w/Inhibit
- Max speed – 1000 rpm
- Max Acceleration – 5000rpm
- RAS Setting – Manual, 4.4 ms

The clearpath servos can be configured with the above settings with the help of a USB cable and the clearpath MSP software.

11 Using non-Clearpath servos

Although the C-arc controller has been designed to use with ClearPath servos, other servo types can be used as well as long as the servos can be configured to run in the same modes (velocity controlled with Unipolar PWM and Bipolar PWM setpoints).

When a non clearpath servo is chosen for the tension control motor, the digital PID+ parameters need to be retuned as the dynamic response of the alternative servo will be different. The PID+ parameters can be changed and saved to the non-volatile memory of the C-arc controller with the help of the serial interface and the commands described in section 16.2

This manual does not go into the details of tuning an industry standard PID+ controller. Control tuning is a large topic by itself for which a lot of information is readily available online.

12 RS-485 termination

If the C-arc controller is the only device on the RS-485 bus, termination is required as well as pull up and pull down of the A and B lines.

Jumper JP3 sets the bus termination. Placing JP3 terminates the bus, removing JP3 eliminates termination.

JP1 and JP2 set the pull-up/pull-down state of the RS-485 bus when the bus in not in use. The normal setting is with JP1 and JP2 placed vertically (see picture below). A reversed setting is achieved by placing JP1 and JP2 horizontally. This reversed setting is reserved for special purposes.

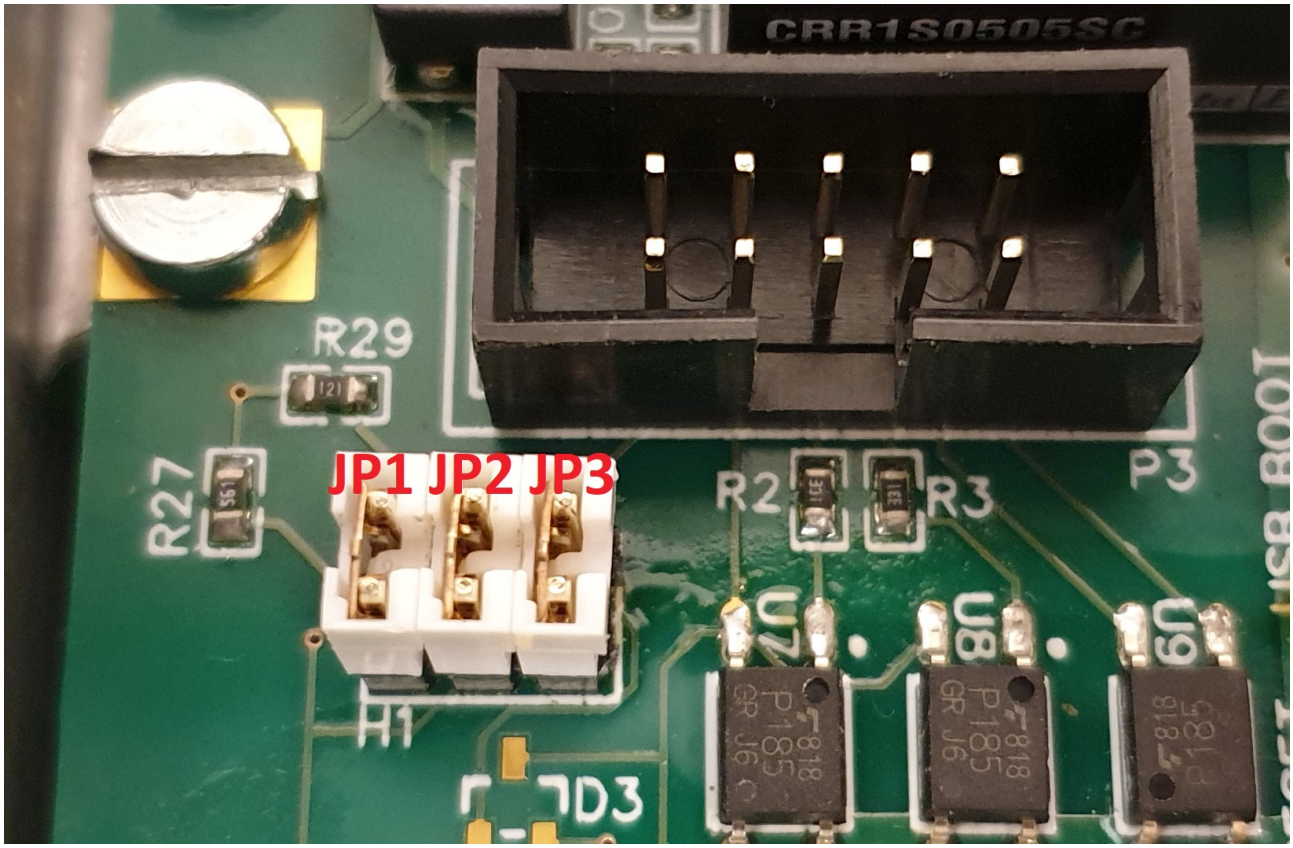


Illustration 9: Jumper names

When the C-Arc controller and the BaxEDM BX17 arc generator share the same bus, the jumpers should ***not*** be placed. If the C-Arc controller is the only device on the RS-485 bus, all jumpers must be placed as depicted in Illustration 9.

