ProtoCycler Command Center Overview – VERSION 3.10

Contents

Introduction

Welcome to the ProtoCycler Command Center software, or PCC! This software allows you to monitor and control all aspects of ProtoCycler's operation. While the software may seem overwhelming at first, most users will find that the "Basic" use cases – connecting to ProtoCycler, viewing and controlling manual extrusion, and modifying automatic extrusion profiles – is sufficient. More advanced users are also able to exert a greater range of control over ProtoCycler using advanced commands, and can fully automate both data collection and control.

Note that this manual has been newly updated to reflect the changes included as part of Software version 3.10, and firmware version 1.10. Any modifications will be noted in blue, like this – and any new sections will have a blue title, but with normal black text for the body to ease reading. Note as well that, similar to the older manuals, any key warnings or safety issues will be flagged in orange text.

This guide is intended as a comprehensive reference and includes multiple appendices that cover each aspect in further detail as required. As a recycling business, we encourage you to keep a digital copy handy at all times on the computer on which PCC is installed, rather than printing the full manual. *Please note that this manual applies specifically to version 3.10 of PCC, but may be largely applicable to other versions as well.*

Basic Use

This section covers basic use of PCC. After reading, you should be able to install PCC, be familiar with its GUI and layout, understand how to connect to ProtoCycler and both monitor and control the basic parameters of extrusion. In addition, this section covers automatic profile updating and firmware updating, so that you can continue to improve your ProtoCyclers operation with PCC. While updating is not required, periodic updates are easy to perform and will result in significant performance or ease of use improvement. Note that upgrading your software to version 3.10 does *require* updating the firmware to 1.10. Going forward, the software will periodically check for new firmware updates, and automatically inform you if a new update is available.

Installation

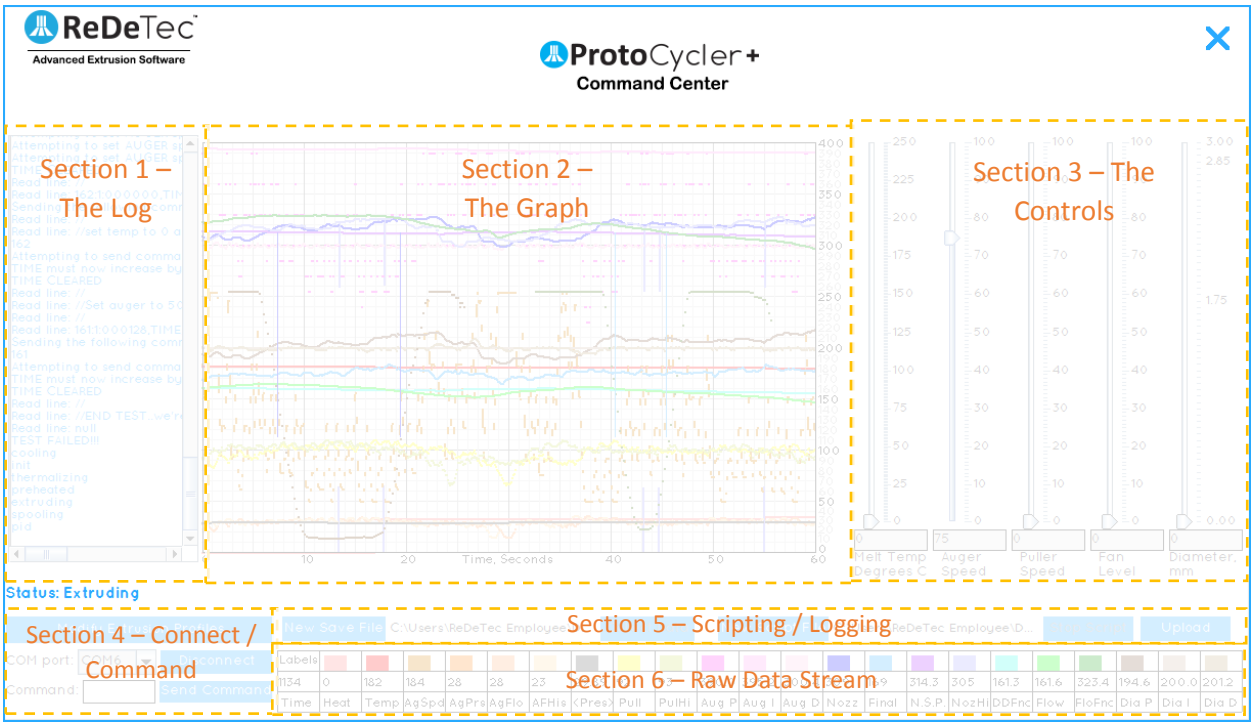
To install PCC, simply use the provided link in your welcome e-mail or on our website, and follow it to completion. If you have lost your welcome e-mail or need a new link, reach out to tech support and we'll provide you with a new one. ProtoCycler Command Center is also be available on the software section of our website, www.redetec.com – the most recent version will always be posted. Note that, periodically, updates may be released with new functionality. These updates are always optional, but may require updating the firmware on ProtoCycler itself (see "Updating ProtoCycler+ Firmware").

