Rotating Test Apparatus

by

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Rotating Test Apparatus

Final Design Report

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Statement of Disclaimer

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Chapter 1: Introduction

Our team, The Spins, has been designated the task of designing a Rotating Test Apparatus (RTA) for use in the development of the California Polytechnic State University San Luis Obispo Boundary Layer Data System (BLDS). The BLDS is an instrument, designed by Cal Poly professor Dr. Russell Westphal that can measure surface friction and flow velocity within a boundary layer (flow close to the surface). So far, the BLDS has only been used in applications where it has experienced linear velocity and accelerations. These applications have included wind tunnel testing and real flights in which it has been affixed to the wings of various aircraft. Dr. Westphal wants to expand the capabilities of the BLDS to applications with rotating machinery, such as wind turbines and/or helicopter blades. Before taking the BLDS into the field for expensive testing, we want to be sure that the electronics and sensors inside of it can experience the levels of centripetal acceleration that are common with these types of applications, while still collecting reliable data. Our task was to design and build a safe and effective apparatus that is capable of spinning the BLDS at speeds that will provide these large accelerations. After we confirm that the BLDS instrumentation can perform properly under high levels of centripetal acceleration, Dr. Westphal will be confident in its abilities to collect flow data on rotating components. This data will hopefully allow for advances in rotor and turbine blade design across the industry.

Chapter 2: Background

The development of the RTA will allow in-house testing of the BLDS to ensure the device is functioning properly before performing field tests to collect data. This is crucial because field-testing can be much more expensive than lab testing. If the BLDS is defective, running a test on the RTA will provide an effective way to determine what the errors may be. Also, by testing the BLDS on the RTA the user can determine if the pressure sensors and accelerometer are capable of recording quality data at rotation rates commonly seen in industry. This application serves as a fail-safe measure in the sense that before applying the BLDS to a rotating system in the field, we can be assured everything will function properly, saving both time and money.

Although there are rotating apparatus available for a wide range of applications, such as centrifuges and fans, nothing has been designed for this specific application, making this an exciting and fresh idea. The closest known existing design is the human centrifuge, which test the reactions and tolerances of pilots and astronauts at high levels of centripetal acceleration. With no competitors we are free to explore various methods of testing and lay the foundation for future systems.

Applicable codes and regulations

Protecting the hearing of the operator(s) is of high importance to this project. After some research we found that The Occupational Safety and Health Administration (OSHA) regulations state, “Hearing protectors are required when noise levels exceed the OSHA permissible exposure limit (PEL) of 90 dB measured as a time-weighted average (TWA).” These are the same standards Cal Poly follows.

Objectives

Through multiple interviews with our sponsor, we have a keen understanding of how to make this a successful project and what goals need to be met. These goals include designing, constructing, and testing a variable-speed rotating test rig with a safety factor of 3 in which a BLDS can be securely mounted to collect data. The test rig must be in an enclosed environment to ensure the safety of those operating the device as well as any bystanders. In order to best test the capabilities of the BLDS, the rig must be able to generate a centripetal acceleration upwards of 10g's while maintaining a safe environment for all involved (including hearing concerns). With a proposed life span of 5 years the rig must be easily accessible and user-friendly during both operation and maintenance to avoid prolonged service time. The design and manufacturing processes will be thoroughly documented and compiled into a comprehensive report and also a simplified users manual. This users manual will provide all instructions for operating the machine, as well as some predicted maintenance issues.

Table 1 below presents our engineering specifications as well as a few properties about them. The column labeled "risk" aims to convey the relative risk of completing each task. Tasks labeled as high risk are usually hard to accomplish, so we will be working primarily with low and medium risk specifications to begin. The column labeled "compliance" demonstrates how we plan to meet the specific requirements. The options for this column are as follows:

1. Analysis (A)
2. Test (T)
3. Similarity to Existing Designs (S)
4. Inspection (I)

Table 1. Project RTA - Formal Engineering Specifications

Spec. #	Parameter Description	Requirement or Target	Tolerance	Risk	Compliance
1	Safety Factor	3	n/a	Low	A,T
2	Impact Energy	124 Joules	Max	Med	A,T
3	Noise	90 dB	Max	Med	A,T
4	Centripetal Acceleration	10 g's	Min	Med	A,T
5	Lifetime	5 Years	Min	Med	A,I
6	Width	60 Inches	Max	Med	A,I
7	Climate Control	Variable weather conditions (hot/cold/wet/dry)	n/a	High	A,T

As seen in Table 1 above, Climate Control is the only parameter with a High-Risk assessment. Because this is beyond the scope of our project and the level of complexity involved in order to simulate multiple weather conditions is quite high, this would be an extra parameter considered once our initial requirements had been met.

The specifications are listed in order of their relative importance, as determined by our Quality Function Deployment (QFD) in Appendix A. To begin the QFD we listed all of the customer requirements that we received from Dr. Westphal. We then gave a weight value to each requirement based on our understanding of the problem. We then filled in the engineering specifications based on some initial analysis. Next, we determined the correlations between the customer requirements and the engineering specifications. The values filled in were either 9 for strong correlation, 3 for moderate correlation, 1 for weak correlation, and 0 for no correlation. The correlation values and weighting factors were then multiplied out and added up. Based on our results the margin for safety is quite high. Safety contributes to 30% of our design requirements, which correlates directly with our safety factor of 3, impact force less than 100N, and operation under 90dB. These resulting values show the importance of the specific engineering specifications, which can be seen in Appendix A.

Chapter 3: Design Development

To begin the design process, we needed to consider some general aspects of our design that would in turn affect the rest of our decisions. The first design consideration we looked at was whether to spin our apparatus about a horizontal or vertical axis. Rotating the apparatus about a horizontal axis would cause the BLDS to experience slightly different levels of centripetal acceleration throughout its rotation cycle. This change in acceleration provides both positive and negative consequences. These changes in acceleration would provide us with important data about the effects of variable levels of acceleration on the BLDS. These changing accelerations would also create cyclic loading conditions on the shaft and bearing supporting the apparatus, which is something we would like to avoid. We decided that we would like to avoid this condition of extra cyclic loading and rotate our apparatus about a vertical axis. Supporting data can be seen in Table 2 below. Later in this report we will return to the idea of collecting data on the BLDS when it is experiencing varying levels of centripetal acceleration.

Table 2. Axis of Rotation Decision Matrix

	Decision to Evaluate	Axis of Rotation	
	Options	Verticle Axis	Horizontal Axis
Qualities of this Decision	Rank	Needs Met?	Needs Met?
Eliminates Moments	3	3	1
Little Cyclic Loading	3	3	2
Cost	1	3	2
	Score	21	11

Rank:	3 = very important
	2 = important
	1 = less important
Needs Met?	3 = very true
	2 = true
	1 = fairly true

After deciding to rotate our apparatus about a vertical axis, we were able to decide on the general layout of our apparatus. As can be seen in Figure 1 below, our initial design consisted of two main boxes supported by a frame. The bottom box would house our electric motor and other electronic components (wires, speed sensor, etc.). The sides of this box would be hinged so that all components would remain accessible for maintenance. The top box would house the actual moving components of our apparatus. We planned to house this section in polycarbonate sheeting so the apparatus could be seen in operation. The top panel of the upper housing would also be hinged allowing the operator to insert and remove the BLDS, as well as perform maintenance on the system.

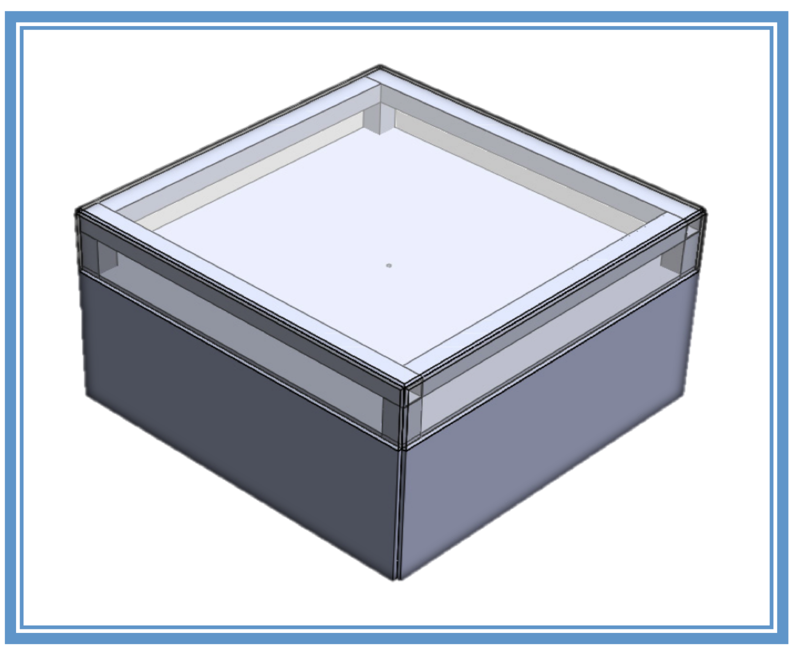


Figure 1. General Layout of Apparatus

Frame

After deciding upon the general layout of our apparatus, we began making decisions about the specifics of our design. We began by designing the frame. We initially chose to use square tubing for the frame because it provided good structure and would be relatively easy to work with and acquire. When deciding what material to use for the frame, we considered both aluminum and steel because both would give us proper structural support, while remaining aesthetically pleasing. We constructed the following decision matrix to help us decide between these two materials.

Table 3. Frame Material Decision Matrix

	Decision to Evaluate	**Frame Material**	
	Options	**Aluminum**	**Steel**
Qualities of this Decision	**Rank**	**Needs Met?**	**Needs Met?**
Rigid	3	3	3
Aesthetically Pleasing	2	3	3
Cost	2	3	2
	Score	21	19

Rank:	3 = very important
	2 = important
	1 = less important
Needs Met?	3 = very true
	2 = true
	1 = fairly true

As can be seen above in Table 3, a frame built from aluminum would be cheaper than a frame constructed from steel. These results, in addition to the fact that aluminum is very easy to machine, lead us to choose square aluminum tubing for the frame of our apparatus. After doing some more research we were able to find the following types of structural aluminum square tubing from McMaster Carr.

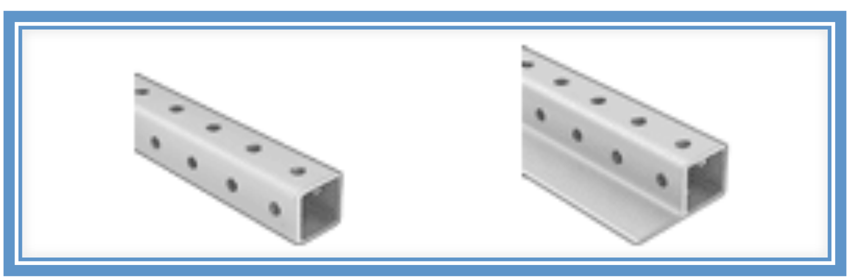


Figure 2. Examples of structural aluminum

Shown above in Figure 2 are two choices of aluminum square-tubing that we found from McMaster Carr. The unique thing about this specific tubing is that is comes with pre-drilled bolt-

holes. This would make the assembly of our apparatus much simpler, as well as make it possible for someone in the future to take it apart to possibly move it or perform some maintenance. The tubing shown on the right is the same, but it included a built in flange. We would be using this for the bottom square of the frame. The purpose of this would be to allow us to bolt (or otherwise attach) our apparatus to a table or lab bench. By fixing the apparatus to a table, we would be able to ensure that it is safely locked in place and would not be able to move during operation. Our initial concept for the frame is shown below in Figure 3.

