DESIGNING AND CNC MACHINING VALVE SUB-PLATES AND QUICK MOUNTS FOR HYDRAULIC POWER TRAINING SYSTEMS

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by

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Accepted by the faculty of the College of Business and Technology, Morehead State University, in partial fulfillment of the requirements for the Master of Science degree.

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In the past century, significant advancements have brought fluid power into virtually all applications of industry. Fluid power is a technology that uses a pressurized liquid (hydraulics) or gas (pneumatics) to transmit power from one location to another. This technology controls nearly all the machines or mechanisms in manufacturing. It is used so extensively that it is regarded as the muscle of modern industry. As a result of its significance, fluid power has become fundamental knowledge for most engineering students to study. The systematic instruction of fluid power must accentuate engineering theories, hands-on skills, and real problem-solving abilities. The problems that commonly occur are that the current lab equipment is neither suitable nor adequate for offering the needed lab training; sometimes, the devices and components for implementing advanced lab activities are simply nonexistent. These inadequacies and shortages often hinder efficient, effective teaching and learning. Many of the

pneumatic and hydraulic power student training systems on the market are too basic for college students, or their costs are economically prohibitive of the department's funding. These obstacles provoke the need to assess the issues with current student training systems and develop an adequate, affordable sub-plate and mount assembly. The objective of this research is to design a valve sub-plate with quick mounts for student hydraulic power training systems that allow students to create their own fluid-power circuits, from simple to complex. The hydraulic directional control valves available for purchase are bare devices without any connectors to link with other hydraulic components. The design of an industry-standard sub-plate is necessary to allow fluid to flow from the standard D03 ports of the control valve to push-connect fittings which are then equipped with hydraulic hoses that could link a hydraulic cylinder or motor. The quick mounting plate design will be used for easily manipulating and mounting the sub-plate to the component rack. By utilizing industry-standard specifications, students can train with different directional control valves including manual and solenoid. Due to the fact that all the devices and components used in this design are D03 industry standard, this training system will enable students to gain practical knowledge by working with components that will also be used later in their professional practice.

Accepted by: ________________________________, Chair

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Acknowledgments

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Chapter One: Introduction

Background

Our industrialized world depends on the use of hydraulics, also known as the workhorse of industry. Fluid power is important because it is one of the three key methods of transmitting power. Other systems of transmitting power are by using mechanical means and by applying electrical energy. Hydraulic systems have favorable properties, such as the large amount of power that can be generated while delivering constant torque or force regardless of speed changes. They can move heavier loads and deliver higher forces than mechanical, electrical, or pneumatic systems.

Fluid power is the force behind nearly every piece of machinery that fabricates the structure of our cities. There are abundant functions of fluid power; some can be easily observed in our everyday lives, such as the vehicle braking and suspension systems on our cars, fuel pumps, forklifts, aircraft wing control, industrial cranes, and many others. The main area where this power is extensively applied is the manufacturing industry. It is used to automate processes through the application of actuators, facilitating mechanical operation. Given its importance, hydraulics are essential knowledge for engineering students to study.

After the sub- and mount plate assembly are developed for an adequate training system, engineering students of Morehead State University will have the ability to learn the many techniques used in industrial systems, manufacturing, and in component handling. Through advanced lab trainings, students will be better prepared for their future endeavors in the industry.

Purpose- Statement of Problem

The problem is that engineers usually receive little fluid power training at college, so they are not prepared to carry out this responsibility in their careers. Current lab equipment is neither suitable nor adequate for offering the needed lab training. Students need hands-on experience to embed the basic concepts of hydraulics in their brains. They will be able to learn the proper techniques to build a functioning fluid power circuit with this hydraulic trainer.

The proposed fluid power parts will engage students in an active learning approach that makes the curriculum more enjoyable and interactive. This training system will promote experiences with real problems that can occur in the field and strengthen problem-solving abilities through troubleshooting and diagnosing issues.

Objectives

Objective 1:

Design valve sub-plate and quick mount part for the hydraulic training system.

Objective 2:

Analyze the functionality of the valve subplate and quick mount in a virtual environment.

Objective 3:

Evaluate the manufacturability of the design by generating g-code and simulating CNC machine cutting operations.

Factors to consider

The following assumptions are necessary circumstances for the research and development of this system. To realize such open-end systems, all the tubes, hydraulic hoses, and valve components should be able to be quickly mounted and dismounted from the training board for the customizability of power circuits. All the hydraulic components supplied and designed need to conform with industrial standards, therefore giving this sub- and mount plate assembly great flexibility in the selection of the valves and actuators used for different trainings sessions. The quick mounts need to meet the specifications of the component rack to be sure they can easily clip into the board and not move once hydraulic pressure is added to the circuit. The following factors were considered for this design:

-Size Requirement: The more compact the trainer, the more training systems can fit into a classroom laboratory. A flexible working area where the students can assemble different hydraulic circuits with ease by placing and connecting components to a component rack.

-Student Experience: A well-designed training station that uses current engineering technology increasing the attraction of fluid power technology to students.

-Lab Experience: An efficient hydraulic trainer that supports basic and advanced lab exercises where students can be exposed to the basic concepts of fluid power and modern industrial technology.

Limitations

All parts will be virtually machined by simulation using the parameters and cutting tools of the Haas Mini Mill located on MSU campus. The material selected is 6061 aluminum stock, which would be used for actually machining the parts. The valve subplate quick mounts must adhere to the training board rail specifications for easy mounting and dismounting.

Definition of terms

Automation: a streamlined process that reduces or eliminates manual steps. There are two types of automation: unattended (actions without human intervention) and attended (actions executed by humans). Some automated tasks may combine the two (Kucera, 2022).

Computer-Aided Design (CAD): the use of computer-based software to aid in design processes. CAD software is frequently used by different types of engineers and designers. CAD software can be used to create two-dimensional (2-D) drawings or three-dimensional (3-D) models and assemblies (Chai, 2020).

Computer Numerical Control (CNC): a manufacturing process in which pre-programmed computer software dictates the movement of factory tools and machinery. The process can be used to control a range of complex machinery, from grinders and lathes to mills and CNC routers. With CNC machining, three-dimensional cutting tasks can be accomplished in a single set of prompts (Hess, 2017).

Control Relay: A control relay is a locally or remotely controlled electromagnetic switch that is widely used in all forms of equipment due to its ability to switch higher currents (Legazpi, 2022).

Engineering Drawings: a two-dimensional representation of three-dimensional objects. In general, it provides necessary information about the shape, size, surface quality, material,

manufacturing process, etc., of the object. It is the graphic language from which a trained person can visualize objects (Reddy, 2008).

G-Code: also known as geometric code, controls the machine’s motion. For example, it might direct the machine to move in a line or an arc. A G-code command is usually written in an alphanumeric format, starting with “G” and followed by a two-digit number (for example, G00) (Lee, 2021).

M-Code: controls the machine or miscellaneous functions of the CNC machine, such as spindle rotation, pallet change, and telling the tools when to operate or cease operation. M-codes are also written in alphanumeric format, beginning with “M” and followed by two digits (Lee, 2021).

Hydraulic Actuator: devices used to convert the energy of fluid back into mechanical power. The amount of output power developed depends upon the flow rate, the pressure drops across the actuator, and overall efficiency. Depending on the type of actuation, hydraulic actuators are classified as linear or rotary (Thorat, 2022).

Hydraulic Trainer: training equipment to support the teaching of hydraulic and pneumatic motion control. It is a customizable test bench with a power unit, valves, actuators, and hoses with connectors (Assaf, 2021).

Industry Standard: A set of criteria within an industry relating to the standard functioning and carrying out of operations in their respective fields of production. In other words, it is the generally accepted requirement followed by the members of the industry (Johnson, 2020).

Mastercam: a computer-aided manufacturing (CAM) software program used by manufacturing professionals, such as machinists and computer numerical control (CNC) programmers. This software helps users produce mechanical drawings of machine parts, learn how to operate CNC lathes and mills, and create 3-dimensional wireframe models (Best Accredited Colleges, 2021).

Programmable Logic Controller (PLC): a digital computer used for industrial automation to automate different electro-mechanical processes. It consists of a programmed microprocessor whose program is written on a computer and later downloaded via a cable to the PLC (Boisset, 2018)

Solidworks: is a design software application used to create 2D and 3D sketches, 3D parts, 3D assemblies, and 2D sketches (Planchard, 2020).

Chapter Two: Review of Literature

Brief History of Hydraulics

The origins of hydraulic engineering go back thousands of years. Ancient societies in Mesopotamia and Egypt established a large-scale drainage and irrigation system that can be dated back to 3200 BC (Houghtalen et al.,2010). The authors also discuss complex water supply systems involving several hundred kilometers of aqueducts that were built to bring water to ancient Rome. Houghtalen (2010) notes a massive irrigation system in Sichuan, China, constructed approximately 2,500 years ago, that is still effective in use today.

Figure 1. Dujiangyan Irrigation System Adapted from- *A magical ecological engineering feat without the use of Dams*. Dujiangyan Irrigation System, Dujiangyan Irrigation Project. (n.d.). Retrieved from https://www.chinadiscovery.com/sichuan/dujiangyan/dujiangyan-irrigation-system.html

Dellinger (2016) studied the history of Europe and their uses of hydraulics. Among the many types of turbines engineered in Europe, the Archimedes Screw Generator (ASG) became notorious for its use in developing and enabling the exploitation of hydro sites. Well-known for more than 2000 years, the operating principle of the Archimedean screw was used as a pumping system to raise large amounts of water for low-head sites. Even after two millennia, the ASG is still used today for pumping wastewater in treatment plants. The groundwork of hydraulics by

Archimedes led to the invention of numerous hydraulic devices and mechanisms useful for different purposes. He also discovered that a floating or immersed body must be acted upon an upward force equal to the weight of the liquid that it displaces, which is the foundation of hydrostatics (Rouse, 1983).

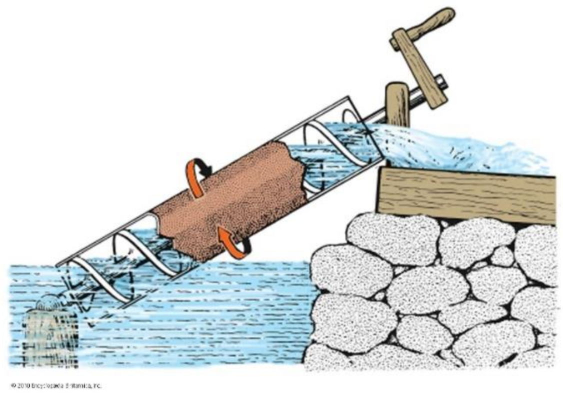


Figure 2. Archimedes Screw Adapted from- Encyclopædia Britannica, inc. (n.d.). *Archimedes Screw*. Encyclopædia Britannica. Retrieved from https://www.britannica.com/technology/Archimedes-screw#/media/1/32831/138823

The Roman aqueduct remains one of the best examples of hydraulic expertise in antiquity (Chanson, 2000). Chanson explains that many aqueducts were used, repaired, and maintained for centuries; some, such as the aqueduct of Carthage, are still partly in use today. The Romans were aware of the hydraulic difficulties posed by supercritical water flows, and the technological solutions they imposed were basic but adequate. Roman engineers built several significant spillway systems to redirect flood waters. The oldest known spillway was built around 1300 B.C. in Greece.

Figure 3. The Zaghouan Aqueduct in the city of Carthage Adapted from- History Hit. *The Zaghouan Aqueduct*. History Hit. Retrieved from https://www.historyhit.com/locations/the-zaghouan-aqueduct/

The mathematician and engineer Heron of Alexandria used hydraulics to invent the first rotating steam engine in the first century AD, known as Aeolipile. First described in his thesis Pneumatica, is deemed a predecessor of the Industrial Revolution's steam engines (Zeleny, 2011). Zeleny (2011) describes that the aeolipile was fixed on a cauldron with tubes leading into a hollow disk with a pair of tubes that allowed steam to escape, triggering a rotational motion. When the flame at the tail end increases, the disk spins more rapidly. Heron would later write a follow-up book, Hydraulica, on the flow of water. Hero's hydraulic engines first ran with the power of water wheels, which were common at the time, but his team would soon invent spinning turbine blades that operated inside water pipes.

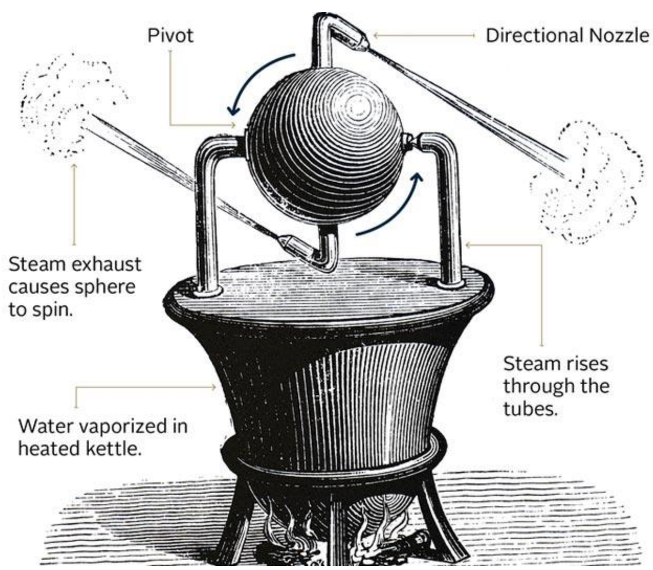


Figure 4. Heron's Aeolipile Steam Engine Adapted from- *Why Heron's aeolipile is one of history's greatest forgotten machines*. Scientia73. (n.d.). Retrieved, from https://www.scientia73.com/why-herons-aeolipile-is-one-of-historys-greatest-forgotten-machines/

The Shushtar region encompasses one of the most ancient collections of multi-purpose hydraulic structures in Iran as well as the world (Torfi et al., 2020). The ancient Persians completed the Shushtar Historical Hydraulic System in the 300s. This system was a massive engineering development and provided a variety of functions, including water supply, irrigation, mills, river transportation, and a defensive system (Royce, 2019). The structures have been

established on the Karun River between Ahwaz and Gotvand, including weir bridges, surface canals, and groundwater conveyance constructs.

Figure 5. Shushtar Historical Hydraulic System Adapted from- Atlas Obscura. - *Shushtar Historical Hydraulic System*. Atlas Obscura. Retrieved from https://www.atlasobscura.com/places/shushtar-historical-hydraulic-system

Rouse (1983) studied the Italian intellect Leonardo da Vinci (1452–1519), who first emphasized the direct study of nature in its many qualities. Leonardo's hydraulic observations expanded to the detailed characteristics of jets, waves, and eddies, even the flight of birds, and similar aspects of basically every other field of knowledge. In particular, it was Leonardo who first correctly formulated the basic principle of hydraulics known as continuity: the velocity of flow varies inversely with the cross-sectional area of a stream (Rouse, 1983).

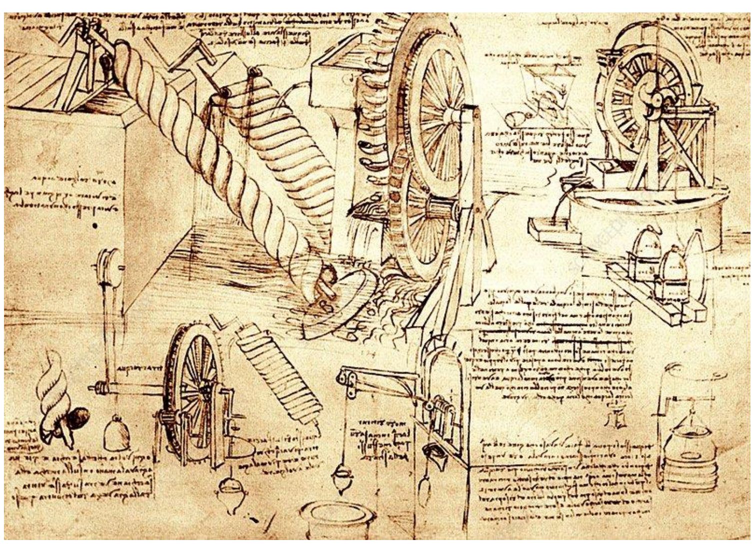


Figure 6 Leonardo Da Vinci's water lifting devices Adapted from- *Leonardo da Vinci's water lifting devices - stock image - C037/7097*. Science Photo Library. (n.d.). Retrieved from https://www.sciencephoto.com/media/892725/view/leonardo-da-vinci-s-water-lifting-devices

Blaise Pascal was an influential French mathematician, physicist, and philosopher (Schuren, 2010). Pascal's research on the subjects of hydrodynamics and hydrostatics concentrated on the properties of fluids in hydraulic systems. His studies led him to invent the hydraulic press and the syringe. Throughout his experiments, he discovered his famous law in 1647. Pascal's law states that when there is an increase in pressure at any point in a contained fluid, there is an equal increase in all directions of the container regardless of where the pressure is applied. Pascal’s principle means that an incompressible fluid transmits applied pressure (Schuren, 2010).

Daniel Bernoulli was a Swiss physicist and mathematician born from a family of similar backgrounds. His most crucial work considered the basic properties of fluid flow, pressure, density, and velocity and gave the Bernoulli principle (O’Connor, 1998). Bernoulli’s equation is one of the essential theories of fluid mechanics, which set the foundation for solving hydraulic calculations in engineering (Qin, 2017). His principle states that during steady flow, the energy at any point in a conduit is the sum of the velocity head (v), pressure head (P), and elevation head (z), which derives the equation for the conservation of energy (Evans, 2012).

Joseph Bramah was an English engineer and inventor during the early years of the Industrial Revolution (Hutchinson, 2018). Using Pascal’s Law, Bramah was the first to patent the hydraulic press in 1795 and is credited for the invention because Pascal did not industrialize his own press. A hydraulic press is a machine using a hydraulic cylinder to generate a compressive force that is used to lift or compress objects (Kumar, 2017). The hydraulic press led to tremendous advancements in the industry and is still widely used today.

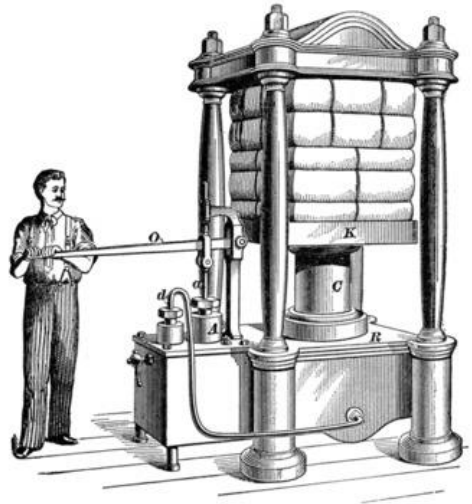


Figure 7. Bramah Press Adapted from- *Hydraulics*. Made up in Britain: Hydraulics: Joseph Bramah 1795. (n.d.). Retrieved November from https://madeupinbritain.uk/Hydraulics

In 1838, William George Armstrong, considered the grandfather of modern hydraulic power, began experimenting with hydraulics and developed a rotary engine (Royce, 2019). Armstrong then found what came to be known as the Armstrong effect, generating an electric charge from the escaped high-pressure steam of a boiler. In 1846 he designed a crane powered by hydraulics that used a reciprocating ram. Armstrong transformed an existing crane to use a city's water resource as a supply of power. Dependent on an external power supply, they were most economical in groups, so dock and harbor work was an ideal application of hydraulic power (Tomlinson, 1997). After the crane’s success, he started a business using this procedure and began manufacturing cranes with this approach. Royce (2019) notes that Armstrong also engineered the hydraulic accumulator, which achieved several goals; it bypassed the need for reservoirs, allowing for much higher pressures, and created a system for hydraulic power to move between widely spaced hydraulic devices.

Today, you can find hydraulic devices everywhere. Current hydraulic technology offers a wide range of options, including high-performance valves, feedback devices, the magnitude of force applied, and the positional accuracy of equipment (Thite, 2021).

Empirical Studies

Korane (2022) examined that many universities shy away from fluid power because teaching the subject requires large and expensive labs. He goes on to note that fluid power can be viewed as a design discipline. Sadly, design courses have been removed from the curriculum of many schools or transferred to electives and special or senior-level projects. However, academic and industry leaders agree that we need flexibility and hands-on experience to teach fluid power (Korane, 2022). The difficulties with current trainers are that they take up a great deal of space, they are costly, safety can be a problem, and the majority of student experiences are not that good. Most trainers don’t give the experience of the newest technology, and they’re not flexible enough to include a broad range of experiences. Industrial trainers have a tendency to be efficiently built and are helpful for simple circuits and troubleshooting, but once again offer limited flexibility and are not very user-friendly.

Assaf and Vacca’s (2021) team devoted numerous days to creating a next-level trainer that conquers many of the current limitations. Operators can explore more than 50 lab experiences, including basic to advanced hydraulic concepts—the project demonstrated to be a success with students. However, the trainers are accessible to only a few users, and the price and space are still problems. His team also developed an E-learning software program that attempts to simulate hydraulic systems, but students don’t receive the hands-on experience needed in industry.

Hamid (2009) reviewed a study conducted by the Faculty of Engineering that showed the need for additional training of students in the field of hydraulics. He explains that expertise and knowledge of hydraulic systems and their mechanisms make students more qualified to identify and analyze the performance of such systems in industrial applications. The agricultural

engineering department received substantial responses from Industrial companies that indicated the department's graduates needed better training in hydraulics and pneumatics (Hamid, 2009).

Collogo (2022) discusses that teaching fluid power is most efficient with hands-on applications and real-life projects. Enhancing undergraduates' knowledge of fluid power systems includes interacting with individual components and systems in their operation. Though, this functional and broadly applied method is limited in implementation because of budgets, the number of participants, and spatial availability. The major downfall is the need for sizable and high-priced equipment also the considerable infrastructure needed for such conventional laboratory classrooms. One of the most valuable methods for teaching about the components is the teardown and reassembly of fluid power circuits.

Lovrec (2019) studied education in the field of Fluid Power technology. The main challenges he discovered dealt with equipment, placement, as well as adequate power for hydraulic trainers, which allows trainees to gain knowledge under real operating conditions. The reality is practical, experimenting equipment is expensive, heavy, and oversized, and a majority requires a fixed arrangement. As these pieces of equipment are usually larger, it is not sensible to re-install, rebuild and check operation before each and every lab experiment. Lovrec reviewed many surveys with engineering students that revealed criticisms of a difficult, boring, and old-fashioned study approach accompanied by poor teaching, often due to the lack of lab equipment.

Advantages of this design

- Less expensive than hydraulic trainers on the market
- Less spatial requirement of the trainer
- Hands-on experience for students
- User-friendly
- Engages students in an active learning approach
- Promotes troubleshooting skills
- Quickly mount/dismount
- Manipulate components to create multiple power circuits from simple to complex
- Component specifications are industry standard
- Interfaces easily with PLC and relay control

Chapter Three: Methodology

Design- D03 Pattern Directional Control Valves

The sub- and mount plate assembly designed for the student training system uses both manually actuated, and solenoid actuated directional control valves. Port O-rings are included with all the valves purchased. The first objective is to design the valve sub-plate and quick mount parts for the hydraulic student training system and model potentially used directional control valves in Solidworks CAD software.