PCC is currently available and verified on Windows 7-10 machines. No Mac version is currently available, though we are working on it. PCC requires both Arduino and Java (along with the RXTX package) to fully communicate with ProtoCycler. All of these are included with the installation package and should be present on your system once installation is complete. Please note that we have a documented issue with

Java updates rendering PCC inoperational. If Java is updated on your system, a simple uninstall and reinstall (using the installer) should remedy the situation. If this does not fix the problem, please reach out to us for further support.

Overview

PCC is a graphical program with 6 key sections, as outlined below:



1. **The Log**

   The log is used to display, in a text form, any updates from either PCC or ProtoCycler itself. It will display updates such as “connected”, “spooling”, or other useful information. Each log item is exactly one line, so scrolling to the left and right may be required. Mostly used for debugging purposes or status updates.

2. **The Graph**

   The graph displays all of the data being streamed live from ProtoCycler that enters the Raw Data Stream (See “Section 6 – Raw Data Stream” for more details). As there’s quite a bit of data, different parameters can be turned on and off by clicking on the corresponding colour in the Raw Data Stream. For instance, to hide the “heat” parameter, click the pink square above the “heat” readout in the Raw Data Stream. To bring it back, click the same (now grey) square. To toggle *all* readouts on or off, click the “labels” button in the Raw Data Stream.

   The graph displays the past minute of data, with a resolution of 10 data points per second. The Y value for all data is shown on the right of the graph, and the Raw Data Stream is used as a

legend. Note that the graph also displays the raw reading of the diameter sensors, shown as two response profiles on the left / right hand side of the graph.

3. **The Controls**
   The controls are used to easily modify the 4 most commonly adjusted parameters of extrusion – the temperature, auger, puller, and fan. Note that the scale for Temperature and Diameter are in real units (degrees C and mm, respectively), while the Auger, Puller, and Fan level are based on the raw values required by firmware, and are different from previous software versions. However, the slider *position* corresponds. For instance, if the old slider was 0-100 and the new slider is 0-80, an old value of 50 would be identical to a new value of 40 (50% of the slider). For all sliders, the real value is displayed in a text box below the slider, and clicking above or below the slider position will increment or decrement the value by 1. The command is only sent when the slider is *released*, so you can click and drag until the desired value is reached, then release the slider to send the command.

4. **Connect and Command**
   A bit of a multipurpose section, this box allows you to connect to ProtoCycler, modify the automatic profiles, and send commands. It's fairly self-explanatory, and further details will be covered in the respective sections for each button. The "Modify Extrusion Profiles" button stands alone and will replace the sliders with a section to modify the stored profiles. The COM port selection and "Connect" button are used to connect (or disconnect) to ProtoCycler. Finally, the Command / Send Command section is used to send manual commands to ProtoCycler (see "Advanced Manual Control")

5. **Scripting / Logging**
   Similar to Connect and Command, this section is somewhat self-explanatory, and is mostly limited to advanced control. The "New Save File" and "Collect Data" buttons are used to log CSV files of all incoming data. The "New Script File" is used to select a script for automated scripting operation, *or* to select a new firmware file to upload. "Start Script" is used to begin that script, whereas "Upload" is used to upload that firmware file.

6. **Raw Data Stream**
   This section displays the live, realtime readouts from ProtoCycler that are then graphed. It allows you to see the exact numerical value of a specific readout, toggle whether that readout is displayed on a graph, and serves as the graph's legend. See "Section 2 – The Graph" for more details.

Connecting to your ProtoCycler

With the supplied USB cord attached to both ProtoCycler and your computer, power on ProtoCycler. If this is the first time you have ever used ProtoCycler with your computer, it may need to install the driver. ProtoCycler uses the Arduino Leonardo drivers to communicate and will be identified as such. Once ProtoCycler is connected to your computer it will be assigned a COM port – this can be found in the Windows Device Manager if required. *Note – there is a known issue with Cura…if Cura is open, it can lock all COM ports from functioning. This is a Cura issue and we have no ability to resolve it on our end.*

To connect ProtoCycler to the PCC, select the correct COM port from the drop down list in the **Connect and Command** section of the GUI. Note that the list will automatically update each time it is opened. With the correct port selected, click "connect", and confirm that you'd like to connect. Then, on ProtoCycler, navigate to the "connections" menu, and confirm your connection there. *Note – There is a 10 second timeout on both the computer and ProtoCycler at which point a connection attempt stops being active. If both the computer and ProtoCycler are not connected by the user within 10 seconds of each other, the connection will fail.*

During the connection process, the software will connect to ProtoCycler and then load all of the installed profiles – please wait a few seconds for this process to complete. The software will also perform a firmware update check at this stage, and prompt for a firmware update if one is available.

Once ProtoCycler is connected, the PCC will become operational, and manual extrusion may begin if desired. To disconnect ProtoCycler, click the "disconnect" button on the PCC, or simply close the PCC. You can also disconnect from ProtoCycler itself. *Note that powering off ProtoCycler before disconnecting may cause the PCC to malfunction, or fail to reconnect, etc – in some cases this may require restarting your computer to fix.*

Data Readouts

One of the most exciting aspects of using the PCC software is being able to watch your ProtoCycler operate in real time. A wealth of data is displayed on both the **Raw Data Stream** and **The Graph**, and it can be overwhelming for some users to watch it all at once. It's recommended that any data that's *not* important to you is disabled from being graphed, by clicking the coloured square above its readout in the **Raw Data Stream**. By focusing only on the key readouts you need, it becomes easier to observe what is happening.