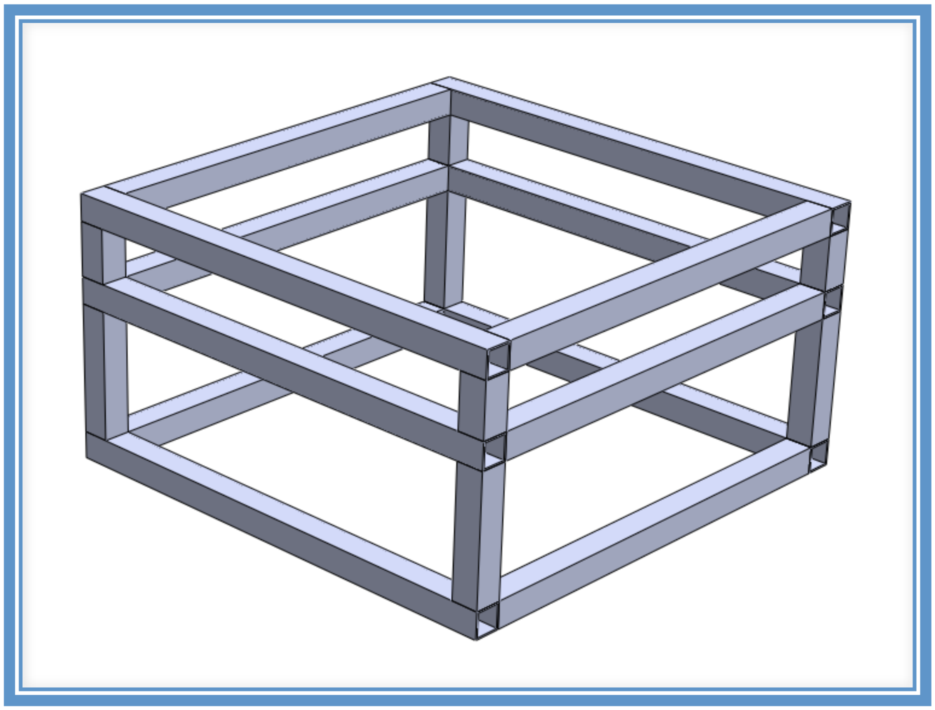


Figure 3. Concept Design of Frame

Housing

After constructing the frame of the Rotating Test Apparatus, we needed to attach the housings for each of the two sections of our machine. For the bottom section, (housing the motor and electrical components), we chose to use ⅛" aluminum sheets. We chose this material because, once again, aluminum is cheap and easy to work with. We felt this will also provide a streamlined, aesthetically pleasing look for our initial design.

Our material decision for the top section was a bit more involved. We wanted to select a transparent material so that the user can observe the machine while it is in operation. In addition to being transparent, the material for the top housing must be very impact resistant. This criterion comes from the fact that if the BLDS were to come loose from the spinning apparatus during

operation, it would essentially become a projectile headed directly for the housing. After investigating options such as acrylic and ABS plastic sheets, we came across polycarbonate. Polycarbonate is unique amongst transparent materials because it is extremely impact resistant. The only downside to polycarbonate is that it is very prone to scratching. After some investigation, however, we found a number of companies that make scratch resistant coatings for polycarbonate. After finding these scratch resistant coatings, we decided that polycarbonate sheets would be the perfect material to house the top part of our apparatus.

Disk vs. Blade

When coming up with our concept design choices for what we are going to rotate, we had to make sure a few criteria were met. First of all, our rotating element must have the capability to support the BLDS as well as various counterweights. Secondly, the surface on which the BLDS will sit must be flat because the BLDS takes the most accurate measurements the closer it is to the surface on which it lies, making our test apparatus a viable source of replication for field applications. This eliminates any rotation of curved surfaces, such as a rod. Intuitively, our concepts were broken down to either a disk or blade, seen in Figures 4 and 5 below. Both are proven to work in a multitude of applications similar to ours, such as centrifuges or ceiling fans, making them both strong contenders for our application.

We initially figured a 16” x ⅛” thick disk to be our top choice for various reasons. Because of the geometry and large surface area the disk is rigid enough to support the BLDS and counterweight without much strain, but material choice would ultimately define the impact during operations. Unlike a blade, a disk won’t generate any lift. This is important to consider because generating lift would cause unnecessary stress and strain on our rotating element, lowering the overall lifespan of our apparatus.

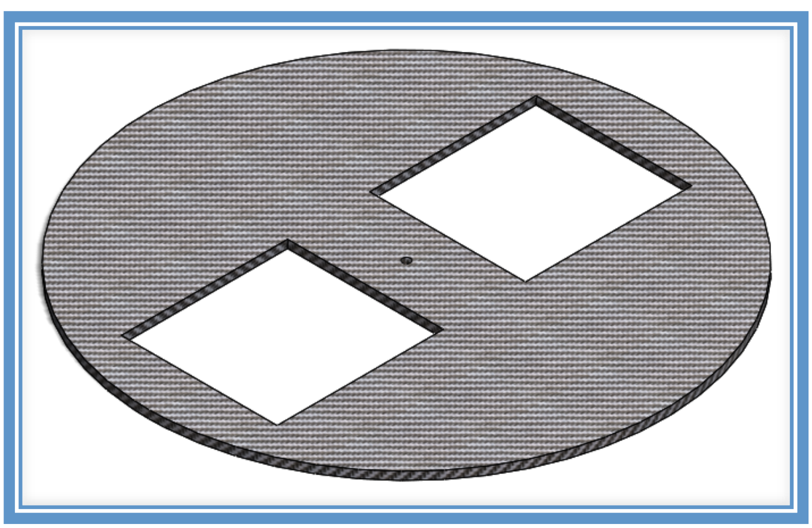


Figure 4. Disk Concept Design

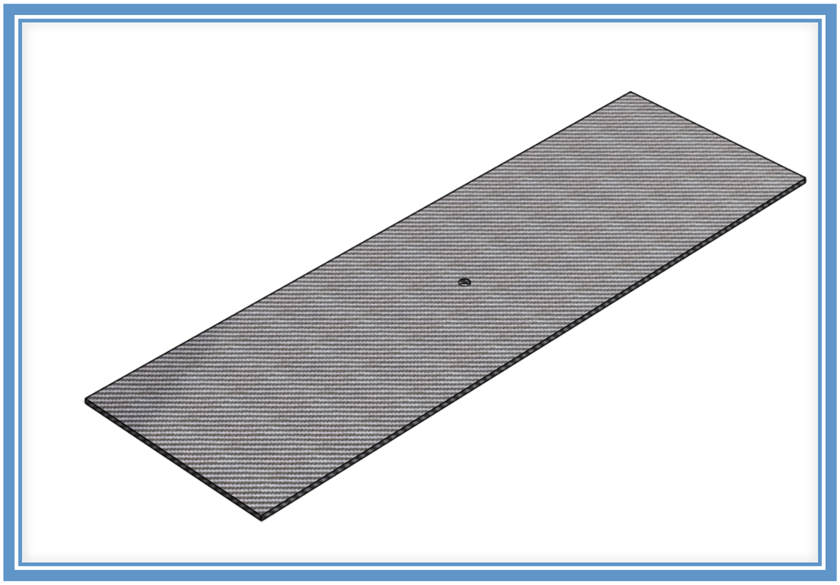


Figure 5. Blade Concept Design

Material Choice

Table 4 below shows a comparison between our top material choices as well as their respected costs based on our concept designs. Aluminum and carbon fiber served as excellent choices for our application due to the fact that they're low in weight (low densities) and high enough in stiffness for our loading conditions. The major difference between the two is the cost: carbon fiber is considerably more expensive than aluminum, which is explained further below. Although we are not currently restricted by our budget, we felt that choosing the most cost effective option is still good practice, so aluminum was the material of choice.

Table 4. Material Comparison

Cost	Weight (lbm)	Material / Geometry
$100	2.5	Aluminum Disk
$50	1.0	Aluminum Blade
$450	1.8	Carbon Fiber Disk
$200	0.72	Carbon Fiber Blade

Motor and Drive Components

We had initially decided to drive our apparatus with a DC Servomotor with an external microcontroller. The microcontroller, as seen below in Figure 6 would be ran through a direct connect to a computer in which the user could input a set of commands to run the motor at various speeds. Our initial attraction to this was it would allow more variability and control over the dynamic parameters of our apparatus, as opposed to an external controller.

Figure 6. Arduino Microcontroller

Concept Design Selection

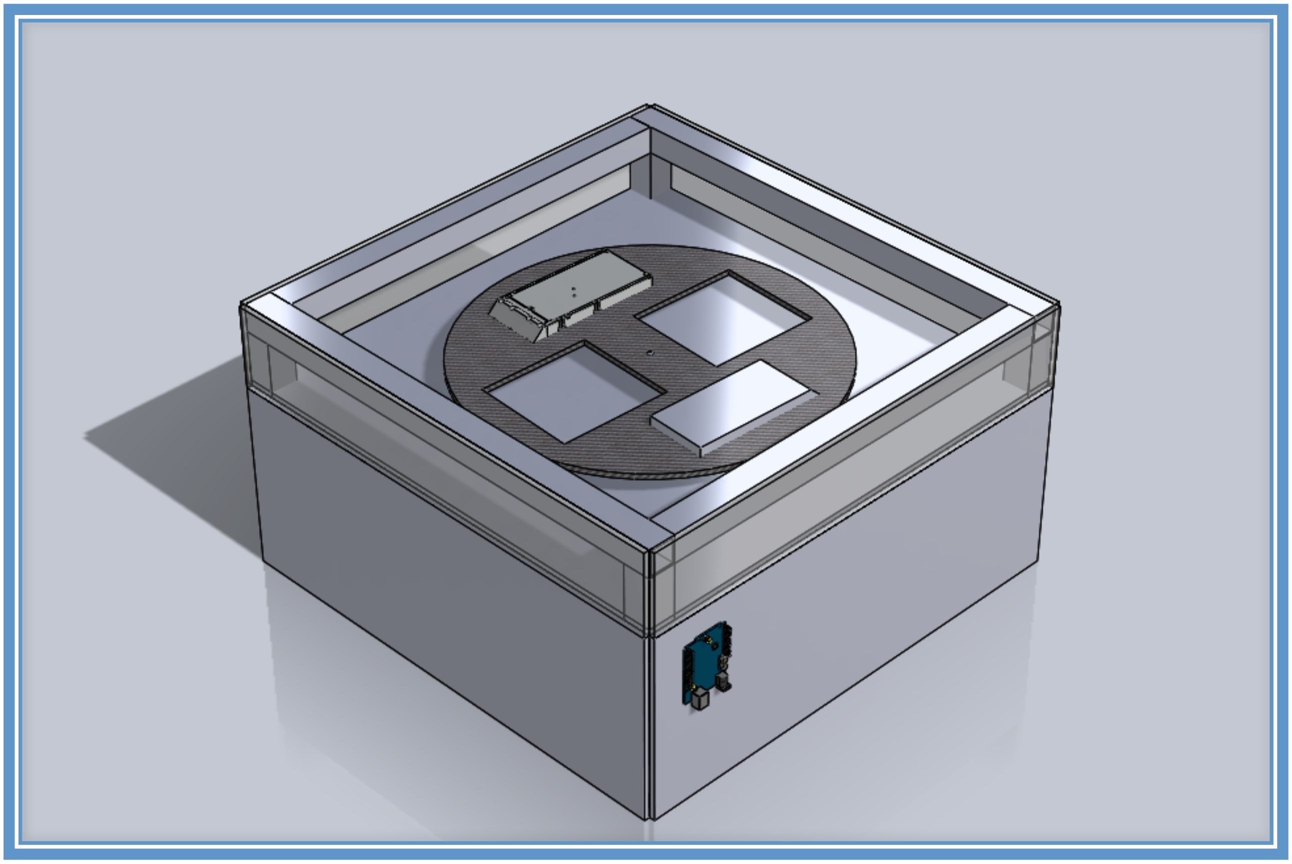


Figure 7. Concept Design For Rotating Test Apparatus

Our initial concept design is shown above in Figure 7. The frame and housings can be seen, along with a mounted disk. A BLDS and a counterweight are each mounted on the disk for rotor balance.

Chapter 4: Final Design

The final design encompasses many components considered in our conceptual design. These components include a disk, aluminum frame/housing, polycarbonate sheeting, and a DC motor. Each component was decided on by comparing them to a multitude of similar options and specific properties that are necessary for optimal performance. Our final design can be broken down into 3 main components: Frame/Housing, Drivetrain, and Devices. These components are labeled in our full assembly as seen in Figure 8 below.