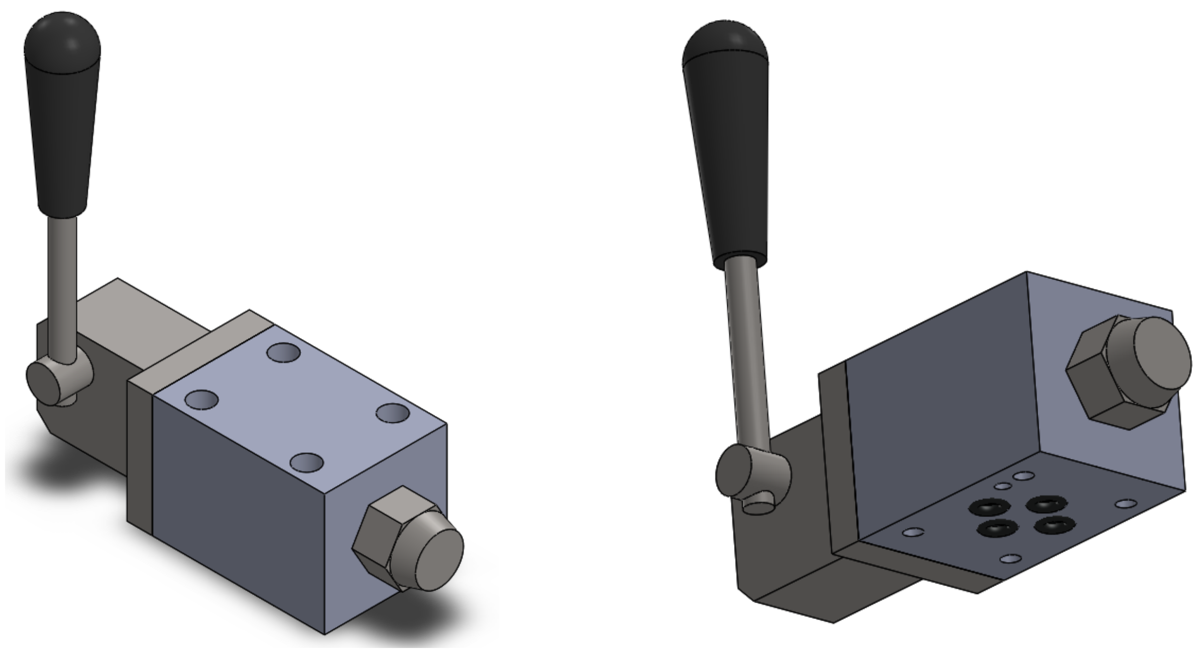


Figure 8. Manual Four-Way Directional Control valve (a) top view (b) bottom view

The manual four-way directional control is lever operated and has three lever positions left, right, and center. The center position of the lever blocks/disconnects port P (pressurized oil) from ports A (actuator) and B (actuator) so that no oil goes through the system and work is not

done. The left position of the lever moves the internal tandem spool and aligns port P with port A, the oil flows through port A and performs work on the hydraulic system then the oil drains back through port B which is aligned with port T (tank). The right position of the lever moves the internal tandem spool and aligns port P with port B, the oil flows through port B and performs work on the hydraulic system then the oil drains back through port A which is aligned with port T (tank).

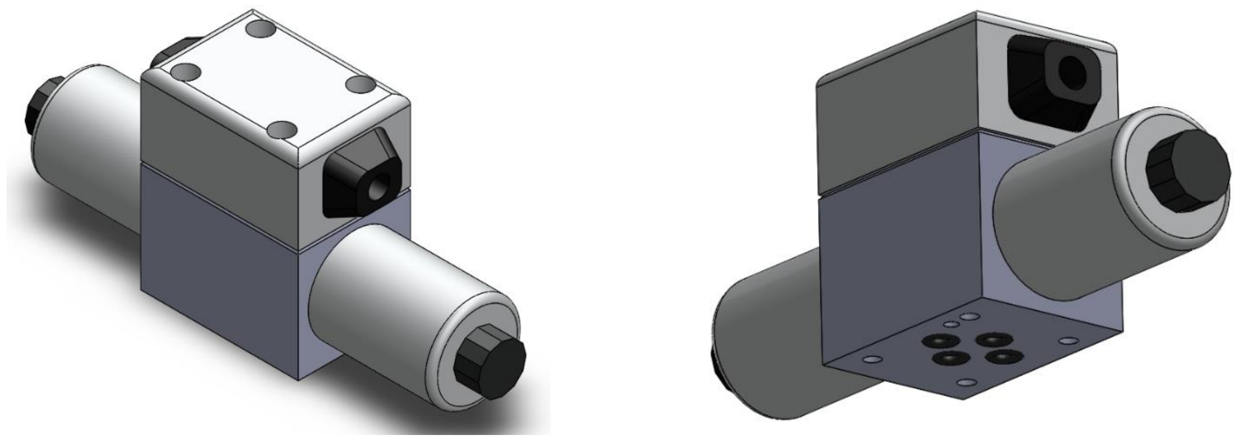


Figure 9. Solenoid Four-Way Directional Control valve (a) top view (b) bottom view

The solenoid four-way directional control valve is electrically operated and converts electrical energy to linear mechanical energy. Solenoids consist of a coil, armature, and push pin. When the solenoid coil is energized it generates an electric field, the field pulls the armature toward the push pin and the push pin moves the spool allowing flow from the pump to an actuator port.

All hydraulic directional control valves use the standard D03 ports. This way, the valves can share the same sub-plates and quick mounts, and, thus, a decrease in the number of sub-plates and quick mounts that need to be machined. Figure 10 shows the dimensions of the standard D03 port pattern. The face of the sub-plate for mounting a valve must be flat within 0.0004 inch/4.0 inches with a surface finish of 32 micro-inches. The mounting surface needs a minimum flush or raised surface to ensure good sealing and no oil leakage during the operation of the hydraulic power system.

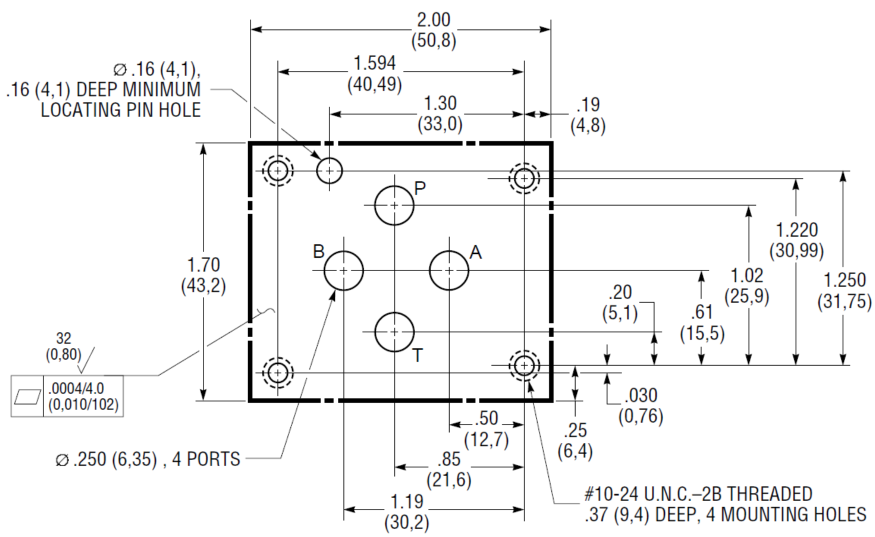


Figure 10. Dimensions of the standard D03 port pattern

In the above figure, P means a pressured oil or pump, T represents tank, and A and B are the ports connected with hydraulic actuators, such as cylinders or motors.

<u>Design of sub-plate and quick mounting plate</u>

The hydraulic directional control valves purchased are bare devices without any connectors to link with other hydraulic components. The hydraulic components being developed are for student training. The highly desired feature for the hydraulic sub- and mount plate assembly is to enable students to easily manipulate hydraulic devices and quickly design their own circuits, from simple to complex. In order to have such a feature, all the valves and other components, hoses and electrical wires should be able to be quickly connected and disconnected. In addition, all the hydraulic components should be able to be quickly mounted and dismounted. As a result, sub-plates with push-connect coupling and quick mounting plates have to be developed. Another consideration for the sub- and mounting plates is that they should be able to be machined by using CNC machines. The sub-plate's functionality will be further analyzed below to meet the conditions of the second objective.

Figure 11 is the finalized sub-plate design. On the top surface, there are holes in the center area to interface with the standard D03 ports on hydraulic valves; there are four 1/4-npt screw holes along the edges, which will be further connected with hydraulic push-connect couplings. On the bottom surface, there are four 10-24 screw holes, which will be used to fasten it to a quick mounting plate.

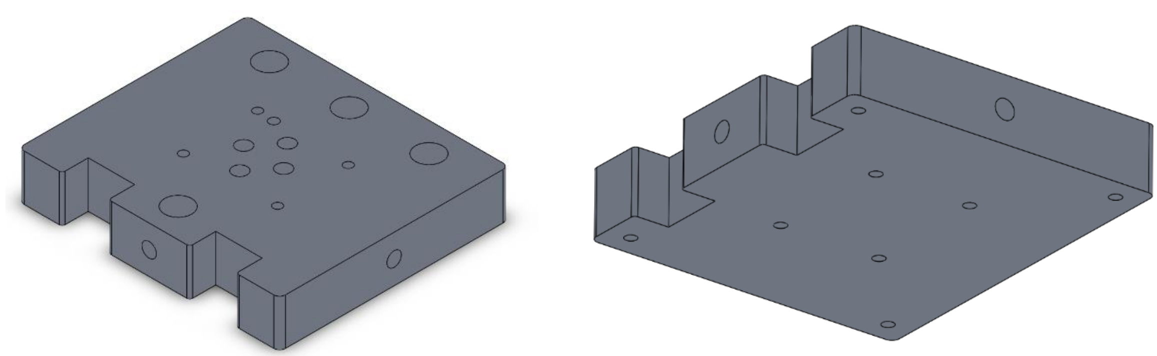


Figure 11. Hydraulic sub-plate (a) top view and (b) bottom view.

Figure 12 shows the internal changes of a hydraulic sub-plate. The channels are used to connect a valve's standard D03 ports with the hydraulic push-connect couplings. All the channels end at the side surfaces because they are made by drilling. They will be blocked by using steel balls.

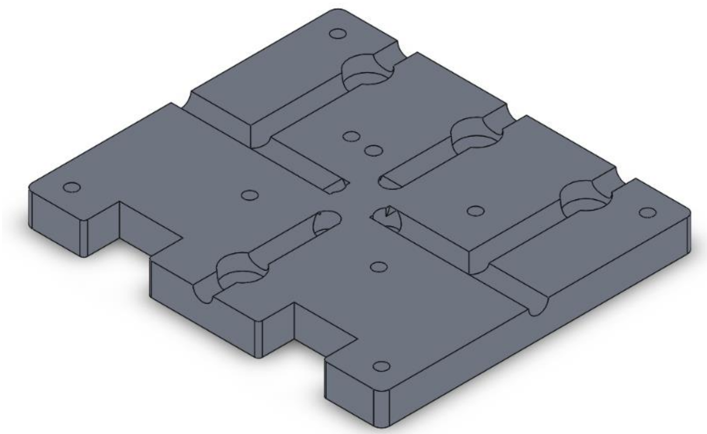


Figure 12. Internal channels of a hydraulic sub-plate.

Figure 13 shows the quick mounting plate design. On the top surface, the two rectangular holes are used to house the quick clip mechanism. On the bottom surface, the two tracks are used to place the plate on the T-slot frame. The two tracks are used in order to increase the clipping strength because the hydraulic valves are heavy and need high holding force. Other components for the quick clip mechanism have been designed and finalized in the development of pneumatic power systems and will be used here as well.

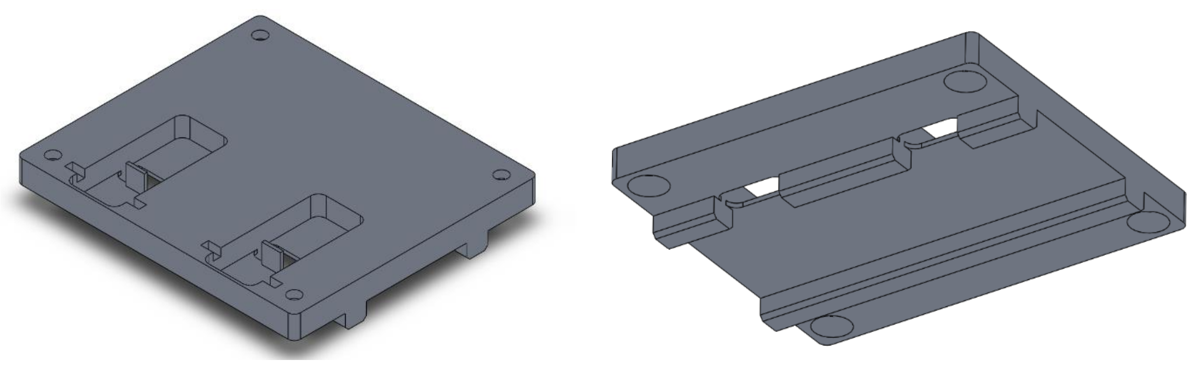


Figure 13. Quick Mounting plate (a) top view and (b) bottom view.

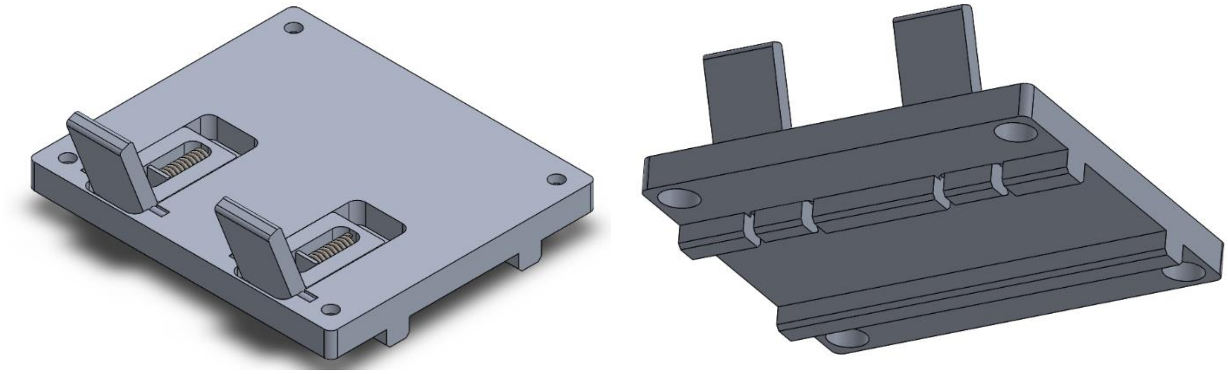


Figure 14. Quick-mounting plate with the quick clip mechanism (a) top view (b) bottom view

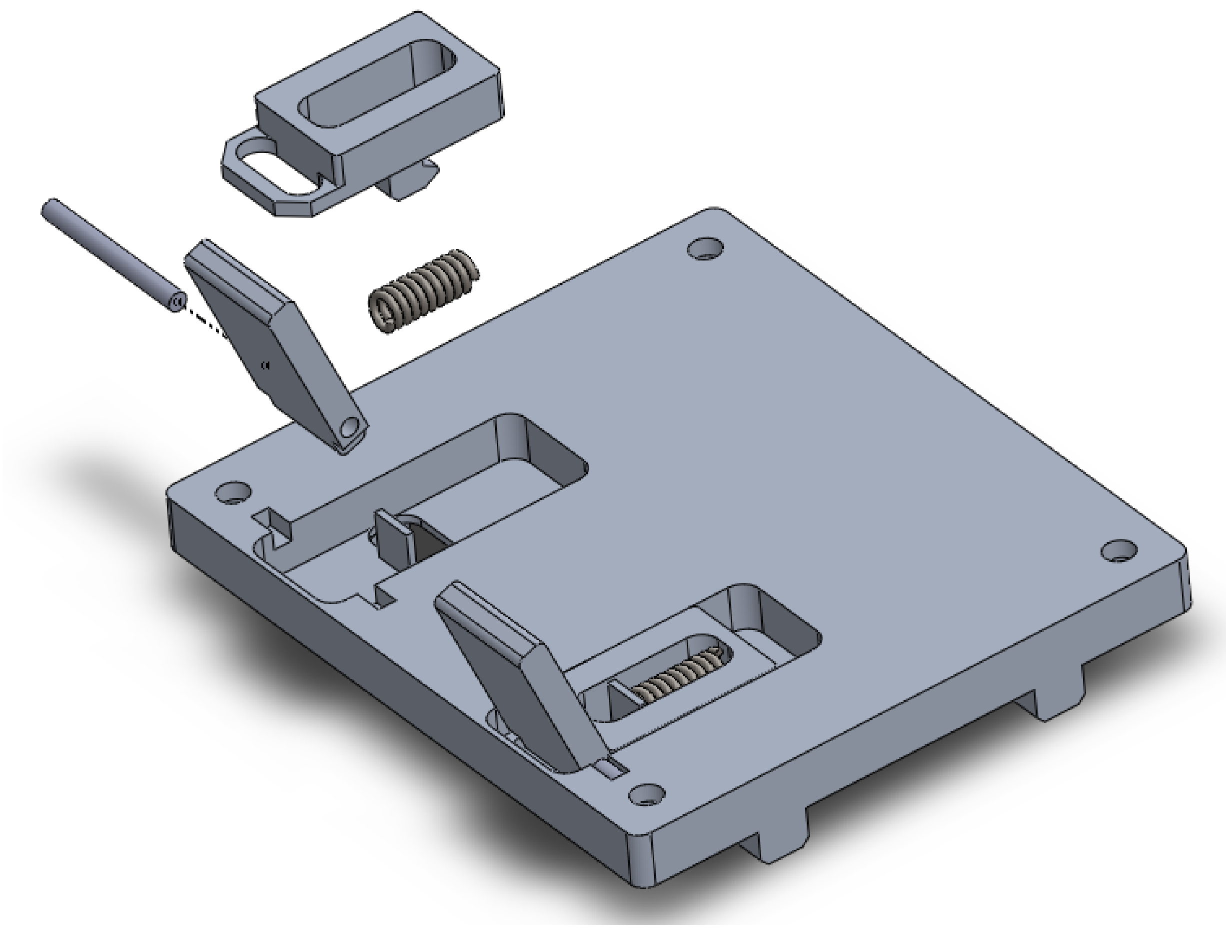


Figure 15. Exploded view of the quick clip mechanism

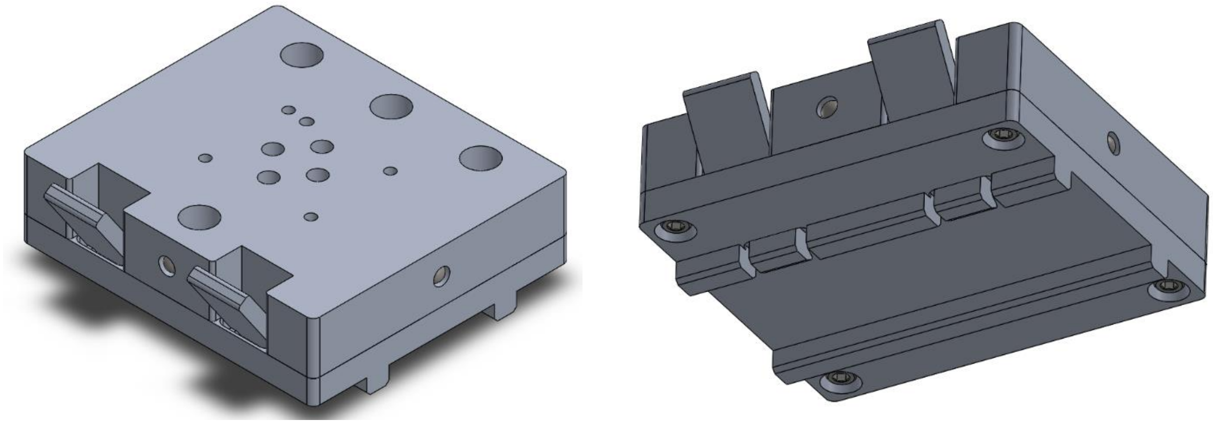


Figure 16. Assembly of sub-plate and quick mount plate (a) top view (b) bottom view

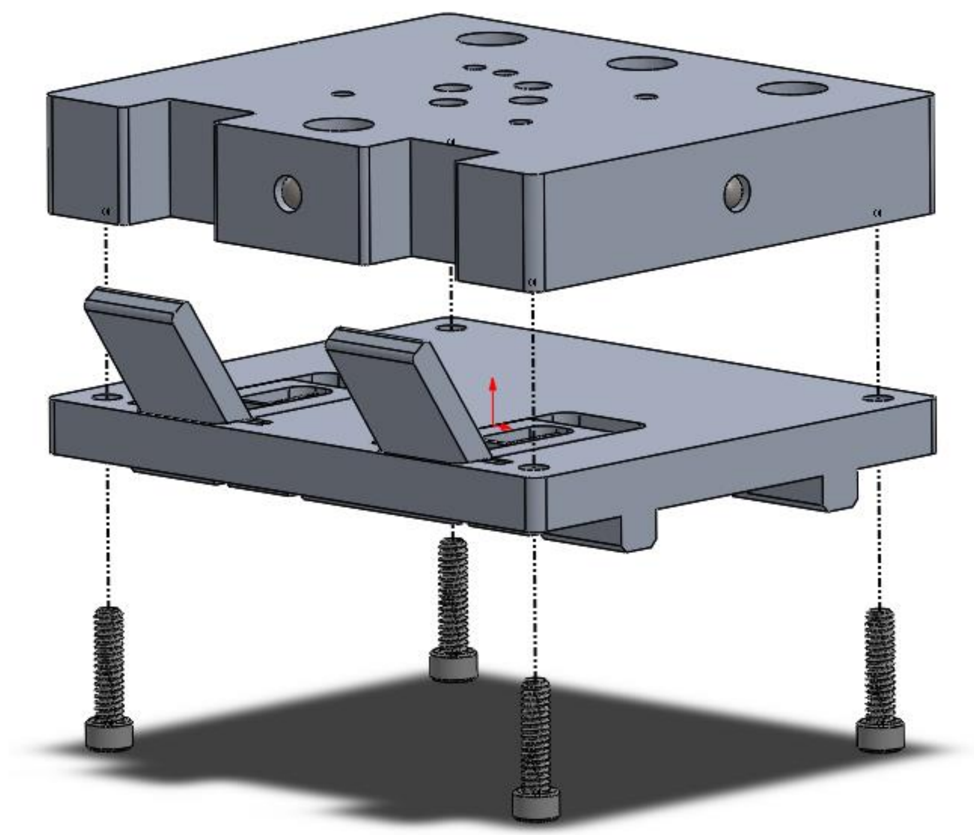


Figure 17. Shows how the sub-plate and mounting plate are fastened together.

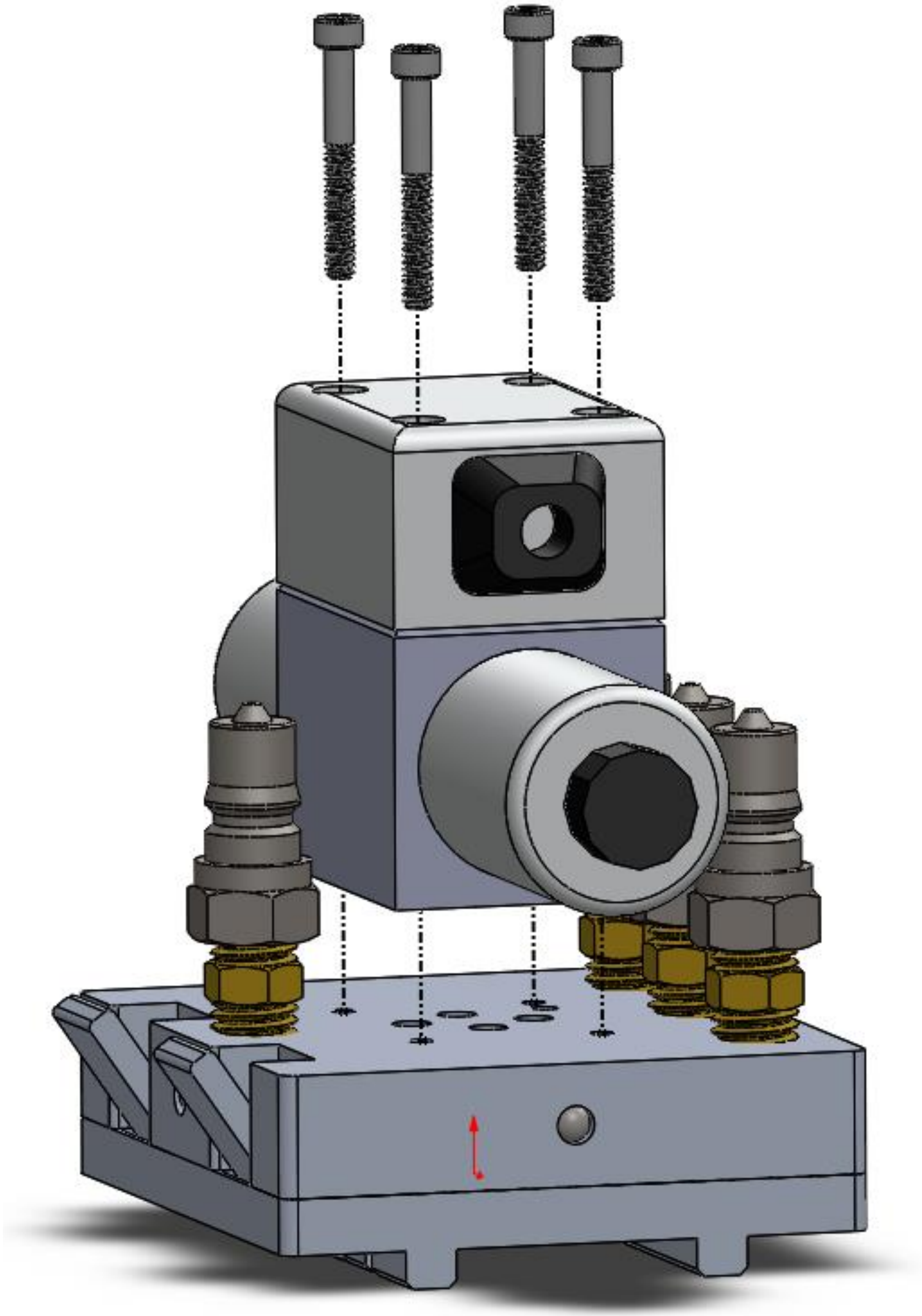


Figure 18. shows how a hydraulic valve is placed on the sub- and mounting plate assembly.