Some readouts – such as "Temp" – will be relatively obvious. Others, such as "DDFnc", will be less so! A full list of all readouts, what they mean, and if they're more of a basic or advanced parameter, is included in Appendix 1 – Readouts Description.

Basic Control of ProtoCycler

Controlling the basic aspects of extrusion is possible using the sliders in **The Controls**. Note that the Melt Temp and Fan Level are "direct" controls. This means that dragging the slider will have an immediate effect on the listed parameter. Auger Pressure, Puller Speed, and Diameter are slightly more complex. The Auger Pressure slider will automatically adjust the auger speed, based on the set PID parameters, to attempt to match the auger pressure to the desired value. Meanwhile, the Puller Speed and Diameter controls always override each other. For instance, if you set puller speed to 50, there is no guarantee that the diameter will be maintained at any set value as setting Puller Speed disables all diameter feedback. Conversely, if you set the Diameter slider, the puller speed will constantly change as required regardless of the setting on the Puller Speed slider.

Each slider controls the following aspect of extrusion:

Temperature – controls the temperature of extrusion. Note that extrusion temperature may vary

compared to what you 3D print with! For example with PLA, ~175-185 is a good starting point, whereas you may print with it closer to 190-195.

Auger Pressure – controls the auger pressure, which dictates how much force ProtoCycler uses to extrude, and along with the temperature, directly influences the speed of extrusion. Note that settings over 75% may lead to increased risk of stalling, where the auger is unable to maintain the pressure requested. This will be noted by a loud clicking or grinding noise, at which point the pressure should be lowered immediately until the auger is able to recover.

Puller Speed – controls the speed of the puller wheel. Using this slider disables diameter feedback automatically, and is useful during to get a rough set point when experimenting with new plastics, or to override the diameter feedback system if needed.

Fan Speed – directly controls the fan. Similar to 3D printing, you always want it on max for plastics like PLA, and on lower settings for plastics like ABS. Note that even with ABS you do want *some* cooling, as the plastic must be sufficiently solid by the time it hits the puller wheels so that it won't deform! Note as well that in automatic extrusion, the fan speed is *flow compensated*. This means that if your flow rate drops (or increases) significantly below the average / expected value, the fan will slow down (or speed up) accordingly, to maintain a consistent cooling rate. *Flow Compensation* is not available with manual extrusion.

Diameter – this slider enables full diameter control – both feedback and PID – to attempt to maintain the diameter of the filament to the set value. It will override the Puller Speed control, and is in turn overridden by the Puller Speed control. While the diameter control algorithm is robust, it's not superhuman, and relies on a number of advanced parameters that are only tunable using advanced control. Therefore attempting to set automatic diameter *may* fail, and the outputs – particularly the puller speed and nozzle / final diameters – should be monitored for any instability for a brief period, once this control is enabled. Similarly, it's preferably to avoid diameter control during any start-up or shutdown procedure, or when experimenting with new plastics.

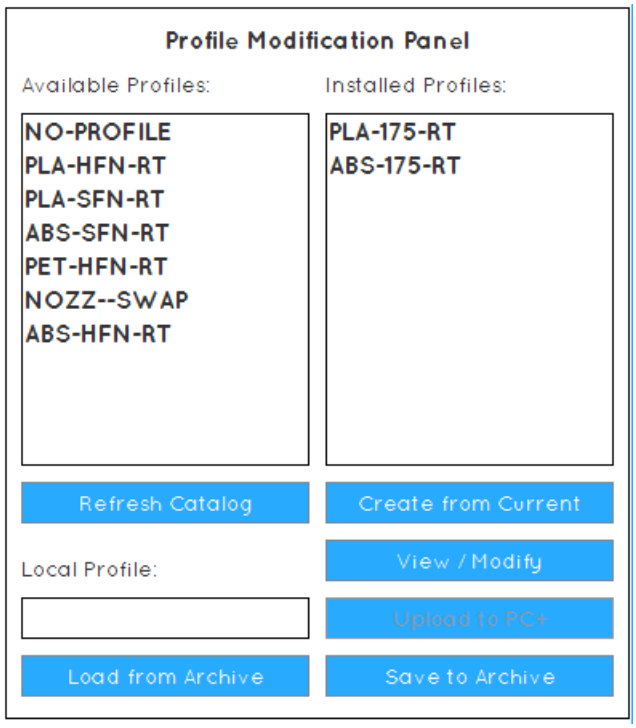
Modifying Automatic Profiles – NEWLY UPDATED

Different blends of plastic may require different settings than others. Similarly, new profiles may be developed over the community or by ReDeTec over time. For this reason, PCC allows you to create, delete, and modify the automatic profiles stored on ProtoCycler (though only a limited number of profiles may be stored at any given time).

