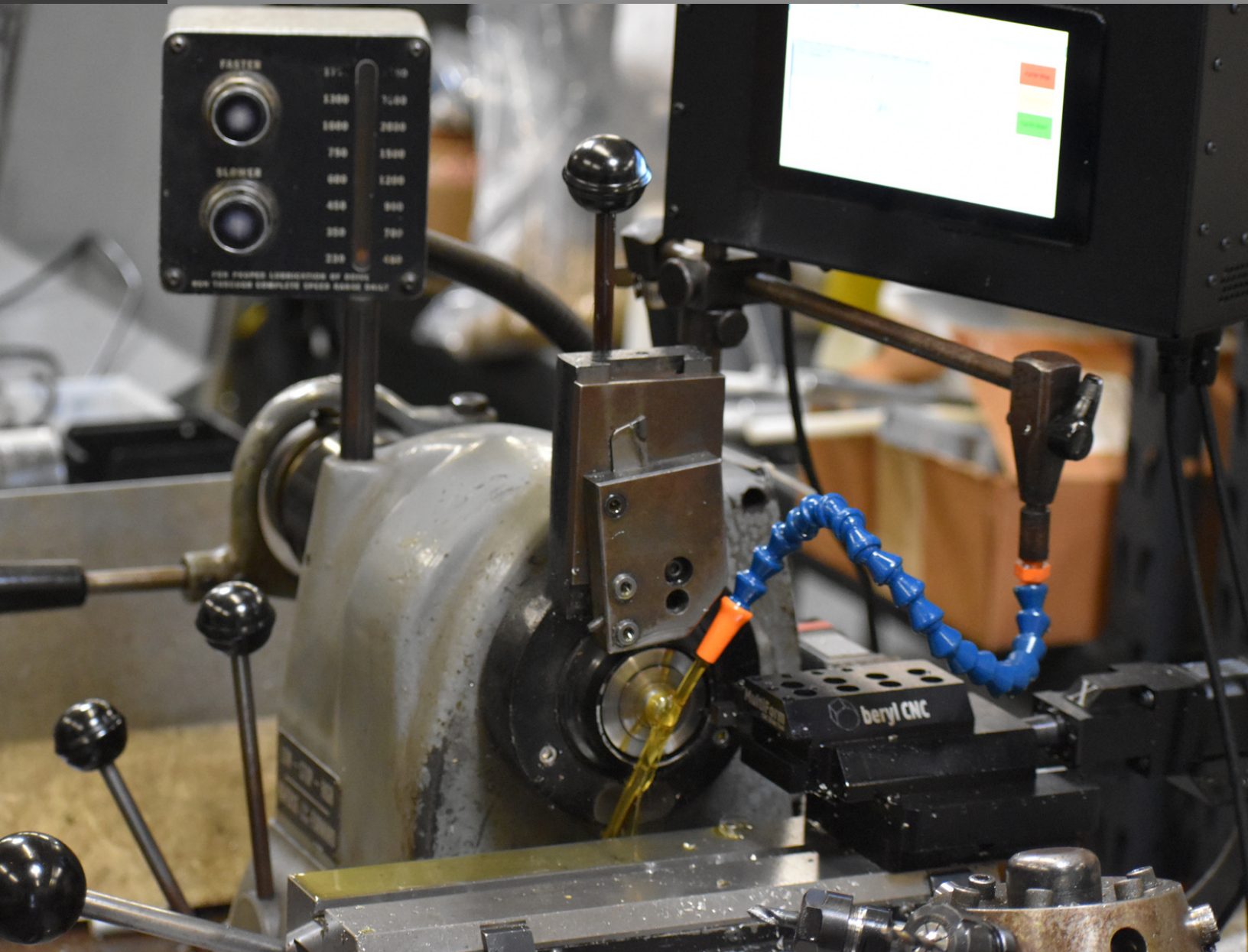


MultiForm

CNC Slide Tool

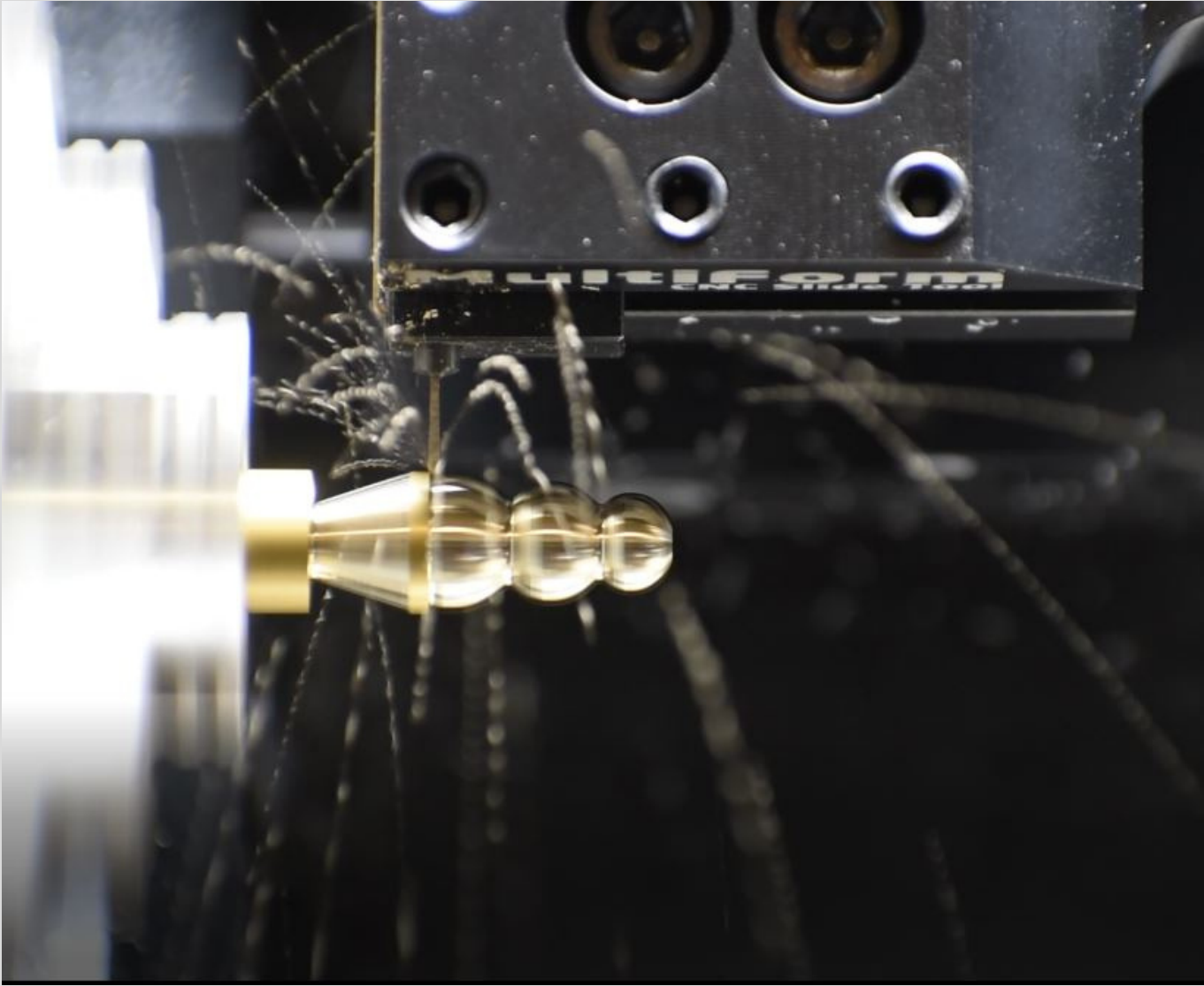


User Manual
Version: 1.0



Revisions

V1.0 - Initial Release



Contents

Revisions.....	2
Introduction.....	4
Important - Read Before Operating Your Machine.....	5-6
Example Parts.....	7
Geometry.....	8
Theory of Operation.....	9
System Components.....	10
MultiForm CNC Slide Tool.....	10
MultiForm CNC Controller Box.....	10
MultiMount for Mini Lathes.....	10
Modular Tool Holders.....	11
Tooling.....	11
Beryllium Pro Control Software.....	12
Fusion 360® CAM Post Processor and Tool Library.....	12
Unboxing.....	13
Break-In and Adjusting.....	13
Cutting a Part.....	14-15
Writing G-Code.....	16
Simplified G-Code Set.....	17-18
Service Intervals.....	19
Daily.....	19
Weekly.....	19
Monthly.....	19
Annually.....	19
Appendix A: Electrical Specifications.....	20
Appendix B: Mechanical Specifications.....	20
Dimensions.....	20
Appendix C: Supported G-Codes.....	21
GRBL G-Codes.....	21
BerylliumPro G-Codes.....	21
Appendix D: Preloaded Ballscrews.....	22
Warrenty.....	22
Returns and Exchanges.....	22
MADE IN USA.....	22
Contact Information.....	23
Notes.....	24-25