13 Adjustments and calibrations

13.1 Loadcell offset adjustment

As loadcells always have a small offset, this offset needs to be compensated for in the controller. This compensation can be adjusted manually by turning the 20-turn potentiometer screw of potentiometer R1 on the board.

The procedure of adjustment is as follows:

- Hook up the load cell of the final application, make sure the cell is unloaded!
- Hook up the 5V supply to the C-arc controller, unpowered
- Hook up the USB to RS-485 cable
- Connect the USB cable to a PC
- Power on the 5V power
- Open a serial terminal program (see paragraph 15.3) and connect to the right COM port

- Type the serial command “SENSORREADOUT” (without the quotes) and send the command by pressing enter.
- The C-Arc controller now reports the sensor readout in the serial terminal.
- Adjust the potentiometer such that the SENSORREADOUT command returns the smallest non-zero positive value possible. This can be done by iterating through turning the potentiometer and sending the SENSORREADOUT command. Turning the potentiometer clockwise increases the readout, turning it counterclockwise decreases the readout. The readout must not be zero, but very slightly positive.

13.2 Tension calibration

When a tension setpoint is sent to the C-arc controller, it translated to a sensor voltage that the controller must realise. As a sensor voltage is not a convenient unit of measure, the C-arc controller implements a configurable tension calibration factor. This factor translates the setpoint figure to the sensor voltage.

By default this calibration factor is exactly 0.1, with this figure the tension setpoint exactly represents Newtons. This means that when a tension setpoint of for instance 20 is chosen, the resulting tension in the wire will be exactly 20 Newtons. Note that for accurate results, the offset adjustment procedure described in section 13.1 must have been performed.

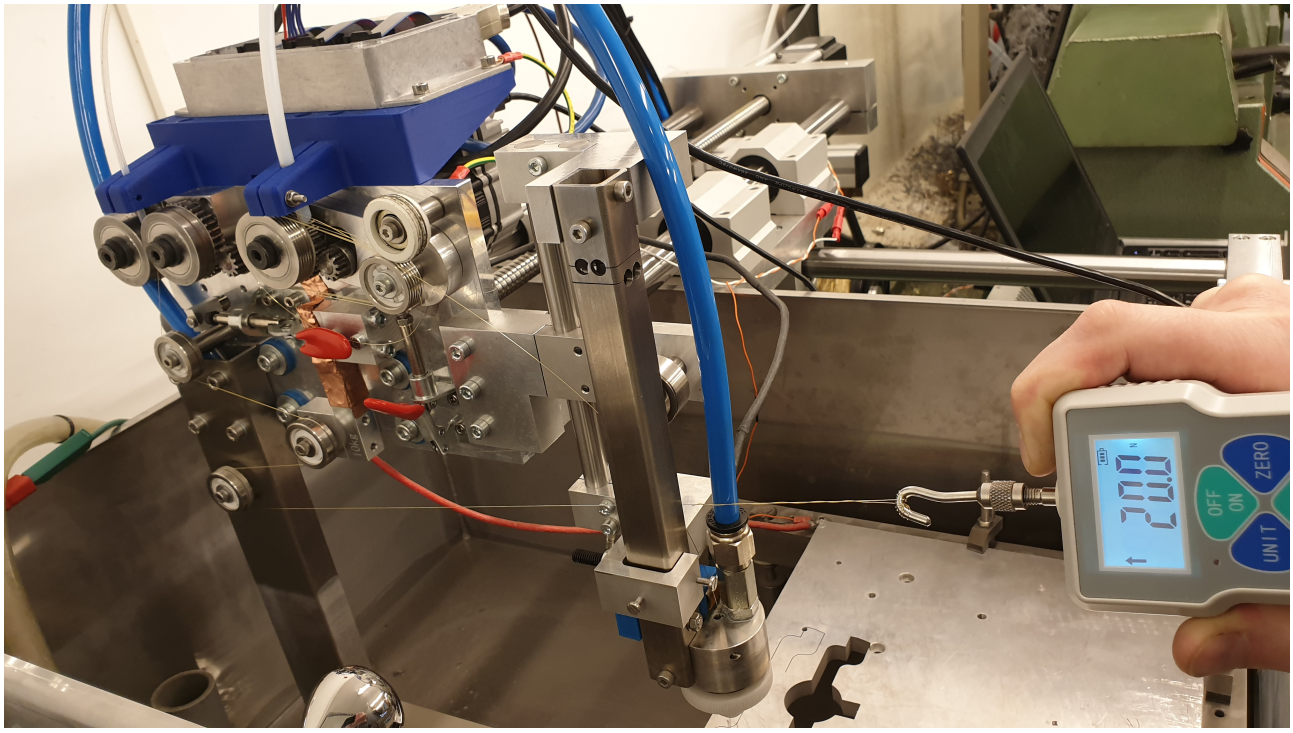


Illustration 10: Example showing a tension measurement

The tension calibration factor can be changed through the serial command interface, given in section 16.2 As this figure can be changed to any value, it can also be used to change the unit of the setpoint from Newtons to something else, e.g. Pounds.