When you click on "Modify automatic profiles", the sliders are replaced by the profile management panel. To return to manual control and finish modifying the automatic profiles, simply click "Return to Manual control". Note that you are able to view the profile management panel even during extrusion, but you are not able to modify the profile you are currently using, while you're using it.

The Profile Management Panel

The profile management panel is new to this version of software, and is the largest upgrade over the old software. It allows you to view and modify installed profiles, view the ReDeTec profile library and upload those profiles to your unit, save profiles to your computer, or open and upload new profiles from your computer. You can also create a new profile from the existing parameters being used for extrusion. This is a fundamental change, and improvement, over the old profile management system.



Clockwise from top left, the profile management panel has the following features:

Available Profiles – This section lists the profiles available for download from the ReDeTec repository. These profiles have been tested and confirmed to work by our internal team, and are the best starting point for a certain plastic.

Installed Profiles – This section lists the profiles that are currently installed on your unit. Note that you may install up to 10 profiles at a time.

Create from Current – This button is used to create a new profile, using your current settings. Note that any setting flagged in red *is unknown by the software, and is only it's best guess based on the PLA defaults.* Any parameter in red should be thoroughly reviewed and in almost every case, modified to the correct value. When developing a new profile yourself, a suggested workflow is to find all of the parameters yourself in manual mode, and then create the profile using those settings. A full description of the various settings that can be saved in a profile are available in Appendix 2 – Profile Settings Description. *Note – many of the profile settings are not necessarily intuitive, or may not be used by the current firmware or software version. It is therefore recommended that you only modify profiles yourself if you're confident enough to do more of the advanced features under the "Advanced Use" section.*

View / Modify – This button is used to view, or modify, the selected profile – either an available profile, a local profile, or an installed profile may be selected. More information on the profile settings panel is displayed below.

Upload to PC+ – This button is used to upload one of the selected available or local profiles, to your ProtoCycler. It will ask you which slot you would like to overwrite with the selected profile, and then perform the upload. Uploaded profiles are immediately available for use on ProtoCycler+ (no power cycling is required).

Save to Archive – An archive is what we call a "local" profile, saved on your computer. This button allows you to save either an available or installed profile into a locally accessible file. Archived profiles are a great way to share profiles across users / machines, or save your established settings outside of the unit or our database. Note that the file extension is locked to .rpap , or "ReDeTec ProtoCycler Automatic Profile – there is little to no input verification of a profile when it is loaded, so modification to an RPAP file outside of command center may render it unusable and is strongly discouraged.

Load from Archive – Similar to above, this button allows you to select a local .rpap file into PCC, for viewing / modification / uploading / etc.

Local Profile – displays the currently loaded profile archive. Only one archive / local profile can be loaded at a time.

Refresh Catalogue – occasionally, the online database will fail to load. Clicking this button attempts to reconnect to the database and refresh the available profiles list. Note that this requires an active internet connection to function correctly.

Saving a profile does not require you to be extruding, but you must be extruding to test any changes in real time. Profiles do take a few seconds to save, so always ensure that the "Successfully Saved Profile" Dialog appears before closing the profile saving window.

The "View / Modify" Window

The View / Modify window displays the currently selected profiles settings. Note that you are unable to save any changes to the currently extruding profile, but are otherwise able to save changes directly to the unit (for any installed profiles). The profile settings are split into three sections – the basic settings used for extrusion, the startup settings used during startup, and the advanced settings that are used to tweak extrusion. A full description of the various settings that can be saved in a profile are available in Appendix 2 – Profile Settings Description. *Note – many of the profile settings are not necessarily intuitive, or may not be used by the current firmware or software version. It is therefore recommended that you only modify profiles yourself if you're confident enough to do more of the advanced features under the "Advanced Use" section.*

Please pay particular attention to the *type* of number expected – some fields are able to take decimals, whereas others are not. The type of value expected is listed alongside the value itself in Appendix 2.

Updating ProtoCycler+ Firmware

On occasion, firmware updates will be released for ProtoCycler. These will mostly be aimed at improving performance and functionality, and are therefore strongly recommended (though not required). ProtoCycler has a special section of code loaded onto it that is used to update the firmware, and which cannot be overwritten. Because of this, even if a firmware update fails for some reason, it is always possible to re-enter firmware update mode and try again. Note also that firmware should not remove or overwrite any of your automatic profiles.

Firmware is updated in the following sequence:

1. With ProtoCycler turned off and your computer turned on, connect the USB cable to both ProtoCycler and the computer. Open up PCC – note that the COM port for ProtoCycler will not appear, as ProtoCycler is turned off.
2. While holding any of the menu buttons on ProtoCycler, turn on the power. This will turn on ProtoCycler into firmware updating mode – the screen should simply say "Update" on it.
3. Click the COM port menu – as it refreshes, ProtoCycler's COM port should appear. Select the correct COM port ***Do not*** *connect to ProtoCycler!*
4. With ProtoCycler connected, click "New Script File", and navigate to / select the updated firmware hex file.
5. Finally, click "upload" – read the warnings and confirm that you'd like to proceed. The log should begin showing progress of the firmware updating. *Note that firmware updates take several minutes (5+) and that ProtoCycler, the PCC, and the connection between them cannot be interrupted during this time!!!*
6. The firmware uploads in two stages. First the new pages are written, then they are verified. Occasionally, verification will fail, and just that page will be rewritten and verified. This is normal.
7. When Firmware updating is done, PCC will automatically disconnect and restart ProtoCycler with the new firmware – the log will also display a number of verification messages that the firmware was successfully verified and updated. If for some reason the firmware update is unsuccessful, disconnect ProtoCycler on the PCC, power off ProtoCycler, and start again at step 1.