Introduction

Unlock the full potential of your lathe with the MultiForm System. Migrate all of your manual machines to CNC in minutes! Effortlessly install it on turret lathes featuring a 60-degree dovetail bed, or take advantage of our versatile mounting options for other machine models. In the majority of cases, no modifications to the machine are necessary. Experience enhanced precision, versatility, and cost savings for high-mix, low-volume part runs with the MultiForm System.





WARNING!

BERYL CNC SAFETY RECOMMENDATIONS:

1. This device installs onto dangerous machinery. Always follow the safety guidelines of the machine you are operating.
2. DO securely fasten long hair in such a way that it cannot encounter moving parts. Tie back or cover long hair and facial hair when operating any machinery.
3. DO keep hands and fingers away from moving axes; these are pinch points and create crushing risks.
4. DO be sure equipment is properly grounded.
5. DO disconnect main electrical power before attempting maintenance.
6. DO wear appropriate eye protection and personal protective equipment.
7. DO keep chemical and flammable material away from electrical equipment.
8. DO provide a safe, clean work area free of slippery surfaces.
9. DO read appropriate manuals or instructions before attempting operation or maintenance of a machine.
10. DON'T operate this machine with rings, watches, jewelry, neck ties, or any other loose clothing or accessories.
11. DON'T leave machine unattended while it is operating.
12. DON'T exceed the specifications of this machinery.
13. DON'T operate this equipment unless proper maintenance has been regularly performed and this equipment is known to be in working order.
14. DON'T operate this machine if unusual or excessive noise or vibrations occur.
15. DON'T operate this machine while any part of the body is in proximity of potentially hazardous areas.



BEST PRACTICES

Please follow these best practices to ensure compliance with the warranty:

1. Never “hot-swap” the motor cables. You must completely power down the system before connecting or removing any motor cables. Failure to do so will permanently damage the motors due to induction effects.
2. Do not overtighten the gib screws. Adjust the gib screws until a suitable level of precision is achieved. Overtightening can cause backlash due to excessive strain forces.
3. Always back up your files to avoid unexpected data loss.
4. Oil the ways before each use.
5. Do not use standard knurling tools or standard bar pullers with the MultiForm System, as these devices will exceed the force specifications of this device. The MultiForm is designed as a high precision instrument for light, repeatable cuts when used within the parameters in this manual.
6. Always use sharp carbide cutters. In some cases these are marketed as "nonferrous" metal cutting inserts. As a first principle, due to the light cutting forces of this system, it's best to apply all force to the sharpest cutting surfaces.

Example Parts

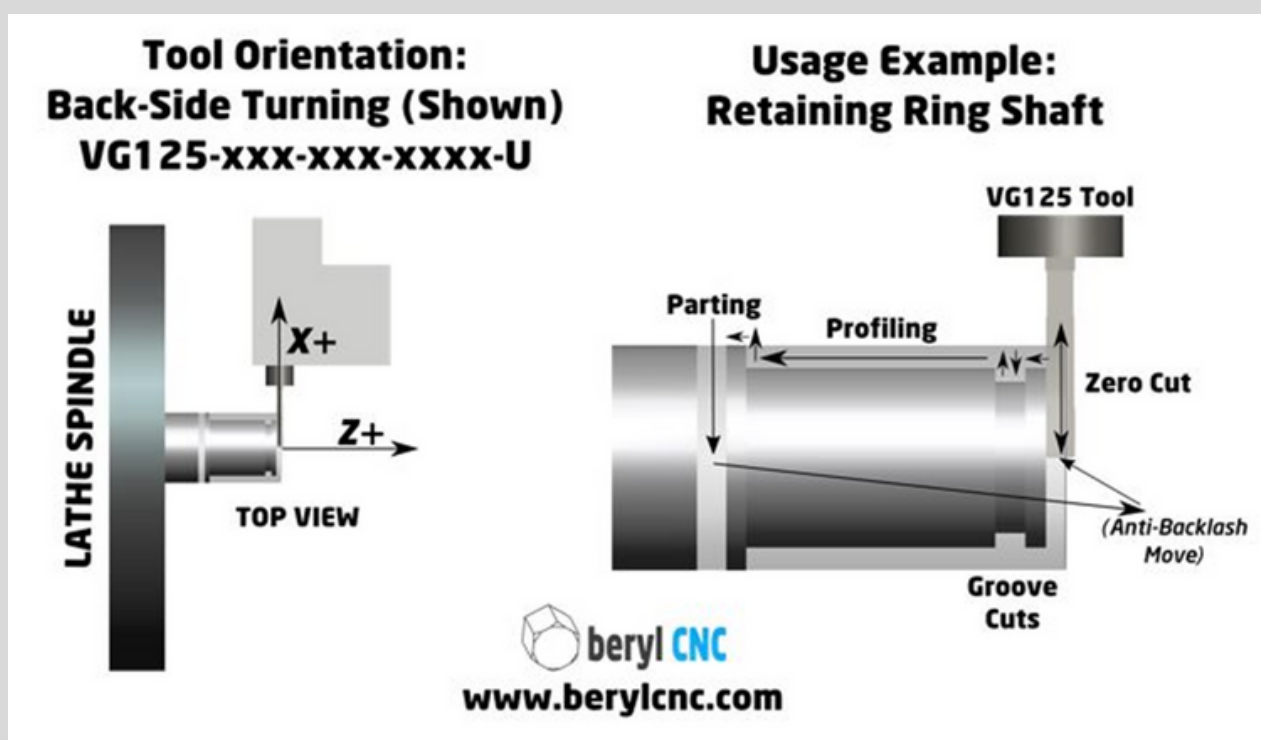
The MultiForm System has been designed specifically for high mix, low volume, small CNC lathe jobs. At the Beryl CNC factory we have multiple systems implemented on turret lathes for prototyping Swiss-style and screw-machine style parts. The following parts were made across the full spectrum of materials, from simple plastics to the most challenging Stainless Steel grades.



Geometry

The typical MultiForm System geometry is oriented such that the cross-slide is mounted on the rear of the lathe, having +X direction away from the spinning axis of the lathe. The spindle axis assumes the headstock is on the user's left side, and the axis of rotation is Z+ as you move away from the lathe headstock. Thus, most lathes will cut profiles in the "reverse" direction and perform boring and drilling operations in the "forward" direction. Your lathe tool will face "UP" on the rear of the lathe when cutting in "reverse". This configuration provides the most rigidity on the slide tool, as the cutting forces push down on the large sliding planes of the MultiForm frame. Alternate strategies can be used but are non-standard.