13.3 Speed calibration

The C-arc controller is acutally unaware of the real wire speed. It only knows the duty cycle of the speed signal output for the wire speed servo. If the speed calibration value is set to 1.0, then setting the speed setpoint to 1.0 as well will result in a 100% duty cycle at the output. Setting the speed setpoint to 0.5 will result in a 50% duty cycle.

The speed calibration value allows you to scale the output duty cycle to the requested speed setpoint. The BX17 dashboard application outputs the speed setpoint in meters/min. As an example, lets calculate the required speed calibation value for a speed servo motor wheel diameter of 36mm, which is the diameter of the wheel used in the BaxEDM reference design, and use a max servo motor speed of 1000 rpm for a duty cycle of 100% (as given in chapter 10).

For a wheel with 36mm diameter the circumference is 113.1 mm. So for a 100% duty cycle of the servo the wheel will feed wire at 1000 revolutions/min, or 113.1 meter of wire per minute. The calibration value that correctly translates the wire feed setpoint (in meters/min) to the right duty cycle value for the rpm that will give the correct wire speed then becomes 1/113.1=0.00884

Note that the the software uses a duty cycle definition that has a range between 0 and 1, not 0 and 100.

The wire speed calibration value of 0.00884 is the default value in the C-Arc controller. This value can be changed if you would like to change the wheel diameter or use a different unit, e.g inches/minute.

Setting and saving this value can be done with a serial command as described in chapter 16.2

14 Automatic Wire Break Detection

The C-arc controller has an automated function that can signal wire break events. The signal is given by the activation of the optically isolated digital output #1. When the wire tension control state is off, the wire break signal will be reset. After the wire tension control has been started, the software will wait a few seconds and then starts monitoring for new wire breaks. If a break is detected, the C-arc controller disables the tension and feed motors and signals the break to the output.

After a break, the wire can be re-treaded manually. To resume wire feeding, the C-Arc controller can be started again by a rising edge on the optically isolated input #1, by sending “STARTWIRE” using the serial terminal or by pressing the start wire button in the BX17 Dashboard application. Upon starting the wire tension and speed control, the wire break flag is automatically reset.

15 PC Software installation

The arc generator and c-arc controller can both be controlled by a dedicated control application called the BX17 Dashboard, or by a standard serial terminal. Communication to the generator and c-arc controller should run through an USB to RS-485 converter. The following sections provide the details to install these applications and required USB driver.

15.1 Installation of the USB-RS485 driver

NOTE:
Although any type of USB to RS-485 interface cable can be used, this section assumes that the USB-RS485-WE-1800-BT from FTDICHIP is used. This cable is available in the BaxEDM webshop: https://baxedm.com/shop/

Visit http://www.ftdichip.com/Drivers/VCP.htm to download the required Virtual Com Port driver for your specific system. An installation guide is also listed on the page. Be careful to find only genuine FTDI parts. Many users of counterfeit USB to serial adapters have problems with their interfaces.

15.2 Installation of the BaxEDM Dashboard application

Perform the following steps to install the BaxEDM Dashboard application:

- Download the "BaxEDM-Dashboard-RevXX.zip" file from: https://baxedm.com/dashboard-application/
- Extract the zip and place the "BaxEDMDashboard.exe" in an installation directory of your choice, e.g. "C:\Program Files\BaxEDMDashboard.exe"
- Download the "EDMparameterLib.json" file which contains the latest material EDM parameters from:

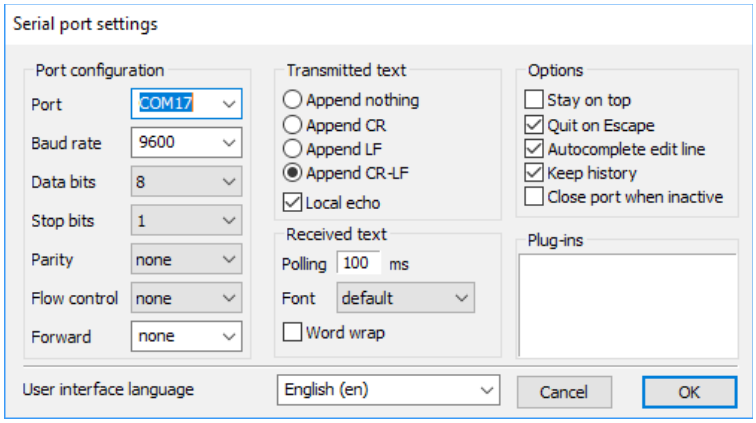
  https://baxedm.com/material-edm-parameter-library/
- Save the "EDMparameterLib.json" file to the same directory as the BX17Dashboard executable
- Create a shortcut to the executable (right click → create shortcut), and move the shortcut to a convenient location, for instance your desktop.

15.3 Installation and configuration of the serial terminal

NOTE:
Although any type of serial terminal can be used, this section assumes that Termite is used. This application is also recommended by BaxEDM.

Perform the following steps to install and configure the Termite teminal application:

- Download the Termite (program only) zip package from https://www.compuphase.com/software_termite.htm
- Extract the zip package and copy the "Termite.exe" file to an installation directory of your choise.
- Create a shortcut to the executable (right click → create shortcut), and move the shortcut to a convenient location, for instance your desktop.
- Run the Termite application and click the "settings" button in the main screen.