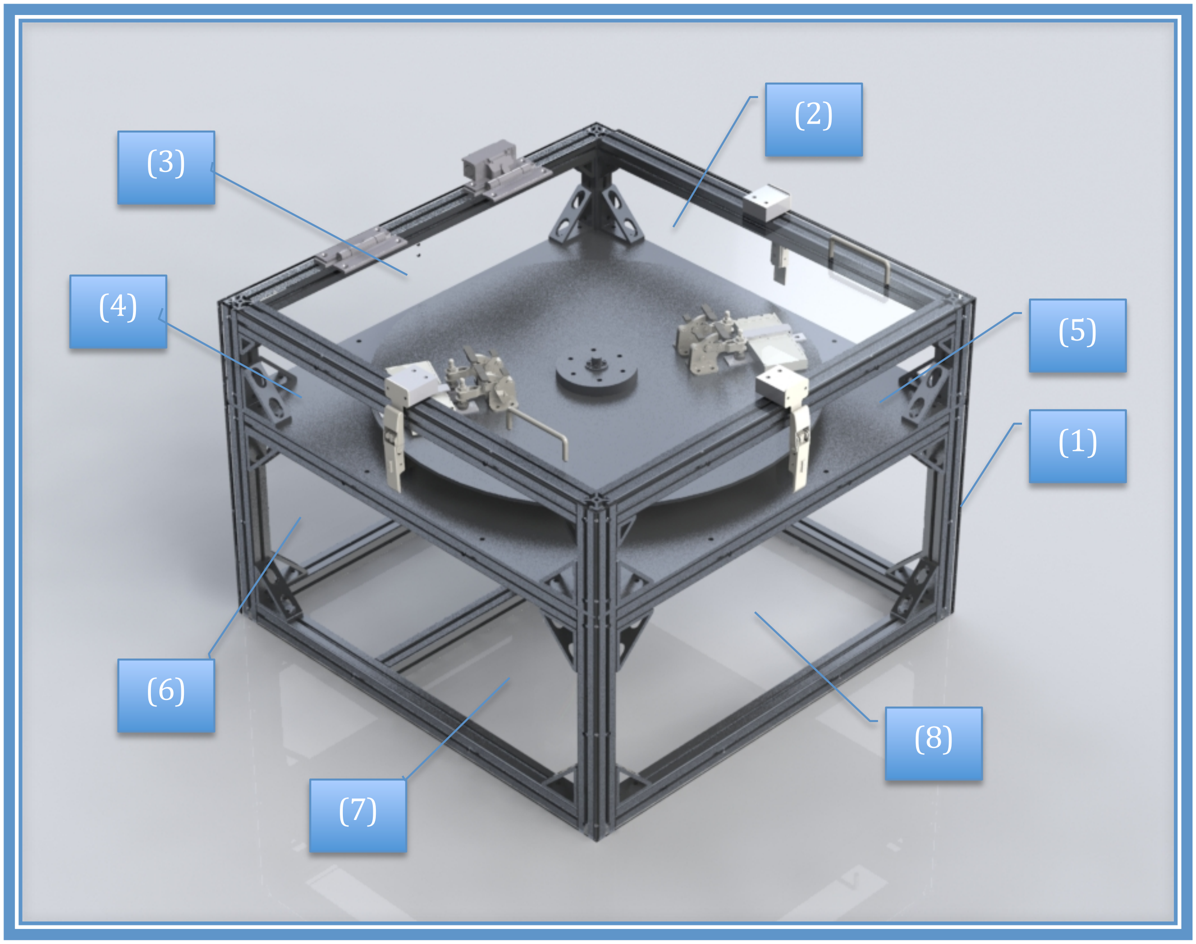


Figure 8. Full Assembly including (1) Frame Assembly, (2) Lid Assembly, (3) Drive Assembly, (4) Side Housing-Top, (5) Font Housing-Top, (6) Expanded Steel Housing, (7) Side Housing-Bottom, (8) Front Housing-Bottom

4.1 Frame/Divider

During the initial design phases of this project, we planned to use simple aluminum square tubing to create the frame for our apparatus. After presenting our conceptual design, we learned about T-slotted extrusions, shown to the right in Figure 9. After doing some research, we found that the T-slotted extrusions are much more customizable, while still providing the necessary structural support for the machine. Shown below in Table 5 is a decision matrix referring to the choice between T-slots and aluminum square tubing.

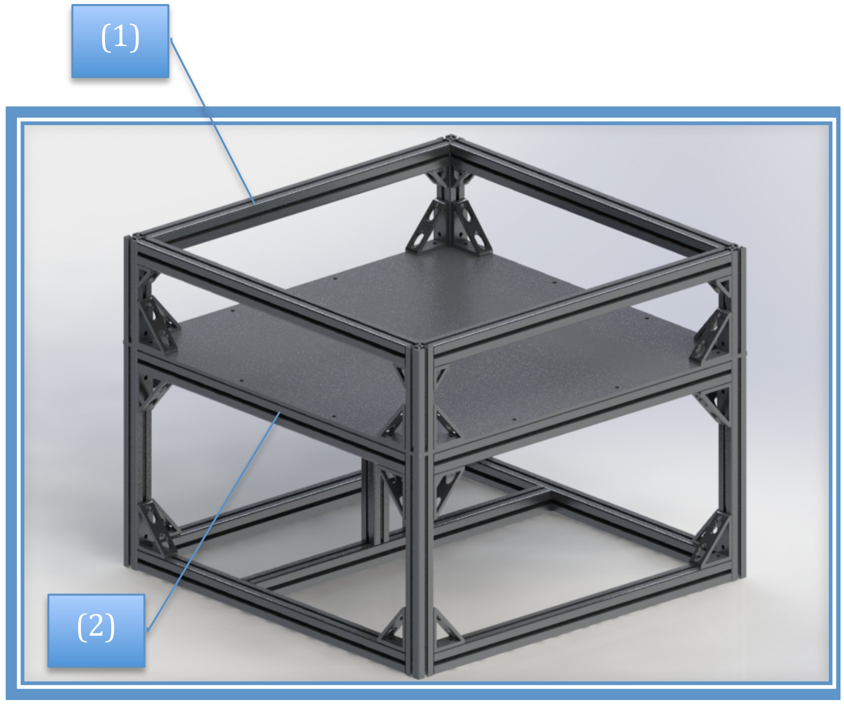


Figure 9. Frame (1) & Divider (2) Assembly

After deciding upon the frame material, we needed to decide how to attach the extrusions together. We found that the manufacturer of the T-slotted extrusions that we were planning on buying offers a wide variety of brackets and hardware for the purpose of making frames out of the T-slots. We have decided upon 4-hole inside corner gussets (shown below in Figure 10) to hold the frame together

Finally, we wanted to separate the spinning disk components of the apparatus from the motor and speed sensor components. For this application, we decided on a ¼" thick aluminum plate that will attach directly to the frame. This sheet protects the components from each other, as well as provide a sturdy surface to mount the bearings on.

Figure 10 – T-slotted Extrusion (1) and Inside Corner Gusset (2)

Table 5. Framing Decision Matrix

	Decision to Evaluate	Frame Type	
	Options	T-Slots	Aluminum Square Tubing
Qualities of this Decision	Rank	Needs Met?	Needs Met?
Ease of Assembly	3	3	2
Rigid	3	3	3
Adjustable	2	3	2
Cost	1	2	3
	Score	26	22

Rank:	3 = very important
	2 = important
	1 = less important
Needs Met?	3 = very true
	2 = true
	1 = fairly true

4.2 Housing

After designing the frame of our apparatus, we looked towards designing a housing to protect users from rotating parts. We decided that we needed to house the components above and below the aluminum divider, because there are rotating components in both areas, as well as some electrical components below the divider. Even though our apparatus will be housed, we wanted the user to be able to see the operation for educational purposes. We decided to use ¼" polycarbonate sheeting to house our components. We decided on polycarbonate because it is a clear material with extremely high impact resistance and it is easy to machine. These polycarbonate sheets were bolted directly to the T-slot frame. One side of the bottom housing is made of expanded steel to provide protection, but also allow ventilation to the motor to avoid overheating.

4.3 Drive Components

Our drivetrain consists of a series of 7 different components: DC motor (1), extension shaft (2), coupling (3), bearings (4), bushing (5), hub (6), and disk (not shown). Each component plays a vital role and can be seen in the assembled drivetrain in Figure 11 to the right. Supporting calculations for each component can be seen in section 4.5.1

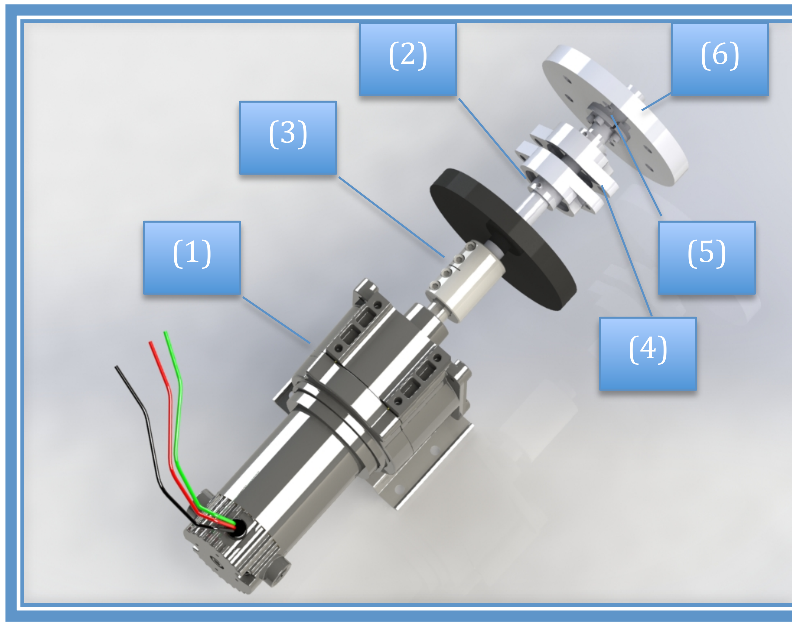


Figure 11. Drive-Train Assembly

4.3.1 Motor Selection

Our first and most difficult component selection was the motor. The motor we used is a DC integrated gear head motor provided by Bison, which can be seen in Figure 12 below. This 1/8 hp motor is rated at 20 in-lbs. of torque, meeting our required value of 5.9 in-lbs. and exceeding our safety factor of 3. It has a side-plate that will allow for easy vertical mounting which will allow us to achieve our desired axis of rotation. With a max RPM of 360 and voltage of 130 we will be able to easily control the output speed with the assistance of an external speed controller. Table 6 below verifies our decision against competing motors.

Figure 12. Bison DC Integrated Gear head Motor

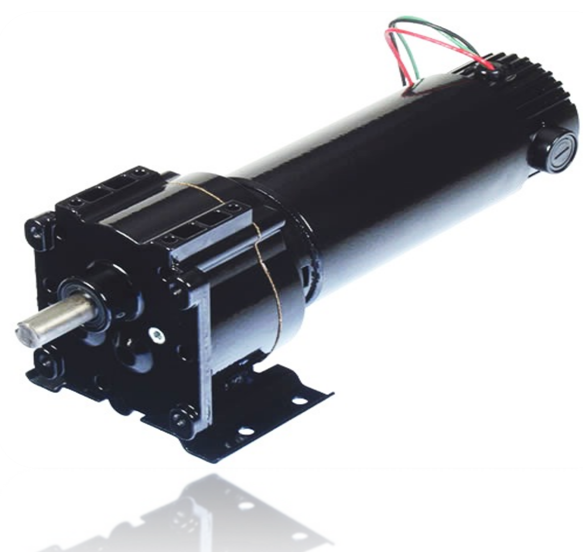


Table 6. Motor Selection Decision Matrix

	Decision to Evaluate	Motor Selection		
	Options	DC Integrated Gear head Motor	DC Coupled Gear head Motor	Stepper Motor
Qualities of this Decision	Rank	Needs Met?	Needs Met?	Needs Met?
Ease of Mounting	3	3	2	2
Manufacturability	2	3	1	1
Speed Control	2	2	3	2
Cost	2	2	1	2
Accessories	1	3	2	2
	Score	26	18	18

Rank:	3 = very important
	2 = important
	1 = less important
Needs Met?	3 = very true
	2 = true
	1 = fairly true

4.3.2 Extension Shaft / Coupling

In order to meet the required clearances and allow sufficient room for device applications, an extension shaft was implemented, as seen in Figure 13 to the right. The 7in, 5/8in diameter shaft was machined out of 6061–T6 aluminum. To connect the shaft to the stock 2in keyed shaft we implemented a shaft coupling with a machined keyway to insure a secure bond and a total shaft length of 9in. A 5/8in diameter shaft allows us to meet our safety factor considerations in both our bearing and bushing selections from the manufacturer's rating.