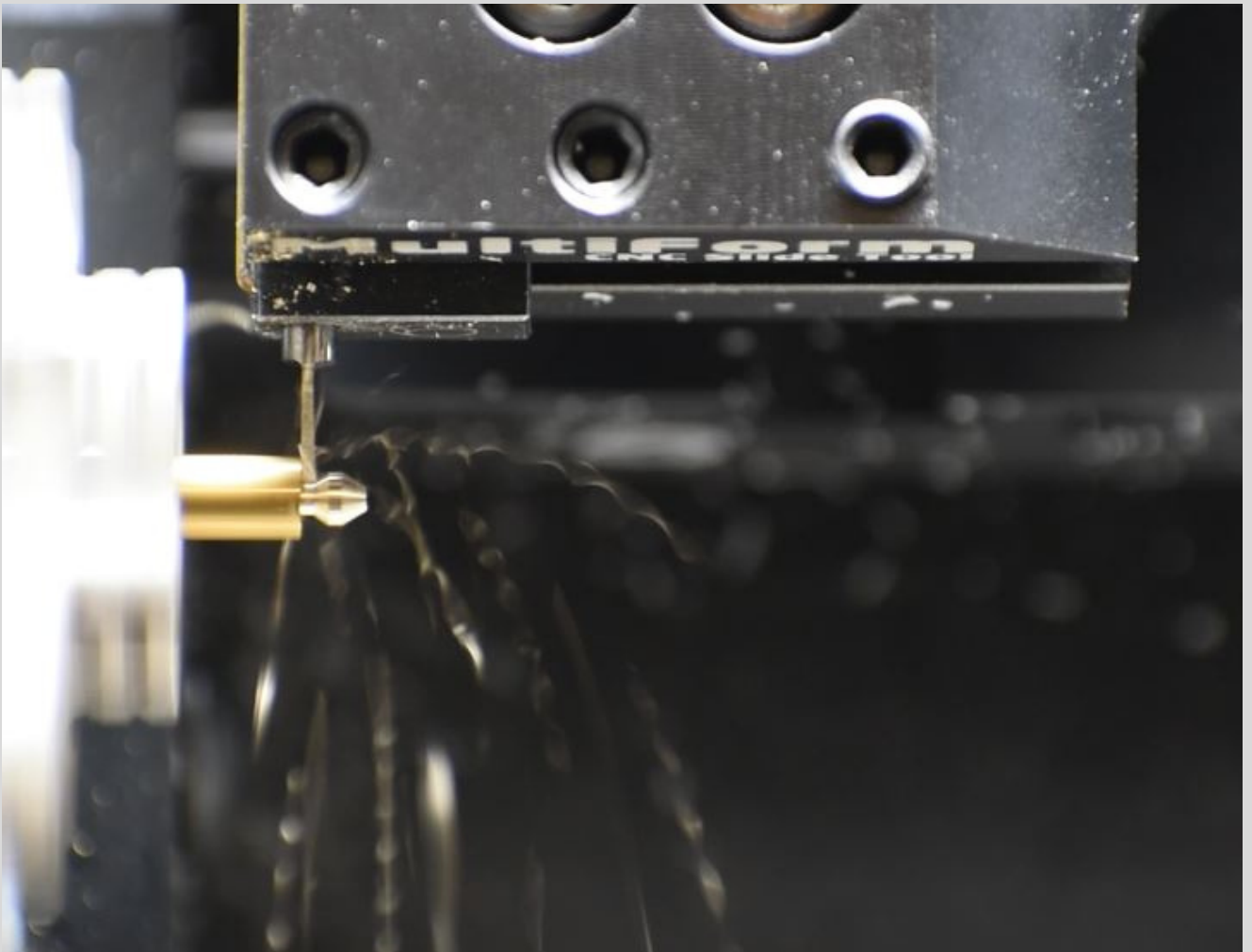
BACKLASH and SPRING NOTE: The MultiForm System uses high precision pre-loaded ballscrews on each axis. Still, it can be beneficial to use anti-backlash moves or G4 Dwell in certain areas to further improve accuracy. System backlash can arise from infinitesimal flexing in the ballscrew and frame system, which is exacerbated by tighter gibs. Achieving accuracy is a balancing act between gib tightness and strain backlash. Loose gibs can be a source of inaccuracy, while over-tight gibs can also generate inaccuracy when they cause flexing within the frame. Additionally, VersaGroove tooling will add an increased level of "spring" to all cuts due to the extreme length to width ratios. Standard insert tooling will exhibit less spring properties when cutting.



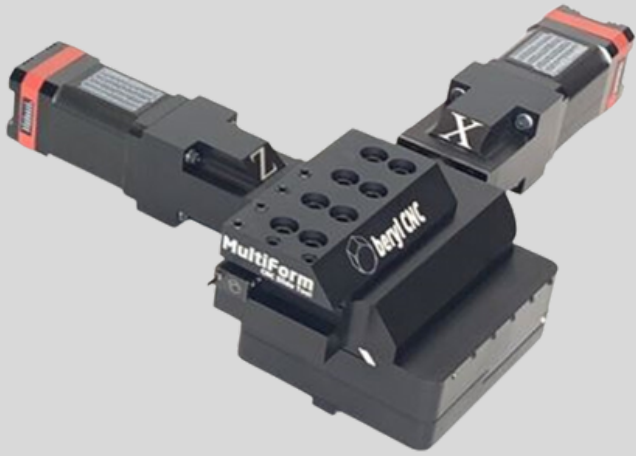
Theory of Operation

The MultiForm System operates under a critical theory of operation – in fact this theory is the mission statement of the MultiForm System:

“The Model-1 MultiForm System is a CNC tool that fits within the smallest possible footprint for use on turret lathes and compact manual lathes. To achieve this, the MultiForm System has been designed to function with small components, operate with high precision, and use sharp cutting tools requiring minimal axial thrust. Shallow depths of cut, low feed rates, and sharp carbide tools are a requirement. Please understand this theory of operation and apply these concepts to your tooling strategies. The reward will be many years of reliable use, and a solution that out competes other CNC lathe configurations in terms of ROI in high-mix, low-volume, semi-manual CNC work.”



System Components

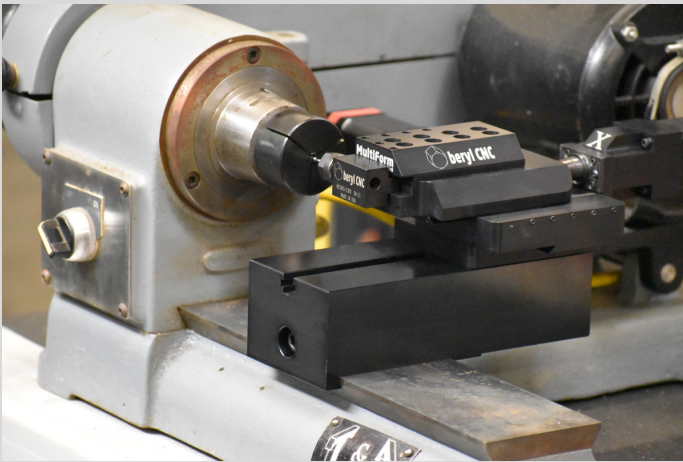


MultiForm CNC
Slide Tool

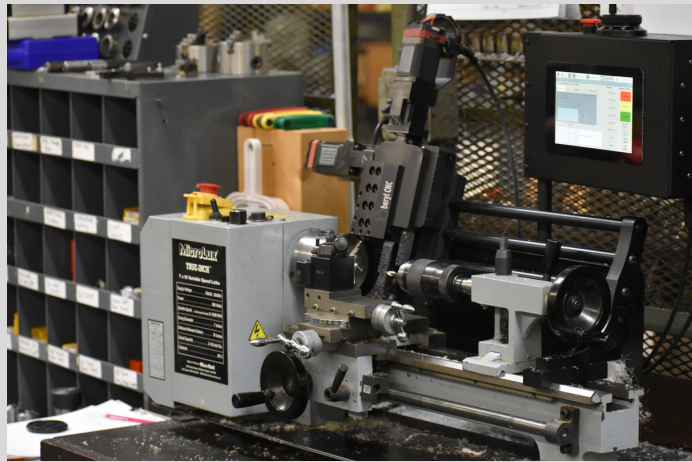


MultiForm CNC
Controller Box

Optional Mounts:



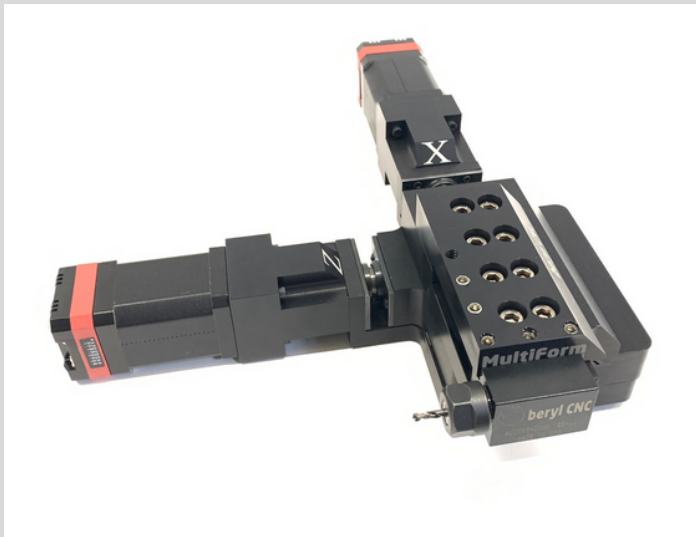
60 Degree
Dovetail
Mount



Mini Lathe
Mount

Modular Tool Holders

The Beryllium Pro control software can zero-out up to six tools, provided the user does a manual tool change using three 60 degree set screws. This modular system has been shown to retain 0.0002" accuracy when used properly. The user is advised to successively tighten each outside set screw, then tighten the center set screw for best relocation when changing tools.



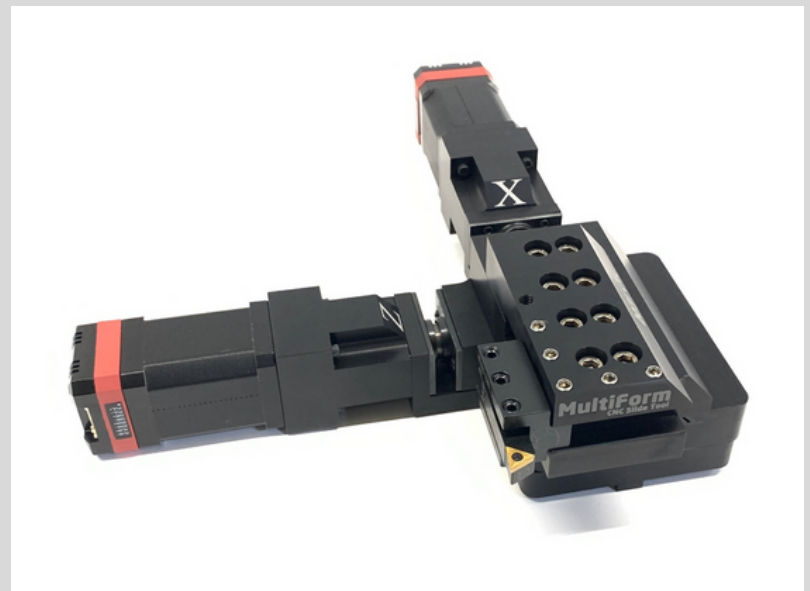
MultiForm Modular Tool Holder, ER11, for drilling and boring



MultiForm Modular Tool Holder for OD Turning



5 Degree Insert Tool Holder, TCGT/TCMT

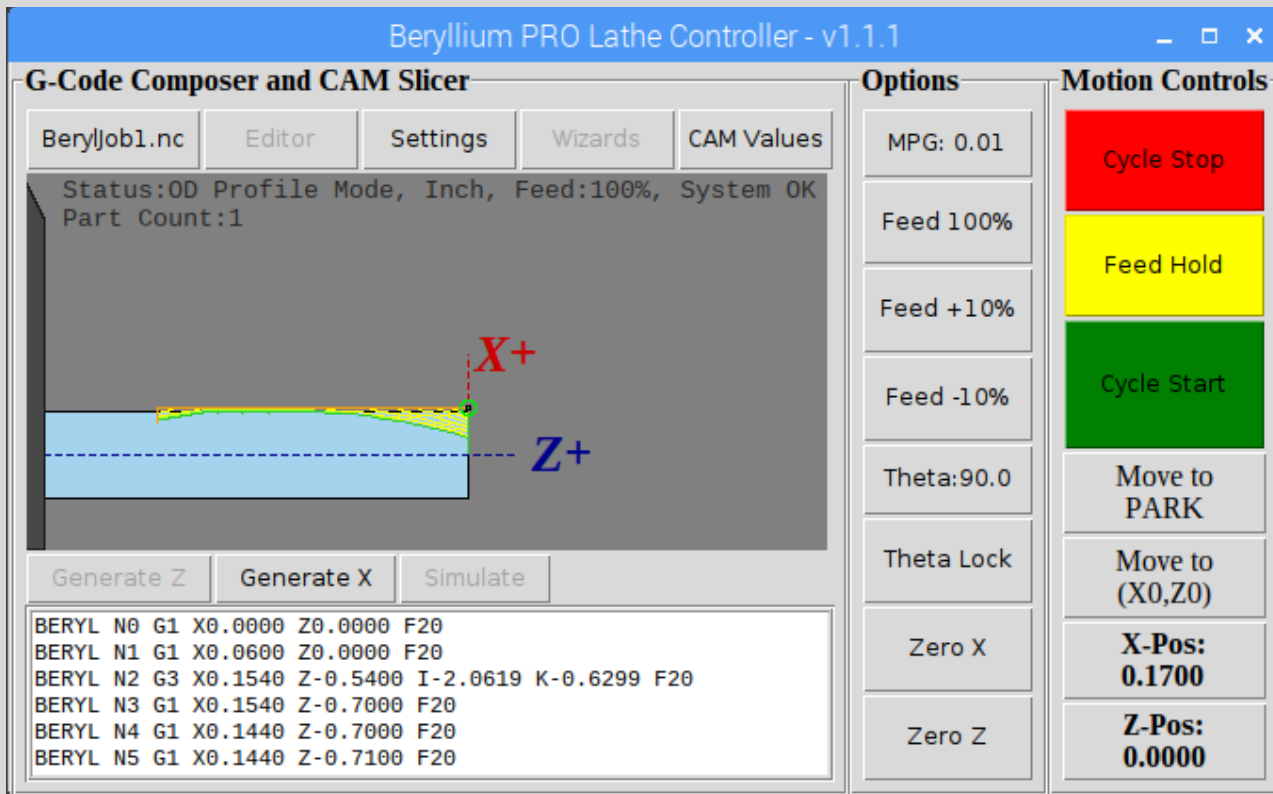


Tooling:

Ideally, the MultiForm System is used with VersaGroove® tooling. The VersaGroove® brand of tooling has been specially designed for the MultiForm System and Beryllium control software. We suggest getting started with VersaGroove® tools and then phasing in standard tooling as needed once you have a good idea of the behavior of your specific setup. A lot of the performance will depend on the rigidity of the setup - less rigidity will require lighter cuts. In any case, be sure to limit cutting pressure to less than 25 lbs.

Beryllium Pro Software

The Beryllium Pro control software is included with the controller. This powerful software runs the CNC slide tool, and offers additional higher-level functionality such as an on-board CAM feature to “slice” a profile tool path into multiple roughing and finishing passes in X (Generate X button on bottom tool bar). This simple CAM utility is extremely powerful in that it allows fast experimentation with difficult materials at the machine, without the need to iterate between a desktop PC and the machine controller, saving time on the factory floor. Software updates are periodically available for download, and typically include improvements to core functionality, as this is a new product line. BerylCNC will send out new software as a ZIP file whenever major updates are completed.