Advanced Use

Advanced Manual Control

In addition to using the basic sliders, a number of additional commands can also be sent to ProtoCycler to further influence its extrusion behaviour. These advanced commands do things like change PID parameters for the various control systems, trigger the spreading servo to go to a certain position, trigger spooling to begin, modify the auger speed lower limit, change the timescales of various calculations, etc. *Modifying these commands is for experienced users only, and should not be attempted by those who are not intimately familiar with both plastic extrusion, and ProtoCycler's operation.*

All commands are sent in the following format of two alphabet characters followed by exactly 6 digits (including decimal) indicating a number:

xx######

Note that six digits are always required! Therefore, to send the value "1", "000001" must be used.

These commands are typed into the box labelled "Command:", at which point the "Send Command" button is used to send the command over. Only one command can be sent at a time, and it must follow the exact (case sensitive) format as shown above. A full list of commands is available in Appendix 3 – Manual Command Description.

In most cases, ProtoCycler will simply echo that a command has been received. In rare cases and depending on firmware, further information may be provided upon receipt of a command. Note as well that it is possible to send a command identical to what a slider would accomplish, *but the slider will not move in this case*. For instance, if the slider is used to set the temperature to 100 C, and then a manual command is sent to change the temperature to 150, the slider will still indicate it is set at 100 C. The Raw Data Stream will, as always, display the real time temperature of the hot end regardless of which method is used to set it. This behaviour is echoed across all the various commands, sliders, and readouts (i.e. the same is true for the puller speed, auger behaviour, fan speed, etc – the sliders will not update if a command is manually sent, but the Raw Data Stream will always display the real data regardless of what triggered the change).

Data Logging and Scripting

One of the most powerful features of the PCC is the ability to log data, and automate nearly every aspect of operation. This allows you to write custom scripts that can, for instance, step through a range of temperatures and pressures for an unknown plastic, and log data for each of them for later processing to determine the best temperature / pressure combination.

Logging data is relatively simple. While extrusion is underway, simply click the "New Save File" button, navigate to the directory of your choice, and create a file – *be sure to include the ".csv" extension. For instance, to save a file called "Extrusion test 1", name the file "Extrusion test 1.csv".* Then, click "Collect Data" to collect data. To stop collecting, click the same button again. Note that you can record many periods of data in the same file without overwriting the previous collection – repeatedly clicking the

"Collect Data" button will continually append the new data streams to the same file. *However, opening an existing file will wipe and overwrite all data on it!*

Scripting is significantly more difficult, and is unfortunately not currently available with the consumer version of ProtoCycler Command Center. If this is something you'd like to see us prioritize in future releases, please let us know!

Appendices

Appendix 1 – Readouts Description

Below is a full list of all readouts available in PCC. The format for each is the short-form title as it appears on the **Raw Data Stream,** The full name, and whether it's an advanced or basic readout.

Time – Running Time – Basic

The time since unit was powered on, measured in seconds.

Heat – Heater Power – Basic

The current power being sent to the heater, out of 128 (128=full power, 64=50% power, etc)

Temp – Temperature – Basic

The current melt section temperature, in degrees Celsius

AgSpd – Auger Speed – Basic

The current auger speed – unitless. The actual speed the auger is spinning at this instant.

AgPrs – Auger Pressure – Basic

The current auger pressure – unitless. There is very minor filtering of this value to eliminate noise, but it's otherwise the actual auger pressure at this instant.

AgFlo – Auger Flow – Basic

A weighted combination of both speed and pressure – some firmware versions may weight it 100% pressure or vice versa.

AFHis – Auger Flow History – Advanced

The "Filament time" history of the Auger flow when the current dNozz section of filament was being extruded.

<Pres> - Average Auger Pressure – Basic

A running weighted average of the auger pressure.

Pull – Puller Speed – Basic

The current puller speed in real time.

PulHi – Puller Speed History – Advanced

The "Filament time" history of the puller speed when the current dPull section of filament was at dNozz.

Aug P – Auger Feedback P term – Advanced

The “P” gain for the auger pressure PID algorithm – note, this is centered around 300 (as opposed to zero) for legibility. Therefore values less than 300 are negative. It is also scaled by a factor of 2 to make small changes easier to detect.

Aug I – Auger Feedback I term – Advanced

The “I” gain for the auger pressure PID algorithm – note, this is centered around 300 (as opposed to zero) for legibility. Therefore values less than 300 are negative. It is also scaled by a factor of 2 to make small changes easier to detect.