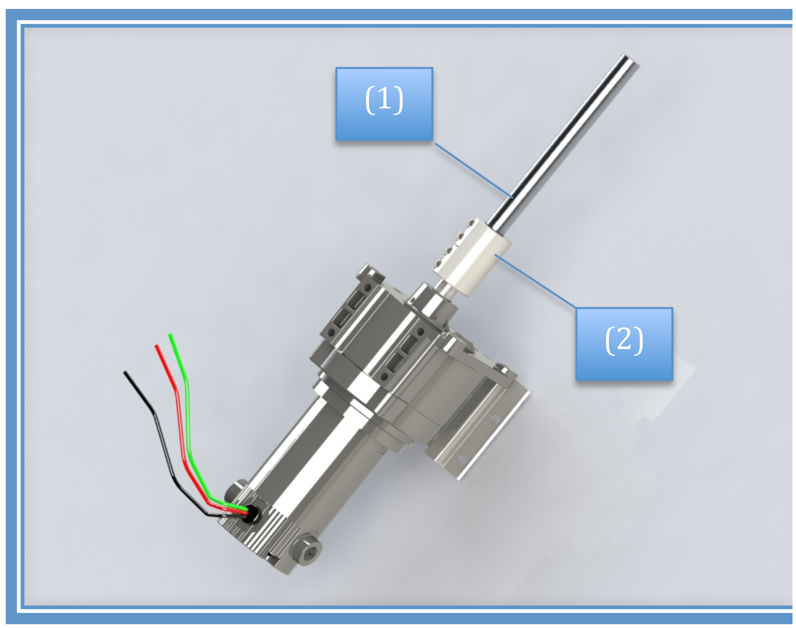


Figure 13. Extension Shaft (1) & Coupling (2)

In order to prevent any potential wear to the stock motor shaft and the extension shaft the correct method of coupling had to be determined. We used a single-piece clamp-on coupling, as seen in Figure 14 below, as opposed to a screw-on coupling to prevent any shaft-bite from the screws. The keyed shaft fit snug inside the keyed coupling, adding additional locking support and adding to the torque-carrying capacity of the coupling. The single-piece coupling is rated to hand a working torque of 1322 in-lbs., easily exceeding our safety factor consideration of 3. Table 7 below verifies our decision.

Table 7. Extension Shaft Attachment Method Decision Matrix

	Decision to Evaluate	Extension Shaft Attachment Method	
	Options	Clamp-On Coupling	Set-Screw Coupling
Qualities of this Decision	Rank	Needs Met?	Needs Met?
Meets Torque Rating (SF=3)	3	3	3
Zero Shaft Misalignment	3	3	3
Doesn't Damage Shaft	3	3	1
Ease of Assembly	2	3	3
Cost	1	3	3
	Score	36	30

Rank:	3 = very important
	2 = important
	1 = less important
Needs Met?	3 = very true
	2 = true
	1 = fairly true

Figure 14. Single Piece Clamp-On Coupling

4.3.3 Bearings

In order to support the axial load and relieve stresses in the motor and shaft, we implemented a set of angular contact bearings. The bearings were aligned together to support both axial loads as well as provide shaft stability during operation. This will prevent unnecessary shaft wobble and insure proper shaft alignment. The bearings chosen, as seen below in Figure 15, are Light 2-Bolt Flanged bearings that have a basic static load rating of 1500 lbs. and a dynamic load rating of 2877 lbs., exceeding our predicted load of 40lbs. Because the bearings chosen are pre-lubed, they require no maintenance when put in place. Other bearings were considered but were deemed too heavy and industrial for our purposes. Table 8 below verifies our decision.

Table 8. Bearing Selection Decision Matrix

	Decision to Evaluate	Bearing Selection		
	Options	Light 2-Bolt Flange Pre-Lubed (FYH)	2-Bolt Flange (SKF)	2-Bolt Flange (Timken)
Qualities of this Decision	Rank	Needs Met?	Needs Met?	Needs Met?
Light-Weight	3	3	1	1
Load Capacity (SF=3)	3	3	3	3
Zero Maintenance	3	3	3	3
Ease of Assembly	2	3	3	3
Cost	1	3	2	2
	Score	36	29	29

Rank:	3 = very important
	2 = important
	1 = less important
Needs Met?	3 = very true
	2 = true
	1 = fairly true

Figure 15. Light 2-Bolt Flange Pre-Lubed Bearing

4.3.4 Bushing / Hub

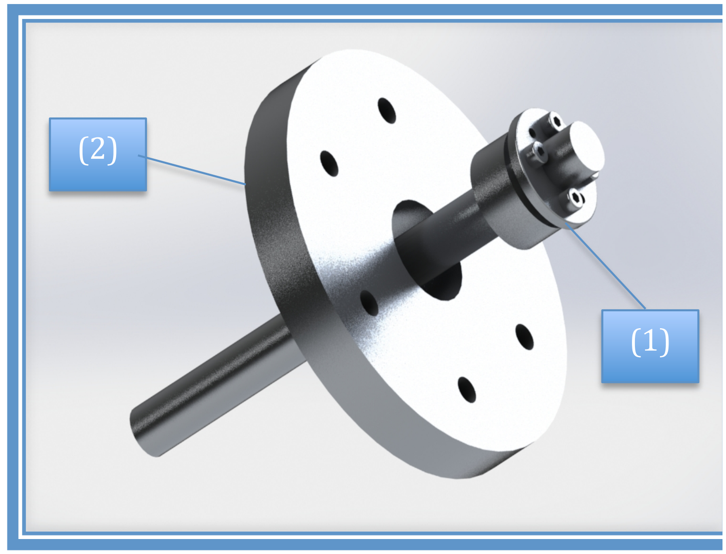


Figure 16. Bushing (1) & Hub (2)

In order to mount the extension shaft to the disk we used a B-LOC bushing in correlation with an in-house manufactured hub, which can be seen in Figure 16 to the right. We initially considered a direct-connect by either welding or press fitting the disk onto the shaft, but both deny the ease of maintenance. The B-LOC bushing, seen alone in Figure 17 below, is the simplest and most practical way to mate the two components together without making any permanent bond. It provides a high capacity, zero-backlash shaft to hub connection for our 5/8 in diameter shaft. It requires very little torque to install (~3.5 ft-lbs.) yet can transmit up to 55 ft-lbs. of torque. This meets our safety factor consideration of 3 and proves to be the best choice as seen in Table 9 below. The ¾ in thick, 5 in diameter hub will provide an adequate amount of surface area for the bushing to rest inside, allowing the bushing to transmit the maximum amount of torque.

Table 9. Disk-Shaft Attachment Method Decision Matrix

	Decision to Evaluate	Disk-Shaft Attachment Method		
	Options	B-LOC Bushing	Press-Fit	Weld
Qualities of this Decision	Rank	Needs Met?	Needs Met?	Needs Met?
Ease of Manufacturability	3	3	2	2
Ease of Maintenance	2	3	1	1
Cost	1	2	3	2
	Score	17	11	10

Rank:	3 = very important
	2 = important
	1 = less important
Needs Met?	3 = very true
	2 = true
	1 = fairly true

Figure 17. B-LOC Bushing

4.4 Disk / Devices

4.4.1 Disk

The disk serves as an optimal geometry for our purposes. We out-sourced a 28" diameter 6061-T6 aluminum disk with a ¾ in diameter center hole for the shaft/bushing connection, which can be seen in Figure 18 to the right. Because of the geometry and large surface area the disk is rigid enough to support the BLDS and counterweight without much strain, but material choice would ultimately define its effects on the entirety of the system. The disk diameter size and material of choice is validated below in Tables 10 and 11.

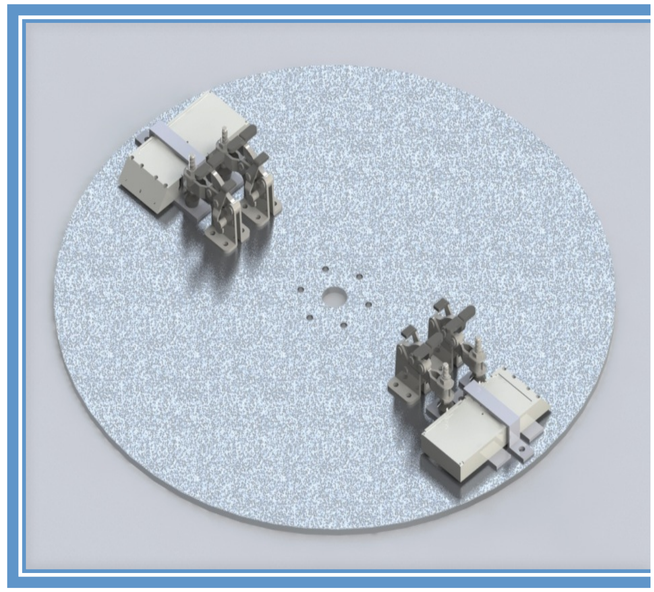


Figure 18. Aluminum Disk

Table 10. Disk Diameter Size Decision Matrix

	Decision to Evaluate	**Disk Diameter Size**		
	Options	**28"**	**48" (max.)**	**16" (min.)**
Qualities of this Decision	**Rank**	**Needs Met?**	**Needs Met?**	**Needs Met?**
Ease of Manufacturability	3	3	1	3
Light-Weight	2	2	1	3
Table Room	2	3	1	3
Longevity of Motor Life	2	2	3	1
Room for Customizing	2	2	3	1
Cost	1	2	1	3
	Score	29	20	28

Rank:	3 = very important
	2 = important
	1 = less important
Needs Met?	3 = very true
	2 = true
	1 = fairly true

Table 11. Disk Material Decision Matrix

	Decision to Evaluate	**Disk Material**		
	Options	**Aluminum**	**Carbon Fiber Composite**	**Steel**
Qualities of this Decision	**Rank**	**Needs Met?**	**Needs Met?**	**Needs Met?**
Stiffness	3	3	3	3
Ease of Manufacturability	3	3	1	2
Light-Weight	2	2	3	1
Cost	1	2	1	2
	Score	24	19	19

Rank:	3 = very important
	2 = important
	1 = less important
Needs Met?	3 = very true
	2 = true
	1 = fairly true

4.4.2 Toggle Clamps / Bracket

We used 2 toggle clamps provided by Mc Master-Carr and a custom bracket to mount the BLDS to the disk. Each clamp, as seen assembled in Figure 19 and alone in Figure 20, has a maximum holding capacity of 750lbs applied directly to the mounting feet on the BLDS. As an added safety measure we will include an overhead bracket as a fail-safe in the case that both clamps should release during operation. This will allow the user to assess the situation and shut off the power to the motor before the BLDS is thrown from the rotating disk.

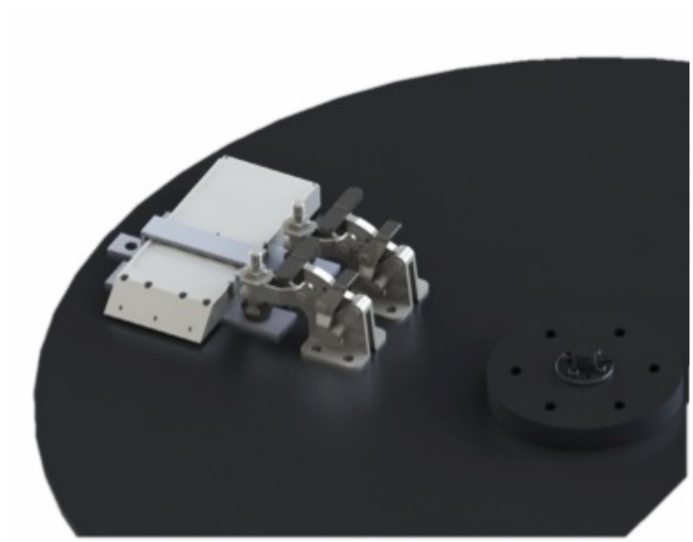


Figure 19. Clamps on Disk

4.4.3 Counterweight

A counterweight with a specified weight equal to the load of the BLDS and accompanying components multiplied by the distance to the center will be mounted to the disk. This counterbalancing weight will help reduce rotor imbalances and excess vibration throughout the system. A mock drawing is provided in Figure 21 below.

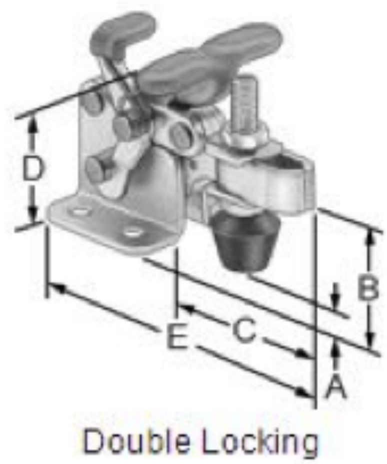


Figure 20. Toggle-Clamp

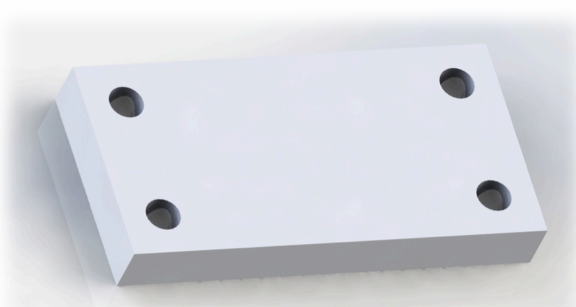


Figure 21. Counterweight

4.4.4 Safety Hinge

For added safety a hinge-actuated access safety switch, as seen in Figure 22 to the right, will replace a normal hinge on the lid of the apparatus. When the hinge rotates at least 4 degrees, the normally closed contacts open and shut off the power to the motor. In other words, this will prevent a user from operating the machine while the lid is open, eliminating the potential for an accident to happen. This specific hinge provided by Mc Master-Carr is designed to work with machine guards constructed from aluminum T-slotted framing, allowing for easy installation.