Fusion 360 CAM Post Processor and Tool Library:

For profiles that need additional horsepower, there is a Fusion 360® CAM post processor and associated VersaGroove tool library that can be used to generate toolpaths specifically for Beryl CNC products. This post processor is included in the USB flash drive you will receive with the MultiForm System.

Unboxing

Your new MultiForm System will arrive in a package containing both the controller and slide tool housed in an external box and custom designed foam packaging. A 6' IEC electrical power cord, flash drive, and other parts will be included in a third foam compartment. The flash drive contains this document, as well as other examples and useful files.

Break-In and Adjusting:

It is critical to understand and apply the proper break-in and adjustment procedures to the MultiForm CNC slide tool. When designing the MultiForm CNC slide tool, many tradeoffs were weighed, and the designer settled on a classic slide configuration. This is a very old and reliable method for linear motion, but it comes with some rules:

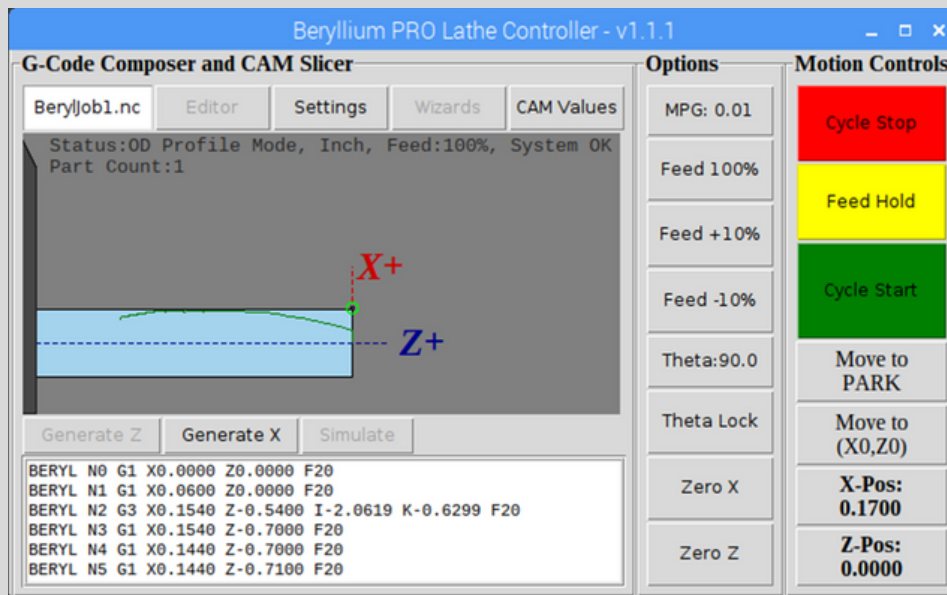
1. Do NOT overtighten the gib screws. Doing so will result in additional wear and tear on the linear motion drive train, from the stepper motor to the ballscrews, and may void your factory warranty if the gibs were found to be overtightened by the user. The gib screws should always be “backed off” enough to allow some freedom for sliding motion on the ways.
2. The slides are designed as hardened surfaces that must run under constant lubrication. We suggest a thin PTFE lubricant such as 3-in-One® brand or similar. All sliding surfaces are hard-anodized to 0.0008-0.0012” thickness. This surface will decrease in friction as it breaks in. The user should apply PTFE lube to the ways once a day.
3. As the ways break in, the user should adjust the gib set screws in the following manner:
 - a. With the MultiForm in the factory position, gently tighten each gib screw until it bottoms on the gib. Then, back off the position by $\frac{1}{4}$ rotation of each set screw. Operate the device.
 - b. Periodically, extend the MultiForm CNC Slide Tool to the limits of the scale markers (1.5” in Z, 2” in X) and try to “wiggle” the tool holder. You may want to use a dial indicator to visualize the “wiggle”. If the movement is greater than a few thousandths of an inch, close the MultiForm CNC Slide tool to the factory position and tighten each set screw another 5 degrees of rotation at a time, and retest.
 - c. After a few hundred parts and periodic set-screw tweaks, it’s likely there will be no additional adjustment of gibs needed.

The optimal sliding situation is a balance between plenty of freedom for the slide to operate, with minimal additional play. Too tight, and you’ll increase backlash due to flexing of the drive train components. Too loose, and you’ll increase error due to deflection of the tool holder under load. Please use discretion.

Cutting a Part

1. After powering on the MultiForm System, navigate to the command terminal in the Raspbian OS.
2. Using the commands “ls” and “cd”, navigate to the Beryllium Pro folder and execute Beryllium.py:
 - ~\$ ls (enter)
 - ~\$ cd berylliumpro (enter)
 - ~\$ ls (enter)
 - ~\$ python3 Beryllium.py (enter)

This will open the Beryllium Pro software:



3. Using the “X-Pos” and “Z-Pos” buttons and the handwheel, jog your tool tip’s leading edge vertex to the zero point of your work in X and Z. Press “Zero X” and “Zero Z” as needed to set your origin.
4. Using the “Settings” menu, adjust “Work Diameter (X)” to your work size, or slightly larger. This will establish the safe parking position for “Move to Park” of the tool, along with informing the embedded CAM slicer of how to process the tool paths for your stock. **NOTE: It’s sometimes beneficial to set the work diameter 0.010” – 0.050” larger than the actual stock if you like having extra clearance and more time before the cutter engages material.**
5. Click in “Beryljob1.nc” button and use the handwheel to navigate to the Beryljob number you wish to run. Ensure that the proper G-code has been entered into the appropriate Beryljob file at the following path: /home/pi/berylliumpro/Programs

Cutting a Part

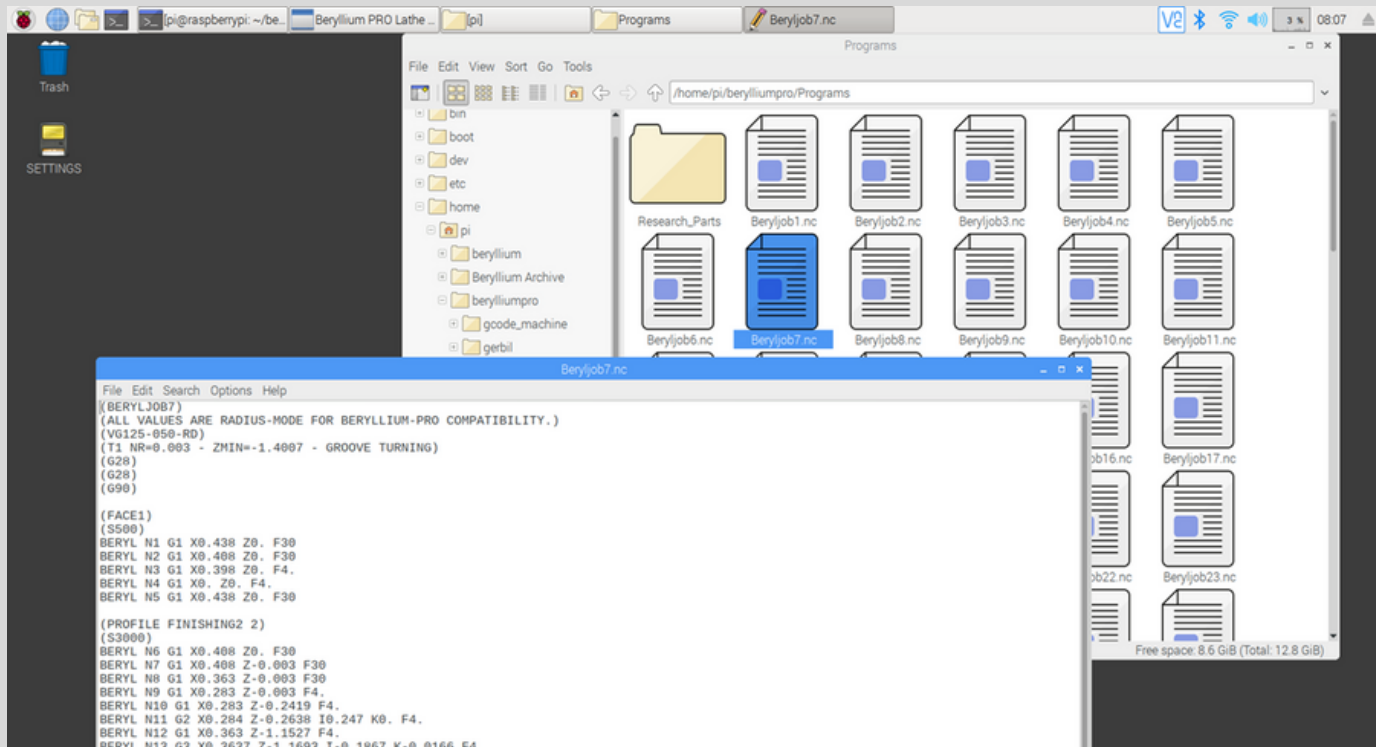
6. At this point, you should see your tool path on the graphical canvas in green. Press “Cycle Start” to run the program.
7. “Generate X” – pressing this button will auto-slice and generate your tool path in steps set by the CAM value menu for roughing and finishing. To optimize cutting time, the auto generated path is bounded by the Work Diameter plus a small safety zone. PRO-TIP: It’s very easy and useful to switch between your original “constellation” tool path (green line) and the “auto generated tool path” (yellow lines) by simply reloading your file (Press Beryljobxx button to reload the file). Sometimes this comes in handy for taking a final spring cut, when you wish to avoid executing a lengthy auto generated tool path.