Aug D – Auger Feedback D term – Advanced

The “D” gain for the auger pressure PID algorithm – note, this is centered around 300 (as opposed to zero) for legibility. Therefore values less than 300 are negative. It is also scaled by a factor of 2 to make small changes easier to detect.

Nozz – Nozzle Diameter – Basic

The diameter of the filament as measured at the nozzle sensor.

Final – Final Diameter – Basic

The diameter of the filament as measured at the final / puller sensor after the cooling fan.

N.S.P. – Nozzle Set Point – Advanced

The diameter control algorithms set point for the nozzle diameter – the diameter the system tries to achieve at the nozzle sensor.

NozHi – Nozzle History – Advanced

The “Filament time” history of the nozzle diameter when the current dPull section of filament was at dNozz.

DDFnc – Draw Down Function – Advanced

The expected ratio of diameters between the nozzle and puller sensors, as calculated on an ongoing basis.

Flow – Flow Rate – Advanced

The (unitless) flow rate of plastic through the system.

FloFnc – Flow Rate Function – Advanced

The expected ratio of auger flow to plastic flow through the system.

Dia P – Diameter P – Advanced

The “P” gain for the diameter PID algorithm – note, this is centered around 200 (as opposed to zero) for legibility. Therefore values less than 200 are negative. It is also scaled by a factor of 2 to make small changes easier to detect.

Dia I – Diameter I – Advanced

The “I” gain for the diameter PID algorithm – note, this is centered around 200 (as opposed to zero) for legibility. Therefore values less than 200 are negative. It is also scaled by a factor of 2 to make small changes easier to detect.

Dia D – Diameter D – Advanced

The “D” gain for the diameter PID algorithm – note, this is centered around 200 (as opposed to zero) for legibility. Therefore values less than 200 are negative. It is also scaled by a factor of 2 to make small changes easier to detect.

Appendix 2 – Profile Settings Description

The Profiles settings are split into basic and advanced settings. Each setting is listed by name, with a brief description of its relevance. Many if not all parameters receive a default value when a new profile is created. Therefore *all* parameters should be examined when you create a new profile yourself! Note that only settings flagged with a “D” are able to accept decimal values – all other fields must be entered as integers.

Basic:

Melt Temp – The melt temperature used during normal, steady state extrusion after startup is complete, in degrees C.

Pressure – The pressure used during normal, steady state extrusion after startup is complete.

Cooling – The cooling fan speed to use during normal, steady state extrusion after startup is complete.

(D) Diameter – The diameter to strive for, usually 1.75mm

(D) Auger KP – the P term of the auger PID control algorithm

(D) Auger KI – the I term of the auger PID control algorithm

(D) Auger KD – the D term of the auger PID control algorithm

(D) Auger Imax – the maximum amount the I term is allowed to increase for the auger PID control algorithm

(D) Diam KP – the P term of the diameter PID control algorithm

(D) Diam KI – the I term of the diameter PID control algorithm

(D) Diam KD – the D term of the diameter PID control algorithm

(D) Diam Imax – the maximum amount the I term is allowed to increase for the diameter PID control algorithm

Startup:

Pre Pressure – the pressure used during startup

Pre Pull – the pulling rate used during startup

Pre Cool – the cooling rate used during startup

Pre heat – the temperature to thermalize to during startup

Pre Heat Time – how long to thermalize for, in seconds

Stabilization time – how long to stabilize for, in seconds

Advanced:

Aug Lower Limit – the slowest speed the auger is allowed to spin in spite of pressure spikes. Used to combat the effect of shearing events by forcing the auger to turn through them.

Min Pressure – the minimum pressure allowed before an error is flagged

Cool Function – how much to vary the cooling speed based on the flow rate

Max Heat – the maximum heat allowed before an error is flagged due to the temp compensation algorithm.

Min Heat – the minimum heat allowed before an error is flagged due to the temp compensation algorithm.

Flow Function Time Scale – how many loops the flow function should be averaged over

Draw Down Time Scale – how many loops the flow function should be averaged over

Flow Rate Time Scale – how many loops the flow function should be averaged over

(D) Flow Function Influence – how important the auger flow is to the output flow

Expected Flow – what we expect the plastic to flow at

(D) Smith Gamma – currently unused

(D) Smith Influence – currently unused

Appendix 3 – Manual Command Description

Below is a full list of all manual commands available in PCC. The format for each is the short-form alphacode, the scripting equivalent, the full name, and the data type expected. The scripting shortform is also listed if applicable. *Please note that entry verification is not performed on commands! Also, case matters…kp =/= kP !*

ff – flow function time scale – Integer

fd – draw down function time scale – Integer

fr – flow rate function time scale – Integer

fi – flow function influence – Float between 0 and 1

tm – current melt temperature – Integer

ts – temperature scale factor – Integer (100=100%)

ma – current auger setting – Integer

mp – current puller speed – Integer

mc – current cooling fan speed – Integer

kp – Auger PID "P" constant – float

ki – Auger PID "I" constant – float

kd – Auger PID "D" constant – float

km – Auger PID I-max term – float

kP – Diameter PID "P" constant – float

kI – Diameter PID "I" constant – float

kD – Diameter PID "D" constant – float

kM – Diameter PID I-max term – float

dd – desired diameter – *Integer, for 1.75mm enter 175! For 1.65mm, enter 165, etc.* Will automatically engage both diameter feedback and diameter PID