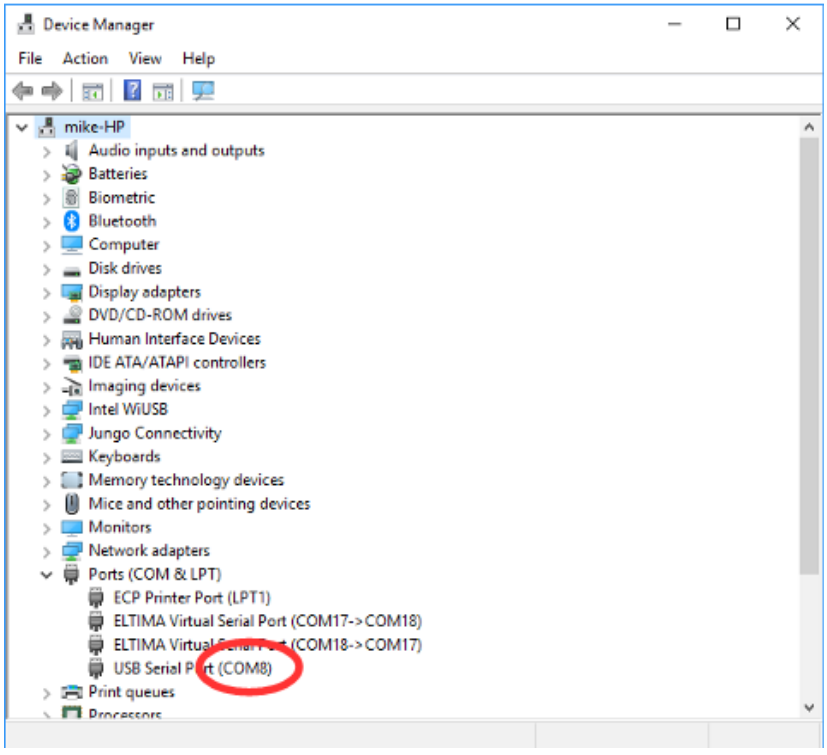
- Set the configuration according to the screenshot below:

NOTE:
The COM port number is different for each PC. To find the right com port number if multiple are listed, follow the steps below.

In order to find the com port number, perform the following steps in Windows:

- Open the windows control panel
- In the control panel, open “Device manager”
- In the Device manager, expand the item “Ports (COM & LPT)”
- Search for an item called “USB Serial Port”

The com port number is listed behind this item:



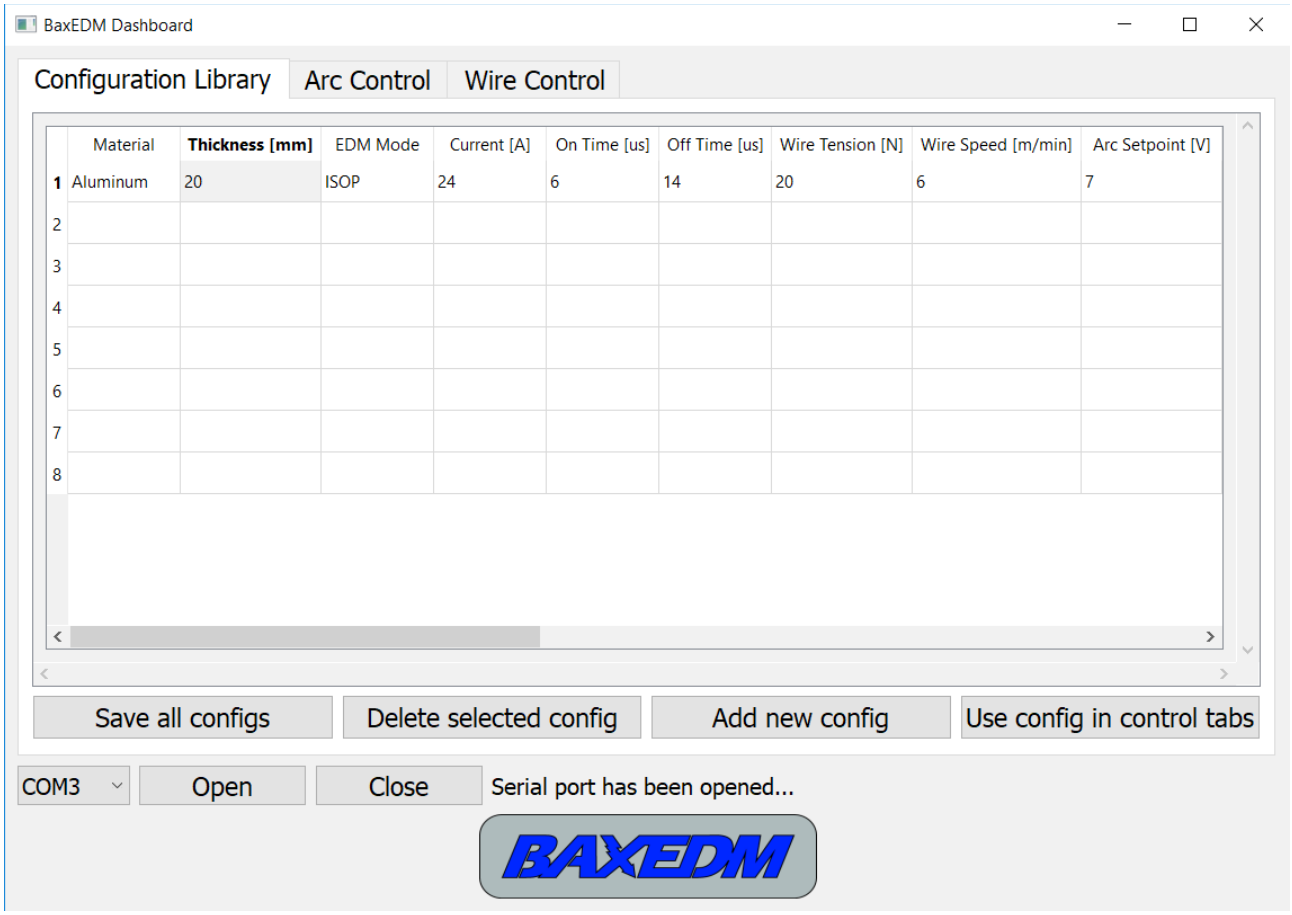
16 Operation

NOTE:
If the C-arc controller and arc generator are connected to the same RS-485 bus, both devices need to be turned in for the communication to work.

16.1.1 Operation by BaxEDM Dashboard control application

The BaxEDM Dashboard application provides a user interface to set and save wire tension and speed in a library of EDM parameters, together with the parameters for the arc generator. The following sections describe how the BaxEDM Dashboard application can be used for operation of the C-Arc specifically.

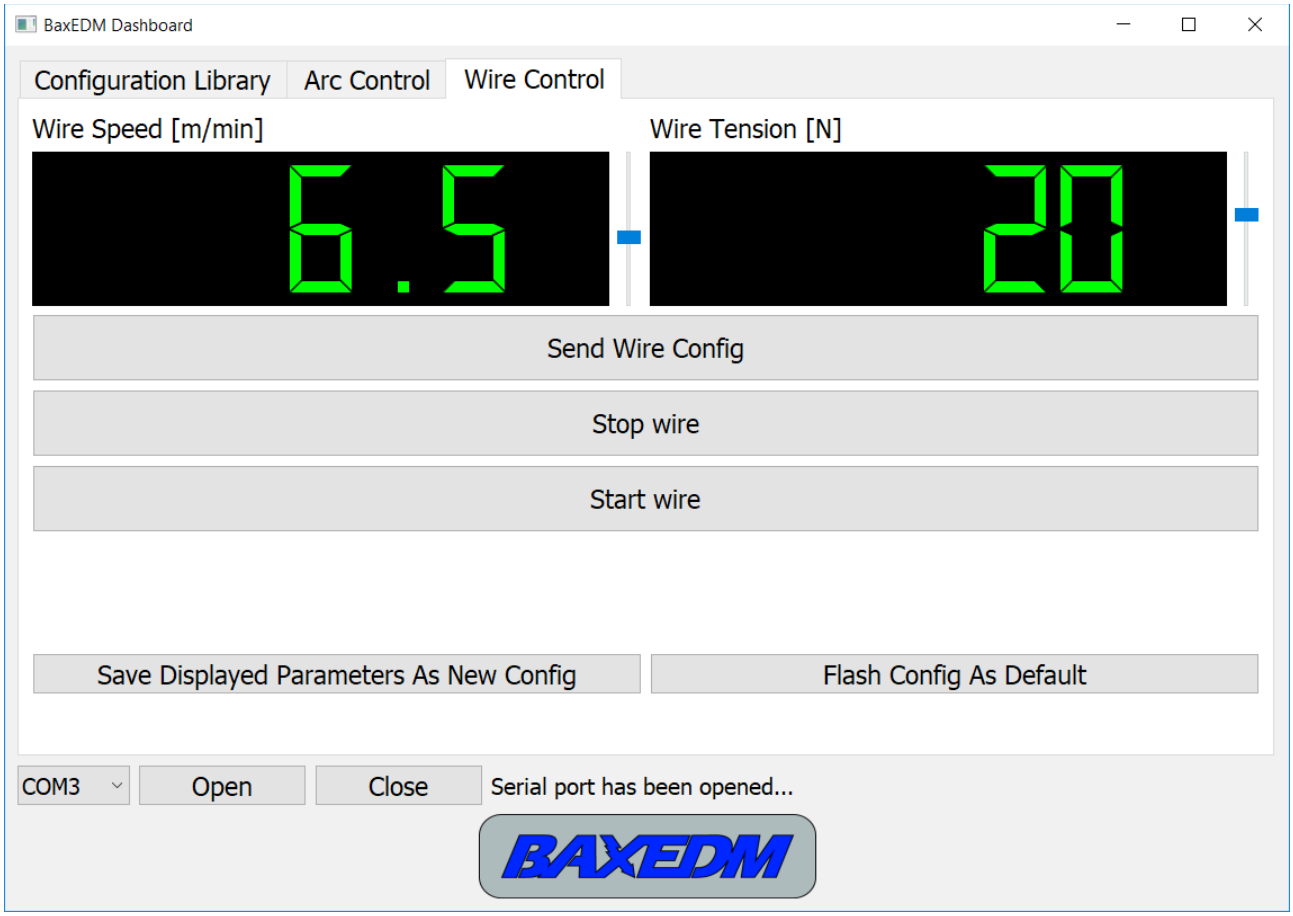
16.1.2 Configuration Library Tab



The configuration library allows you to pick a configuration set that includes the settings for the arc generator as well as the EDM wire tension and speed for a particular material type and thickness. These setting can then be sent to the arc generator in the Arc control tab and to the C-arc controller in the Wire control tab.
The library consists of a single file, library file “EDMparameterLib.json”. This file must be located in the same directory as the BaxEDM Dashboard executable.
The default library contains just a few configuration sets. These are intended to get the operator going and to give an initial starting point. Since the arc generator and C-arc controller will be used