Figure 22. Safety Hinge

4.4.5 Speed Controller

We used a Bison Tight-Drive as the speed controller in conjunction with the motor, as seen in Figure 23 to the right. This 1/8 in, 90V driver converts AC to DC through a direct connect into any common outlet. The wires provided in the motor connect directly to the drive, allowing motor voltage control. Three adjustable potentiometers provide settings for minimum RPM, maximum RPM, and current limit.

Figure 23. Bison Tight-Drive

4.4.6 Speed Sensor / Pulser Disk / Tachometer

To verify the output shaft speed during operation we will implement a speed sensor and its complementary components. The speed sensor, as seen in Figure 24, will sense the rotation rate of a pulser disk, as seen in Figure 25, as it rotates with the extension shaft. The speed sensor is connected to a tachometer, as seen in Figure 26, which will provide a digital readout of the RPM's of the shaft. This will allow the user to verify the input speed with the output speed of the shaft and allow them to note any discrepancies with the apparatus. The full assembly can be seen in Figure 27.

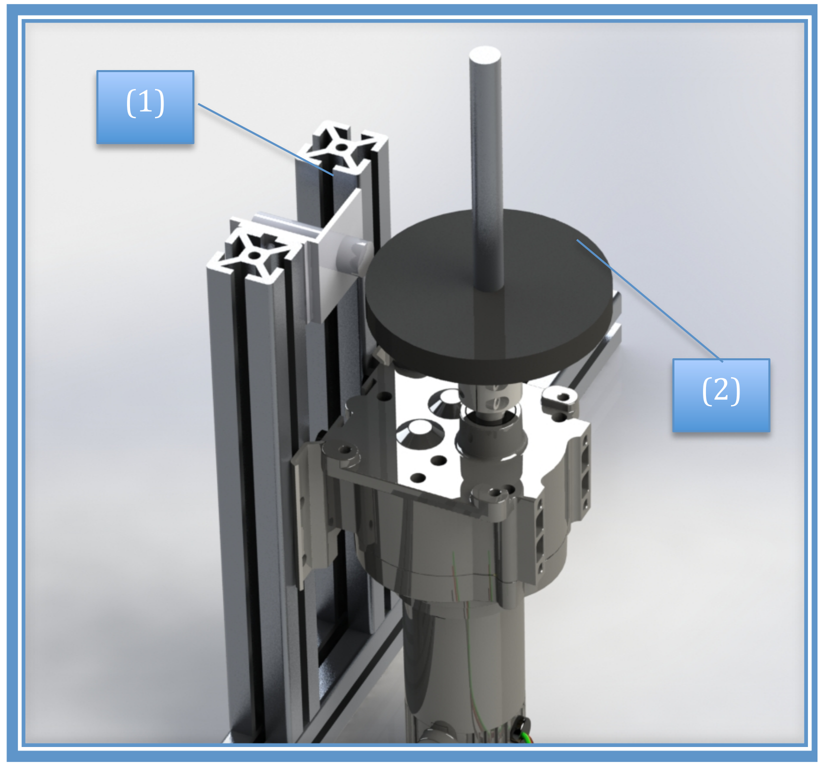


Figure 24. Speed Sensor (1), Pulser Disk (2)

Figure 25. Speed Sensor

Figure 26. Pulser Disk

Figure 27. Tachometer

4.5 Analysis Results

To ensure proper operation of our apparatus, we needed to perform some analysis. Specific areas that we analyzed were: torque requirement, disk deflection, energy absorption of polycarbonate, clamping force required to hold BLDS.

4.5.1 Torque Requirements

We found that in order to get our disk spinning to the required speeds in approximately one second we needed 5.9 in-lbs. of torque.

$$\tau = \frac{\rho \cdot \pi^2 \cdot r^4 \cdot h \cdot \frac{W}{t}}{60}$$

τ_{MOTOR} = 20 in-lbs.

$\tau_{REQUIRED}$ = 5.9 in-lbs.

Variables:

τ = Torque

ρ = Density of 6061 Aluminum

r = Radius of Disk

h = Thickness of Disk

W = Angular Velocity

t = Time

Meets Safety Factor of 3 ✓

4.5.2 Disk Deflection

To verify the disk wouldn't deflect beyond the allowable clearance to the top of the divider (2in), we modeled our system as a cantilever beam constrained at the center of the disk as seen in Figure 28 to the right.

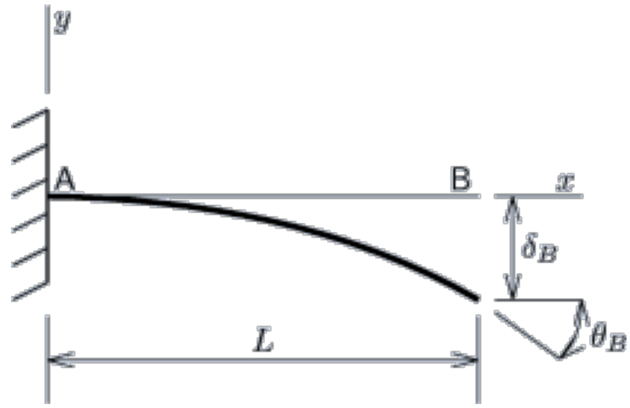


Figure 28. Cantilever Beam Bending

$$\delta_B = \frac{FL^3}{3EI}$$

δ_B = 0.07” < 2.00” Clearance

Max Allowable Load = 28.00 lbf

Max Allowable Radius = 42.00”

Variables:
δ = Deflection of the Disk
F = Force
L = Radius of Disk
E = Modulus of Elasticity (Aluminum)
I = Mass Moment of Inertia

Meets Safety Factor of 3 ✓

4.5.3 Polycarbonate Impact Resistance

From some experimental data provided by a manufacturer of polycarbonate we verified that if the BLDS were to come loose during operation it would not damage the polycarbonate.

$$K.E. = 1/2 \cdot m \cdot (r \cdot \omega)^2$$

$K.E._{MAX} = 275$ ft-lb

Variables:
K.E. = Kinetic Energy
m = Mass
r = Radius
w = Angular velocity

$K.E._{BLDS} = 5.21$ ft-lbs

Meets Safety Factor of 3 ✓

4.5.4 Clamping Power

Finally, we found that the 350 pounds of clamping force provided by our clamps is more than enough to hold the BLDS on to the disk. The detailed analysis for these calculations can be seen below.

Required Clamping Force = F/μ

Required Clamping Force = 15 lbf.

Variables:
F = Friction Force
μ = Coefficient of Friction Force

Meets Safety Factor of 3 ✓

4.6 Procurement & Cost Analysis

The materials for the Rotating Test Apparatus will be purchased from several different locations. Each component has its accompanying supplier, size, quantity, individual and combined costs. The material/manufacturing sourcing and the quantities of each material may change, but Appendix C serves as a good representation of a total cost estimation.

4.6 Manufacturing Plan

Our manufacturing plan is very straightforward. To begin, we acquired all of our raw materials and specific components from various suppliers (Appendix E). We outsourced the manufacturing of our 6061 aluminum disk due to the complexity of the geometry and lack of machinery capable of such cuts. Other components, such as the hub and lid connectors were machined in-house. The polycarbonate sheeting was then drilled and cut to size. After all of the machining was completed, the process of assembling the various parts together as instructed in the assembly drawings in Appendix B commenced.

We faced a number of issues throughout the manufacturing process. The polycarbonate sheeting acquired wasn't cut to the appropriate size, so we had to alter the positioning of some of the panels to allow for proper fits. We also had issues with the bars-stock received from McMaster Carr. The amount of bar-stock needed for the lid mounts was underestimated as well as the geometry (wasn't completely square). After ordering another bar and a bit of machining, the bar was cut to size and implemented into the design. Lastly, the biggest issue we encountered was the overall geometry of the disk. Our initial disk was cut out of 5052 Aluminum, which turned out to be too uneven. In other words, there was significant wobble during operation. This is due to the initial manufacturing process of the aluminum in which 5052 is rolled into large rolls, so our disk was inherently off-kilter. Once deemed unusable, we outsourced another disk made out of 6061 Aluminum, due to the difference in initial manufacturing. Our disk turned out to be more flat, but still it produced significant wobble during operation. We've concluded that due to the size of the disk it would be extremely difficult to acquire a disk that size while also being completely flat. Possible solutions involve designing a smaller disk and running the machine at a faster speed (which our motor is capable of). Or, a different material, such as a carbon fiber composite, could be used for a more precise geometry. Overall, we don't expect the small oscillatory effects to effect the data collection from the BLDS. Our final design can be seen below in Figure 29.

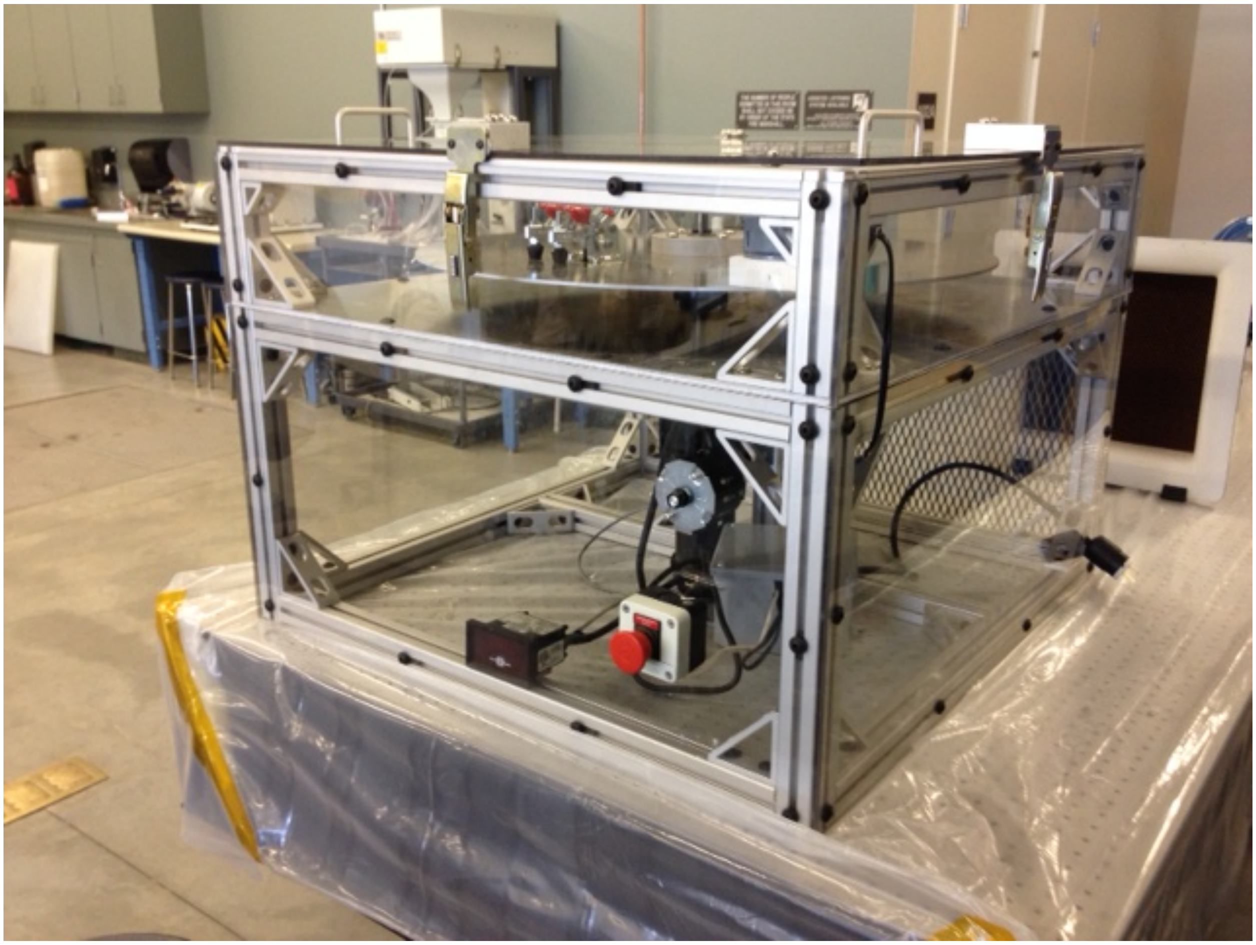


Figure 29. Final Assembly of the RTA

Chapter 5. Design Verification Plan

To insure we are satisfying all of the design specifications and requirements we performed a variety of component and system checks. Some included verifying manufacturers ratings whereas others verified our calculations and initial assumptions. The tests performed were as follows:

1. Speed Verification
2. G-Force Verification
3. Vibrations
4. Noise
5. Polycarbonate Impact Rating
6. Clamp Strength

5.1 Speed Verification

We verified the output speed of the shaft during multiple stages of operation. The importance of this was to insure accurate data collection and to verify the user's RPM input. We mounted a speed sensor directly to the frame of the apparatus where it provided a digital readout to a tachometer mounted inside the apparatus. As the motor shaft rotated, the laser from the speed sensor sensed each rotation of a small pulser disk, which was attached directly onto the shaft itself. Not only will the user be able to control the speed of the motor with the Bison Tight-Drive, they will also be able to verify it with this speed-sensing assembly.