pm – set maximum pressure before auger cutoff – Integer

ps – set pressure scale – Integer (100=100%)

pl – set the minimum auger speed during low pressures – Integer

sm – send the servo to the listed pulse length in microseconds – Integer

ss – start spooling, expecting an empty spool – Value ignored, use 000000 for consistency

se – Toggle smith control on / off (not currently used) – Value ignored, use 000000 for consistency

sg – smith control gain (not currently used) – float

si – smith control influence (not currently used) – float between 0 and 1

Appendix 4 – Firmware 1.10 Changes

Please read this section carefully. We have made a number of changes to the firmware and failure to understand them may result in your extrusion failing prematurely.

This version of software and firmware are likely the biggest leap forward we've made beneath the surface since 0.9 went to 1.01, and 2.9 went to 3.1.1…which was a long time ago! There are a number of bug fixes that we've done, as well as a number of new improvements, with significant work done to how

automatic profiles are handled as we start (hopefully) rolling out more plastics. It's important to note that 1.10 and 3.10 MUST be run together, as they communicate slightly differently than the older versions. Firmware upgrades should still work across various platforms…i.e. if you connect a 1.04 unit to 3.10 software, it should work well enough to upgrade the firmware on the unit to 1.10 and then be able to do everything else. **Finally, please note that the old profiles WILL NO LONGER WORK, due to the changes in scaling factors. You can either modify the required profiles yourself by scaling the required values accordingly (see *"No more (stupid) scaling factors",* below), or replace your existing profiles with those from our database.**

Bugs

- Manual commands are now input verified to a stronger degree. If you don't exactly match an expected command, it should fail to send, before trying to send and potentially messing stuff up.
- We had a few users report that the profiles on their unit were not updating correctly. This should be fixed now.
- Save files not saving…CSV log files used to not save correctly unless you opened a new save file, before closing the unit. This is obviously ridiculous behaviour, and in theory is now fixed, but this one was a bit of a "quick fix" and may still not work as intended. **Please verify all of your save file behaviour works as expected before logging hours' worth of important data!**
- The window used to scale up properly…but would also try to scale down. It also wouldn't scale correctly on some screens. This should all be fixed.
- Window now locks and displays progress bar for both firmware and profile updates.
- File extensions / naming / etc are now limited. If something already has a file name (like a profile), then you don't get to pick when you save. Similarly if you're opening an rpap file, only rpap files will be shown.
- If you spot any bugs, please let us know! We have done extensive testing both in house and out of house with the new releases – but we may still have missed something.

Improvements

Fault Detection

The unit should now automatically turn itself off if any number of things happen that shouldn't happen. **Please note that this might prove to be somewhat frustrating to get the hang of – don't try to do a full spool until you've become accustomed to this!** There are a few things that will cause the unit to automatically shut down, explained in detail below. Note that fault detection is only activated in automatic mode, once PID is enabled – roughly 2 minutes after spooling begins.

If the unit *does* have a fault triggered, it will both log this to the software (which should display a somewhat descriptive message), as well as flag an internal error code that will be displayed upon power cycle. Note that restarting extrusion which ends successfully will clear the error code. The following faults will trigger shutdown:

Time expired – On the unit itself, in the settings menu, you can set the maximum time you want the unit to extrude (in minutes). This is meant as a convenience…it will now automatically shut down after a user specified amount of time.

Length Expired – Same as above, but with meters of filament instead of seconds of time. Note that this counter may not be as accurate, but it shouldn't be too far off.

Auger Slip – If the auger cannot build pressure or runs dry of pellets, the unit will shut off. Note that it's almost impossible to trigger this fault, before the Diam fault below, but it's here just in case you've got some *really* good settings ;)

Diam Error – Triggered if the puller sensor believes itself to be in error…due to a completely static reading, or no reading, or similar. If more than 5 seconds pass where it cannot correctly read the filament, shut down is triggered. Helpful if something fails catastrophically and the plastic begins going places it shouldn't…i.e. the "blob of doom"

Diam Stability – Triggered if the filament gets smaller than 1.40mm or bigger than 2.10mm.

Nozzle Sensor Error – If the filament has "fallen off" the nozzle sensor for whatever reason, then the system is blind to any upstream changes, and can't see what's happening…so it triggers this fault.

Temp out of range – This error will make a lot more sense after reading the next section, but is triggered if the temperature compensation algorithm attempts to set the desired temperature higher than "temp max" or lower than "temp min". This one can be tricky to master, especially when playing around with different grades of plastic. It is extremely important that your automatic profile has the correct expected flowrate, and reasonable max / min temps (wider range = less chance of failure) or your unit will continue to fail. Please ensure you've fully read and understand the Temperature Compensation section below before proceeding!