PRO-TIPS:

1. Some of the best strategies make use of many Beryljob files. You might face cut with one file, move the cutter out of the way with another file, cut a profile, then part off all with different files. Do not try to pack too much into one Beryljob file. Your best designs will likely have a series of very simple Beryljob files. You can describe what the file does by entering comments between parentheses at the beginning of the file:
 - a. (Widget, 303 Stainless, VG125-030-005-L320-U Cutter, File 1 of 4, Parting Off)
 - b. (Use Generate-X with Roughing 0.006”, Finishing 0.002”)
2. Complex turning profiles can be hand-written with straight lines (all G1 commands) or a combination of G1 and G2, G3, simple 90-degree circle sectors. If your curves are not exactly 90 degrees for G2,G3, then the math becomes a little trickier as you’ll see in your I and K terms. Always use 4 decimal places when calculating G2, G3 arcs, and triple check your math. GRBL (the motor driver) does extra calculations on these codes, and is very sensitive to math and rounding errors. Any errors will stop the GRBL motor controller and you’ll have to fix your G-code. One suggestion for more complicated curvy paths is to use Fusion360 and the Beryllium post processor to generate a single tool path from the origin to the parting position in Z. Then use a second manually written program to part off. This way, you can use “Generate-X” on the Fusion360 toolpath to quickly obtain your roughing and finishing passes, and test out various pass depths to obtain the best finish and tool life. When you are ready to part off, run the other Beryljob program. Switching between the two files takes a button press and handwheel click, and is designed to be super easy!

Writing G-Code

Your G-code will reside at a predetermined location (path) in the Raspberry Pi computer: /home/pi/berylliumpro/Programs



It is critical that you don't change the names of any files, rather, you can open them with a text editor and change the G-code to whatever you want your file to be. For quick navigation, the MultiForm System uses the handwheel on top of the controller box to point the "Beryljobxx.nc" button to the file of the same name at the path:

/home/pi/berylliumpro/Programs.

This eliminates the need for cumbersome file navigation every time you wish to change .NC files. So, for example, you could construct your tool path such that there are three separate files you work between when cutting parts. One might be a peck-facing operation, another might be a profiling operation, and a third might be a peck-parting operation. These three example files could be switched between within seconds using the button and hand wheel.

SUGGESTION: Save copies of your optimized NC files in the /Documents folder, or an external flash drive, so you don't wipe them out when upgrading Beryllium Pro. We suggest backing everything up externally to avoid data loss.

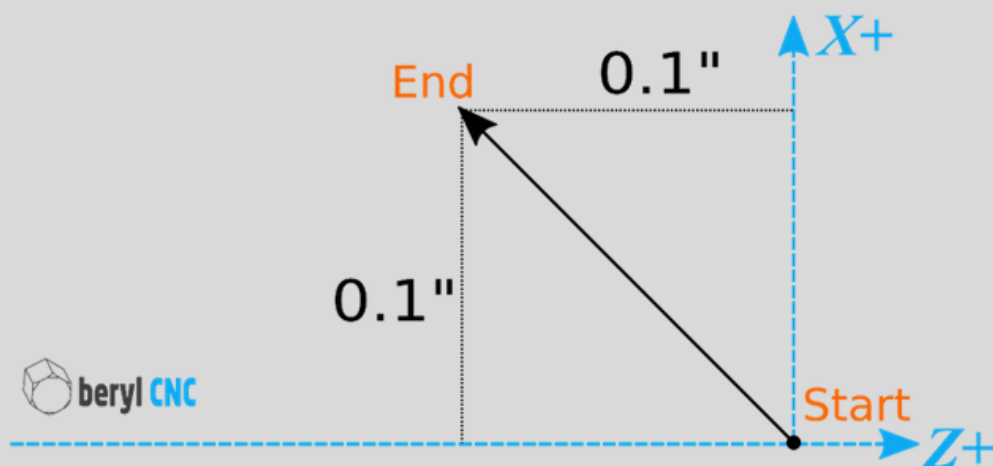
Simplified G-Code

Beryllium Pro requires the user to understand only three G-codes: G1, G2, and G3. Because the MultiForm System is an add-on to manual lathes, we've inherently eliminated the need for additional G- and M-codes. No M30 code is required at the end of a file. The program stops when the last line of code is executed by the GRBL hardware controller. One key concept worth noting - this setup is "homeless", I.E., you can crash this machine if you do not keep track of the limits of your G-code constellation. The alternative would be to require the user to install limit and homing switches on their machine, which goes against our fundamental goal of simplicity for this model of MultiForm System.

See Appendix-A for the details of the three fundamental G-codes.

G1: Straight Line Move

G1: Straight Line Move

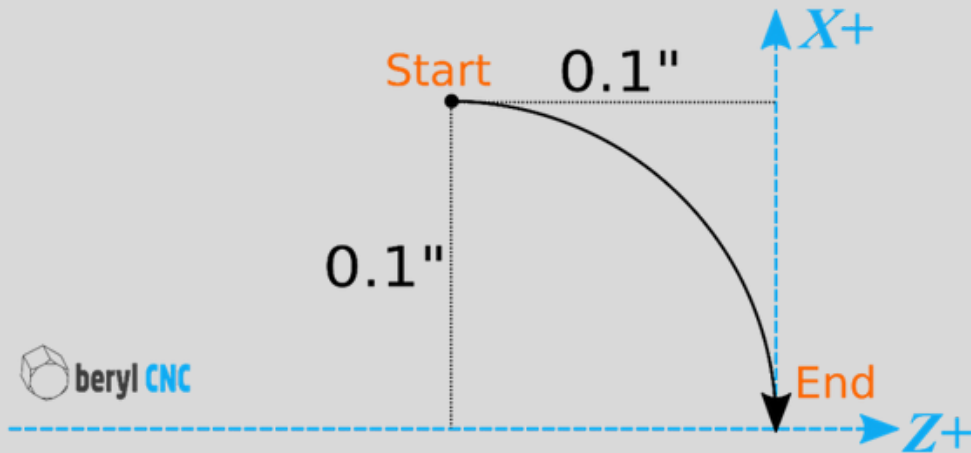


```
Start  
BERYL N0 G1 X0.000 Z0.000 F2  
BERYL N1 G1 X0.100 Z-0.100 F2  
End
```