5.2 G-Force Verification

One of the most critical aspects of this apparatus is that it must have the capabilities to induce a minimum of 10g's on the BLDS. Although the BLDS has such capabilities, we don't have the means of checking the data without proper guidance. This verification has been left in the appropriate hands of Dr. Russ Westphal through the use of the BLDS. This will verify at exactly what speed is necessary to induce the required 10g minimum on the BLDS.

5.3 Vibrations

Due to the overall mass of the apparatus and low operating speed with little inertial effects, vibration wasn't an issue. The motor can operate at maximum capabilities with little to no vibrational effects.

5.4 Noise

As specified in our design requirements we had to design and build a device that, while during operation, would not exceed the 90dB threshold as identified in OSHA's Hearing Protection Requirements. Once successfully assembled, we experimentally verified that the apparatus performed well below the rated 90dB threshold. Protective hearing devices were worn during testing.

5.5 Polycarbonate Impact Rating

The polycarbonate sheeting used to help contain our drive components is rated to absorb 275 ft-lbs. In order to verify the manufacturers ratings we performed an impact test in which we created a simulated impact test and calculate the energy required to crack the polycarbonate. This gave us accurate data to compare against the manufacturers ratings, thus insuring the safety of our design. Below in Figure 30 is a representation between disk diameter and the energy of the BLDS if it were to detach from the disk into the polycarbonate sheeting.

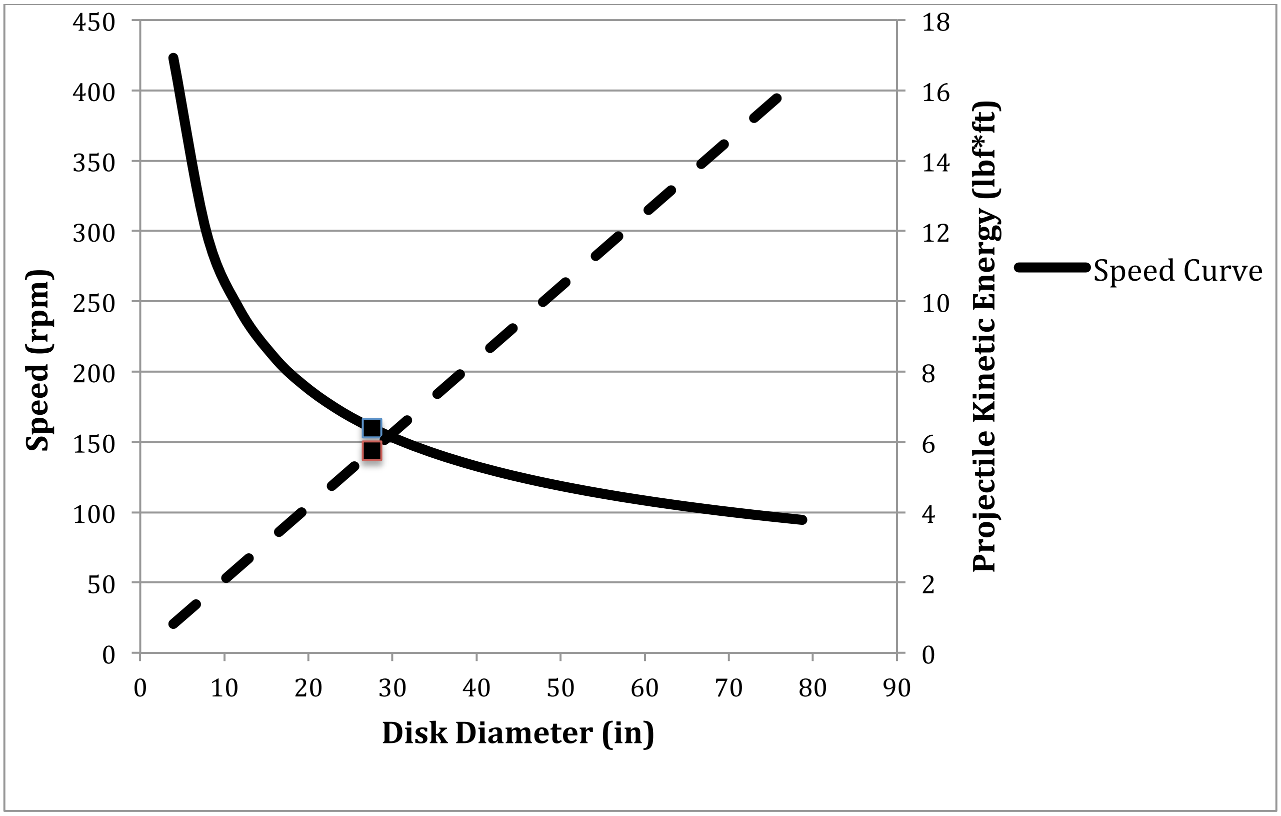


Figure 30. Operation Point in Conjunction with Speed and Diameter

Our drop-test of a 30lbm weight at a height of 6” replicated an impact with a safety factor of 3. Upon impact, there was no cracking or plastic deformation of the polycarbonate, verifying our choice to use this as a protective barrier.

5.6 Clamp Strength

This specific test also verified the manufacturer's ratings on the maximum clamping strength of each toggle-clamp used to mount the BLDS to the disk and to verify we specified the correct clamp for this application. We created a test in which a "dummy BLDS" was mounted to a disk with an eyebolt screwed into the side, as seen in Figure 31 to the right. From here we attached a force gauge to the bolt and applied the maximum amount of force required for the dummy BLDS to detach from the system. Due to the limitations of our force gauge, we were unable to verify the manufacturer's rating but instead concluded that the toggle clamps were overdesigned for the application, but were chosen due to the ease of use and high performance ratings.

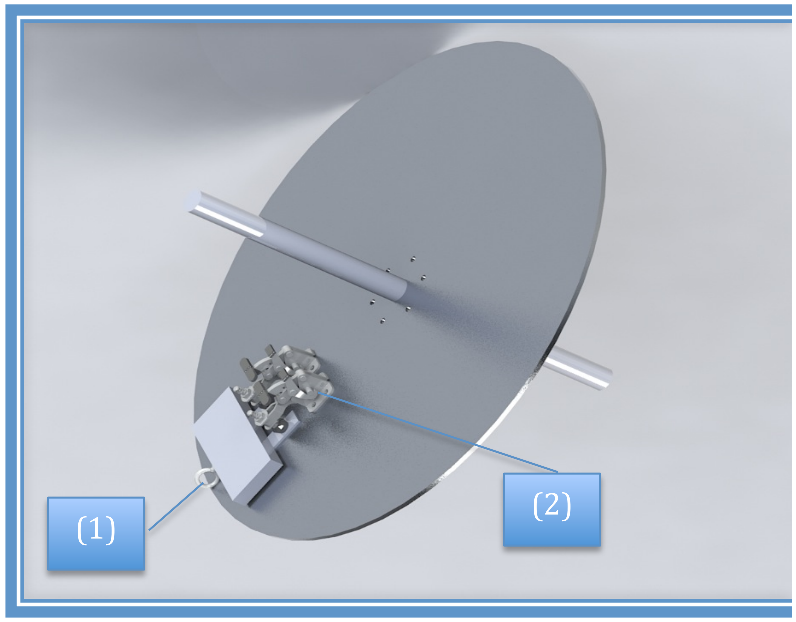


Figure 31. Clamp Test Assembly with Eyebolt (1) and Toggle Clamps (2)

Chapter 6. Project Management Plan

6.1 Members Roles and Responsibilities

Each member has been assigned a specific role in the development of our final design. Being in a team of 2 we have agreed to divvy up the work equally while staying in close contact with each other in regards to any questions, comments, or decisions. Weekly meetings have insured steady progression and forward thinking. Specific roles and responsibilities can be seen below:

David Shelton

- Point of Contact for:
    - Dr. Russ Westphal
    - Dr. Sarah Harding
- Research Concerning:
    - Drive Components
    - Devices
    - Testing/Manufacturing
- Meeting Scheduling
- Report Writing

Brian Yale

- Solid Modeling Concerning:
    - Individual Components
    - Design Assembly
    - Detailed Drawings
- Research Concerning:
    - Frame/Housing Components
    - Devices
- Treasurer
- Report Writing

Chapter 7. Safety

The most important concern and specification we verified every decision against is safety. It is our sole responsibility to insure we have designed, built, and approved a machine that will not only meet the specific design requirements but is also designed to insure the safety of others. Proper analysis and testing was completed to insure no part fails during operation. We took every measure possible to account for any unforeseeable events that may occur during the operation of our machine. This report serves as a user manual to warn each operator of the potentials for failure to help them use better judgment when operating the device. Our design includes devices that aim on preventing serious injury or harm to both the user and bystanders, such as a safety-buttons, external speed control with a quick power-disconnect, and high-strength polycarbonate sheeting.

Chapter 8. Conclusion

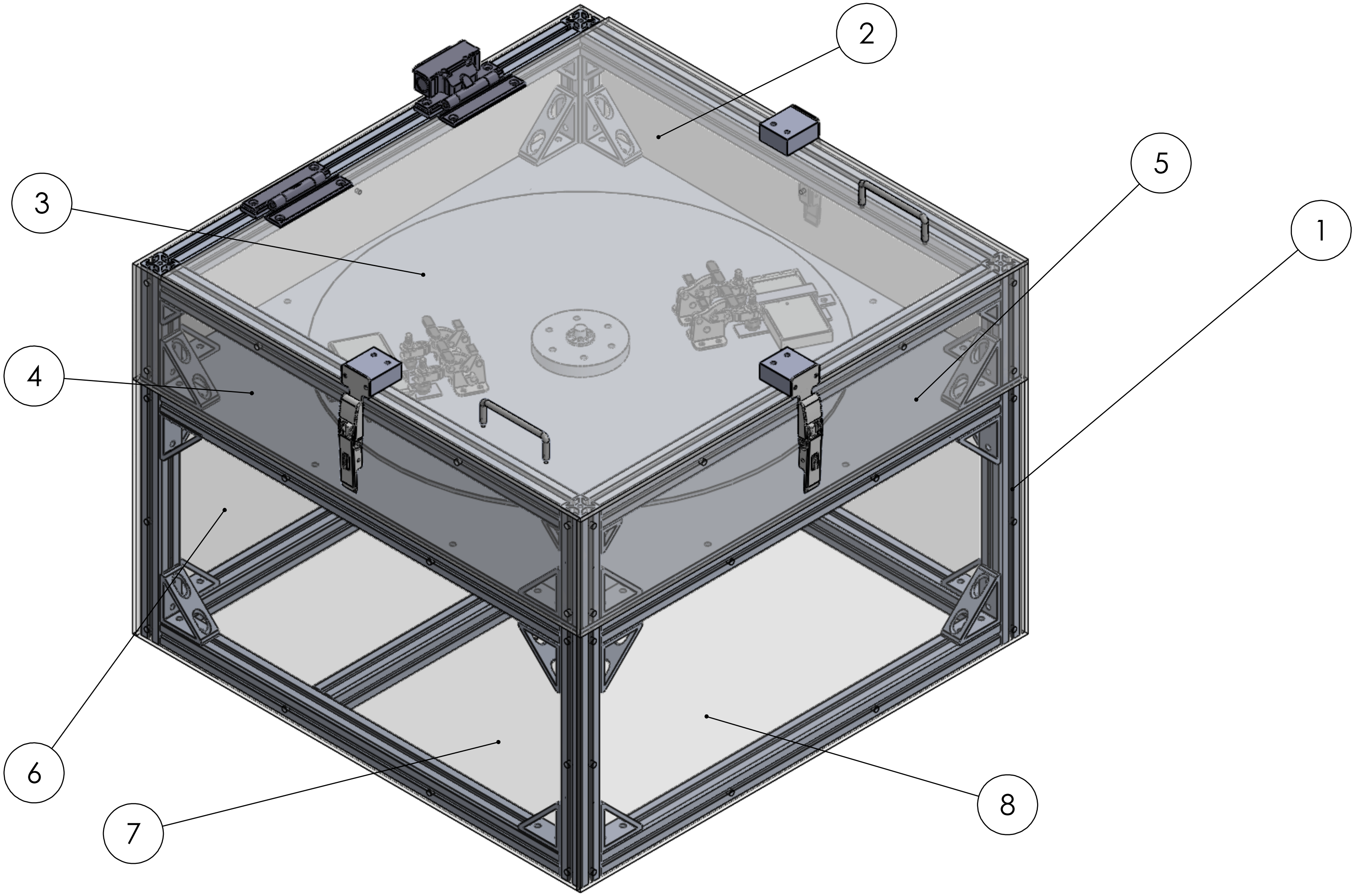
We hope this Final Design Report has clearly defined our main objectives and has outlined the description of our final design. With safety held in the highest regard we are confident we manufactured a safe, easy to use device with a well detailed report capable of informing each user the effective steps for operating the machine as well as the potential dangers during operation. This report clearly identifies our goals, results, and future considerations for a better, more concrete design.