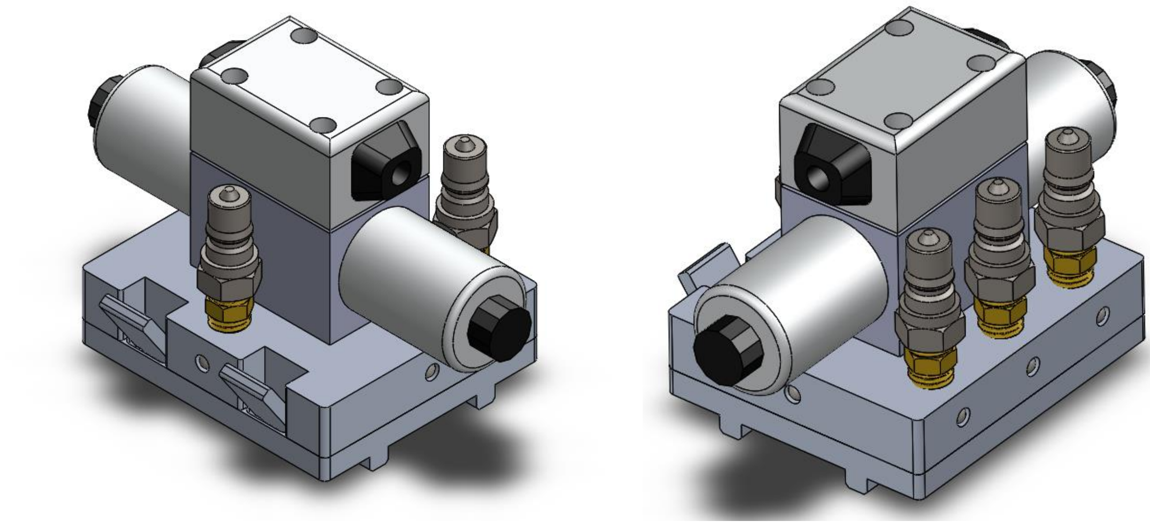


Figure 19. Shows a solenoid directional valve placed on the sub- and mounting plate assembly.

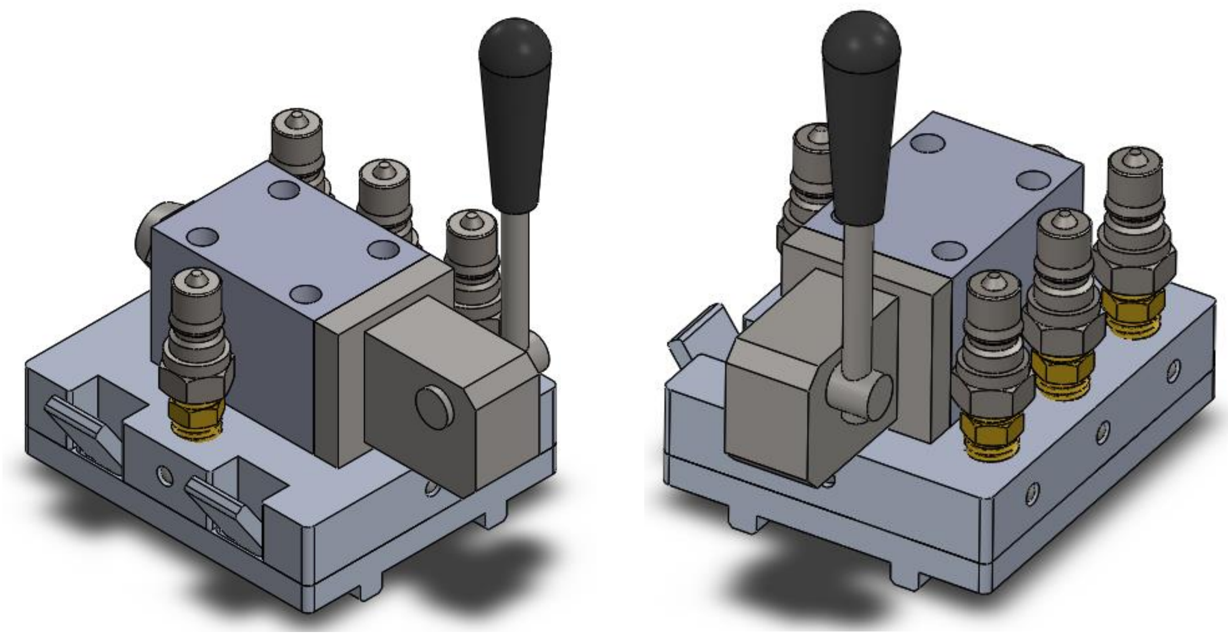


Figure 20. Shows a manual directional valve placed on the sub- and mounting plate assembly.

Chapter Four: CNC Machining and G-code

CNC Machining of the sub-plate

To complete the third objective of evaluating the manufacturability of the design, a virtual mini-HAAS mill is used to machine the parts by simulating CNC machine cutting operations. In order to increase the machining efficiency, a small number of tools are selected to minimize the time of tool change. The following table is the tool crib for developing the g-codes.

Select Tool Crib ConnorToolCrib ▾ Total stations 12 Define mill tools using tool ass

Id	Stn. No.	Sub. No.	Stati...	Comb I D	Tool Type	Tool I D	Diameter
57	1	0		"N.A."	Flat End Mill	68	1
58	2	0		"N.A."	Center Drill	6	1
59	3	0		"N.A."	Drill	57	1
60	4	0		"N.A."	Tap-Cutting	8	1
61	5	0		"N.A."	Drill	87	1
62	6	0		"N.A."	Drill	153	1
63	7	0		"N.A."	Tap-Cutting	141	1
64	8	0		"N.A."	Flat End Mill	46	1
65	9	0		"N.A."	Counter Sink	2	1

Figure 21. Tool Crib

The part bounding box vertexes are used to define the fixture coordinate system. In convention, the upper top right vertex is defined as zeros, as shown in the following figure.

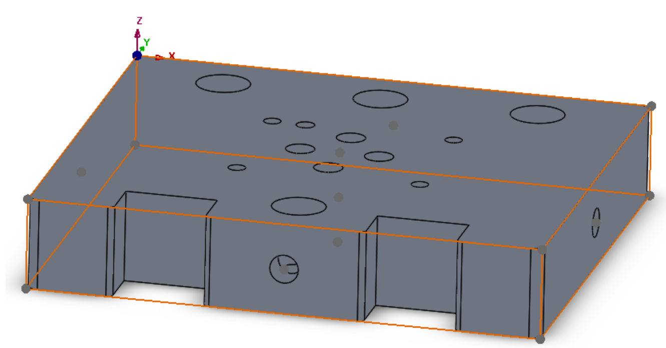


Figure 22. Part Bounding Box

The standard rectangular aluminum bar, 4” x 1” 6061-T6511, is used for machining the part. The stock size is 4” x 1” x 4.7”. Figure 23 shows the management of the stock. The 0.175” thick material is left at the bottom for the vise to hold the stock.

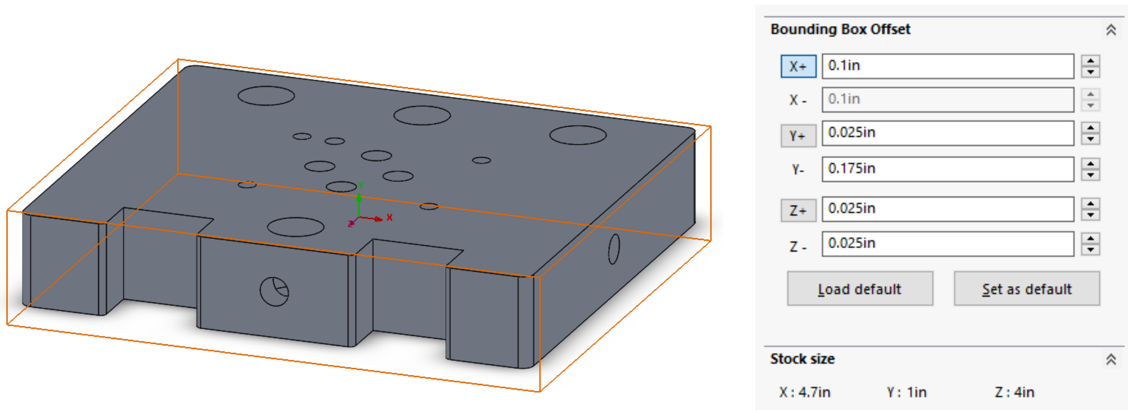


Figure 23. Stock Block Model and Offset parameters

1. Machine the top surface

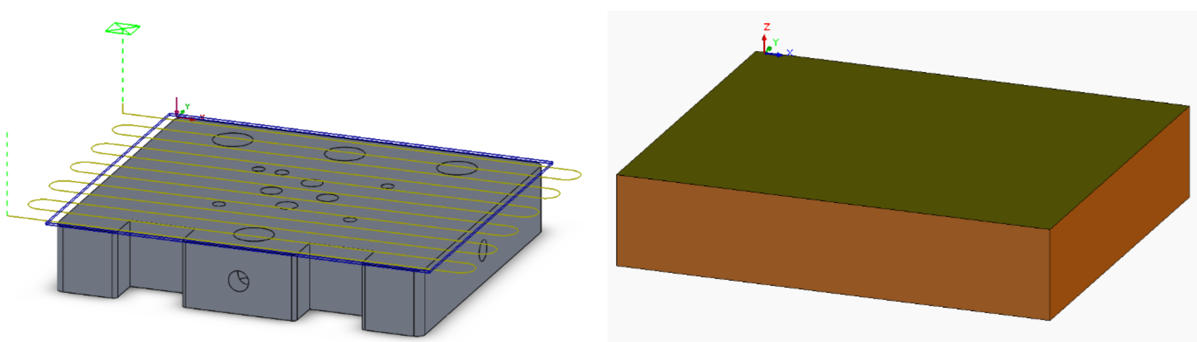


Figure 24. Facing top surface (a) tool path (b) machined result

2. Machine the side walls

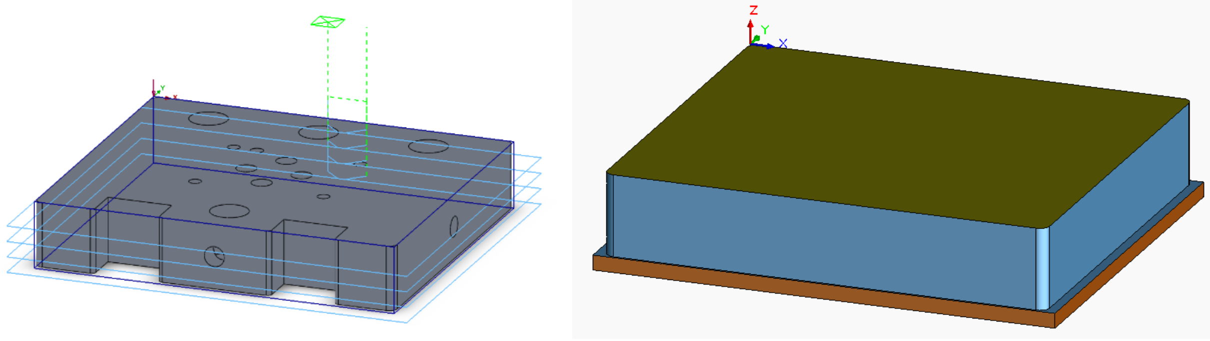


Figure 25. Machining side walls (a) tool path (b) machined result

3. Drill and tap the four 10-24 screw holes

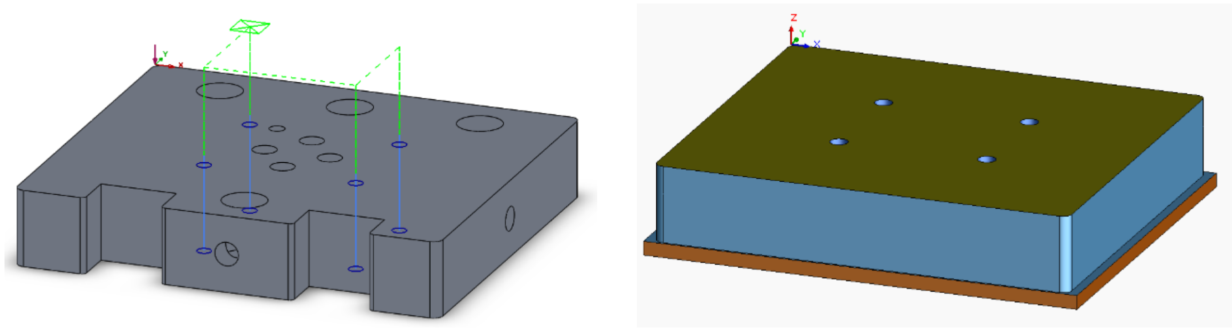


Figure 26. Drilling 10-24 holes (a) tool path (b) machined result

4. Drill and tap the ¼-npt screw holes for hydraulic fitting and push-connect coupling

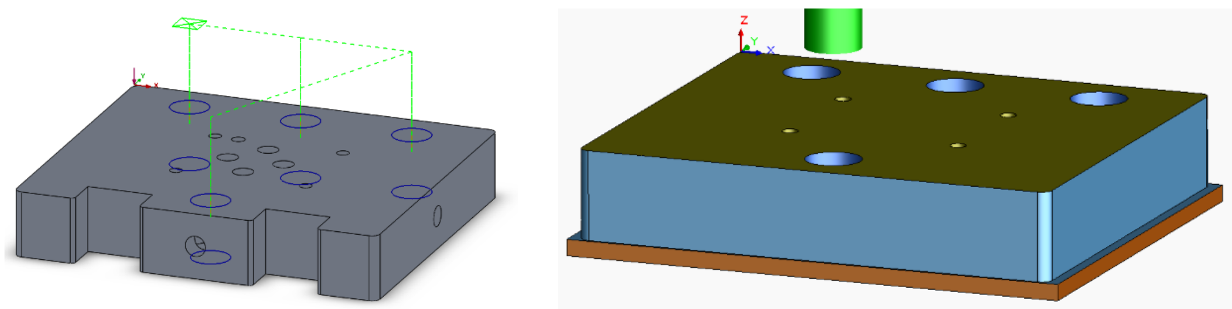


Figure 27. Drilling and tapping 1/4 – npt holes (a) tool path (b) machined result

5. Drill the pin hole

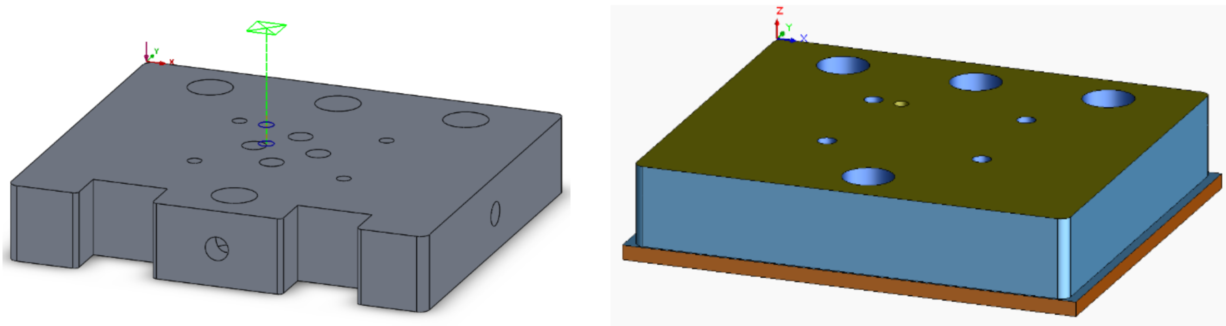


Figure 28. Drilling pin hole (a) tool path (b) machined result

6. Drill four standard D03 port holes

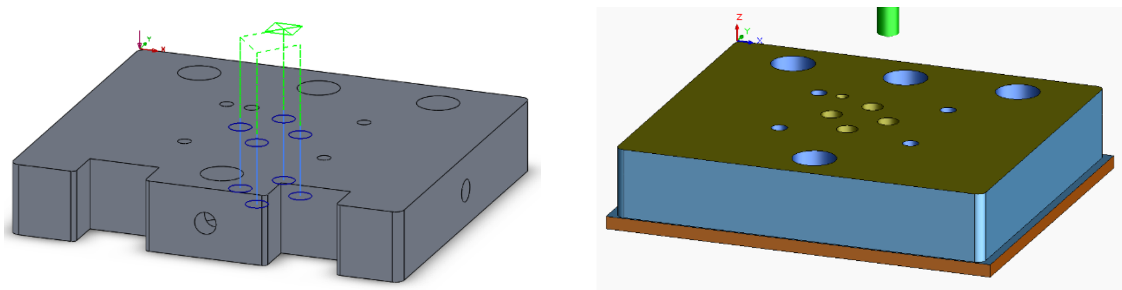


Figure 29. Drill D03 port holes (a) tool path (b) machined result

In figure 29b the orange material left at the bottom is the material being used by the vice to hold the part. Now we must flip the part over and resecure in the vice to machine the bottom surface.

7. Machine bottom surface

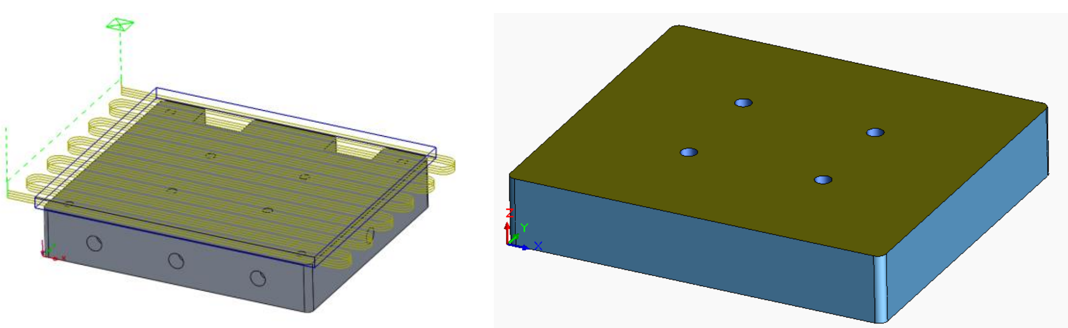


Figure 30. Machining Bottom surface (a) tool path (b) machined result

8. Machine two slots for the quick clip mechanism

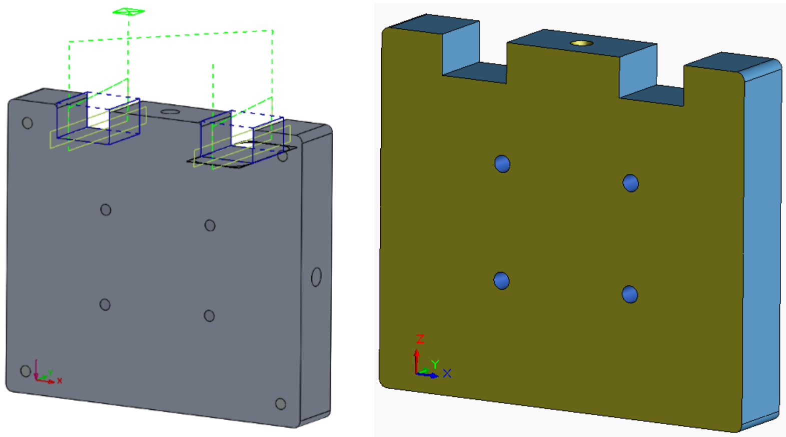


Figure 31. Machining two slots

CNC Machining of quick-mount plate

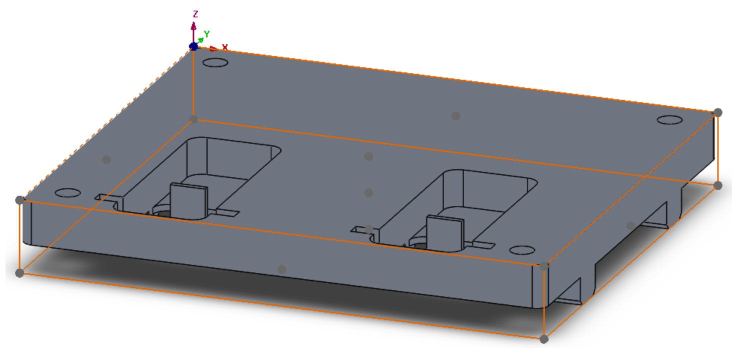


Figure 32. Quick-Mount Plate Bounding Box

The standard rectangular aluminum bar, 4” x 0.75” 6061-T6511, is used for machining the part. The stock size is 4” x 0.75” x 4.7”. Figure x shows the management of the stock. The 0.105” thick material is left at the bottom for the vise to hold the stock.