Simplified G-Code

G2: Clockwise Arc

G2: Clockwise Arc

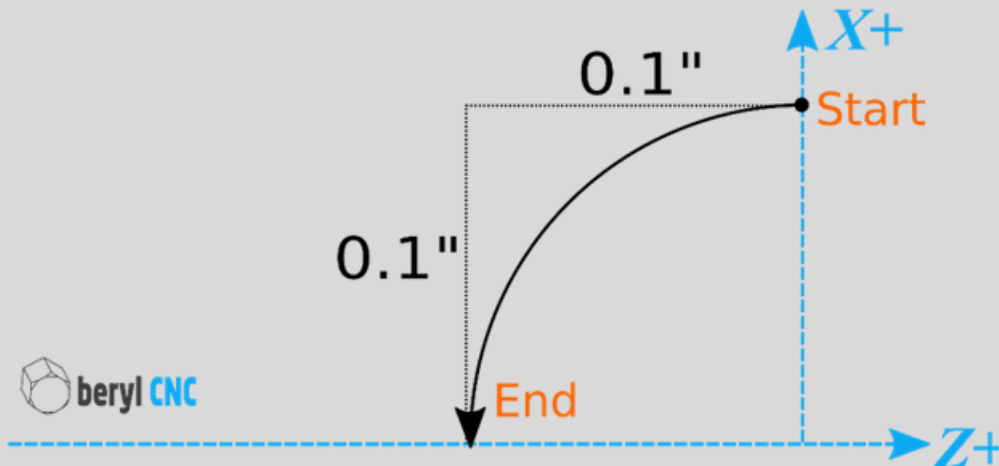


```
BERYL N0 G1 X0.100 Z-0.100 F2
BERYL N1 G2 X0.000 Z0.000 I-0.100 K0.000 F2
```

Start
End
Start to Arc Center in X
Start to Arc Center in Z

G2: Counter-Clockwise Arc

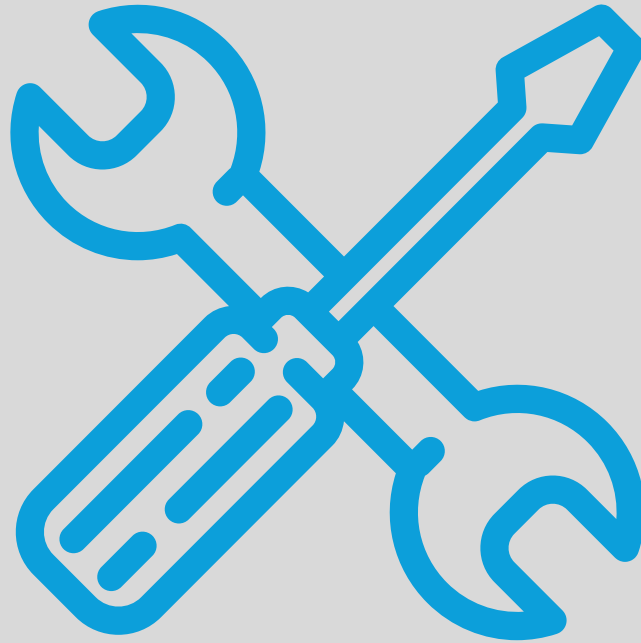
G3: Counter-Clockwise Arc



```
BERYL N0 G1 X0.100 Z0.000 F2
BERYL N1 G3 X0.000 Z-0.100 I-0.100 K0.000 F2
```

Start
End
Start to Arc Center in X
Start to Arc Center in Z

Service Intervals



Daily

- PTFE lube on slides (Included with the MultiForm System)
- Clear all chips from the ballscrew covers and ways
- Power down the Raspberry Pi when not in use for more than a day.

Weekly

- Shut down and power off the controller, restart.

Monthly

- Check / adjust the gib set screws for optimal accuracy.

Annually

- Update software to pull in any new features

Appendices

Appendix A: Electrical Specifications

Input Power.....	120 VAC, 60 Hz
Input Power Connector.....	IEC 3-Position Connector
Input Power Cord.....	IEC 6 foot power cord
Internal Power Supply.....	24VAC
120VAC Max Input Current.....	10 Amps (Fused)
24VAC Internal Power Rail Max Current.....	6.3 Amps (Fused)
5V DC Internal Power Rail Max Current.....	3 Amps (Fused)
Touch Screen.....	7" Diagonal, Capacitive Touch, full RGB
X-Axis, Y-Axis Connectors.....	12mm Circular Connector

Appendix B: Mechanical Specifications

X-Axis Travel: 2" Maximum

Z-Axis Travel (Spindle Axis): 1.5" Maximum

Resolution: 0.0001"*

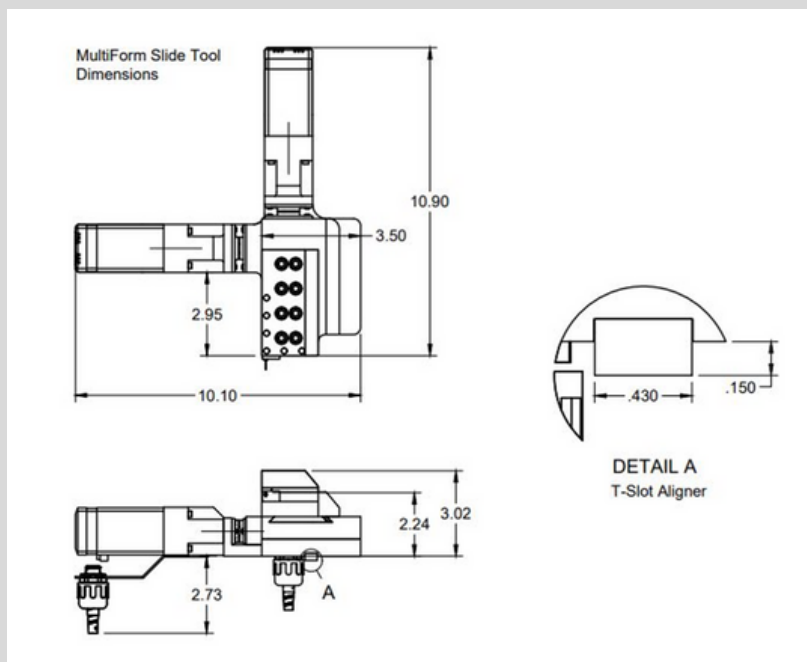
Repeatability: +/-0.00015"*

Backlash: Maximum 0.0015"*

Standard Tool Holder: 3/8" Capacity

*Dependent on Gib adjustments and proper break-in

Dimensions:



Appendix C: Supported G-Codes

Beryllium Pro (GRBL) G-Codes:

Standard Codes

G1 - Line Move at Feed Rate

G2 - Clockwise Arc

G3 - CCW Arc

G4 - Dwell

Spindle Control

M5 - Spindle Disable (Available on Automation Packages)

M3 - Spindle CW (Available on Automation Packages)

M4 - Spindle CCW (Available on Automation Packages)

Coolant

M9 - Coolant Disable (Available on Automation Packages)

M8 - Flood Enable (Available on Automation Packages)

M7 - Mist Coolant (Available on Automation Packages)