Appendix A - Quality Function Deployment

BLDS Rotating Test Aparatus		Weighting (Total 100)	Must Experience 10 g's	S.F. =3	Impact force less than 100 N	Less than 36" wide	Must last 5 years	Nothing sharp/pinching	Under 90 dB	Bicycle Wheel Test (Benchmarks)
Customer Requirements	High Centripetal Acc*	15	9	3	3	1	3	1	3	1
	Must be Safe**	30	3	9	9	1	3	9	9	3
	Safe for Hearing*	10	3	9	3	0	0	0	9	5
	Must be Enclosed*	20	1	9	9	3	0	3	3	1
	Will be Fixed in Place	5	1	0	0	1	0	0	0	2
	Will be User Friendly*	10	1	1	1	0	1	3	3	4
	Looks professional	2	0	0	0	1	3	1	3	1
	Lifetime	8	3	1	1	0	9	0	1	4
	Climate Control	0	0	0	0	0	0	0	0	0
	Units		g's	n/a	N	in.	yrs	n/a	dB	
	Targets		10	3	≤100	≤36	5	0	≤85	
	Benchmark #1		2	n/a	n/a	n/a	n/a	n/a	n/a	
	Weighted Scores		314	603	543	112	223	377	509	
	Percentage Values		11.71	22.49	20.25	4.18	8.32	14.06	18.99	

Appendix B – Part Drawings

- 100 – Full Assembly
- 101 – PC Side Housing – Bottom
- 102 – PC Side Housing – Top
- 103 – PC Front Housing – Bottom
- 104 – PC Front/Back Housing – Top
- 200 – Frame Assembly
- 201 – Aluminum Divider
- 210 – Bottom Frame Assembly
- T-Slot Extrusions
- 220 – Top Assembly
- 300 – Drive Assembly
- 302 – Coupling
- 303 – Shaft
- 309 – Speed Sensor Mount
- 310 – Disk Assembly
- 311 – Disk
- 312 – Hub
- 313 – Clamps
- 314 – BLDS Bracket
- 400 –Lid Assembly
- 403 – Hinge Mount
- 404 – Lid
- 405 – Latch
- 407 - Handle



No.	Part Name	Part No.	Qnty
1	Frame Assembly	200	1
2	Lid Assembly	400	1
3	Drive Assembly	300	
4	Side Housing - Top	102	2
5	Front Housing - Top	104	2
6	Expanded Steel Housing	105	1
7	Side Housing - Bottom	101	2
8	Front Housing - Bottom	103	1

UNLESS OTHERWISE SPECIFIED:

DIMENSIONS ARE IN INCHES

Next Assy: n/a

MATERIAL Various

DO NOT SCALE DRAWING

	NAME	DATE
DRAWN	Brian Yale	2/6/14
CHECKED	David Shelton	2/6/14

COMMENTS:

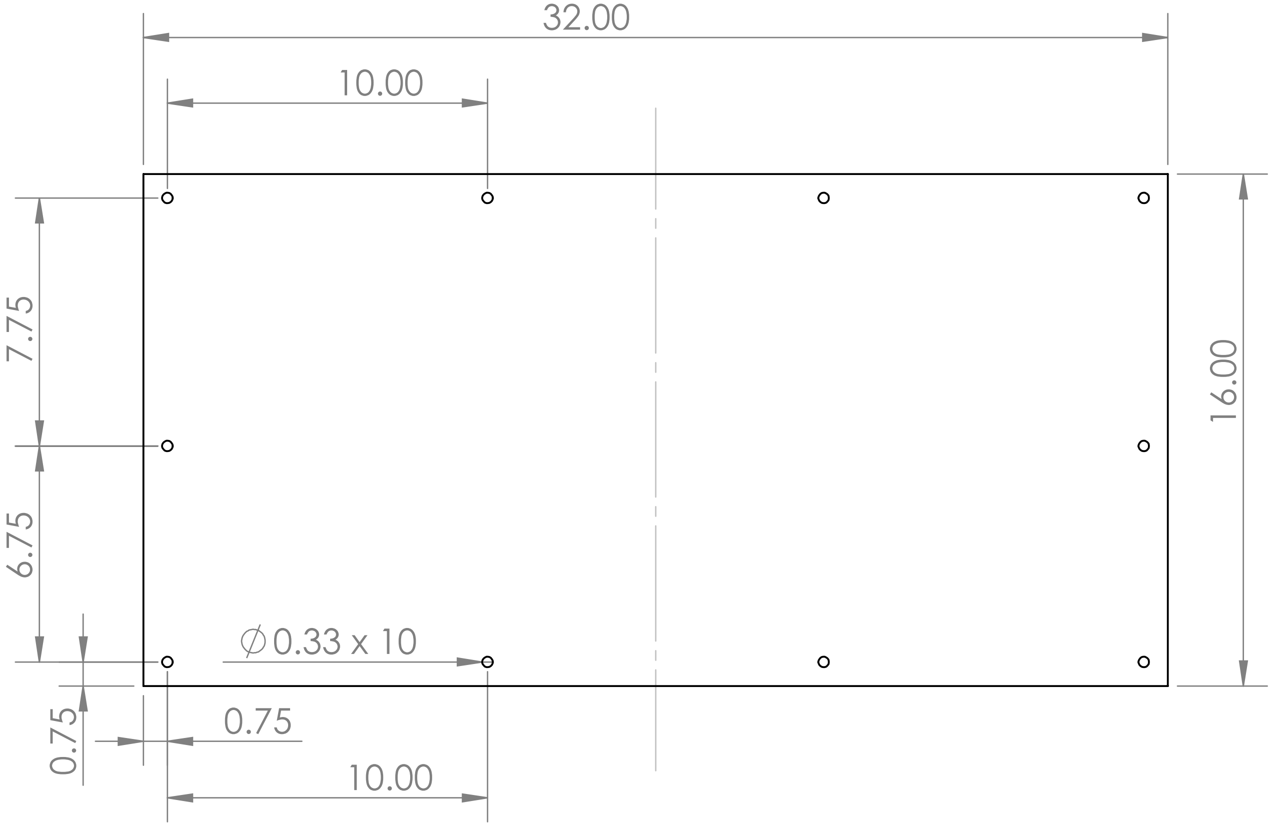
TITLE:

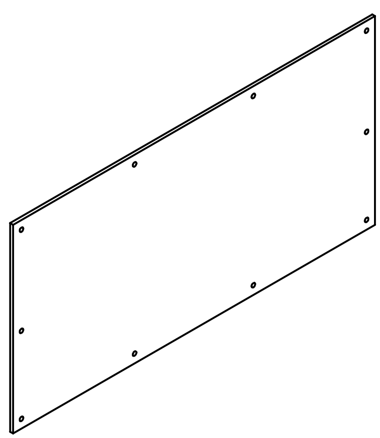
Full Assembly

SIZE A | DWG. NO. 100 | REV 1

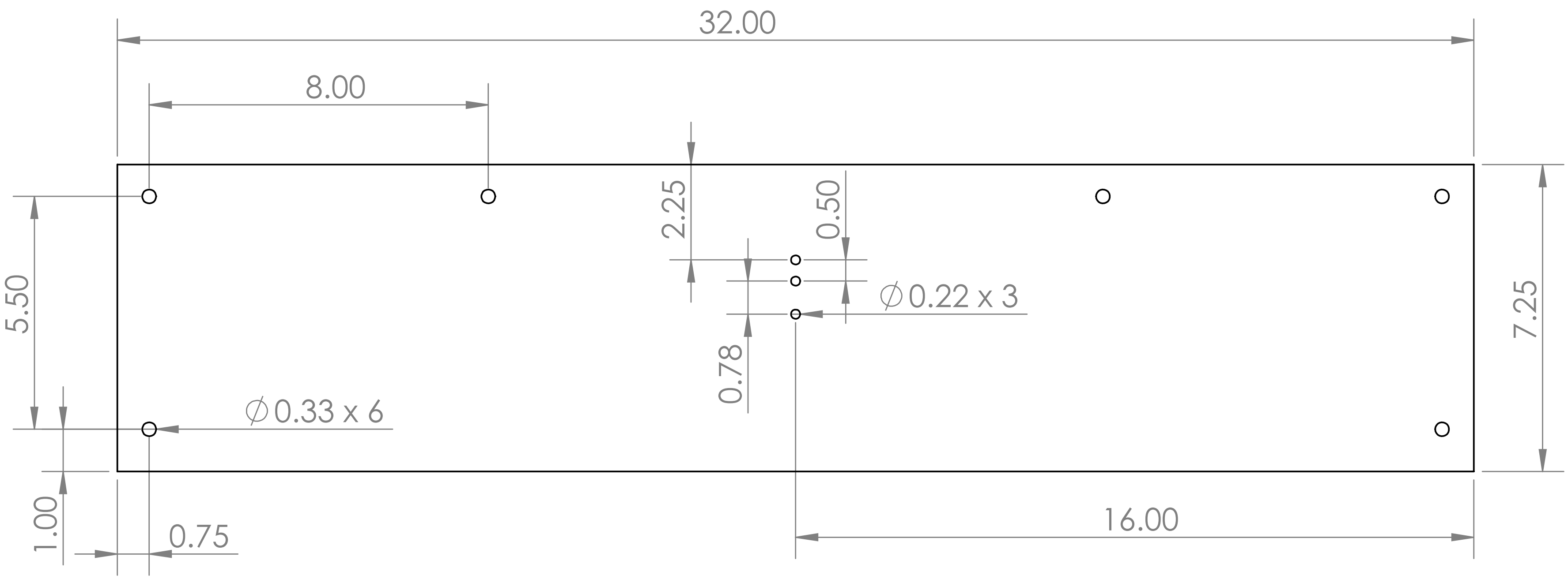
SCALE: 1:8 | SHEET 1 OF 1

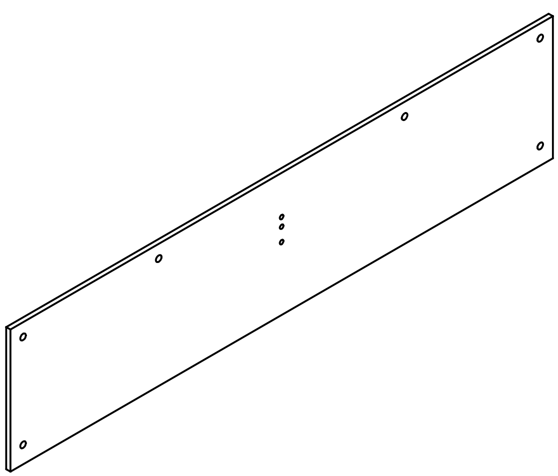
5 4 3 2 1





UNLESS OTHERWISE SPECIFIED:		NAME	DATE	
DIMENSIONS ARE IN INCHES	DRAWN	Brian Yale	2/6/14	
Tolerances: Plate Dimensions: ±0.05 in. Hole Locations: ±0.005 in.	CHECKED	David Shelton	2/6/14	TITLE: PC Side Housing - Bottom
Next Assy: 100	COMMENTS:			SIZE A
MATERIAL 1/4" Polycarbonate				DWG. NO. 101
DO NOT SCALE DRAWING				REV 1
				SCALE: 1:6
				SHEET 1 OF 1





UNLESS OTHERWISE SPECIFIED:		NAME	DATE
DIMENSIONS ARE IN INCHES	DRAWN	Brian Yale	2/6/14
Tolerances: Plate Dimensions: ±0.05 in. Hole Locations: ±0.005 in.	CHECKED	David Shelton	2/6/14
Next Assy: 100	COMMENTS:		
MATERIAL 1/4" Polycarbonate			
DO NOT SCALE DRAWING			