in custom build EDM machines, these parameters will vary from one machine to another. Factors that affect this variation are the for instance the flushing conditions and the dynamic performance of the positioning XY stage.
Because of this, the intention is that the operator of the custom EDM machine finds the optimal parameters for that specific machine by experiment and trail and error, after which the parameters can be saved to the configuration library for quick access lateron. Once a good working parameter set has been found for a known material and thickness, this set can then be conveniently reused at a later time if the same material needs to be cut, simplifying setup greatly.

16.1.3 Wire Control Tab



The sliders next to the wire speed and wire tension digital readouts can be used to change the values. This can also be done by the up and down keyboard keys if the slider is selected. When the values are changed the C-arc controller is not updated with these changed values. In order to update the C-arc controller, the button “Send Wire Config” needs to be pressed. The “Stop Wire” and “Start Wire” button enable or disable the wire tension and wire speed simultaneously. The “Flash Config As Default” can be clicked to overwrite the default wire speed and tension set in the C-arc controller with the current active speed and tension. Lastly, the “Save Displayed Parameters As New Config” button creates a new entry in the configuration library with the current values of the digital readouts. If this new entry is not saved in the configuration library tab (“Save All Configs” button) the new entry will be lost when the program is closed.

16.2 Operation by serial terminal (ASCII API)

Once Termite has been installed and configured (see chapter 15.3) the serial port can be opened. The following command list can then be used to control the C-Arc controller. Type the command in the entry line in the bottom of the Termite screen and press enter.

NOTE:
All commands are case sensitive.

Single spaces in the commands are indicated by a blue mark . Required input values for commands or replied values are indicated by greens marks, e.g. X.

Command	Description
SERCARC	Returns the unique C-Arc controller serial number
CARCVER	Returns the installed firmware revision number
SPEEDSP X	This command sets the EDM wire speed. X is a floating point number. The unit and magnitude depend on the speed calibration setting. Default is meters/min.
TENSIONSP X	This command sets the EDM wire tension. X is a floating point number. The unit and magnitude depend on the tension calibration setting. Default is Newtons.
SENSORREADOUT X	This command returns the raw sensor voltage, uncorrected with any calibrations. This command is used to help adjust the load cell offset.
KC = X	This command sets the PID+ controller KC value, but does not save it. A reboot will return the KC to the default value of 0.4, unless the defaults have been overwritten.
TI = X	This command sets the PID+ controller TI value, but does not save it. A reboot will return the TI to the default value of 0.1, unless the defaults have been overwritten. 0.1 0.003
TD = X	This command sets the PID+ controller TD value, but does not save it. A reboot will return the TD to the default value of 0.003, unless the defaults have been overwritten.
SAVEPARAM	Saves the current KC, TI and TD to non-volatile memory, by overwriting the default values.
LOADPARAM	Loads the KC, TI and TD parameters from non-volatile memory
STARTWIRE	Enables the tension control and activates the speed motor at commanded speed.
STOPWIRE	Disables the tension and speed control, stopping the wire

	travel.
CLEARPATHSTATE	Reports the state of the servos
SETTENSIONCALIBRATION=X	Sets the tensioncalibration factor and saves it to non-volatile memory, overwriting the default.
SETSPEEDCALIBRATION=X	Sets the speed calibration factor and saves it to non-volatile memory, overwriting the default.
CARCSTATE	Reports an overview of control parameters and state
FLASHCARC	Overwrites the default tension and speed with the current active tension and speed. The default values are 15N tension and 2.0 m/min speed.

17 Firmware updates

The firmware of the arc generator can be updated through an USB interface on the board. In order to install new firmware, a PC tool is required. A link to download the installer for this tool is provided on:

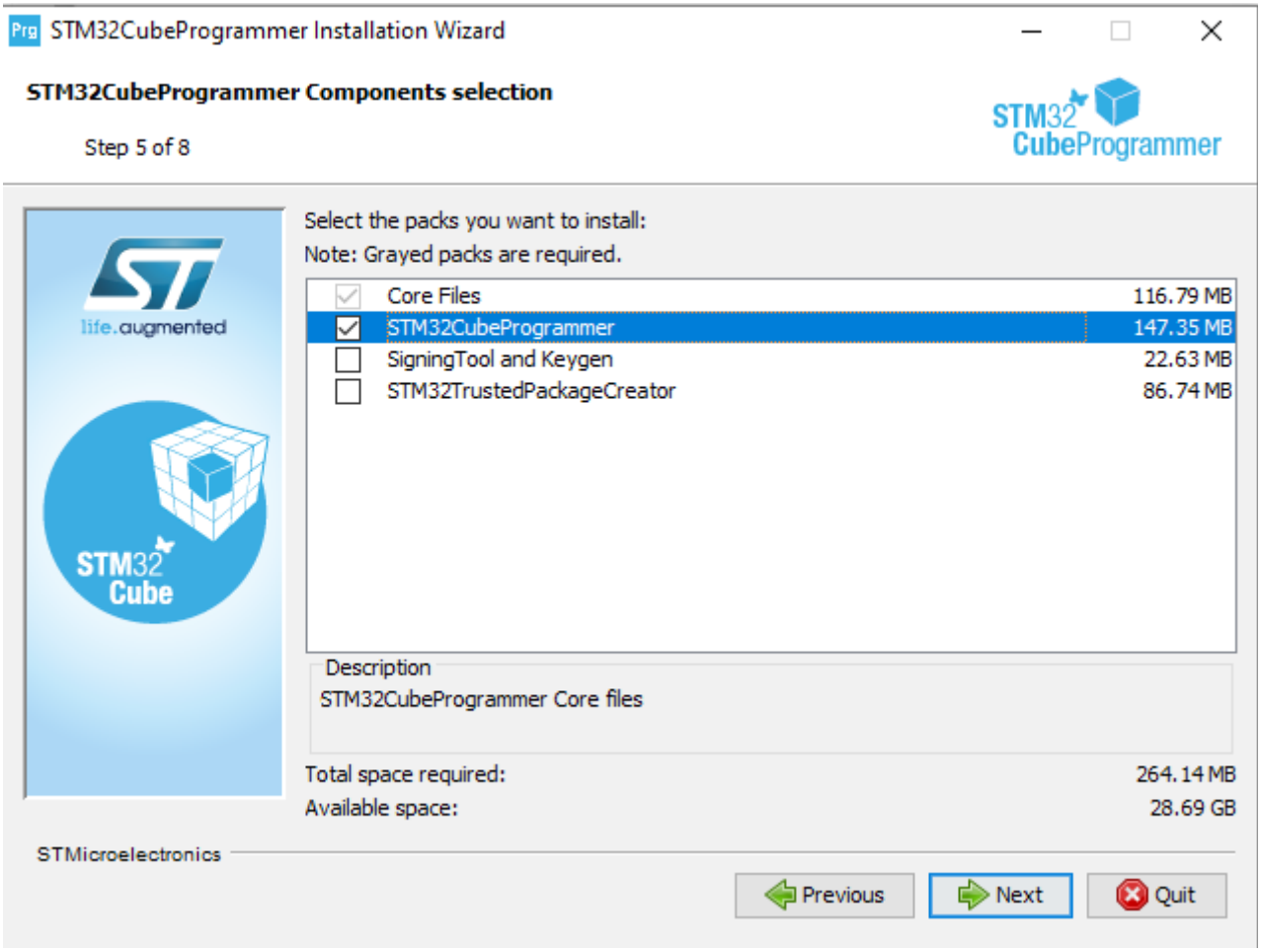
https://www.st.com/en/development-tools/stm32cubeprog.html

The latest firmware for the C-arc controller can be downloaded from the following page:

https://baxedm.com/c-arc-controller-firmware/

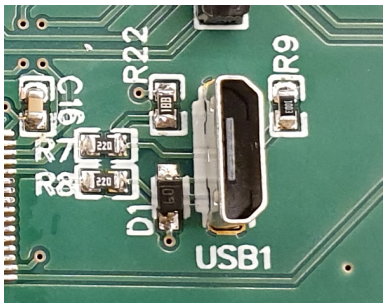
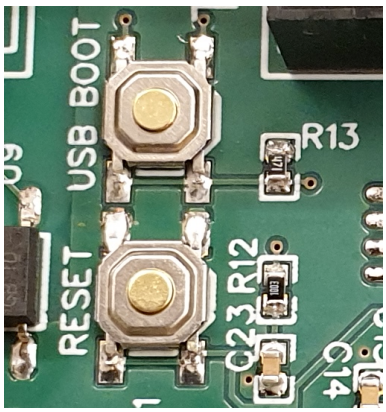
17.1 Installation of update PC tool