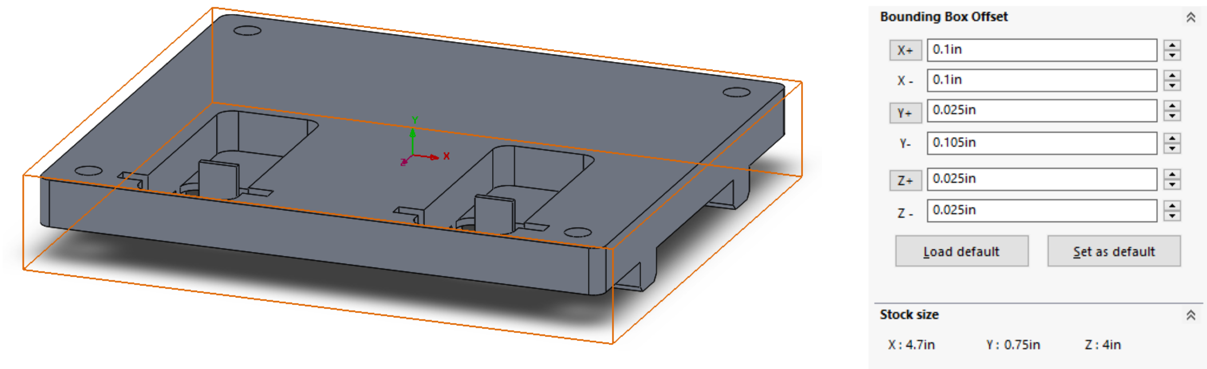


Figure 33. Quick-Mount Stock Model and Offset

1. Machine the top surface

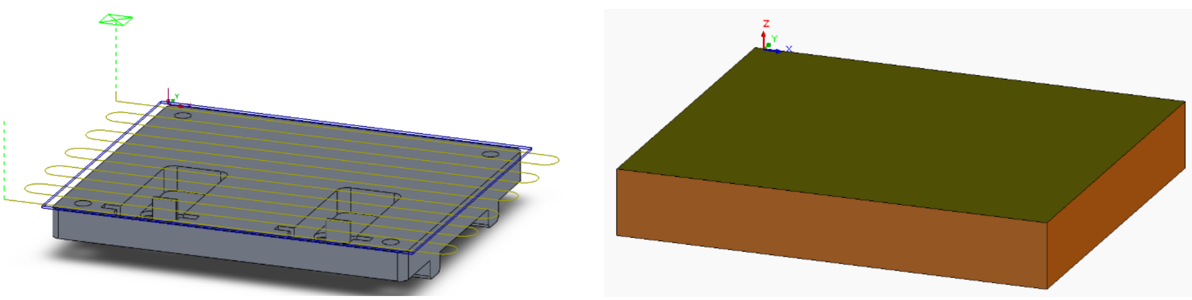


Figure 34. Quick mount facing top surface (a) Tool path (b) Machined result

2. Machine clip body slots

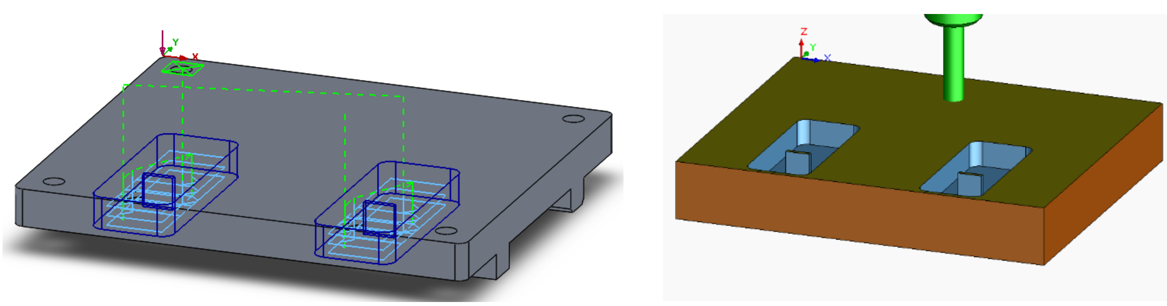


Figure 35. Machining clip body slots (a) Tool path (b) Machined result

3. Machine mounting holes

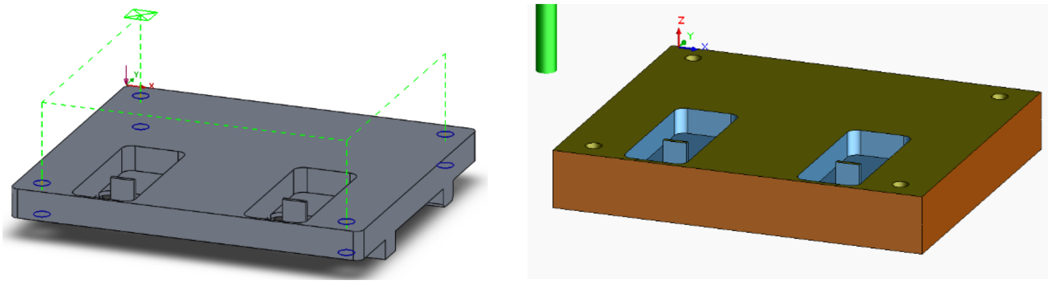


Figure 36. Machining mount holes for mount plate (a) Tool path (b) Machined result

4. Machine bottom slots for clip to go through

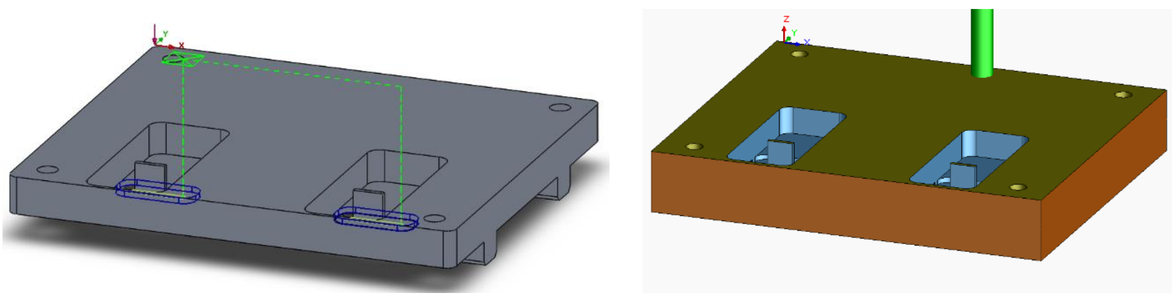


Figure 37. Machining bottom slots for clips (a) Tool path (b) Machined result

5. Machine sidewalls

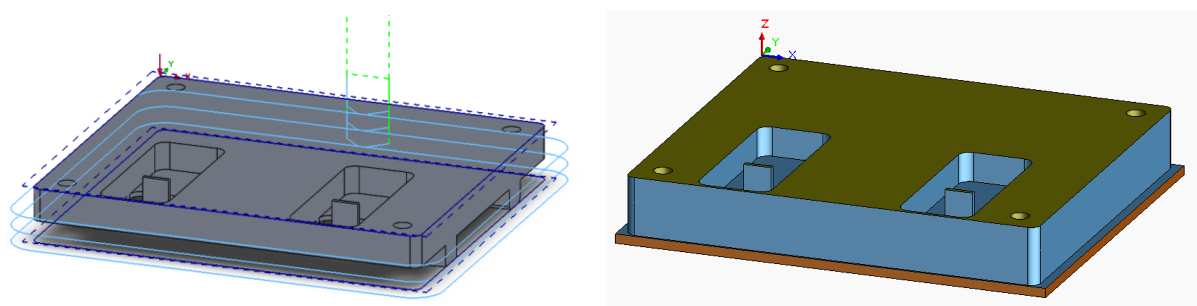


Figure 38. Machining sidewalls (a) Tool path (b) Machined result

6. Machine bottom surface

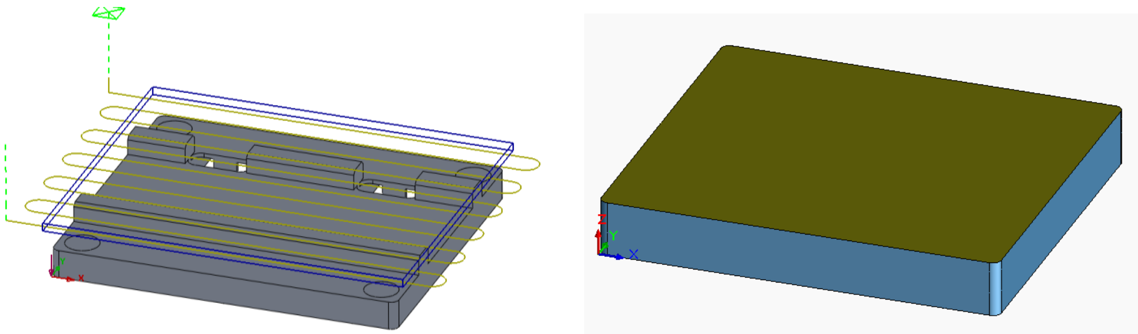


Figure 39. Machining bottom of quick mount plate (a) Tool path (b) Machined result

7. Machine the tracks

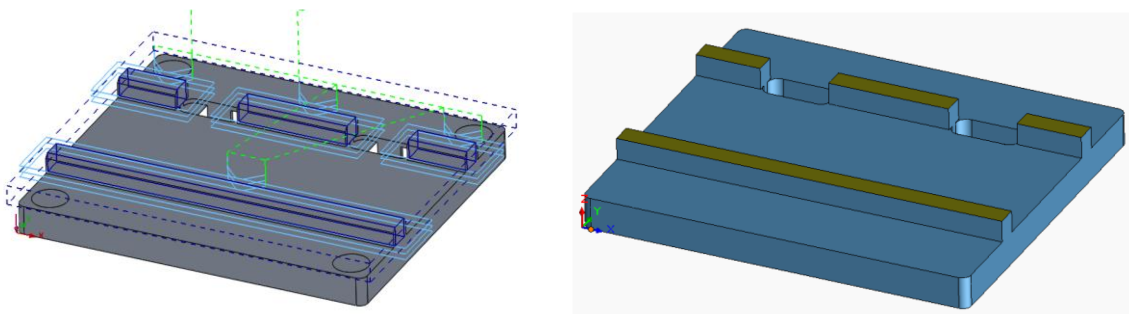


Figure 40. Machining the bottom tracks (a) Tool path (b) Machined result

8. Chamfer the tracks

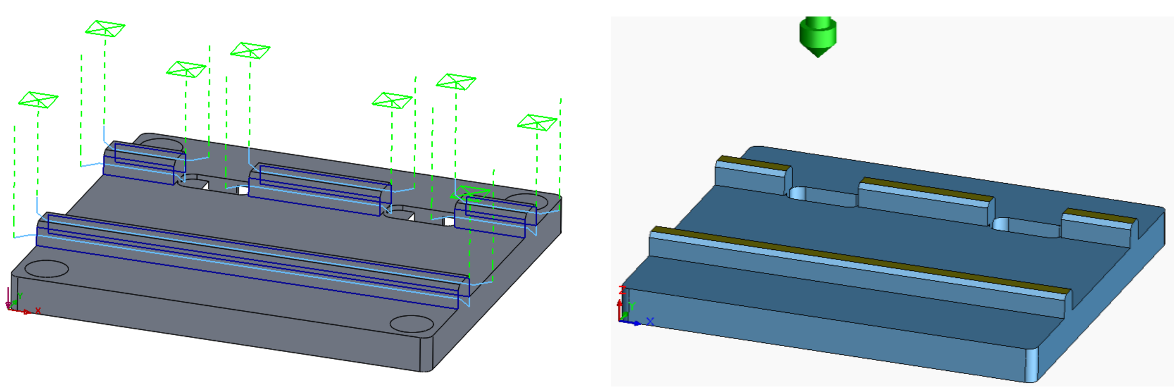


Figure 41. Chamfering the tracks (a) Tool path (b) Machined result

The following are what the parts look like after the plate is machined.

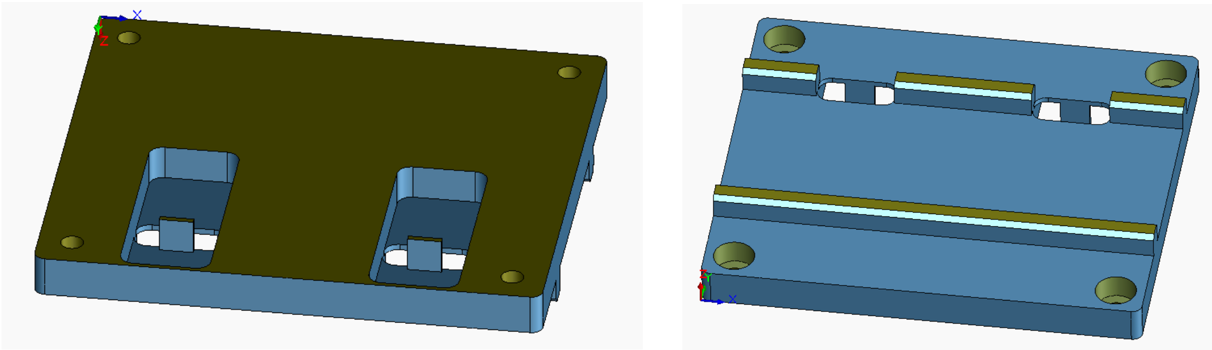


Figure 42. Machined quick mount plate

Machining Experience

I had the pleasure of working with Dr. Xu on CNC machining parts for a pneumatic power training system. Unfortunately, due to time conflicts and Dr. Xu's busy schedule, we did not finish machining the hydraulic trainer parts.

Figure 43. CNC cutting session

Figure 43 shows a cutting session I ran for a pneumatic part.

Figure 44. Removing a finished part from CNC

Figure 45. Haas Mini Mill Control Panel

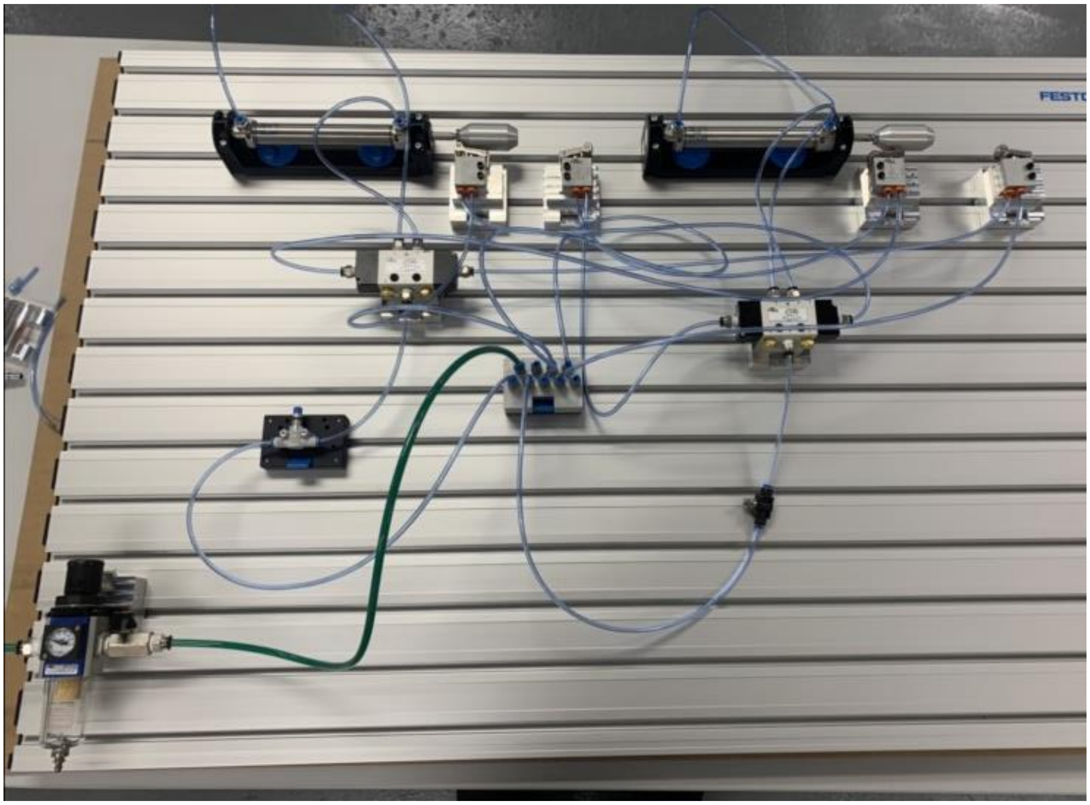


Figure 46. Pneumatic Training System - Simple power circuit

Pictured above is a simple pneumatic power circuit containing two double-action pistons. The hydraulic student trainer will look very similar to the pneumatic version but will utilize the power of pressurized hydraulic fluid and include a manual or solenoid directional control valve fastened to the designed hydraulic valve subplate. The same component rack will be used as well.

CNC Machining Advantages

Through research and hands-on experience with the CNC machine, I have found the lists below to be the major benefits and pitfalls of CNC machining.

1. Precision

The most substantial advantage of using a CNC machine compared with manual machining processes is precision. CNC mills use computer instructions for fabricating parts, eradicating the human error present with conventional milling. The operator is responsible for the accuracy of the CNC mill by controlling the operating conditions and cutting tool calibration. Lastly, operators must recognize when cutting tools become dull or damaged and must be replaced.

2. Stamina

CNC machines do not get tired! Manual machining processes can only continue while skilled operators are present to run the machines. Manufacturing stops when the operators leave. However, operating a CNC machine requires less human intervention, and once a program starts, the machine carries out the rest of the cutting process from start to finish. In many cases, the operator can program the machine's computer and set it to create the required part as often as needed. Unlike manual mills that require extensive setup and, in many instances, are used for the same cutting operation in a process, CNC mills have tremendous flexibility in cutting many different parts with minimal setup changes.

3. Production

Once the operator has programmed the machine with the necessary design specifications, production can start. Once the CNC machine has started a production run, there are no limitations to the number of parts you can manufacture, allowing companies to use their resources and finances more efficiently (3ERP, 2022).

4. Pace

Another valuable advantage of CNC machining is the higher speed it presents. When using CNC machines, machinists can be much more efficient because the machines can use their fastest parameters and settings. CNC machines can run continuously without taking a break which an operator of a manual mill may need. When manually milling, the machinist must often manually operate the machine and change tooling based on the cutting operation needed. This can be extraordinarily time-consuming and inefficient (3ERP, 2022).

5. Capabilities

A CNC machine houses a rotational carousel that can hold many cutting tools. These tools can be automatically changed throughout the machining process. CNC milling machines can interface with advanced design software producing complex geometry that a manual machine cannot reproduce. CNC machines are more efficient than any engineer, no matter how skilled or experienced (3ERP, 2022).

6. Raw Materials

CNC machines are compatible with various materials. While you can use a wide range of materials in a CNC machine, the most commonly employed materials used are metals, plastics, wood, and foam (Custom Components, 2022). Considering material selection for CNC milling, factors such as design tolerance, tensile strength, hardness, wear resistance, and heat tolerance must be considered.

7. Less Human Errors

Since precision turning machines operate autonomously without any manual intervention, they bypass the possibility of human errors seeping into the manufacturing process, leading to defects. With code and software programs governing the end-to-end process, machines can deliver greater accuracy without any flaws (Jacobs, 2021).

8. Repeatability

It doesn't matter how many cutting cycles are performed unless changes are made deliberately to the input code; the final products will be consistent each time.

9. Cutting Simulations

Simulations of the cutting program are possible using CNC machining and milling. This allows manufacturers to check the program's efficacy before it is put into full-time production mode (3ERP, 2022).

10. Lower Costs

The initial investment in a CNC machine may be expensive, but minimizing operational costs will economically benefit the business in the long term. The high output rate, minimal mistakes, and low production costs of CNC machining make it cost-effective (3ERP, 2022)

11. Safety

CNC machines isolate the cutting process from humans and mitigate the risk of danger. Besides the operator entering the code for the machine, the process is autonomous. Human intervention is limited to a supervisory role where they can remotely monitor the execution of the software programs and preventive or reactive maintenance to avoid breakdowns, which minimizes the need to engage and makes the workplace safer (Jacobs, 2021).

12. Low Maintenance

CNC milling machines usually demand minimal levels of maintenance. Generally, the service involves changing the cutting implements at the proper interval and doing light cleaning (Reed, 2022).

13. Flexibility

The CNC software can be reprogrammed quickly and easily to produce different parts, allowing operations to keep up with shifting customer demands (IMH, 2022).

After researching the advantages of CNC machining, it is abundantly clear that precision-turned components produced by CNC machines are far superior to their manual milling counterparts (Jacobs, 2021).

CNC Machining Disadvantages

1. Initial Cost

CNC machines are more costly and involve a more significant initial investment than milling machines that can be operated manually. However, as this technology becomes the standard, supply is increasing, resulting in costs gradually decreasing (IMH, 2022).

2. Skill Loss

Many institutions no longer educate students on how to operate manually operated lathes/milling machines. Students no longer develop the detailed skills required by engineers of the past, including mathematical and engineering skills (McCoy, 2022)

3. Unemployment

Automation reduces the need for a large workforce, and fewer laborers are employed. Now with CNC machines, one operator can supervise multiple machines. That said, the need is now shifting to software and mechanical engineers, and education and training must adjust to meet that need (IMH, 2022).

4. Increased Material Wastage

CNC machining is a subtractive manufacturing process that starts with a fixed raw material and removes the material through cutting. The result is more significant material wastage than produced by additive manufacturing processes like 3D printing (3ERP, 2022).

Chapter 5: Conclusions

Final thoughts

Fluid power has become fundamental knowledge for most engineering students to study, although most colleges don't have the necessary equipment to provide lab training. The valve subplate designed for the hydraulic power trainer successfully solves the problem of students receiving too little fluid power lab training in college. This design provides the needed lab equipment for adequate student lab training. Students can receive hands-on experience and enhance their problem-solving skills, which will better prepare them for their future endeavors in the industry.

The valve subplate design met the specifications of the D03 pattern of directional control valves, allowing an industry-standard manual or solenoid directional control valve to be utilized for lab training. 3-D models of the different control valves, hydraulic push connect fittings, and the valve subplate assembly were effectively created in CAD software. Machining tool paths were simulated as well using the CAM feature of Solidworks.

The quick mount plate design met the specifications of the component rack and can easily clip into the board and not move once hydraulic pressure is added to the circuit. This also provides the customizability of power circuits as components can be easily moved to accommodate the creation of simple and complex circuits.

Developing the g-codes for all the parts of this assembly was a crucial part of the CNC process. Now that the codes have been developed, machining multiple assemblies are as simple as loading a new piece of raw material and rerunning the same codes.

Potential Improvement: PLC and Relay Control Integration

The key to industrial automation is Programmable Logic Controllers (PLC) and relay control. The valve subplate designed in this thesis can easily interface with PLC and relay control. Programmable Logic Controllers are industrial computers that automate and control mechanical systems and processes. Acting as the brain of an operation, PLCs continually monitor input devices and make assessments using pre-programmed logic and parameters by the user to achieve the desired result and control the output devices in a process. Industries integrate PLCs for automation to improve reliability and increase quality.

Many educators are reluctant to introduce PLC-related Courses in the industry because of a lack of teachers, lab equipment, or insufficient funds for this emerging technology (Siddiqi, 2016). Siddiqi (2016) designed and developed a learning module to address a knowledge gap between two courses—one on pneumatics/hydraulics and another on automated control—and employs cost-effective hardware and software tools to provide engaging hands-on experiences for college students.

A control relay is a locally or remotely controlled electromagnetic switch that is widely used in all forms of equipment due to its ability to switch higher currents that would otherwise be impossible without it (Legazpi, 2022). The benefits of relay control include remote control, easily changing contacts, robustness (ability to operate at high temperatures), and the relay is activated with low current and can activate high-powered machines.

Automation is dominating the manufacturing industry. The trainer designed in this thesis can integrate automation with hydraulics, giving students another avenue of knowledge, and more experience, further preparing them for the future.

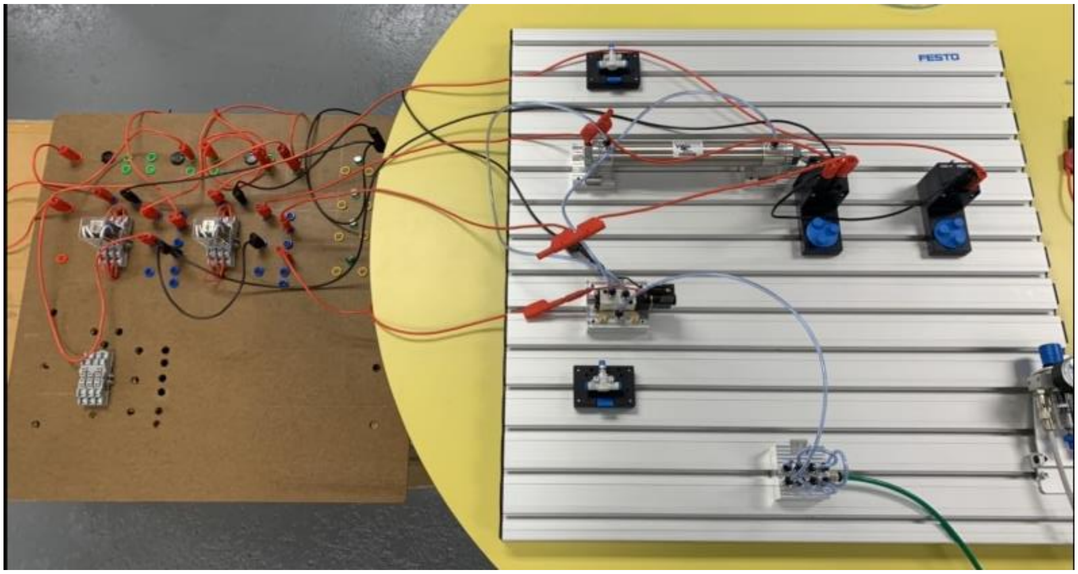
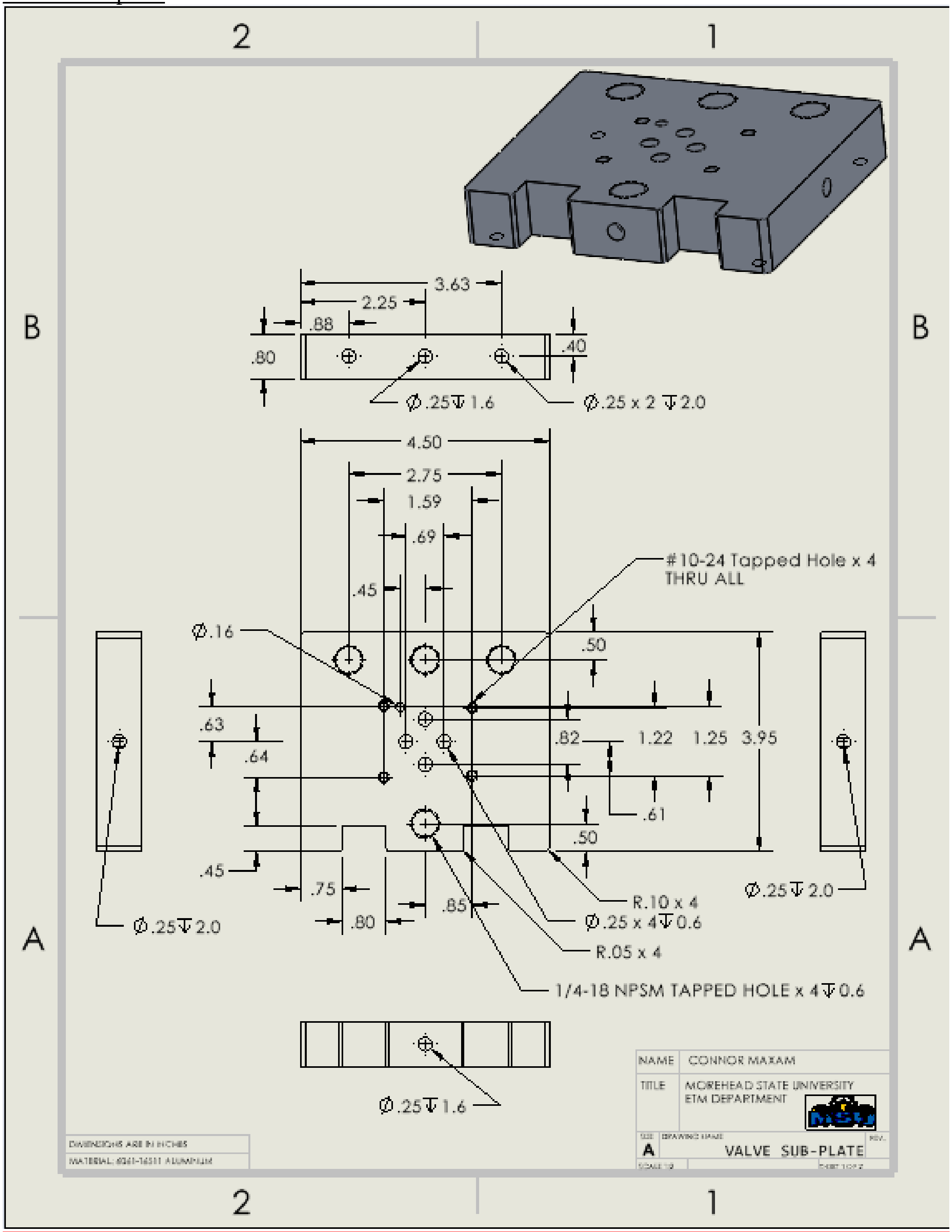