Tool Numbers

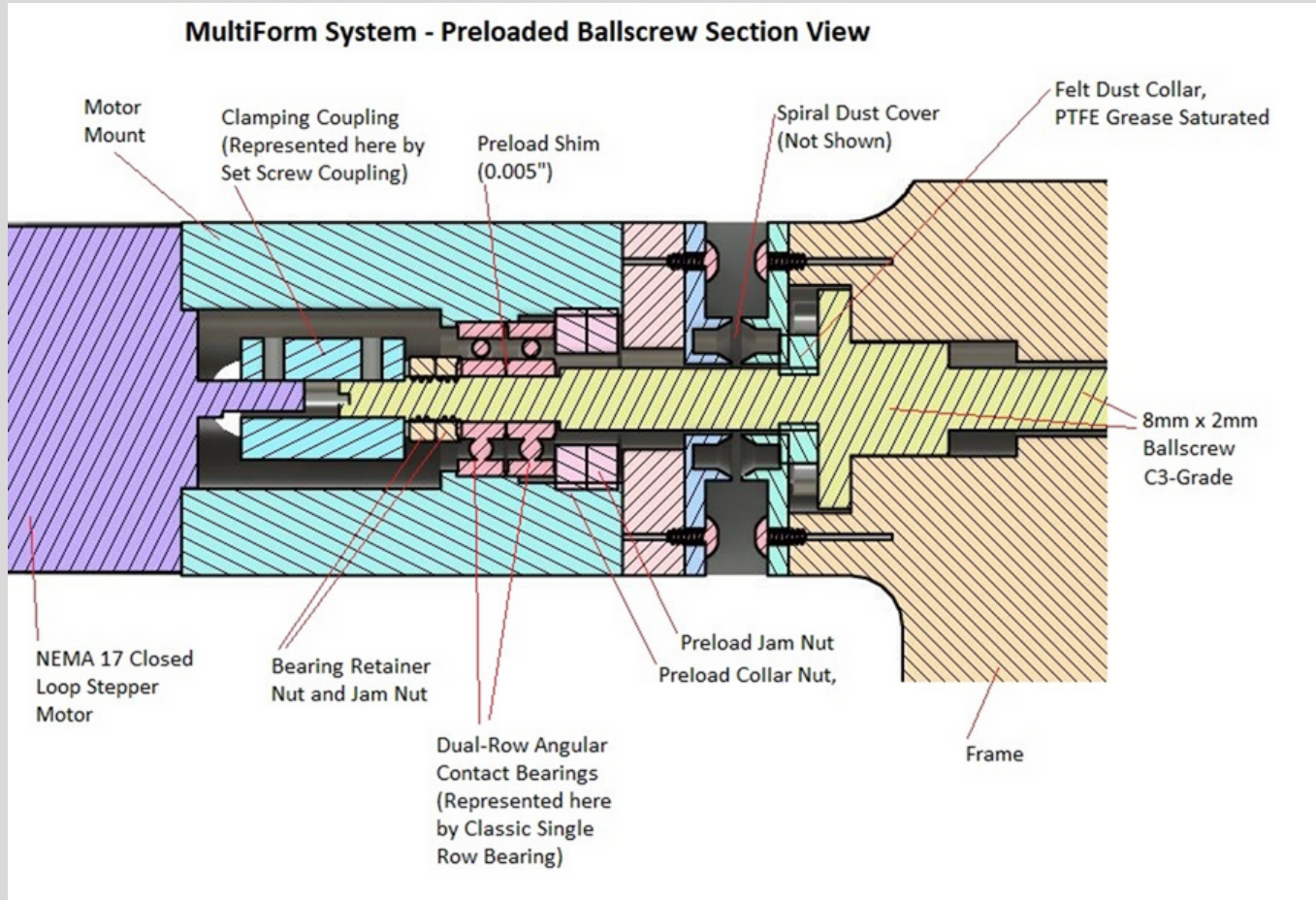
Tools

T1-T6 (Available for selection from GUI menu only)

Appendices

Appendix D: Preloaded Ballscrews

The MultiForm System uses preloaded ballscrews and a carefully designed drive train to ensure maximum accuracy. A diagram of the ballscrew system follows:



Warranty:

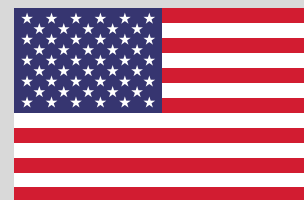
Beryl CNC, LLC provides a limited warranty. Please visit berylcnc.com/warranty for full details.

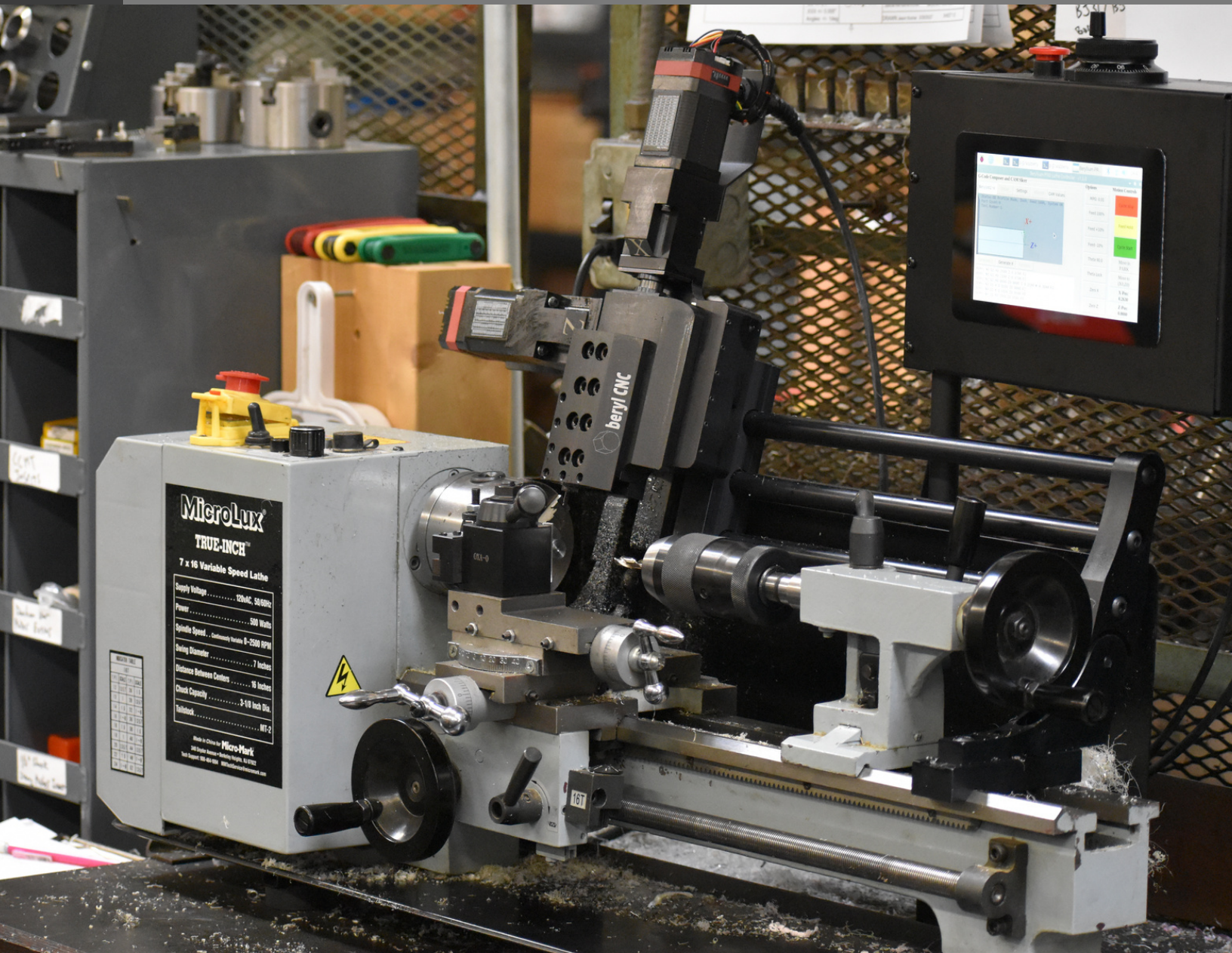
Returns/Exchanges:

Please visit berylcnc.com/returns for current return policy.

MADE IN USA:

The MultiForm System is proudly Made in USA





GET IN TOUCH

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216-223-8890

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Notes