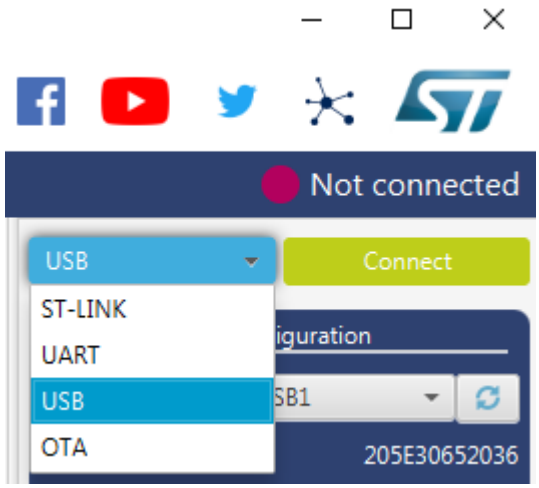
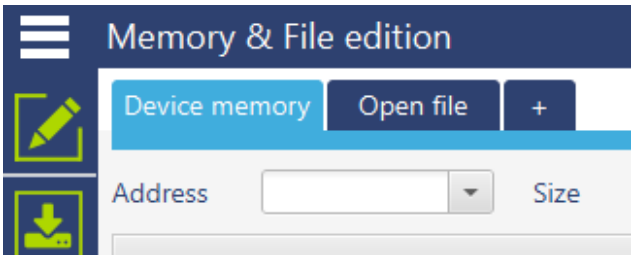
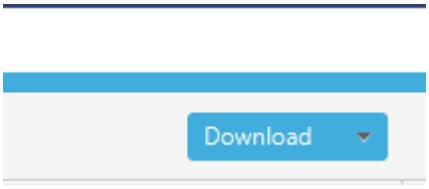
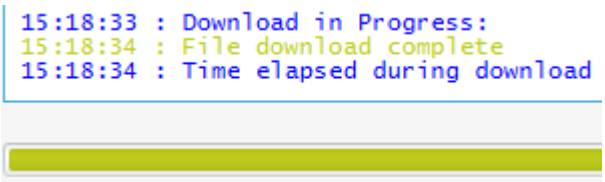
The installation of the PC tool is very straightforward. After running the installer continue clicking “Next” until you reach the components selection screen. In the screen only select the STM32CubeProgrammer, the other options are not required. Finish the installation clicking “Next” through to following screens until the installation is compete.



17.2 Update procedure

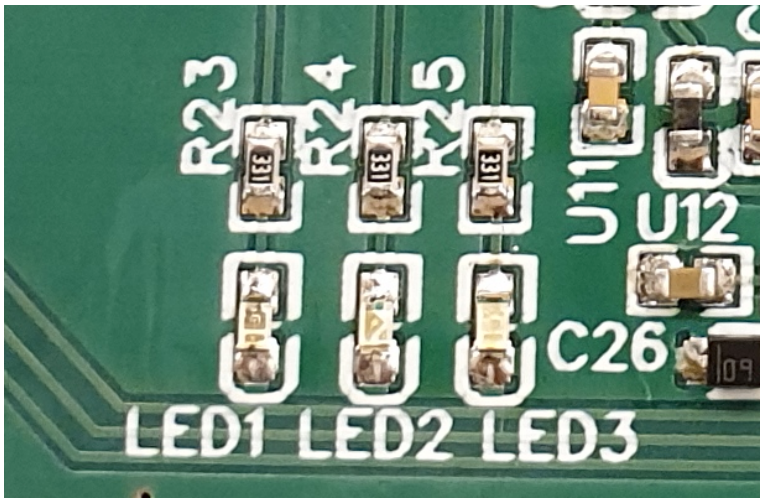
The following steps are required to update the firmware of the C-arc controller:

1. Make sure the board is powered on.	
2. Locate the USB interface on the board.	
4. Connect your PC with the help of a micro USB cable to the board. A green LED should flash on the board aftr connecting.	
5. • Locate the “USB BOOT” and “RESET” switch on the board. • Make sure your PC is turned on and connected to the board • Press and hold the “USB BOOT” switch • Press and release the “RESET” switch • Release the “USB BOOT” switch • The green LED should not flash anymore. If it still flashes, retry the steps above.	
6. Start the STM32CubeProgrammer PC application that you have installed.	

7. In the upper right corner of the screen, select “USB” from the dropdown menu and click “Connect”.	
8. • Download the latest firmware file from https://baxedm.com/carc-controller-firmware/ with your internet browser and store it locally. • In the STM32CubeProgrammer window, select “Open File” and open the “CarcController_RevXX.hex” file	
9. • After the hex file has been loaded, press the “Download” button.	
10. Wait until the log sceen section reports that the download is complete	
11. Disconnect the board from USB, the software update has been finished.	

18 LED Indicators and Error Codes

On the circuit board of the C-arc contoller there are 3 LED's which show the status of the C-arc controller.



LED Name	Color	Meaning
LED1	Red	Continuous on: A problem has been detected, error code 001
		Slow blinking (1 Hz): A problem has been detected, error code 002
		Fast blinking (2.5 Hz): A problem has been detected, error code 003
LED2	Green	A green blinking LED indicates that the C-arc controller is operational
LED3	Blue	Reserved

Table 11: Led codes

19 Technical specifications

Characteristic	Specification
Input voltage	5V DC, +/- 5%
Input current	Less than 100 mA
Maximum isolated output sink current	20 mA
Output voltages	5V +/- 5%
Operation temparature conditions	0C – 30C
Storage temperature conditions	0C – 40C
Relative Humidity conditions	20% – 80%, non condensing
Air pressure range	950 hPa – 1050 hPa

Table 12: Technical specifications

20 List of Terms and Abbreviations

Term/Abbreviation	Meaning
EDM	Electric Discharge Machining
us	Micro Seconds
mA	milli Ampere
Hz	Herz
EMC	Electromagnetic Compatibility
LVD	Low Voltage Directive
SPS	Switching Power Supply
RS-485	Serial Communication Protocol
AC	Alternating Current
ASCII	American Standard Code for Information Interchange
API	Application Programming Interface
N.A.	Not Applicable

Table 13: Terms and abbreviations