Figure 47. Pneumatic Power Circuit integrated with Relay Control Board

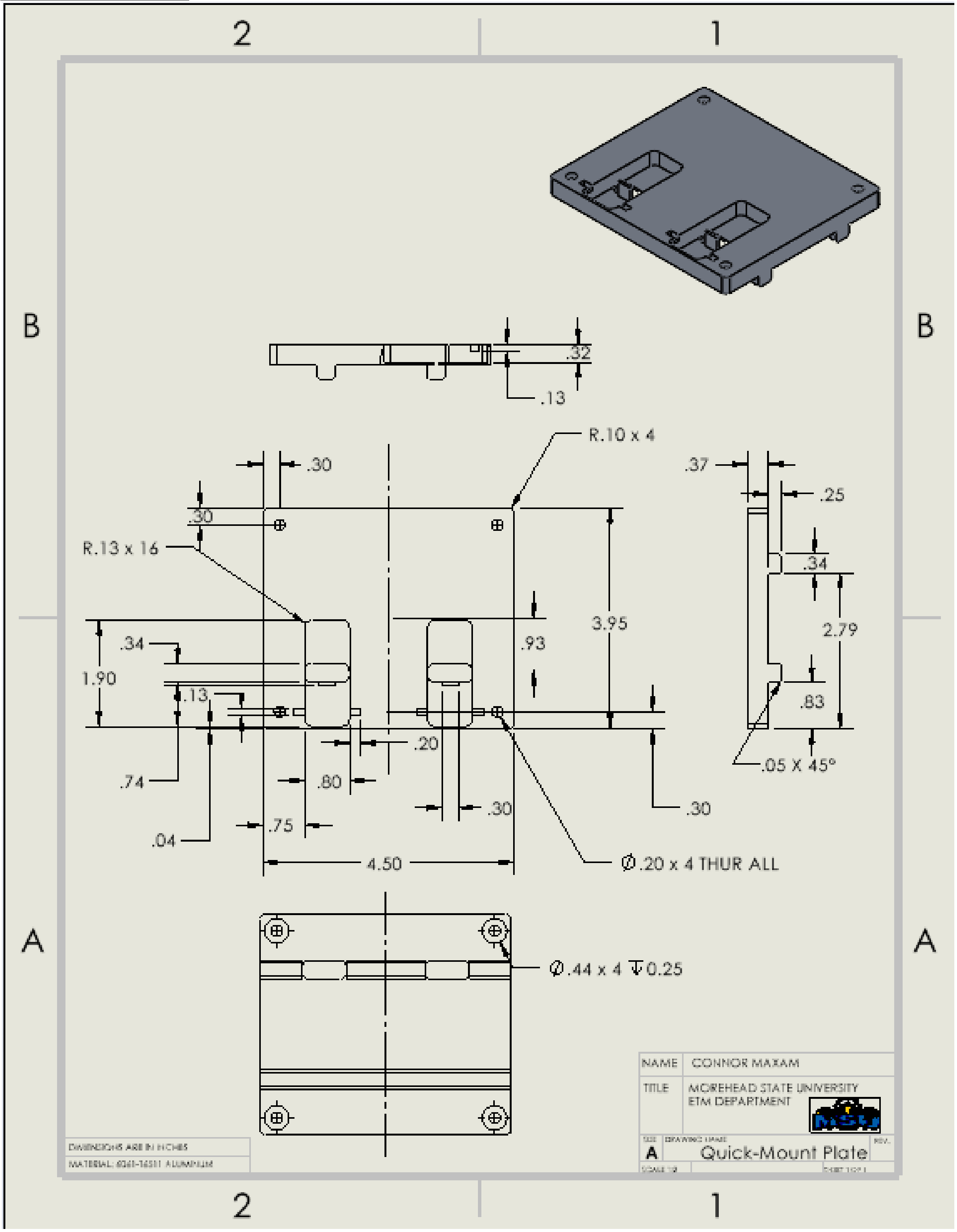
The pneumatic power circuit integrated with relay control can now be electronically controlled. Integrating the hydraulic fluid power trainer with relay control would be the same process.

Appendix A1
Parts and Assembly Drawings

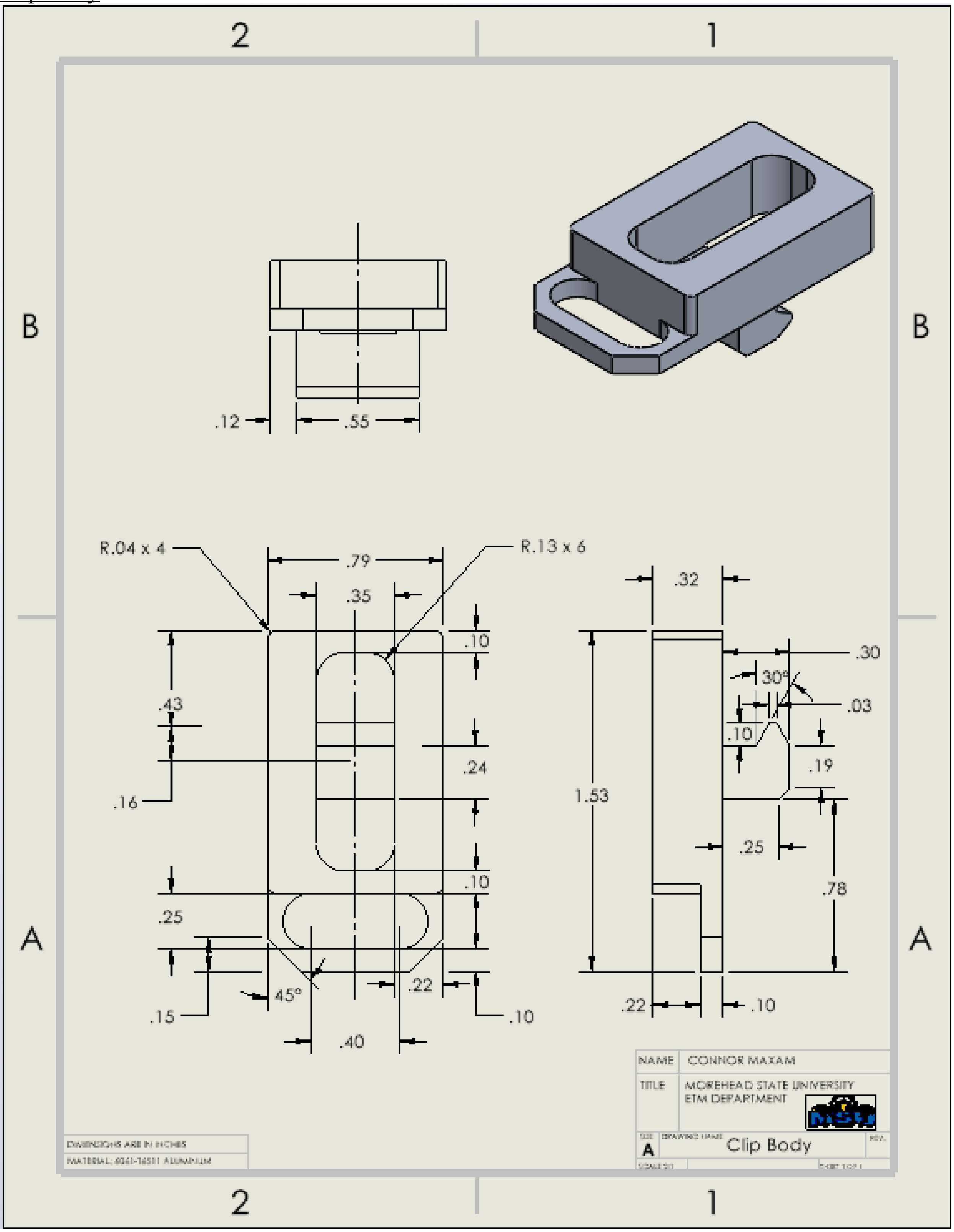
Valve Sub-plate



Quick-Mount Plate



Clip Body


2
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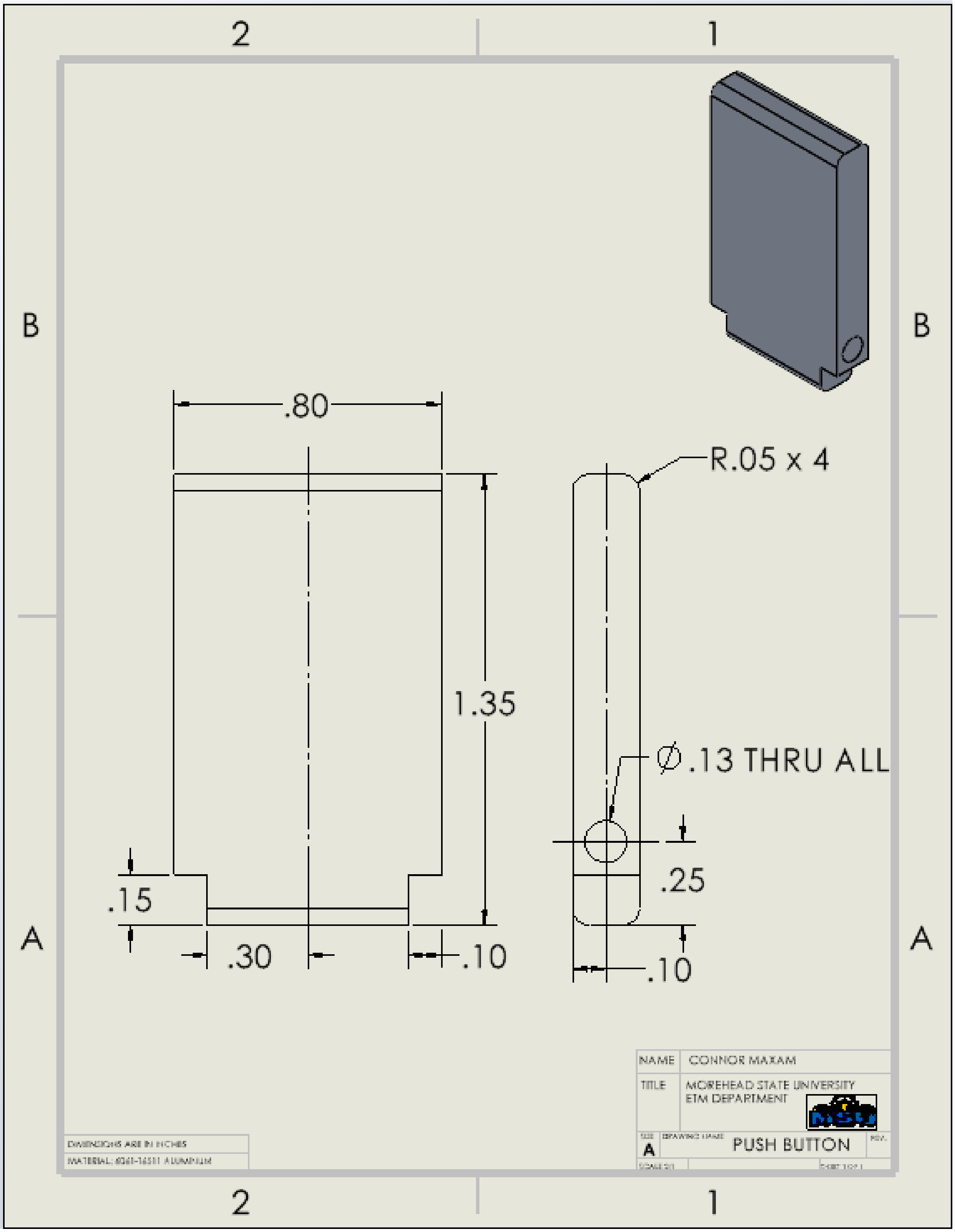
.79
R.13 x 6
.35
.32
.10
.30
30°
.03
.43
.10
.24
.19
.16
1.53
.25
.78
.10
.25
.45°
.22
.15
.10
.22
.10
.40
NAME CONNOR MAXAM
TITLE MOREHEAD STATE UNIVERSITY
ETM DEPARTMENT
A
Clip Body

Push Button


2
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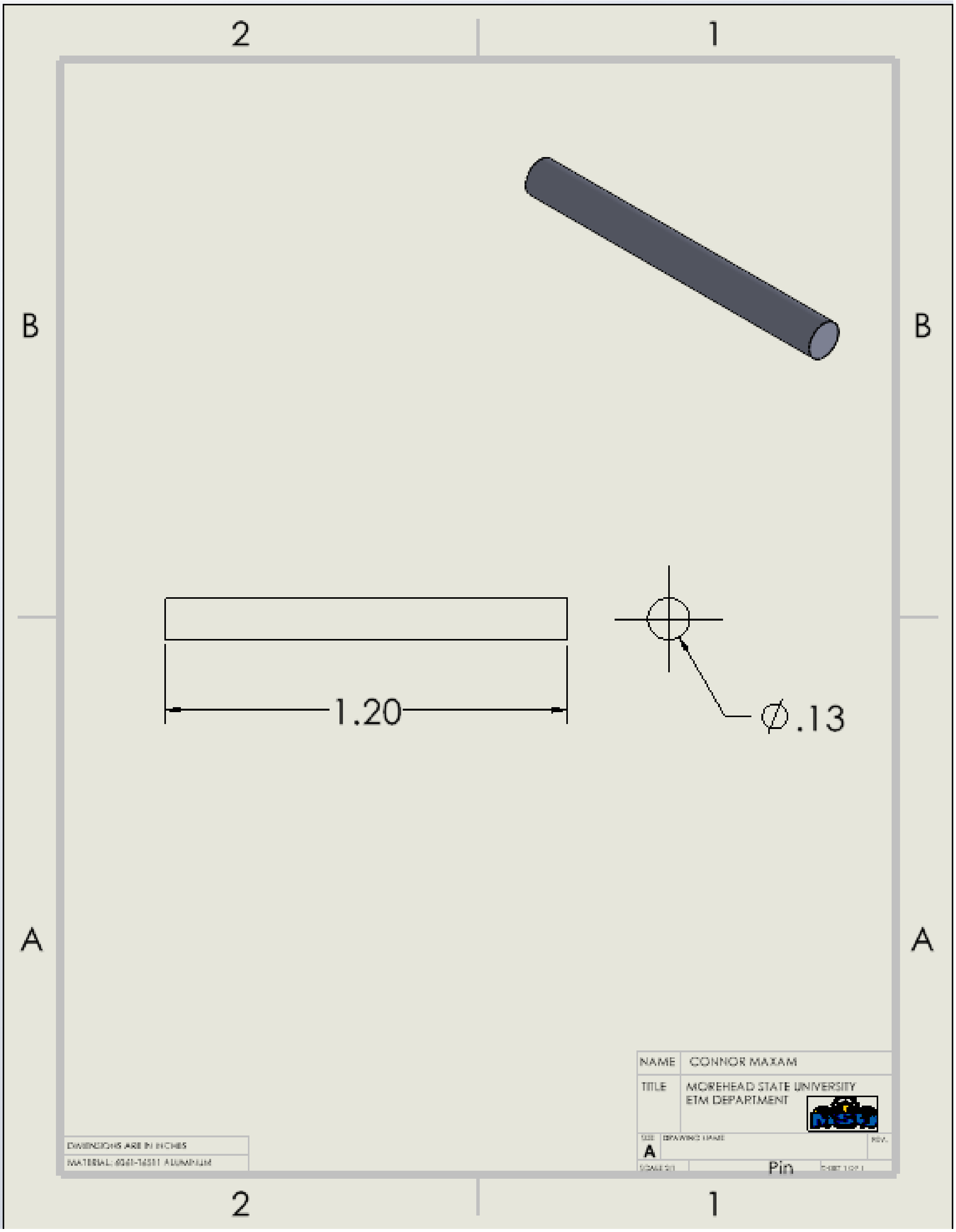
B
A
A
.80
R.05 x 4
1.35
∅.13 THRU ALL
.25
.15
.30
.10
.10
NAME
CONNOR MAXAM
TITLE
MOREHEAD STATE UNIVERSITY
ETM DEPARTMENT
SIZE
A
PUSH BUTTON
2
1

Pin


2
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NAME
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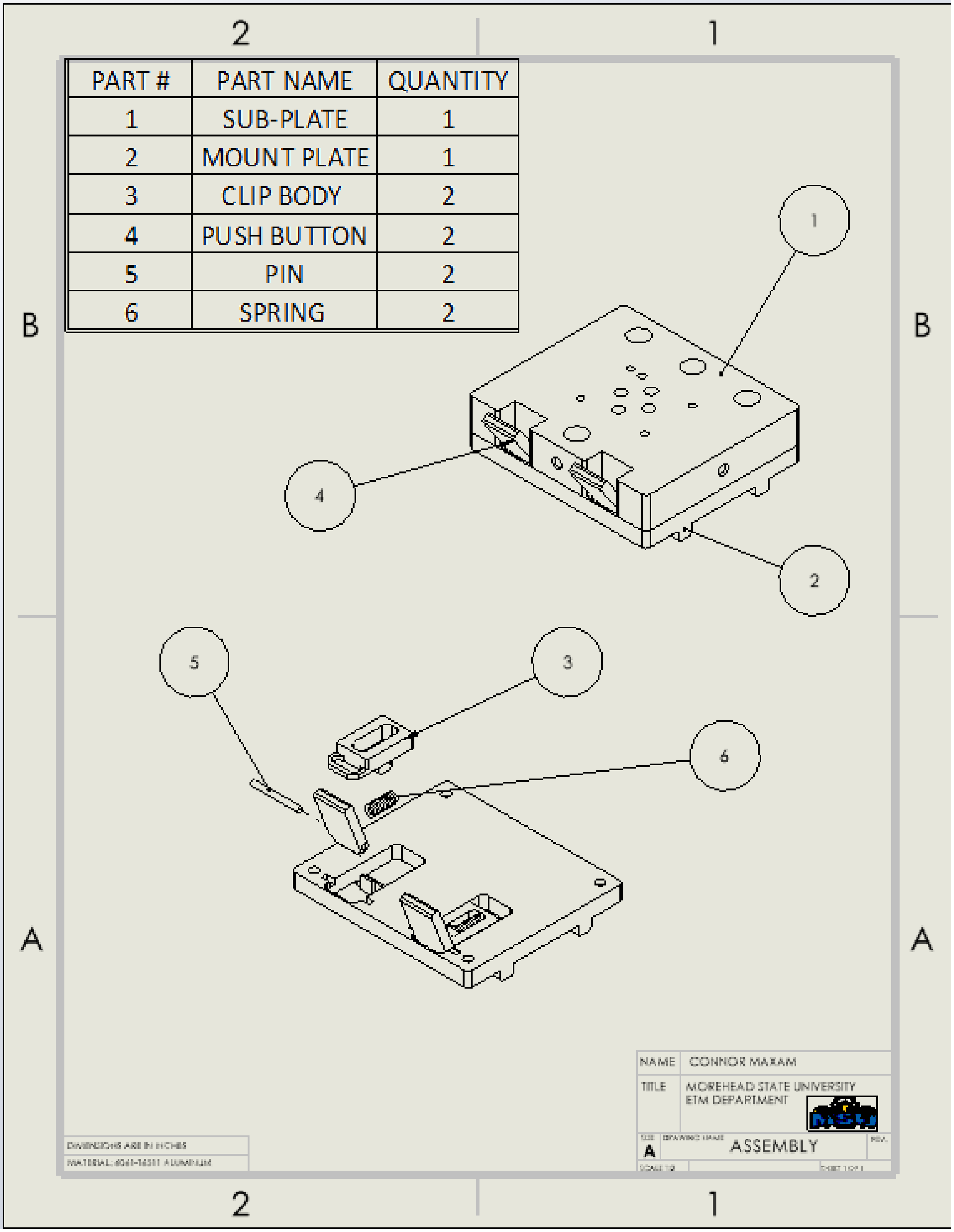
MOREHEAD STATE UNIVERSITY
ETM DEPARTMENT
DIMENSIONS ARE IN INCHES
A
REV.
Pin