Temperature compensation

Units aren't always identical in the real world, and so specific settings that work on one unit may not work on another as well. More importantly, there's some real variation in grades of plastic…4043D and 3D850 just aren't the same, even though they're both PLA. This algorithm was added in an attempt to make the units a bit more forgiving, and is the first step towards making them smart enough to tweak settings on their own, and always work flawlessly without needing you to tell them what to do. Note that it is *only* active in automatic mode.

Basically, every minute, they check the flow rate. If it seems a bit low, they raise the temperature a bit…and vice versa. It's been extensively tested, and works quite well in our in house testing across a range of plastics. **Note however that "min temp", "max temp", and "expected flow"** are now increasingly important parameters in you profile…because you want this algorithm to work, but you don't want it to be so aggressive that it's always triggering a temperature out of range fault. So now, in automatic mode, the "expected temperature" is *just a guideline* – a base setting to try at first. Similar to how the auger speed is constantly changed to optimize the pressure, the temperature is now constantly changed to optimize the expected flow.

This means, as noted above, that min temp, max temp, and expected flow are now really important. If you found your unit was always extruding a bit on the slower side, this algorithm may well fix that – it will bump up the temp a few degrees until it's going a bit better. However, if your min <-> max temp range is too tight, you'll trigger an error. Similarly if your expexted flow is just too high or low, you'll

trigger an error before you try to hit it. We'll be putting out some more documentation on this specific feature soon, but for now, just pay close attention to your unit during it's first few minutes of extrusion. If the flow is at 100 and it's extruding well, but your expected flow is 300…stop extrusion, change expected flow to 100, and then try again. You want your expected flow value in your automatic profile to match where the plastic wants to be extruded.

Note that the expected flow also affects the cooling compensation…so if you set the expected flow really high, and you're not hitting it, your cooling fan will automatically lower. This can result in a runaway failure. Let's say you want your PLA to go faster, so you increase expected flow to 250 to see what happens, even though it's normally happy at 125. Now your fan speed will drop drastically, as the system thinks it's only at 50% of expected flow. It will also increase the temperature, to try and hit that expected flow. Increased temp + less cooling = bad news for the PLA filament…so please be careful with this!

PL in profiles

The auger "lower limit" has proved to be critical in maintaining output stability while shear events occur – but it's quite different for different plastics. Therefore, we've now integrated it fully into the profiles themselves.

Confirm shutdown / exit cooldown

Nothing, and I mean nothing, is more annoying than accidently clicking "stop extrusion" when you didn't mean too…and being stuck in cooldown for what seems like eternity. Two changes were made to mitigate this frustration. The first is that the unit will now ask you to confirm you want to cancel extrusion whenever you click "cancel" or "stop". The second is that, once in cooldown, you are free to leave the cooldown screen and do whatever you want. Note that you cannot return to the cooldown screen – if you begin extrusion again, even on the same plastic, it will restart the entire procedure.

Improved stall performance

Basically, the pressure sensor is more sensitive, which *should* reduce stalls, without having any negative effect on output. We also realized that in previous iterations of firmware, the "notification beep" that the auger stepper makes when "spooling is ready" could occasionally lead to stalls. A "soft start" program has been added to ensure the auger never tries to go right to max after a notification beep, which has so far eliminated any stalling previously caused by this.

No more (stupid) scaling factors

This one will likely be somewhat confusing for a little bit, and means that profiles / software / firmware are all not backwards compatible. We should have done this a *long* time ago. Basically, a lot of things used to be scaled for no reason…which made things confusing. You'd set your auger to 75, yet it would only reach about 30 on the graph. What gives? A stupid scaling factor, that's what. Same thing goes for the puller and the fan. So these have all been removed…the real values are now displayed on the sliders, and in the profiles themselves. Note that other than sending a manual command for diameter, this means that you want your diameter to be "1.75", not "175". There's also a bit of a conversion to do if you've made your own settings previously and want to keep using them. Here's how everything got converted:

Auger – Multiply by ~41% of what it used to be. What used to be “100” is now “41”…so to set the auger to what used to be “75”, you now set it to “29”

Puller – Multiply by 255% of what it used to be. What used to be “100” is now “255”…so to set the puller to what used to be “30” is now “75”.

Fan – Multiply by 80% of what it used to be. What used to be “100” is now “80”.

PL – Multiply by 50% of what it used to be…what used to be 70 is now 35, etc.

Standalone profiles

This is one of the two big ones, but probably the biggest one the user will notice. Profiles are now a real, discrete, vastly improved thing. You can do all sorts of stuff with them – view and modify them like you used to, but also download them from our website, save them to standalone files, swap them to the unit in real time, all sorts of great stuff. This is the real meat and potatoes of the update so there’s lots to cover - See the automatic profiles section for more info.

Cloud Enabled

The software now communicates with the cloud to get new firmware and profile updates. Profiles are always optional – firmware updates will always be optional beyond 1.10, unless a new software comes out that mandates a new firmware (similar to how software 3.10 *requires* firmware 1.10 to actually work). The cloud connection somewhat obviously requires internet connection, and if you’re not connected, then none of this will happen (and no error will be thrown, and everything else should still work fine…but let us know if not).

That’s it for this round of updates. We hope you enjoy the new software as much as we do, and thank you very much for selecting ProtoCycler+ as your extrusion system of choice!