<u>Assembly</u>

PART #	PART NAME	QUANTITY
1	SUB-PLATE	1
2	MOUNT PLATE	1
3	CLIP BODY	2
4	PUSH BUTTON	2
5	PIN	2
6	SPRING	2



Appendix A2

G-Code for Machined Parts

G-Code for sub-plate

The g-code for machining the top surface of the sub-plate.

```
%
O00001
N5 G20 G17 G40 G80 G90
N10 T01 M06 (1/2 EM CRB 4FL 1 LOC)
N15 G54 G90 G94
N20 S9789 M03
N25 G00 G90 X-.625 Y-.1
N30 G43 H01 Z.125 M08
N35 G01 Z0 F5.
N40 X-.1 F487.5
N45 X4.6 F650.
N50 X4.875
N55 G02 Y-.4409 I0 J-.1705
N60 G01 X4.6
N65 X-.1
N70 X-.375
N75 G03 Y-.7818 I0 J-.1705
N80 G01 X-.1
N85 X4.6
N90 X4.875
N95 G02 Y-1.1227 I0 J-.1705
N100 G01 X4.6
N105 X-.1
N110 X-.375
N115 G03 Y-1.4636 I0 J-.1705
N120 G01 X-.1
N125 X4.6
N130 X4.875
N135 G02 Y-1.8045 I0 J-.1705
N140 G01 X4.6
N145 X-.1
N150 X-.375
N155 G03 Y-2.1455 I0 J-.1705
N160 G01 X-.1
N165 X4.6
N170 X4.875
N175 G02 Y-2.4864 I0 J-.1705
N180 G01 X4.6
```

```
N185 X-.1
N190 X-.375
N195 G03 Y-2.8273 I0 J-.1705
N200 G01 X-.1
N205 X4.6
N210 X4.875
N215 G02 Y-3.1682 I0 J-.1705
N220 G01 X4.6
N225 X-.1
N230 X-.375
N235 G03 Y-3.5091 I0 J-.1705
N240 G01 X-.1
N245 X4.6
N250 X4.875
N255 G02 Y-3.85 I0 J-.1705
N260 G01 X4.6
N265 X-.1
N270 X-.625 F487.5
N275 G00 Z.125
N280 Z1.025
N285 S6195
N290 G90 G54 X2.0058 Y.4485
N295 Z.1
N300 G01 Z-.25 F13.6303
N305 G90 G41 X2.1896 Y.2646 D01 F40.8909
N310 G03 X2.225 Y.25 I.0354 J.0354
N315 G01 X4.4 F54.5211
N320 G02 X4.75 Y-.1 I0 J-.35
N325 G01 Y-3.85
N330 G02 X4.4 Y-4.2 I-.35 J0
N335 G01 X.1
N340 G02 X-.25 Y-3.85 I0 J.35
N345 G01 Y-.1
N350 G02 X.1 Y.25 I.35 J0
N355 G01 X2.275
N360 G03 X2.3104 Y.2646 I0 J.05
N365 G40 G01 X2.4942 Y.4485
N370 G00 Z.1
N375 G90 G54 X2.0058 Y.4485
N380 Z-.15
N385 G01 Z-.4417 F13.6303
N390 G90 G41 X2.1896 Y.2646 D01 F40.8909
N395 G03 X2.225 Y.25 I.0354 J.0354
N400 G01 X4.4 F54.5211
N405 G02 X4.75 Y-.1 I0 J-.35
N410 G01 Y-3.85
N415 G02 X4.4 Y-4.2 I-.35 J0
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N420 G01 X.1
N425 G02 X-.25 Y-3.85 I0 J.35
N430 G01 Y-.1
N435 G02 X.1 Y.25 I.35 J0
N440 G01 X2.275
N445 G03 X2.3104 Y.2646 I0 J.05
N450 G40 G01 X2.4942 Y.4485
N455 G00 Z.1
N460 G90 G54 X2.0058 Y.4485
N465 Z-.3417
N470 G01 Z-.6333 F13.6303
N475 G90 G41 X2.1896 Y.2646 D01 F40.8909
N480 G03 X2.225 Y.25 I.0354 J.0354
N485 G01 X4.4 F54.5211
N490 G02 X4.75 Y-.1 I0 J-.35
N495 G01 Y-3.85
N500 G02 X4.4 Y-4.2 I-.35 J0
N505 G01 X.1
N510 G02 X-.25 Y-3.85 I0 J.35
N515 G01 Y-.1
N520 G02 X.1 Y.25 I.35 J0
N525 G01 X2.275
N530 G03 X2.3104 Y.2646 I0 J.05
N535 G40 G01 X2.4942 Y.4485
N540 G00 Z.1
N545 G90 G54 X2.0058 Y.4485
N550 Z-.5333
N555 G01 Z-.825 F13.6303
N560 G90 G41 X2.1896 Y.2646 D01 F40.8909
N565 G03 X2.225 Y.25 I.0354 J.0354
N570 G01 X4.4 F54.5211
N575 G02 X4.75 Y-.1 I0 J-.35
N580 G01 Y-3.85
N585 G02 X4.4 Y-4.2 I-.35 J0
N590 G01 X.1
N595 G02 X-.25 Y-3.85 I0 J.35
N600 G01 Y-.1
N605 G02 X.1 Y.25 I.35 J0
N610 G01 X2.275
N615 G03 X2.3104 Y.2646 I0 J.05
N620 G40 G01 X2.4942 Y.4485
N625 G00 Z.1
N630 G01 Z1.025 F19.685 M09
N635 G00 G90 G53 G49 H0 Z0 M05
N640 T02 M06 (5/8 X 90DEG CBT SPOT DRILL)
N645 G54 G90 G94
N650 S5989 M03
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N655 G90 X1.506 Y-1.335
N660 G43 H02 Z1.025 M08
N665 G98 G82 Z-.0673 R.1 P00 F31.7434
N670 Y-2.615
N675 X3.1 Y-2.585
N680 Y-1.365
N685 G80
N690 G01 Z1.025 F39.3701 M09
N695 G00 G90 G53 G49 H0 Z0 M05
N700 T03 M06 (#25 SCREW MACH DRILL)
N705 G54 G90 G94
N710 S12000 M03
N715 G90 X1.506 Y-1.335
N720 G43 H03 Z1.025 M08
N725 G98 G83 Z-.9 Q.1 R.1 F43.2
N730 Y-2.615
N735 X3.1 Y-2.585
N740 Y-1.365
N745 G80
N750 G01 Z1.025 F39.3701 M09
N755 G00 G90 G53 G49 H0 Z0 M05
N760 T04 M06 (10-24 UNC TAP)
N765 G54 G90 G94
N770 S350 M03
N775 G90 X1.506 Y-1.335
N780 G43 H04 Z1.025 M08
N785 G98 G84 Z-.9 R.1 F14.5833
N790 Y-2.615
N795 X3.1 Y-2.585
N800 Y-1.365
N805 G80
N810 G01 Z1.025 F39.3701 M09
N815 G00 G90 G53 G49 H0 Z0 M05
N820 T02 M06 (5/8 X 90DEG CBT SPOT DRILL)
N825 G54 G90 G94
N830 S5989 M03
N835 G90 X.875 Y-.5
N840 G43 H02 Z1.025 M08
N845 G98 G82 Z-.2106 R.1 P00 F31.7434
N850 X2.25
N855 X3.625
N860 X2.25 Y-3.45
N865 G80
N870 G01 Z1.025 F39.3701 M09
N875 G00 G90 G53 G49 H0 Z0 M05
N880 T06 M06 (7/16 SCREW MACH DRILL)
N885 G54 G90 G94
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N890 S7805 M03
N895 G90 X.875 Y-.5
N900 G43 H06 Z1.025 M08
N905 G98 G83 Z-.7 Q.1 R.1 F39.0266
N910 X2.25
N915 X3.625
N920 X2.25 Y-3.45
N925 G80
N930 G01 Z1.025 F39.3701 M09
N935 G00 G90 G53 G49 H0 Z0 M05
N940 T07 M06 (1/4-18 NPT TAP)
N945 G54 G90 G94
N950 S350 M03
N955 G90 X.875 Y-.5
N960 G43 H07 Z1.025 M08
N965 G98 G84 Z-.7 R.1 F19.4444
N970 X2.25
N975 X3.625
N980 X2.25 Y-3.45
N985 G80
N990 G01 Z1.025 F39.3701 M09
N995 G00 G90 G53 G49 H0 Z0 M05
N1000 T02 M06 (5/8 X 90DEG CBT SPOT DRILL)
N1005 G54 G90 G94
N1010 S5989 M03
N1015 G90 X1.8 Y-1.35
N1020 G43 H02 Z1.025 M08
N1025 G98 G82 Z-.072 R.1 P00 F31.7434
N1030 G80
N1035 G01 Z1.025 F39.3701 M09
N1040 G00 G90 G53 G49 H0 Z0 M05
N1045 T03 M06 (#25 SCREW MACH DRILL)
N1050 G54 G90 G94
N1055 S12000 M03
N1060 G90
N1065 G43 H03 Z1.025 M08
N1070 G98 G83 Z-.2 Q.1 R.1 F43.2
N1075 G80
N1080 G01 Z1.025 F39.3701 M09
N1085 G00 G90 G53 G49 H0 Z0 M05
N1090 G54 X0 Y0
N1095 M30
%
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The g-code for machining bottom and two slots in sub-plate

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%
O00001
N5 G20 G17 G40 G80 G90
N10 T01 M06 (1/2 EM CRB 4FL 1 LOC)
N15 G54 G90 G94
N20 S3000 M03
N25 G00 G90 X1.01 Y.625
N30 G43 H01 Z4.075 M08
N35 G01 Z3.775 F1.25
N40 Y-1.425 F5.
N45 Z3.6375 F1.25
N50 Y.625 F5.
N55 Z3.5 F1.25
N60 Y-1.425 F5.
N65 G00 Z4.075
N70 G90 G54 X1.29 Y-1.425
N75 G01 Z3.775 F1.25
N80 Y.625 F5.
N85 Z3.6375 F1.25
N90 Y-1.425 F5.
N95 Z3.5 F1.25
N100 Y.625 F5.
N105 G00 Z4.075
N110 G90 G54 X1.01 Y.625
N115 G01 Z3.775 F1.25
N120 Y-1.425 F5.
N125 Z3.6375 F1.25
N130 Y.625 F5.
N135 Z3.5 F1.25
N140 Y-1.425 F5.
N145 G00 Z4.075
N150 G90 G54 X1.29 Y-1.425
N155 G01 Z3.775 F1.25
N160 Y.625 F5.
N165 Z3.6375 F1.25
N170 Y-1.425 F5.
N175 Z3.5 F1.25
N180 Y.625 F5.
N185 G00 Z4.075
N190 Z4.975
N195 G90 G54 X3.21 Y.625
N200 Z4.075
N205 G01 Z3.775 F1.25
N210 Y-1.425 F5.
N215 Z3.6375 F1.25
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N220 Y.625 F5.
N225 Z3.5 F1.25
N230 Y-1.425 F5.
N235 G00 Z4.075
N240 G90 G54 X3.49 Y-1.425
N245 G01 Z3.775 F1.25
N250 Y.625 F5.
N255 Z3.6375 F1.25
N260 Y-1.425 F5.
N265 Z3.5 F1.25
N270 Y.625 F5.
N275 G00 Z4.075
N280 G90 G54 X3.21 Y.625
N285 G01 Z3.775 F1.25
N290 Y-1.425 F5.
N295 Z3.6375 F1.25
N300 Y.625 F5.
N305 Z3.5 F1.25
N310 Y-1.425 F5.
N315 G00 Z4.075
N320 G90 G54 X3.49 Y-1.425
N325 G01 Z3.775 F1.25
N330 Y.625 F5.
N335 Z3.6375 F1.25
N340 Y-1.425 F5.
N345 Z3.5 F1.25
N350 Y.625 F5.
N355 G00 Z4.075
N360 Z4.975
N365 S4000
N370 G90 G54 X1.1015 Y-1.0692
N375 Z4.075
N380 G01 Z3.775 F.5
N385 G90 G41 X1.2854 Y-.8854 D01 F3.75
N390 G03 X1.3 Y-.85 I-.0354 J.0354
N395 G01 Y.05 F5.
N400 G03 X1.2854 Y.0854 I-.05 J0 F3.75
N405 G40 G01 X1.1015 Y.2692
N410 G00 Z4.075
N415 G90 G54 X1.1985 Y.2692
N420 G01 Z3.775 F.5
N425 G90 G41 X1.0146 Y.0854 D01 F3.75
N430 G03 X1. Y.05 I.0354 J-.0354
N435 G01 Y-.85 F5.
N440 G03 X1.0146 Y-.8854 I.05 J0 F3.75
N445 G40 G01 X1.1985 Y-1.0692
N450 G00 Z4.075
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N455 G90 G54 X1.1015 Y-1.0692
N460 Z3.875
N465 G01 Z3.6375 F.5
N470 G90 G41 X1.2854 Y-.8854 D01 F3.75
N475 G03 X1.3 Y-.85 I-.0354 J.0354
N480 G01 Y.05 F5.
N485 G03 X1.2854 Y.0854 I-.05 J0 F3.75
N490 G40 G01 X1.1015 Y.2692
N495 G00 Z4.075
N500 G90 G54 X1.1985 Y.2692
N505 Z3.875
N510 G01 Z3.6375 F.5
N515 G90 G41 X1.0146 Y.0854 D01 F3.75
N520 G03 X1. Y.05 I.0354 J-.0354
N525 G01 Y-.85 F5.
N530 G03 X1.0146 Y-.8854 I.05 J0 F3.75
N535 G40 G01 X1.1985 Y-1.0692
N540 G00 Z4.075
N545 G90 G54 X1.1015 Y-1.0692
N550 Z3.7375
N555 G01 Z3.5 F.5
N560 G90 G41 X1.2854 Y-.8854 D01 F3.75
N565 G03 X1.3 Y-.85 I-.0354 J.0354
N570 G01 Y.05 F5.
N575 G03 X1.2854 Y.0854 I-.05 J0 F3.75
N580 G40 G01 X1.1015 Y.2692
N585 G00 Z4.075
N590 G90 G54 X1.1985 Y.2692
N595 Z3.7375
N600 G01 Z3.5 F.5
N605 G90 G41 X1.0146 Y.0854 D01 F3.75
N610 G03 X1. Y.05 I.0354 J-.0354
N615 G01 Y-.85 F5.
N620 G03 X1.0146 Y-.8854 I.05 J0 F3.75
N625 G40 G01 X1.1985 Y-1.0692
N630 G00 Z4.075
N635 Z4.975
N640 G90 G54 X3.3015 Y-1.0692
N645 Z4.075
N650 G01 Z3.775 F.5
N655 G90 G41 X3.4854 Y-.8854 D01 F3.75
N660 G03 X3.5 Y-.85 I-.0354 J.0354
N665 G01 Y.05 F5.
N670 G03 X3.4854 Y.0854 I-.05 J0 F3.75
N675 G40 G01 X3.3015 Y.2692
N680 G00 Z4.075
N685 G90 G54 X3.3985 Y.2692
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N690 G01 Z3.775 F.5
N695 G90 G41 X3.2146 Y.0854 D01 F3.75
N700 G03 X3.2 Y.05 I.0354 J-.0354
N705 G01 Y-.85 F5.
N710 G03 X3.2146 Y-.8854 I.05 J0 F3.75
N715 G40 G01 X3.3985 Y-1.0692
N720 G00 Z4.075
N725 G90 G54 X3.3015 Y-1.0692
N730 Z3.875
N735 G01 Z3.6375 F.5
N740 G90 G41 X3.4854 Y-.8854 D01 F3.75
N745 G03 X3.5 Y-.85 I-.0354 J.0354
N750 G01 Y.05 F5.
N755 G03 X3.4854 Y.0854 I-.05 J0 F3.75
N760 G40 G01 X3.3015 Y.2692
N765 G00 Z4.075
N770 G90 G54 X3.3985 Y.2692
N775 Z3.875
N780 G01 Z3.6375 F.5
N785 G90 G41 X3.2146 Y.0854 D01 F3.75
N790 G03 X3.2 Y.05 I.0354 J-.0354
N795 G01 Y-.85 F5.
N800 G03 X3.2146 Y-.8854 I.05 J0 F3.75
N805 G40 G01 X3.3985 Y-1.0692
N810 G00 Z4.075
N815 G90 G54 X3.3015 Y-1.0692
N820 Z3.7375
N825 G01 Z3.5 F.5
N830 G90 G41 X3.4854 Y-.8854 D01 F3.75
N835 G03 X3.5 Y-.85 I-.0354 J.0354
N840 G01 Y.05 F5.
N845 G03 X3.4854 Y.0854 I-.05 J0 F3.75
N850 G40 G01 X3.3015 Y.2692
N855 G00 Z4.075
N860 G90 G54 X3.3985 Y.2692
N865 Z3.7375
N870 G01 Z3.5 F.5
N875 G90 G41 X3.2146 Y.0854 D01 F3.75
N880 G03 X3.2 Y.05 I.0354 J-.0354
N885 G01 Y-.85 F5.
N890 G03 X3.2146 Y-.8854 I.05 J0 F3.75
N895 G40 G01 X3.3985 Y-1.0692
N900 G00 Z4.075
N905 G01 Z4.975 F19.685 M09
N910 G00 G90 G53 G49 H0 Z0 M05
N915 T09 M06 (3/8 X 90DEG CBT SPOT DRILL)
N920 G54 G90 G94
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N925 S1000 M03
N930 G90 X2.25 Y-.4
N935 G43 H09 Z4.975 M08
N940 G98 G82 Z3.8375 R4.05 P00 F4.4
N945 G80
N950 G01 Z4.975 F39.3701 M09
N955 G00 G90 G53 G49 H0 Z0 M05
N960 T10 M06 (1/4,E SCREW MACH DRILL)
N965 G54 G90 G94
N970 S300 M03
N975 G90
N980 G43 H10 Z4.975 M08
N985 G98 G83 Z2.35 Q.1 R4.05 F1.08
N990 G80
N995 G01 Z4.975 F39.3701 M09
N1000 G00 G90 G53 G49 H0 Z0 M05
N1005 G54 X0 Y0
N1010 M30
%
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The g-code for machining the top face of the mounting plate:

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%
O00001
N5 G20 G17 G40 G80 G90
N10 T01 M06 (1/2 EM CRB 4FL 1 LOC)
N15 G54 G90 G94
N20 S3000 M03
N25 G00 G90 X-.625 Y-.1
N30 G43 H01 Z.125 M08
N35 G01 Z0 F5.
N40 X-.1 F149.4
N45 X4.6 F199.2
N50 X4.875
N55 G02 Y-.4409 I0 J-.1705
N60 G01 X4.6
N65 X-.1
N70 X-.375
N75 G03 Y-.7818 I0 J-.1705
N80 G01 X-.1
N85 X4.6
N90 X4.875
N95 G02 Y-1.1227 I0 J-.1705
N100 G01 X4.6
N105 X-.1
N110 X-.375
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N115 G03 Y-1.4636 I0 J-.1705
N120 G01 X-.1
N125 X4.6
N130 X4.875
N135 G02 Y-1.8045 I0 J-.1705
N140 G01 X4.6
N145 X-.1
N150 X-.375
N155 G03 Y-2.1455 I0 J-.1705
N160 G01 X-.1
N165 X4.6
N170 X4.875
N175 G02 Y-2.4864 I0 J-.1705
N180 G01 X4.6
N185 X-.1
N190 X-.375
N195 G03 Y-2.8273 I0 J-.1705
N200 G01 X-.1
N205 X4.6
N210 X4.875
N215 G02 Y-3.1682 I0 J-.1705
N220 G01 X4.6
N225 X-.1
N230 X-.375
N235 G03 Y-3.5091 I0 J-.1705
N240 G01 X-.1
N245 X4.6
N250 X4.875
N255 G02 Y-3.85 I0 J-.1705
N260 G01 X4.6
N265 X-.1
N270 X-.625 F149.4
N275 G00 Z.125
N280 Z1.025
N285 G90 G54 X1.01 Y-2.27
N290 Z.1
N295 G01 Z-.2 F1.25
N300 Y-2.865 F5.
N305 X1.29
N310 Y-2.27
N315 X1.01
N320 Y-2.865
N325 X1.29
N330 Y-2.27
N335 X1.01
N340 G00 Z.1
N345 Z-.1
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N350 G01 Z-.305 F1.25
N355 Y-2.865 F5.
N360 X1.29
N365 Y-2.27
N370 X1.01
N375 Y-2.865
N380 X1.29
N385 Y-2.27
N390 X1.01
N395 G00 Z.1
N400 Z-.205
N405 G01 Z-.315 F1.25
N410 Y-2.865 F5.
N415 X1.29
N420 Y-2.27
N425 X1.01
N430 Y-2.865
N435 X1.29
N440 Y-2.27
N445 X1.01
N450 G00 Z.1
N455 G90 G54 X1.29 Y-3.435
N460 G01 Z-.2 F1.25
N465 X1.01 F5.
N470 Y-3.65
N475 X1.29
N480 Y-3.435
N485 X1.01
N490 Y-3.65
N495 X1.29
N500 Y-3.435
N505 G00 Z.1
N510 Z-.1
N515 G01 Z-.305 F1.25
N520 X1.01 F5.
N525 Y-3.65
N530 X1.29
N535 Y-3.435
N540 X1.01
N545 Y-3.65
N550 X1.29
N555 Y-3.435
N560 G00 Z.1
N565 Z-.205
N570 G01 Z-.315 F1.25
N575 X1.01 F5.
N580 Y-3.65
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N585 X1.29
N590 Y-3.435
N595 X1.01
N600 Y-3.65
N605 X1.29
N610 Y-3.435
N615 G00 Z.1
N620 Z1.025
N625 G90 G54 X1.29 Y-3.125
N630 Z.1
N635 G01 Z.01 F1.25
N640 X1.01 F5.
N645 Y-3.175
N650 X1.29
N655 Y-3.125
N660 G00 Z.1
N665 G01 Z0 F1.25
N670 X1.01 F5.
N675 Y-3.175
N680 X1.29
N685 Y-3.125
N690 G00 Z.1
N695 Z1.025
N700 G90 G54 X1.01 Y-3.65
N705 Z.1
N710 G01 Z-.2 F1.25
N715 X1.29 F5.
N720 Y-3.435
N725 X1.01
N730 Y-3.65
N735 X1.29
N740 Y-3.435
N745 X1.01
N750 Y-3.65
N755 G00 Z.1
N760 Z-.1
N765 G01 Z-.305 F1.25
N770 X1.29 F5.
N775 Y-3.435
N780 X1.01
N785 Y-3.65
N790 X1.29
N795 Y-3.435
N800 X1.01
N805 Y-3.65
N810 G00 Z.1
N815 Z-.205
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N820 G01 Z-.315 F1.25
N825 X1.29 F5.
N830 Y-3.435
N835 X1.01
N840 Y-3.65
N845 X1.29
N850 Y-3.435
N855 X1.01
N860 Y-3.65
N865 G00 Z.1
N870 G90 G54 X1.01 Y-2.865
N875 G01 Z-.2 F1.25
N880 X1.29 F5.
N885 Y-2.27
N890 X1.01
N895 Y-2.865
N900 X1.29
N905 Y-2.27
N910 X1.01
N915 Y-2.865
N920 G00 Z.1
N925 Z-.1
N930 G01 Z-.305 F1.25
N935 X1.29 F5.
N940 Y-2.27
N945 X1.01
N950 Y-2.865
N955 X1.29
N960 Y-2.27
N965 X1.01
N970 Y-2.865
N975 G00 Z.1
N980 Z-.205
N985 G01 Z-.315 F1.25
N990 X1.29 F5.
N995 Y-2.27
N1000 X1.01
N1005 Y-2.865
N1010 X1.29
N1015 Y-2.27
N1020 X1.01
N1025 Y-2.865
N1030 G00 Z.1
N1035 Z1.025
N1040 G90 G54 X1.01 Y-3.175
N1045 Z.1
N1050 G01 Z.01 F1.25
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N1055 X1.29 F5.
N1060 Y-3.125
N1065 X1.01
N1070 Y-3.175
N1075 G00 Z.1
N1080 G01 Z0 F1.25
N1085 X1.29 F5.
N1090 Y-3.125
N1095 X1.01
N1100 Y-3.175
N1105 G00 Z.1
N1110 Z1.025
N1115 G90 G54 X3.21 Y-2.27
N1120 Z.1
N1125 G01 Z-.2 F1.25
N1130 Y-2.865 F5.
N1135 X3.49
N1140 Y-2.27
N1145 X3.21
N1150 Y-2.865
N1155 X3.49
N1160 Y-2.27
N1165 X3.21
N1170 G00 Z.1
N1175 Z-.1
N1180 G01 Z-.305 F1.25
N1185 Y-2.865 F5.
N1190 X3.49
N1195 Y-2.27
N1200 X3.21
N1205 Y-2.865
N1210 X3.49
N1215 Y-2.27
N1220 X3.21
N1225 G00 Z.1
N1230 Z-.205
N1235 G01 Z-.315 F1.25
N1240 Y-2.865 F5.
N1245 X3.49
N1250 Y-2.27
N1255 X3.21
N1260 Y-2.865
N1265 X3.49
N1270 Y-2.27
N1275 X3.21
N1280 G00 Z.1
N1285 G90 G54 X3.49 Y-3.435
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N1290 G01 Z-.2 F1.25
N1295 X3.21 F5.
N1300 Y-3.65
N1305 X3.49
N1310 Y-3.435
N1315 X3.21
N1320 Y-3.65
N1325 X3.49
N1330 Y-3.435
N1335 G00 Z.1
N1340 Z-.1
N1345 G01 Z-.305 F1.25
N1350 X3.21 F5.
N1355 Y-3.65
N1360 X3.49
N1365 Y-3.435
N1370 X3.21
N1375 Y-3.65
N1380 X3.49
N1385 Y-3.435
N1390 G00 Z.1
N1395 Z-.205
N1400 G01 Z-.315 F1.25
N1405 X3.21 F5.
N1410 Y-3.65
N1415 X3.49
N1420 Y-3.435
N1425 X3.21
N1430 Y-3.65
N1435 X3.49
N1440 Y-3.435
N1445 G00 Z.1
N1450 Z1.025
N1455 G90 G54 X3.49 Y-3.125
N1460 Z.1
N1465 G01 Z.01 F1.25
N1470 X3.21 F5.
N1475 Y-3.175
N1480 X3.49
N1485 Y-3.125
N1490 G00 Z.1
N1495 G01 Z0 F1.25
N1500 X3.21 F5.
N1505 Y-3.175
N1510 X3.49
N1515 Y-3.125
N1520 G00 Z.1
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N1525 Z1.025
N1530 G90 G54 X3.21 Y-3.65
N1535 Z.1
N1540 G01 Z-.2 F1.25
N1545 X3.49 F5.
N1550 Y-3.435
N1555 X3.21
N1560 Y-3.65
N1565 X3.49
N1570 Y-3.435
N1575 X3.21
N1580 Y-3.65
N1585 G00 Z.1
N1590 Z-.1
N1595 G01 Z-.305 F1.25
N1600 X3.49 F5.
N1605 Y-3.435
N1610 X3.21
N1615 Y-3.65
N1620 X3.49
N1625 Y-3.435
N1630 X3.21
N1635 Y-3.65
N1640 G00 Z.1
N1645 Z-.205
N1650 G01 Z-.315 F1.25
N1655 X3.49 F5.
N1660 Y-3.435
N1665 X3.21
N1670 Y-3.65
N1675 X3.49
N1680 Y-3.435
N1685 X3.21
N1690 Y-3.65
N1695 G00 Z.1
N1700 G90 G54 X3.21 Y-2.865
N1705 G01 Z-.2 F1.25
N1710 X3.49 F5.
N1715 Y-2.27
N1720 X3.21
N1725 Y-2.865
N1730 X3.49
N1735 Y-2.27
N1740 X3.21
N1745 Y-2.865
N1750 G00 Z.1
N1755 Z-.1
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N1760 G01 Z-.305 F1.25
N1765 X3.49 F5.
N1770 Y-2.27
N1775 X3.21
N1780 Y-2.865
N1785 X3.49
N1790 Y-2.27
N1795 X3.21
N1800 Y-2.865
N1805 G00 Z.1
N1810 Z-.205
N1815 G01 Z-.315 F1.25
N1820 X3.49 F5.
N1825 Y-2.27
N1830 X3.21
N1835 Y-2.865
N1840 X3.49
N1845 Y-2.27
N1850 X3.21
N1855 Y-2.865
N1860 G00 Z.1
N1865 Z1.025
N1870 G90 G54 X3.21 Y-3.175
N1875 Z.1
N1880 G01 Z.01 F1.25
N1885 X3.49 F5.
N1890 Y-3.125
N1895 X3.21
N1900 Y-3.175
N1905 G00 Z.1
N1910 G01 Z0 F1.25
N1915 X3.49 F5.
N1920 Y-3.125
N1925 X3.21
N1930 Y-3.175
N1935 G00 Z.1
N1940 G01 Z1.025 F19.685 M09
N1945 G00 G90 G53 G49 H0 Z0 M05
N1950 T08 M06 (1/4 EM CRB 4FL 3/4  LOC)
N1955 G54 G90 G94
N1960 S3000 M03
N1965 G90 X1.3258 Y-2.9831
N1970 G43 H08 Z.1 M08
N1975 G01 Z-.125 F1.25
N1980 G90 G41 X1.4177 Y-2.8912 D08 F3.75
N1985 G03 X1.425 Y-2.8735 I-.0177 J.0177
N1990 G01 Y-2.135 F5.
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N1995 X.875

N2000 Y-3.125

N2005 Y-3.

N2010 X1.425

N2015 Y-3.125

N2020 Y-2.8485

N2025 G03 X1.4177 Y-2.8308 I-.025 J0

N2030 G40 G01 X1.3258 Y-2.7389

N2035 G00 Z.1

N2040 G90 G54 X1.3258 Y-2.9831

N2045 Z-.025

N2050 G01 Z-.22 F1.25

N2055 G90 G41 X1.4177 Y-2.8912 D08 F3.75

N2060 G03 X1.425 Y-2.8735 I-.0177 J.0177

N2065 G01 Y-2.135 F5.

N2070 X.875

N2075 Y-3.125

N2080 Y-3.

N2085 X1.425

N2090 Y-3.125

N2095 Y-2.8485

N2100 G03 X1.4177 Y-2.8308 I-.025 J0

N2105 G40 G01 X1.3258 Y-2.7389

N2110 G00 Z.1

N2115 G90 G54 X1.3258 Y-2.9831

N2120 Z-.12

N2125 G01 Z-.315 F1.25

N2130 G90 G41 X1.4177 Y-2.8912 D08 F3.75

N2135 G03 X1.425 Y-2.8735 I-.0177 J.0177

N2140 G01 Y-2.135 F5.

N2145 X.875

N2150 Y-3.125

N2155 Y-3.

N2160 X1.425

N2165 Y-3.125

N2170 Y-2.8485

N2175 G03 X1.4177 Y-2.8308 I-.025 J0

N2180 G40 G01 X1.3258 Y-2.7389

N2185 G00 Z.1

N2190 G90 G54 X.9742 Y-3.3579

N2195 G01 Z-.125 F1.25

N2200 G90 G41 X.8823 Y-3.4498 D08 F3.75

N2205 G03 X.875 Y-3.4675 I.0177 J-.0177

N2210 G01 Y-3.785 F5.

N2215 X1.425

N2220 Y-3.175

N2225 Y-3.3

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N2230 X.875
N2235 Y-3.175
N2240 Y-3.4925
N2245 G03 X.8823 Y-3.5102 I.025 J0
N2250 G40 G01 X.9742 Y-3.6021
N2255 G00 Z.1
N2260 G90 G54 X.9742 Y-3.3579
N2265 Z-.025
N2270 G01 Z-.22 F1.25
N2275 G90 G41 X.8823 Y-3.4498 D08 F3.75
N2280 G03 X.875 Y-3.4675 I.0177 J-.0177
N2285 G01 Y-3.785 F5.
N2290 X1.425
N2295 Y-3.175
N2300 Y-3.3
N2305 X.875
N2310 Y-3.175
N2315 Y-3.4925
N2320 G03 X.8823 Y-3.5102 I.025 J0
N2325 G40 G01 X.9742 Y-3.6021
N2330 G00 Z.1
N2335 G90 G54 X.9742 Y-3.3579
N2340 Z-.12
N2345 G01 Z-.315 F1.25
N2350 G90 G41 X.8823 Y-3.4498 D08 F3.75
N2355 G03 X.875 Y-3.4675 I.0177 J-.0177
N2360 G01 Y-3.785 F5.
N2365 X1.425
N2370 Y-3.175
N2375 Y-3.3
N2380 X.875
N2385 Y-3.175
N2390 Y-3.4925
N2395 G03 X.8823 Y-3.5102 I.025 J0
N2400 G40 G01 X.9742 Y-3.6021
N2405 G00 Z.1
N2410 Z1.025
N2415 G90 G54 X.9742 Y-3.3009
N2420 Z.1
N2425 G01 Z-.125 F1.25
N2430 G90 G41 X.8823 Y-3.3928 D08 F3.75
N2435 G03 X.875 Y-3.4105 I.0177 J-.0177
N2440 G01 Y-3.785 F5.
N2445 X1.425
N2450 Y-3.175
N2455 Y-3.3
N2460 X.875
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N2465 Y-3.175
N2470 Y-3.4355
N2475 G03 X.8823 Y-3.4532 I.025 J0
N2480 G40 G01 X.9742 Y-3.5451
N2485 G00 Z.1
N2490 G90 G54 X.9742 Y-3.3009
N2495 Z-.025
N2500 G01 Z-.22 F1.25
N2505 G90 G41 X.8823 Y-3.3928 D08 F3.75
N2510 G03 X.875 Y-3.4105 I.0177 J-.0177
N2515 G01 Y-3.785 F5.
N2520 X1.425
N2525 Y-3.175
N2530 Y-3.3
N2535 X.875
N2540 Y-3.175
N2545 Y-3.4355
N2550 G03 X.8823 Y-3.4532 I.025 J0
N2555 G40 G01 X.9742 Y-3.5451
N2560 G00 Z.1
N2565 G90 G54 X.9742 Y-3.3009
N2570 Z-.12
N2575 G01 Z-.315 F1.25
N2580 G90 G41 X.8823 Y-3.3928 D08 F3.75
N2585 G03 X.875 Y-3.4105 I.0177 J-.0177
N2590 G01 Y-3.785 F5.
N2595 X1.425
N2600 Y-3.175
N2605 Y-3.3
N2610 X.875
N2615 Y-3.175
N2620 Y-3.4355
N2625 G03 X.8823 Y-3.4532 I.025 J0
N2630 G40 G01 X.9742 Y-3.5451
N2635 G00 Z.1
N2640 G90 G54 X1.3258 Y-2.7521
N2645 G01 Z-.125 F1.25
N2650 G90 G41 X1.4177 Y-2.6602 D08 F3.75
N2655 G03 X1.425 Y-2.6425 I-.0177 J.0177
N2660 G01 Y-2.135 F5.
N2665 X.875
N2670 Y-3.125
N2675 Y-3.
N2680 X1.425
N2685 Y-3.125
N2690 Y-2.6175
N2695 G03 X1.4177 Y-2.5998 I-.025 J0
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N2700 G40 G01 X1.3258 Y-2.5079
N2705 G00 Z.1
N2710 G90 G54 X1.3258 Y-2.7521
N2715 Z-.025
N2720 G01 Z-.22 F1.25
N2725 G90 G41 X1.4177 Y-2.6602 D08 F3.75
N2730 G03 X1.425 Y-2.6425 I-.0177 J.0177
N2735 G01 Y-2.135 F5.
N2740 X.875
N2745 Y-3.125
N2750 Y-3.
N2755 X1.425
N2760 Y-3.125
N2765 Y-2.6175
N2770 G03 X1.4177 Y-2.5998 I-.025 J0
N2775 G40 G01 X1.3258 Y-2.5079
N2780 G00 Z.1
N2785 G90 G54 X1.3258 Y-2.7521
N2790 Z-.12
N2795 G01 Z-.315 F1.25
N2800 G90 G41 X1.4177 Y-2.6602 D08 F3.75
N2805 G03 X1.425 Y-2.6425 I-.0177 J.0177
N2810 G01 Y-2.135 F5.
N2815 X.875
N2820 Y-3.125
N2825 Y-3.
N2830 X1.425
N2835 Y-3.125
N2840 Y-2.6175
N2845 G03 X1.4177 Y-2.5998 I-.025 J0
N2850 G40 G01 X1.3258 Y-2.5079
N2855 G00 Z.1
N2860 Z1.025
N2865 G90 G54 X3.5258 Y-2.9831
N2870 Z.1
N2875 G01 Z-.125 F1.25
N2880 G90 G41 X3.6177 Y-2.8912 D08 F3.75
N2885 G03 X3.625 Y-2.8735 I-.0177 J.0177
N2890 G01 Y-2.135 F5.
N2895 X3.075
N2900 Y-3.125
N2905 Y-3.
N2910 X3.625
N2915 Y-3.125
N2920 Y-2.8485
N2925 G03 X3.6177 Y-2.8308 I-.025 J0
N2930 G40 G01 X3.5258 Y-2.7389
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N2935 G00 Z.1
N2940 G90 G54 X3.5258 Y-2.9831
N2945 Z-.025
N2950 G01 Z-.22 F1.25
N2955 G90 G41 X3.6177 Y-2.8912 D08 F3.75
N2960 G03 X3.625 Y-2.8735 I-.0177 J.0177
N2965 G01 Y-2.135 F5.
N2970 X3.075
N2975 Y-3.125
N2980 Y-3.
N2985 X3.625
N2990 Y-3.125
N2995 Y-2.8485
N3000 G03 X3.6177 Y-2.8308 I-.025 J0
N3005 G40 G01 X3.5258 Y-2.7389
N3010 G00 Z.1
N3015 G90 G54 X3.5258 Y-2.9831
N3020 Z-.12
N3025 G01 Z-.315 F1.25
N3030 G90 G41 X3.6177 Y-2.8912 D08 F3.75
N3035 G03 X3.625 Y-2.8735 I-.0177 J.0177
N3040 G01 Y-2.135 F5.
N3045 X3.075
N3050 Y-3.125
N3055 Y-3.
N3060 X3.625
N3065 Y-3.125
N3070 Y-2.8485
N3075 G03 X3.6177 Y-2.8308 I-.025 J0
N3080 G40 G01 X3.5258 Y-2.7389
N3085 G00 Z.1
N3090 G90 G54 X3.1742 Y-3.3579
N3095 G01 Z-.125 F1.25
N3100 G90 G41 X3.0823 Y-3.4498 D08 F3.75
N3105 G03 X3.075 Y-3.4675 I.0177 J-.0177
N3110 G01 Y-3.785 F5.
N3115 X3.625
N3120 Y-3.175
N3125 Y-3.3
N3130 X3.075
N3135 Y-3.175
N3140 Y-3.4925
N3145 G03 X3.0823 Y-3.5102 I.025 J0
N3150 G40 G01 X3.1742 Y-3.6021
N3155 G00 Z.1
N3160 G90 G54 X3.1742 Y-3.3579
N3165 Z-.025
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N3170 G01 Z-.22 F1.25
N3175 G90 G41 X3.0823 Y-3.4498 D08 F3.75
N3180 G03 X3.075 Y-3.4675 I.0177 J-.0177
N3185 G01 Y-3.785 F5.
N3190 X3.625
N3195 Y-3.175
N3200 Y-3.3
N3205 X3.075
N3210 Y-3.175
N3215 Y-3.4925
N3220 G03 X3.0823 Y-3.5102 I.025 J0
N3225 G40 G01 X3.1742 Y-3.6021
N3230 G00 Z.1
N3235 G90 G54 X3.1742 Y-3.3579
N3240 Z-.12
N3245 G01 Z-.315 F1.25
N3250 G90 G41 X3.0823 Y-3.4498 D08 F3.75
N3255 G03 X3.075 Y-3.4675 I.0177 J-.0177
N3260 G01 Y-3.785 F5.
N3265 X3.625
N3270 Y-3.175
N3275 Y-3.3
N3280 X3.075
N3285 Y-3.175
N3290 Y-3.4925
N3295 G03 X3.0823 Y-3.5102 I.025 J0
N3300 G40 G01 X3.1742 Y-3.6021
N3305 G00 Z.1
N3310 Z1.025
N3315 G90 G54 X3.1742 Y-3.3009
N3320 Z.1
N3325 G01 Z-.125 F1.25
N3330 G90 G41 X3.0823 Y-3.3928 D08 F3.75
N3335 G03 X3.075 Y-3.4105 I.0177 J-.0177
N3340 G01 Y-3.785 F5.
N3345 X3.625
N3350 Y-3.175
N3355 Y-3.3
N3360 X3.075
N3365 Y-3.175
N3370 Y-3.4355
N3375 G03 X3.0823 Y-3.4532 I.025 J0
N3380 G40 G01 X3.1742 Y-3.5451
N3385 G00 Z.1
N3390 G90 G54 X3.1742 Y-3.3009
N3395 Z-.025
N3400 G01 Z-.22 F1.25
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N3405 G90 G41 X3.0823 Y-3.3928 D08 F3.75
N3410 G03 X3.075 Y-3.4105 I.0177 J-.0177
N3415 G01 Y-3.785 F5.
N3420 X3.625
N3425 Y-3.175
N3430 Y-3.3
N3435 X3.075
N3440 Y-3.175
N3445 Y-3.4355
N3450 G03 X3.0823 Y-3.4532 I.025 J0
N3455 G40 G01 X3.1742 Y-3.5451
N3460 G00 Z.1
N3465 G90 G54 X3.1742 Y-3.3009
N3470 Z-.12
N3475 G01 Z-.315 F1.25
N3480 G90 G41 X3.0823 Y-3.3928 D08 F3.75
N3485 G03 X3.075 Y-3.4105 I.0177 J-.0177
N3490 G01 Y-3.785 F5.
N3495 X3.625
N3500 Y-3.175
N3505 Y-3.3
N3510 X3.075
N3515 Y-3.175
N3520 Y-3.4355
N3525 G03 X3.0823 Y-3.4532 I.025 J0
N3530 G40 G01 X3.1742 Y-3.5451
N3535 G00 Z.1
N3540 G90 G54 X3.5258 Y-2.7521
N3545 G01 Z-.125 F1.25
N3550 G90 G41 X3.6177 Y-2.6602 D08 F3.75
N3555 G03 X3.625 Y-2.6425 I-.0177 J.0177
N3560 G01 Y-2.135 F5.
N3565 X3.075
N3570 Y-3.125
N3575 Y-3.
N3580 X3.625
N3585 Y-3.125
N3590 Y-2.6175
N3595 G03 X3.6177 Y-2.5998 I-.025 J0
N3600 G40 G01 X3.5258 Y-2.5079
N3605 G00 Z.1
N3610 G90 G54 X3.5258 Y-2.7521
N3615 Z-.025
N3620 G01 Z-.22 F1.25
N3625 G90 G41 X3.6177 Y-2.6602 D08 F3.75
N3630 G03 X3.625 Y-2.6425 I-.0177 J.0177
N3635 G01 Y-2.135 F5.
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N3640 X3.075
N3645 Y-3.125
N3650 Y-3.
N3655 X3.625
N3660 Y-3.125
N3665 Y-2.6175
N3670 G03 X3.6177 Y-2.5998 I-.025 J0
N3675 G40 G01 X3.5258 Y-2.5079
N3680 G00 Z.1
N3685 G90 G54 X3.5258 Y-2.7521
N3690 Z-.12
N3695 G01 Z-.315 F1.25
N3700 G90 G41 X3.6177 Y-2.6602 D08 F3.75
N3705 G03 X3.625 Y-2.6425 I-.0177 J.0177
N3710 G01 Y-2.135 F5.
N3715 X3.075
N3720 Y-3.125
N3725 Y-3.
N3730 X3.625
N3735 Y-3.125
N3740 Y-2.6175
N3745 G03 X3.6177 Y-2.5998 I-.025 J0
N3750 G40 G01 X3.5258 Y-2.5079
N3755 G00 Z.1
N3760 Z1.025
N3765 S4000
N3770 G90 G54 X1.3 Y-3.125
N3775 Z.1
N3780 G01 Z.01 F1.25
N3785 X1. F5.
N3790 Y-3.175
N3795 X1.3
N3800 Y-3.125
N3805 G00 Z.1
N3810 G01 Z0 F1.25
N3815 X1. F5.
N3820 Y-3.175
N3825 X1.3
N3830 Y-3.125
N3835 G00 Z.1
N3840 Z1.025
N3845 G90 G54 X3.5 Y-3.125
N3850 Z.1
N3855 G01 Z.01 F1.25
N3860 X3.2 F5.
N3865 Y-3.175
N3870 X3.5
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N3875 Y-3.125
N3880 G00 Z.1
N3885 G01 Z0 F1.25
N3890 X3.2 F5.
N3895 Y-3.175
N3900 X3.5
N3905 Y-3.125
N3910 G00 Z.1
N3915 Z1.025
N3920 G90 G54 X1.2721 Y-3.3992
N3925 Z.1
N3930 G01 Z-.125 F1.25
N3935 G90 G41 X1.1802 Y-3.3073 D08 F3.75
N3940 G03 X1.1625 Y-3.3 I-.0177 J-.0177
N3945 G01 X.875 F5.
N3950 Y-3.125
N3955 G02 X1. Y-3. I.125 J0
N3960 G01 X1.3
N3965 G02 X1.425 Y-3.125 I0 J-.125
N3970 G01 Y-3.3
N3975 X1.1375
N3980 G03 X1.1198 Y-3.3073 I0 J-.025
N3985 G40 G01 X1.0279 Y-3.3992
N3990 G00 Z.1
N3995 G90 G54 X1.2721 Y-3.3992
N4000 Z-.025
N4005 G01 Z-.22 F1.25
N4010 G90 G41 X1.1802 Y-3.3073 D08 F3.75
N4015 G03 X1.1625 Y-3.3 I-.0177 J-.0177
N4020 G01 X.875 F5.
N4025 Y-3.125
N4030 G02 X1. Y-3. I.125 J0
N4035 G01 X1.3
N4040 G02 X1.425 Y-3.125 I0 J-.125
N4045 G01 Y-3.3
N4050 X1.1375
N4055 G03 X1.1198 Y-3.3073 I0 J-.025
N4060 G40 G01 X1.0279 Y-3.3992
N4065 G00 Z.1
N4070 G90 G54 X1.2721 Y-3.3992
N4075 Z-.12
N4080 G01 Z-.315 F1.25
N4085 G90 G41 X1.1802 Y-3.3073 D08 F3.75
N4090 G03 X1.1625 Y-3.3 I-.0177 J-.0177
N4095 G01 X.875 F5.
N4100 Y-3.125
N4105 G02 X1. Y-3. I.125 J0
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N4110 G01 X1.3
N4115 G02 X1.425 Y-3.125 I0 J-.125
N4120 G01 Y-3.3
N4125 X1.1375
N4130 G03 X1.1198 Y-3.3073 I0 J-.025
N4135 G40 G01 X1.0279 Y-3.3992
N4140 G00 Z.1
N4145 Z1.025
N4150 G90 G54 X3.4721 Y-3.3992
N4155 Z.1
N4160 G01 Z-.125 F1.25
N4165 G90 G41 X3.3802 Y-3.3073 D08 F3.75
N4170 G03 X3.3625 Y-3.3 I-.0177 J-.0177
N4175 G01 X3.075 F5.
N4180 Y-3.125
N4185 G02 X3.2 Y-3. I.125 J0
N4190 G01 X3.5
N4195 G02 X3.625 Y-3.125 I0 J-.125
N4200 G01 Y-3.3
N4205 X3.3375
N4210 G03 X3.3198 Y-3.3073 I0 J-.025
N4215 G40 G01 X3.2279 Y-3.3992
N4220 G00 Z.1
N4225 G90 G54 X3.4721 Y-3.3992
N4230 Z-.025
N4235 G01 Z-.22 F1.25
N4240 G90 G41 X3.3802 Y-3.3073 D08 F3.75
N4245 G03 X3.3625 Y-3.3 I-.0177 J-.0177
N4250 G01 X3.075 F5.
N4255 Y-3.125
N4260 G02 X3.2 Y-3. I.125 J0
N4265 G01 X3.5
N4270 G02 X3.625 Y-3.125 I0 J-.125
N4275 G01 Y-3.3
N4280 X3.3375
N4285 G03 X3.3198 Y-3.3073 I0 J-.025
N4290 G40 G01 X3.2279 Y-3.3992
N4295 G00 Z.1
N4300 G90 G54 X3.4721 Y-3.3992
N4305 Z-.12
N4310 G01 Z-.315 F1.25
N4315 G90 G41 X3.3802 Y-3.3073 D08 F3.75
N4320 G03 X3.3625 Y-3.3 I-.0177 J-.0177
N4325 G01 X3.075 F5.
N4330 Y-3.125
N4335 G02 X3.2 Y-3. I.125 J0
N4340 G01 X3.5
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N4345 G02 X3.625 Y-3.125 I0 J-.125
N4350 G01 Y-3.3
N4355 X3.3375
N4360 G03 X3.3198 Y-3.3073 I0 J-.025
N4365 G40 G01 X3.2279 Y-3.3992
N4370 G00 Z.1
N4375 G01 Z1.025 F19.685 M09
N4380 G00 G90 G53 G49 H0 Z0 M05
N4385 T09 M06 (3/8 X 90DEG CBT SPOT DRILL)
N4390 G54 G90 G94
N4395 S3000 M03
N4400 G90 X.3 Y-.3
N4405 G43 H09 Z1.025 M08
N4410 G98 G82 Z-.0904 R.1 P00 F13.2
N4415 Y-3.65
N4420 X4.2
N4425 Y-.3
N4430 G80
N4435 G01 Z1.025 F39.3701 M09
N4440 G00 G90 G53 G49 H0 Z0 M05
N4445 T05 M06 (#7 SCREW MACH DRILL)
N4450 G54 G90 G94
N4455 S12000 M03
N4460 G90 X.3
N4465 G43 H05 Z1.025 M08
N4470 G98 G83 Z-.3937 Q.1 R.1 F43.2
N4475 Y-3.65
N4480 X4.2
N4485 Y-.3
N4490 G80
N4495 G01 Z1.025 F39.3701 M09
N4500 G00 G90 G53 G49 H0 Z0 M05
N4505 T08 M06 (1/4 EM CRB 4FL 3/4  LOC)
N4510 G54 G90 G94
N4515 S3000 M03
N4520 G90 X1.415 Y-2.99
N4525 G43 H08 Z-.215 M08
N4530 G01 Z-.37 F1.25
N4535 Y-2.92 F5.
N4540 X.885
N4545 Y-2.99
N4550 X1.415
N4555 Y-2.92
N4560 X.885
N4565 Y-2.99
N4570 X1.415
N4575 G00 Z-.215
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N4580 Z1.025
N4585 G90 G54 X3.615 Y-2.99
N4590 Z-.215
N4595 G01 Z-.37 F1.25
N4600 Y-2.92 F5.
N4605 X3.085
N4610 Y-2.99
N4615 X3.615
N4620 Y-2.92
N4625 X3.085
N4630 Y-2.99
N4635 X3.615
N4640 G00 Z-.215
N4645 Z1.025
N4650 G90 G54 X1.0133 Y-2.9181
N4655 Z-.215
N4660 G01 Z-.37 F1.25
N4665 G90 G41 X1.1198 Y-2.9927 D08 F3.75
N4670 G03 X1.1375 Y-3. I.0177 J.0177
N4675 G01 X1.425 F5.
N4680 Y-2.91
N4685 X.875
N4690 Y-3.
N4695 X1.1625
N4700 G03 X1.1802 Y-2.9927 I0 J.025
N4705 G40 G01 X1.2867 Y-2.9181
N4710 G00 Z-.215
N4715 Z1.025
N4720 G90 G54 X3.2133 Y-2.9181
N4725 Z-.215
N4730 G01 Z-.37 F1.25
N4735 G90 G41 X3.3198 Y-2.9927 D08 F3.75
N4740 G03 X3.3375 Y-3. I.0177 J.0177
N4745 G01 X3.625 F5.
N4750 Y-2.91
N4755 X3.075
N4760 Y-3.
N4765 X3.3625
N4770 G03 X3.3802 Y-2.9927 I0 J.025
N4775 G40 G01 X3.4867 Y-2.9181
N4780 G00 Z-.215
N4785 G01 Z1.025 F19.685 M09
N4790 G00 G90 G53 G49 H0 Z0 M05
N4795 T01 M06 (1/2 EM CRB 4FL 1 LOC)
N4800 G54 G90 G94
N4805 S3000 M03
N4810 G90 X-.2225 Y-4.0975
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N4815 G43 H01 Z.125 M08
N4820 G01 Z-.225 F3.75
N4825 Y-4.01 F15.
N4830 G03 X-.1614 Y-4.0975 I.3225 J.16
N4835 G01 X-.2225
N4840 X-.1614
N4845 G02 X-.2225 Y-4.01 I.2614 J.2475
N4850 G01 Y-4.0975
N4855 G00 Z.125
N4860 Z-.125
N4865 G01 Z-.425 F3.75
N4870 Y-4.01 F15.
N4875 G03 X-.1614 Y-4.0975 I.3225 J.16
N4880 G01 X-.2225
N4885 X-.1614
N4890 G02 X-.2225 Y-4.01 I.2614 J.2475
N4895 G01 Y-4.0975
N4900 G00 Z.125
N4905 Z-.325
N4910 G01 Z-.625 F3.75
N4915 Y-4.01 F15.
N4920 G03 X-.1614 Y-4.0975 I.3225 J.16
N4925 G01 X-.2225
N4930 X-.1614
N4935 G02 X-.2225 Y-4.01 I.2614 J.2475
N4940 G01 Y-4.0975
N4945 G00 Z.125
N4950 G90 G54 X4.7225 Y-4.01
N4955 G01 Z-.225 F3.75
N4960 Y-4.0975 F15.
N4965 X4.6614
N4970 G03 X4.7225 Y-4.01 I-.2614 J.2475
N4975 G02 X4.6614 Y-4.0975 I-.3225 J.16
N4980 G01 X4.7225
N4985 Y-4.01
N4990 G00 Z.125
N4995 Z-.125
N5000 G01 Z-.425 F3.75
N5005 Y-4.0975 F15.
N5010 X4.6614
N5015 G03 X4.7225 Y-4.01 I-.2614 J.2475
N5020 G02 X4.6614 Y-4.0975 I-.3225 J.16
N5025 G01 X4.7225
N5030 Y-4.01
N5035 G00 Z.125
N5040 Z-.325
N5045 G01 Z-.625 F3.75
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N5050 Y-4.0975 F15.
N5055 X4.6614
N5060 G03 X4.7225 Y-4.01 I-.2614 J.2475
N5065 G02 X4.6614 Y-4.0975 I-.3225 J.16
N5070 G01 X4.7225
N5075 Y-4.01
N5080 G00 Z.125
N5085 G90 G54 X4.6614 Y.1475
N5090 G01 Z-.225 F3.75
N5095 X4.7225 F15.
N5100 Y.06
N5105 G03 X4.6614 Y.1475 I-.3225 J-.16
N5110 G02 X4.7225 Y.06 I-.2614 J-.2475
N5115 G01 Y.1475
N5120 X4.6614
N5125 G00 Z.125
N5130 Z-.125
N5135 G01 Z-.425 F3.75
N5140 X4.7225 F15.
N5145 Y.06
N5150 G03 X4.6614 Y.1475 I-.3225 J-.16
N5155 G02 X4.7225 Y.06 I-.2614 J-.2475
N5160 G01 Y.1475
N5165 X4.6614
N5170 G00 Z.125
N5175 Z-.325
N5180 G01 Z-.625 F3.75
N5185 X4.7225 F15.
N5190 Y.06
N5195 G03 X4.6614 Y.1475 I-.3225 J-.16
N5200 G02 X4.7225 Y.06 I-.2614 J-.2475
N5205 G01 Y.1475
N5210 X4.6614
N5215 G00 Z.125
N5220 G90 G54 X-.2225 Y.06
N5225 G01 Z-.225 F3.75
N5230 Y.1475 F15.
N5235 X-.1614
N5240 G03 X-.2225 Y.06 I.2614 J-.2475
N5245 G02 X-.1614 Y.1475 I.3225 J-.16
N5250 G01 X-.2225
N5255 Y.06
N5260 G00 Z.125
N5265 Z-.125
N5270 G01 Z-.425 F3.75
N5275 Y.1475 F15.
N5280 X-.1614
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N5285 G03 X-.2225 Y.06 I.2614 J-.2475
N5290 G02 X-.1614 Y.1475 I.3225 J-.16
N5295 G01 X-.2225
N5300 Y.06
N5305 G00 Z.125
N5310 Z-.325
N5315 G01 Z-.625 F3.75
N5320 Y.1475 F15.
N5325 X-.1614
N5330 G03 X-.2225 Y.06 I.2614 J-.2475
N5335 G02 X-.1614 Y.1475 I.3225 J-.16
N5340 G01 X-.2225
N5345 Y.06
N5350 G00 Z.125
N5355 Z1.025
N5360 G90 G54 X2.0058 Y.4485
N5365 Z.125
N5370 G01 Z-.25 F3.75
N5375 G90 G41 X2.1896 Y.2646 D01 F11.25
N5380 G03 X2.225 Y.25 I.0354 J.0354
N5385 G01 X4.4 F15.
N5390 G02 X4.75 Y-.1 I0 J-.35
N5395 G01 Y-3.85
N5400 G02 X4.4 Y-4.2 I-.35 J0
N5405 G01 X.1
N5410 G02 X-.25 Y-3.85 I0 J.35
N5415 G01 Y-.1
N5420 G02 X.1 Y.25 I.35 J0
N5425 G01 X2.275
N5430 G03 X2.3104 Y.2646 I0 J.05
N5435 G40 G01 X2.4942 Y.4485
N5440 G00 Z.125
N5445 G90 G54 X2.0058 Y.4485
N5450 Z-.15
N5455 G01 Z-.4375 F3.75
N5460 G90 G41 X2.1896 Y.2646 D01 F11.25
N5465 G03 X2.225 Y.25 I.0354 J.0354
N5470 G01 X4.4 F15.
N5475 G02 X4.75 Y-.1 I0 J-.35
N5480 G01 Y-3.85
N5485 G02 X4.4 Y-4.2 I-.35 J0
N5490 G01 X.1
N5495 G02 X-.25 Y-3.85 I0 J.35
N5500 G01 Y-.1
N5505 G02 X.1 Y.25 I.35 J0
N5510 G01 X2.275
N5515 G03 X2.3104 Y.2646 I0 J.05
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N5520 G40 G01 X2.4942 Y.4485
N5525 G00 Z.125
N5530 G90 G54 X2.0058 Y.4485
N5535 Z-.3375
N5540 G01 Z-.625 F3.75
N5545 G90 G41 X2.1896 Y.2646 D01 F11.25
N5550 G03 X2.225 Y.25 I.0354 J.0354
N5555 G01 X4.4 F15.
N5560 G02 X4.75 Y-.1 I0 J-.35
N5565 G01 Y-3.85
N5570 G02 X4.4 Y-4.2 I-.35 J0
N5575 G01 X.1
N5580 G02 X-.25 Y-3.85 I0 J.35
N5585 G01 Y-.1
N5590 G02 X.1 Y.25 I.35 J0
N5595 G01 X2.275
N5600 G03 X2.3104 Y.2646 I0 J.05
N5605 G40 G01 X2.4942 Y.4485
N5610 G00 Z.125
N5615 G01 Z1.025 F19.685 M09
N5620 G00 G90 G53 G49 H0 Z0 M05
N5625 G54 X0 Y0
N5630 M30
%
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G-code for machining bottom surface of the quick mount plate

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%
O00001
(This Post Processor is distributed on an "AS IS" BASIS, )
(WITHOUT WARRANTIES OR CONDITIONS OF ANY KIND, either express or implied. )
N5 G20 G17 G40 G80 G90
N10 T01 M06 (1/2 EM CRB 4FL 1 LOC)
N15 G54 G90 G94
N20 S3000 M03
N25 G00 G90 X-.625 Y3.85
N30 G43 H01 Z.825 M08
N35 G01 Z.625 F5.
N40 X-.1 F11.25
N45 X4.6 F15.
N50 X4.875
N55 G02 Y3.5091 I0 J-.1705
N60 G01 X4.6
N65 X-.1
N70 X-.375
N75 G03 Y3.1682 I0 J-.1705
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N80 G01 X-.1
N85 X4.6
N90 X4.875
N95 G02 Y2.8273 I0 J-.1705
N100 G01 X4.6
N105 X-.1
N110 X-.375
N115 G03 Y2.4864 I0 J-.1705
N120 G01 X-.1
N125 X4.6
N130 X4.875
N135 G02 Y2.1455 I0 J-.1705
N140 G01 X4.6
N145 X-.1
N150 X-.375
N155 G03 Y1.8045 I0 J-.1705
N160 G01 X-.1
N165 X4.6
N170 X4.875
N175 G02 Y1.4636 I0 J-.1705
N180 G01 X4.6
N185 X-.1
N190 X-.375
N195 G03 Y1.1227 I0 J-.1705
N200 G01 X-.1
N205 X4.6
N210 X4.875
N215 G02 Y.7818 I0 J-.1705
N220 G01 X4.6
N225 X-.1
N230 X-.375
N235 G03 Y.4409 I0 J-.1705
N240 G01 X-.1
N245 X4.6
N250 X4.875
N255 G02 Y.1 I0 J-.1705
N260 G01 X4.6
N265 X-.1
N270 X-.625 F11.25
N275 G00 Z.825
N280 G90 G54 X-.625 Y3.85
N285 Z.725
N290 G01 Z.62 F5.
N295 X-.1 F11.25
N300 X4.6 F15.
N305 X4.875
N310 G02 Y3.5091 I0 J-.1705
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N315 G01 X4.6
N320 X-.1
N325 X-.375
N330 G03 Y3.1682 I0 J-.1705
N335 G01 X-.1
N340 X4.6
N345 X4.875
N350 G02 Y2.8273 I0 J-.1705
N355 G01 X4.6
N360 X-.1
N365 X-.375
N370 G03 Y2.4864 I0 J-.1705
N375 G01 X-.1
N380 X4.6
N385 X4.875
N390 G02 Y2.1455 I0 J-.1705
N395 G01 X4.6
N400 X-.1
N405 X-.375
N410 G03 Y1.8045 I0 J-.1705
N415 G01 X-.1
N420 X4.6
N425 X4.875
N430 G02 Y1.4636 I0 J-.1705
N435 G01 X4.6
N440 X-.1
N445 X-.375
N450 G03 Y1.1227 I0 J-.1705
N455 G01 X-.1
N460 X4.6
N465 X4.875
N470 G02 Y.7818 I0 J-.1705
N475 G01 X4.6
N480 X-.1
N485 X-.375
N490 G03 Y.4409 I0 J-.1705
N495 G01 X-.1
N500 X4.6
N505 X4.875
N510 G02 Y.1 I0 J-.1705
N515 G01 X4.6
N520 X-.1
N525 X-.625 F11.25
N530 G00 Z.825
N535 Z1.725
N540 G90 G54 X-.2225 Y4.0975
N545 Z.72
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N550 G01 Z.47 F2.5
N555 X4.7225 F10.
N560 Y3.2095
N565 G03 X4.5 Y3.335 I-.2225 J-.1345
N570 G01 X3.75
N575 G03 X3.49 Y3.075 I0 J-.26
N580 G01 Y2.835
N585 G03 X3.75 Y2.575 I.26 J0
N590 G01 X4.5
N595 G03 X4.7225 Y2.7005 I0 J.26
N600 G01 Y1.2495
N605 G03 X4.5 Y1.375 I-.2225 J-.1345
N610 G01 X0
N615 G03 X-.2225 Y1.2495 I0 J-.26
N620 G01 Y2.7005
N625 G03 X0 Y2.575 I.2225 J.1345
N630 G01 X.75
N635 G03 X1.01 Y2.835 I0 J.26
N640 G01 Y3.075
N645 G03 X.75 Y3.335 I-.26 J0
N650 G01 X0
N655 G03 X-.2225 Y3.2095 I0 J-.26
N660 G01 Y4.0975
N665 X-.0225 Y3.8975
N670 X4.5225
N675 Y3.5344
N680 G03 X4.5 Y3.535 I-.0225 J-.4594
N685 G01 X3.75
N690 G03 X3.29 Y3.075 I0 J-.46
N695 G01 Y2.835
N700 G03 X3.3109 Y2.6979 I.46 J0
N705 G01 X3.12 Y2.6383
N710 G03 X3.75 Y2.175 I.63 J.1967
N715 G01 X4.3225
N720 Y1.775
N725 X.1775
N730 Y2.175
N735 X.75
N740 G03 X1.38 Y2.6383 I0 J.66
N745 X1.55 Y2.575 I.17 J.1967
N750 G01 X2.95
N755 G03 X3.12 Y2.6383 I0 J.26
N760 G01 X3.02 Y2.3804
N765 G03 X3.75 Y1.975 I.73 J.4546
N770 G01 X.75
N775 G03 X1.48 Y2.3804 I0 J.86
N780 X1.55 Y2.375 I.07 J.4546
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N785 G01 X2.95
N790 G03 X3.02 Y2.3804 I0 J.46
N795 G01 X3.12 Y2.6383
N800 X3.3109 Y2.6979
N805 G03 X3.75 Y2.375 I.4391 J.1371
N810 G01 X4.5
N815 G03 X4.5225 Y2.3756 I0 J.46
N820 G01 Y1.5744
N825 G03 X4.5 Y1.575 I-.0225 J-.4594
N830 G01 X0
N835 G03 X-.0225 Y1.5744 I0 J-.46
N840 G01 Y2.3756
N845 G03 X0 Y2.375 I.0225 J.4594
N850 G01 X.75
N855 G03 X1.21 Y2.835 I0 J.46
N860 G01 Y3.075
N865 G03 X.75 Y3.535 I-.46 J0
N870 G01 X0
N875 G03 X-.0225 Y3.5344 I0 J-.46
N880 G01 Y3.8975
N885 X.9693 Y3.6975
N890 X3.5307
N895 G03 X3.12 Y3.2717 I.2193 J-.6225
N900 X2.95 Y3.335 I-.17 J-.1967
N905 G01 X1.55
N910 G03 X1.38 Y3.2717 I0 J-.26
N915 X.9693 Y3.6975 I-.63 J-.1967
N920 G00 Z.72
N925 G90 G54 X-.2225 Y4.0975
N930 G01 Z.47 F2.5
N935 Y3.2095 F10.
N940 G02 X0 Y3.335 I.2225 J-.1345
N945 G01 X.75
N950 G02 X1.01 Y3.075 I0 J-.26
N955 G01 Y2.835
N960 G02 X.75 Y2.575 I-.26 J0
N965 G01 X0
N970 G02 X-.2225 Y2.7005 I0 J.26
N975 G01 Y1.2495
N980 G02 X0 Y1.375 I.2225 J-.1345
N985 G01 X4.5
N990 G02 X4.7225 Y1.2495 I0 J-.26
N995 G01 Y2.7005
N1000 G02 X4.5 Y2.575 I-.2225 J.1345
N1005 G01 X3.75
N1010 G02 X3.49 Y2.835 I0 J.26
N1015 G01 Y3.075
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N1020 G02 X3.75 Y3.335 I.26 J0
N1025 G01 X4.5
N1030 G02 X4.7225 Y3.2095 I0 J-.26
N1035 G01 Y4.0975
N1040 X-.2225
N1045 G00 Z.72
N1050 G90 G54 X3.21 Y2.835
N1055 G01 Z.47 F2.5
N1060 G02 X2.95 Y2.575 I-.26 J0 F10.
N1065 G01 X1.55
N1070 G02 X1.29 Y2.835 I0 J.26
N1075 G01 Y3.075
N1080 G02 X1.55 Y3.335 I.26 J0
N1085 G01 X2.95
N1090 G02 X3.21 Y3.075 I0 J-.26
N1095 G01 Y2.835
N1100 G00 Z.72
N1105 G90 G54 X-.2225 Y4.0975
N1110 Z.57
N1115 G01 Z.37 F2.5
N1120 X4.7225 F10.
N1125 Y3.2095
N1130 G03 X4.5 Y3.335 I-.2225 J-.1345
N1135 G01 X3.75
N1140 G03 X3.49 Y3.075 I0 J-.26
N1145 G01 Y2.835
N1150 G03 X3.75 Y2.575 I.26 J0
N1155 G01 X4.5
N1160 G03 X4.7225 Y2.7005 I0 J.26
N1165 G01 Y1.2495
N1170 G03 X4.5 Y1.375 I-.2225 J-.1345
N1175 G01 X0
N1180 G03 X-.2225 Y1.2495 I0 J-.26
N1185 G01 Y2.7005
N1190 G03 X0 Y2.575 I.2225 J.1345
N1195 G01 X.75
N1200 G03 X1.01 Y2.835 I0 J.26
N1205 G01 Y3.075
N1210 G03 X.75 Y3.335 I-.26 J0
N1215 G01 X0
N1220 G03 X-.2225 Y3.2095 I0 J-.26
N1225 G01 Y4.0975
N1230 X-.0225 Y3.8975
N1235 X4.5225
N1240 Y3.5344
N1245 G03 X4.5 Y3.535 I-.0225 J-.4594
N1250 G01 X3.75
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N1255 G03 X3.29 Y3.075 I0 J-.46
N1260 G01 Y2.835
N1265 G03 X3.3109 Y2.6979 I.46 J0
N1270 G01 X3.12 Y2.6383
N1275 G03 X3.75 Y2.175 I.63 J.1967
N1280 G01 X4.3225
N1285 Y1.775
N1290 X.1775
N1295 Y2.175
N1300 X.75
N1305 G03 X1.38 Y2.6383 I0 J.66
N1310 X1.55 Y2.575 I.17 J.1967
N1315 G01 X2.95
N1320 G03 X3.12 Y2.6383 I0 J.26
N1325 G01 X3.02 Y2.3804
N1330 G03 X3.75 Y1.975 I.73 J.4546
N1335 G01 X.75
N1340 G03 X1.48 Y2.3804 I0 J.86
N1345 X1.55 Y2.375 I.07 J.4546
N1350 G01 X2.95
N1355 G03 X3.02 Y2.3804 I0 J.46
N1360 G01 X3.12 Y2.6383
N1365 X3.3109 Y2.6979
N1370 G03 X3.75 Y2.375 I.4391 J.1371
N1375 G01 X4.5
N1380 G03 X4.5225 Y2.3756 I0 J.46
N1385 G01 Y1.5744
N1390 G03 X4.5 Y1.575 I-.0225 J-.4594
N1395 G01 X0
N1400 G03 X-.0225 Y1.5744 I0 J-.46
N1405 G01 Y2.3756
N1410 G03 X0 Y2.375 I.0225 J.4594
N1415 G01 X.75
N1420 G03 X1.21 Y2.835 I0 J.46
N1425 G01 Y3.075
N1430 G03 X.75 Y3.535 I-.46 J0
N1435 G01 X0
N1440 G03 X-.0225 Y3.5344 I0 J-.46
N1445 G01 Y3.8975
N1450 X.9693 Y3.6975
N1455 X3.5307
N1460 G03 X3.12 Y3.2717 I.2193 J-.6225
N1465 X2.95 Y3.335 I-.17 J-.1967
N1470 G01 X1.55
N1475 G03 X1.38 Y3.2717 I0 J-.26
N1480 X.9693 Y3.6975 I-.63 J-.1967
N1485 G00 Z.72
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N1490 G90 G54 X-.2225 Y4.0975
N1495 Z.57
N1500 G01 Z.37 F2.5
N1505 Y3.2095 F10.
N1510 G02 X0 Y3.335 I.2225 J-.1345
N1515 G01 X.75
N1520 G02 X1.01 Y3.075 I0 J-.26
N1525 G01 Y2.835
N1530 G02 X.75 Y2.575 I-.26 J0
N1535 G01 X0
N1540 G02 X-.2225 Y2.7005 I0 J.26
N1545 G01 Y1.2495
N1550 G02 X0 Y1.375 I.2225 J-.1345
N1555 G01 X4.5
N1560 G02 X4.7225 Y1.2495 I0 J-.26
N1565 G01 Y2.7005
N1570 G02 X4.5 Y2.575 I-.2225 J.1345
N1575 G01 X3.75
N1580 G02 X3.49 Y2.835 I0 J.26
N1585 G01 Y3.075
N1590 G02 X3.75 Y3.335 I.26 J0
N1595 G01 X4.5
N1600 G02 X4.7225 Y3.2095 I0 J-.26
N1605 G01 Y4.0975
N1610 X-.2225
N1615 G00 Z.72
N1620 G90 G54 X3.21 Y2.835
N1625 Z.57
N1630 G01 Z.37 F2.5
N1635 G02 X2.95 Y2.575 I-.26 J0 F10.
N1640 G01 X1.55
N1645 G02 X1.29 Y2.835 I0 J.26
N1650 G01 Y3.075
N1655 G02 X1.55 Y3.335 I.26 J0
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N1670 G01 Y2.835
N1675 G00 Z.72
N1680 G90 G54 X4.7225 Y.7405
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N1695 X-.2225
N1700 Y.7405
N1705 G03 X0 Y.615 I.2225 J.1345
N1710 G01 X4.5
N1715 G03 X4.7225 Y.7405 I0 J.26
N1720 G00 Z.72
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N1740 Y.0525 F10.
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N1765 G03 X4.5225 Y.4156 I0 J.46
N1770 G00 Z.72
N1775 G90 G54 X4.7225 Y.7405
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N1795 G01 X0
N1800 G02 X-.2225 Y.7405 I0 J.26
N1805 G01 Y-.1475
N1810 X4.7225
N1815 Y.7405
N1820 G00 Z.72
N1825 Z.57
N1830 G01 Z.37 F2.5
N1835 Y-.1475 F10.
N1840 X-.2225
N1845 Y.7405
N1850 G03 X0 Y.615 I.2225 J.1345
N1855 G01 X4.5
N1860 G03 X4.7225 Y.7405 I0 J.26
N1865 G00 Z.72
N1870 G90 G54 X4.5225 Y.4156
N1875 Z.57
N1880 G01 Z.37 F2.5
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N1895 Y.4156
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N1915 G00 Z.72
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N1995 G03 X2.225 Y3.325 I.0354 J.0354
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N2015 Y3.325
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N2025 G03 X2.3104 Y3.3396 I0 J.05
N2030 G40 G01 X2.4942 Y3.5235
N2035 G00 Z.72
N2040 G90 G54 X2.0058 Y3.5235
N2045 Z.62
N2050 G01 Z.445 F2.5
N2055 G90 G41 X2.1896 Y3.3396 D01 F7.5
N2060 G03 X2.225 Y3.325 I.0354 J.0354
N2065 G01 X3.2 F10.
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N2085 X2.275
N2090 G03 X2.3104 Y3.3396 I0 J.05
N2095 G40 G01 X2.4942 Y3.5235
N2100 G00 Z.72
N2105 G90 G54 X2.0058 Y3.5235
N2110 Z.545
N2115 G01 Z.37 F2.5
N2120 G90 G41 X2.1896 Y3.3396 D01 F7.5
N2125 G03 X2.225 Y3.325 I.0354 J.0354
N2130 G01 X3.2 F10.
N2135 Y2.585
N2140 X1.3
N2145 Y3.325
N2150 X2.275
N2155 G03 X2.3104 Y3.3396 I0 J.05
N2160 G40 G01 X2.4942 Y3.5235
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N2170 G90 G54 X2.0058 Y1.5635
N2175 G01 Z.52 F2.5
N2180 G90 G41 X2.1896 Y1.3796 D01 F7.5
N2185 G03 X2.225 Y1.365 I.0354 J.0354
N2190 G01 X4.75 F10.
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N2220 G40 G01 X2.4942 Y1.5635
N2225 G00 Z.72
N2230 G90 G54 X2.0058 Y1.5635
N2235 Z.62
N2240 G01 Z.445 F2.5
N2245 G90 G41 X2.1896 Y1.3796 D01 F7.5
N2250 G03 X2.225 Y1.365 I.0354 J.0354
N2255 G01 X4.75 F10.
N2260 Y.625
N2265 X-.25
N2270 Y1.365
N2275 X2.275
N2280 G03 X2.3104 Y1.3796 I0 J.05
N2285 G40 G01 X2.4942 Y1.5635
N2290 G00 Z.72
N2295 G90 G54 X2.0058 Y1.5635
N2300 Z.545
N2305 G01 Z.37 F2.5
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N2650 Y3.325
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N2705 Y2.585
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N2715 Y3.325
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N2730 G40 G01 X.6192 Y3.5235
N2735 G00 Z.72
N2740 G01 Z1.725 F19.685 M09
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N2750 T09 M06 (3/8 HSS 90DEG 4FL COUNTERSINK)
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N3160 G40 G01 X.9332 Y3.2989
N3165 G00 Z.67
N3170 G01 Z1.725 F19.685 M09
N3175 G00 G90 G53 G49 H0 Z0 M05
N3180 G54 X0 Y0
N3185 M30
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