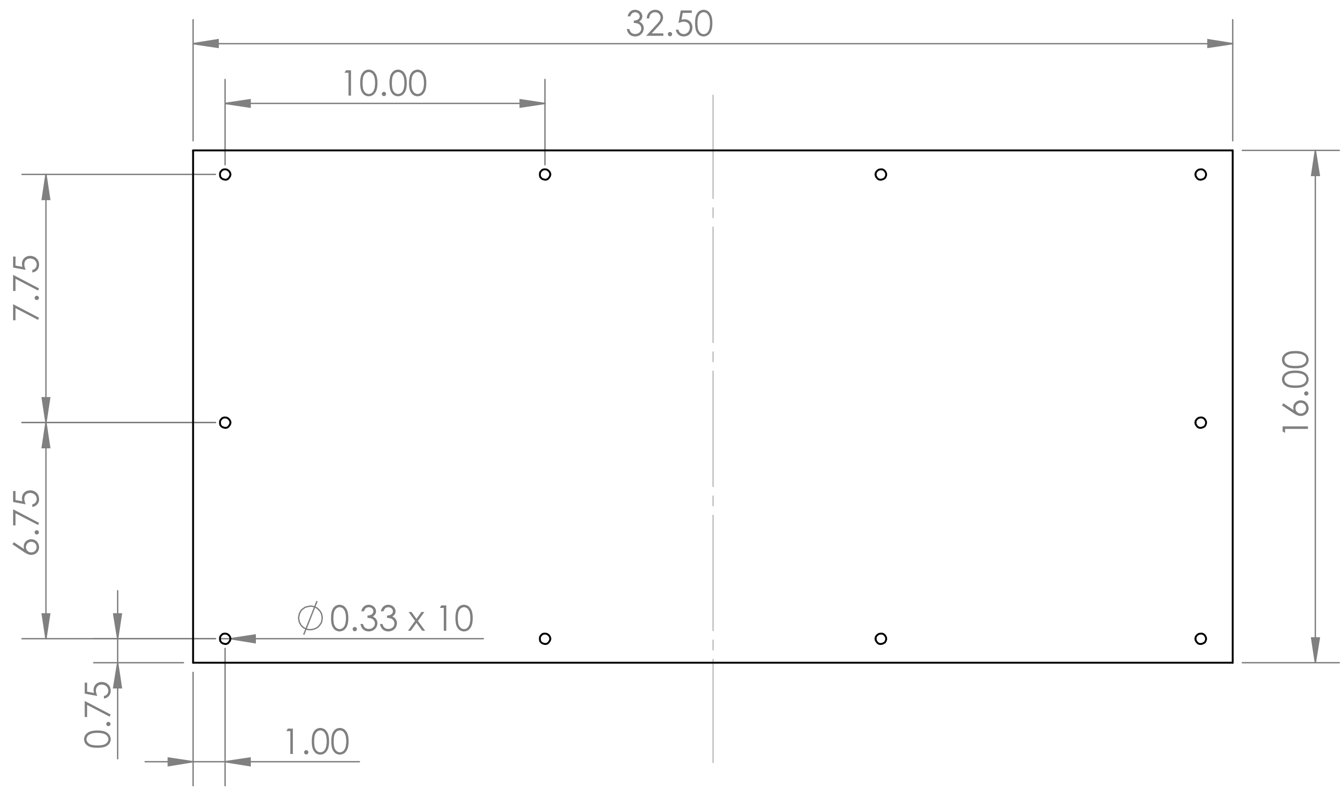
TITLE:

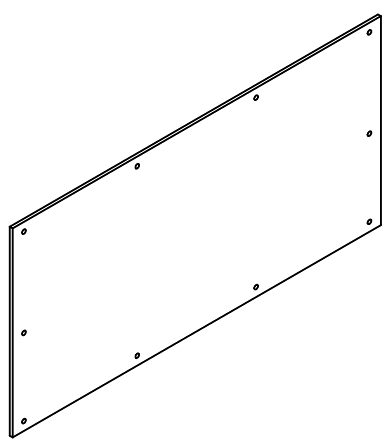
PC Side Housing - Top

SIZE	DWG. NO.	REV
A	102	1

SCALE: 1:4 SHEET 1 OF 1

5 4 3 2 1





UNLESS OTHERWISE SPECIFIED:

DIMENSIONS ARE IN INCHES

Tolerances:
Plate Dimensions: ±0.05 in.
Hole Locations: ±0.005 in.

MATERIAL
1/4" Polycarbonate

DO NOT SCALE DRAWING

	NAME	DATE
DRAWN	Brian Yale	2/6/14
CHECKED	David Shelton	2/6/14

COMMENTS:

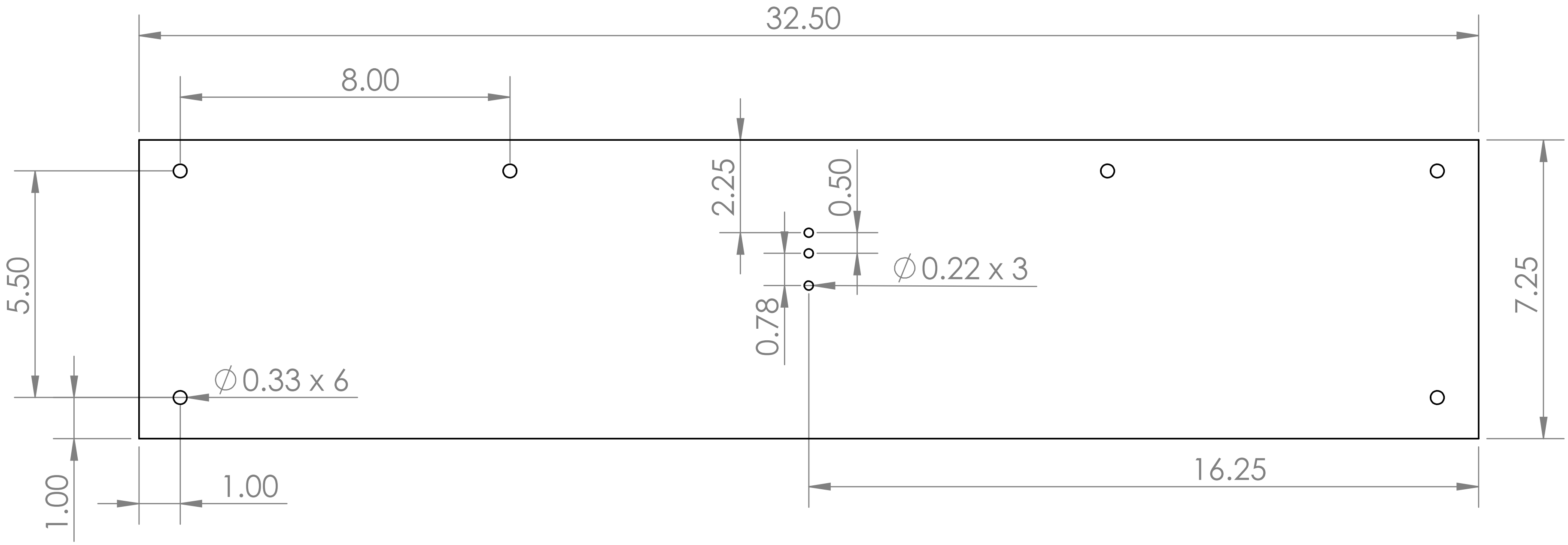
TITLE:

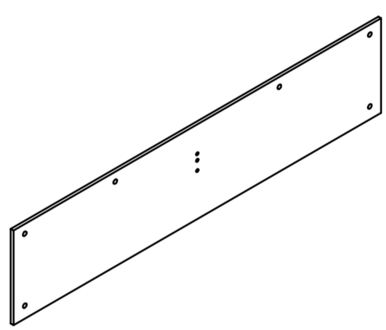
PC Front Housing - Bottom

SIZE A | DWG. NO. 103 | REV 1

SCALE: 1:6 | SHEET 1 OF 1

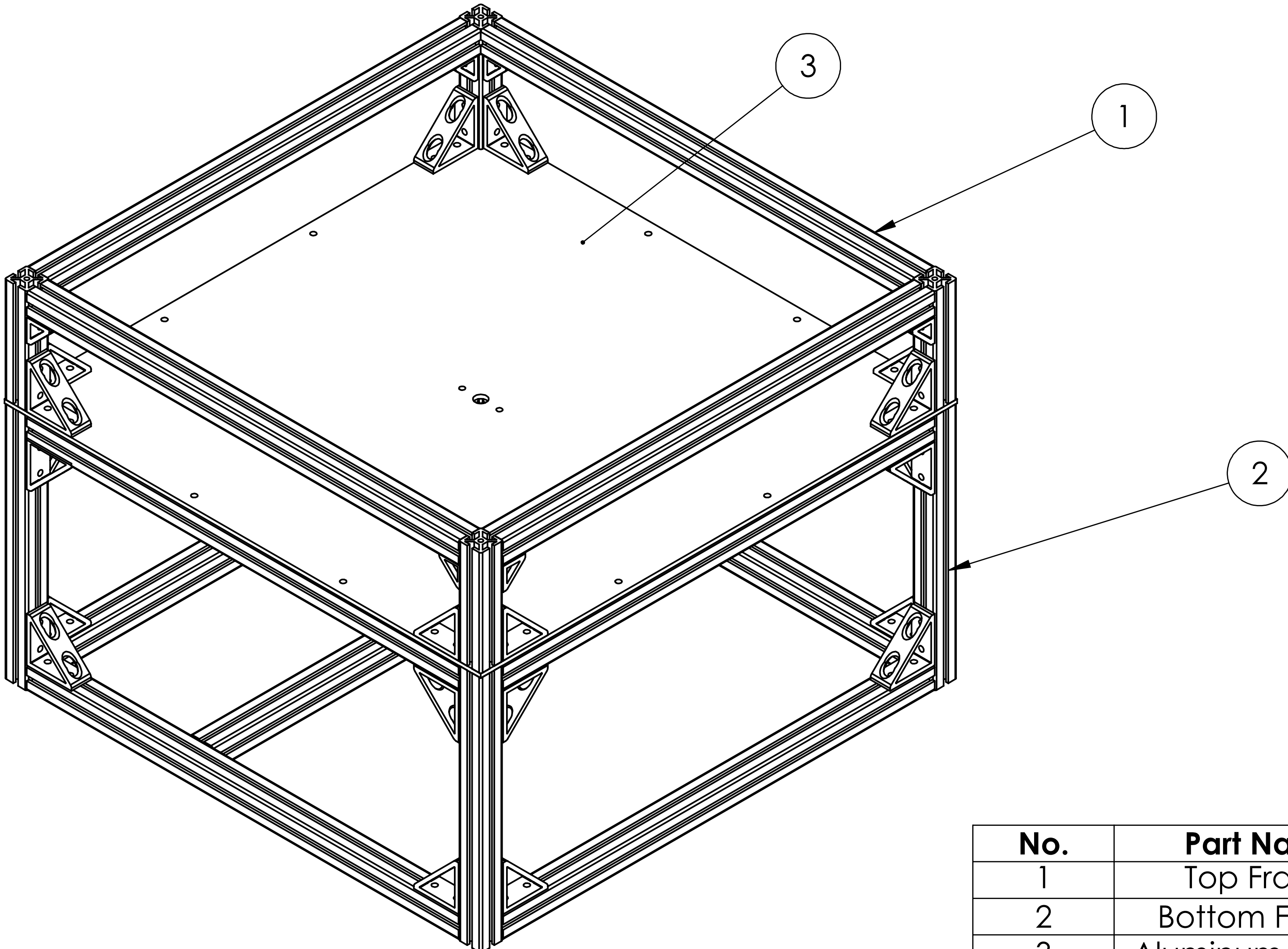
5 4 3 2 1





UNLESS OTHERWISE SPECIFIED:		NAME	DATE	
DIMENSIONS ARE IN INCHES	DRAWN	Brian Yale	2/6/14	
Tolerances: Plate Dimensions: ±0.05 in. Hole Locations: ±0.005 in.	CHECKED	David Shelton	2/6/14	TITLE: PC Front/Back Housing - Top
Next Assy: 100	COMMENTS:			SIZE A · DWG. NO. 104 · REV 1
MATERIAL 1/4" Polycarbonate				SCALE: 1:4 · SHEET 1 OF 1
DO NOT SCALE DRAWING				

5 4 3 2 1



No.	Part Name	Part No.
1	Top Frame	220
2	Bottom Frame	210
3	Aluminum Divider	201

UNLESS OTHERWISE SPECIFIED:		NAME	DATE
DIMENSIONS ARE IN INCHES	DRAWN	Brian Yale	2/6/14
	CHECKED	David Shelton	2/6/14

Next Assy: 100

MATERIAL
Various

DO NOT SCALE DRAWING

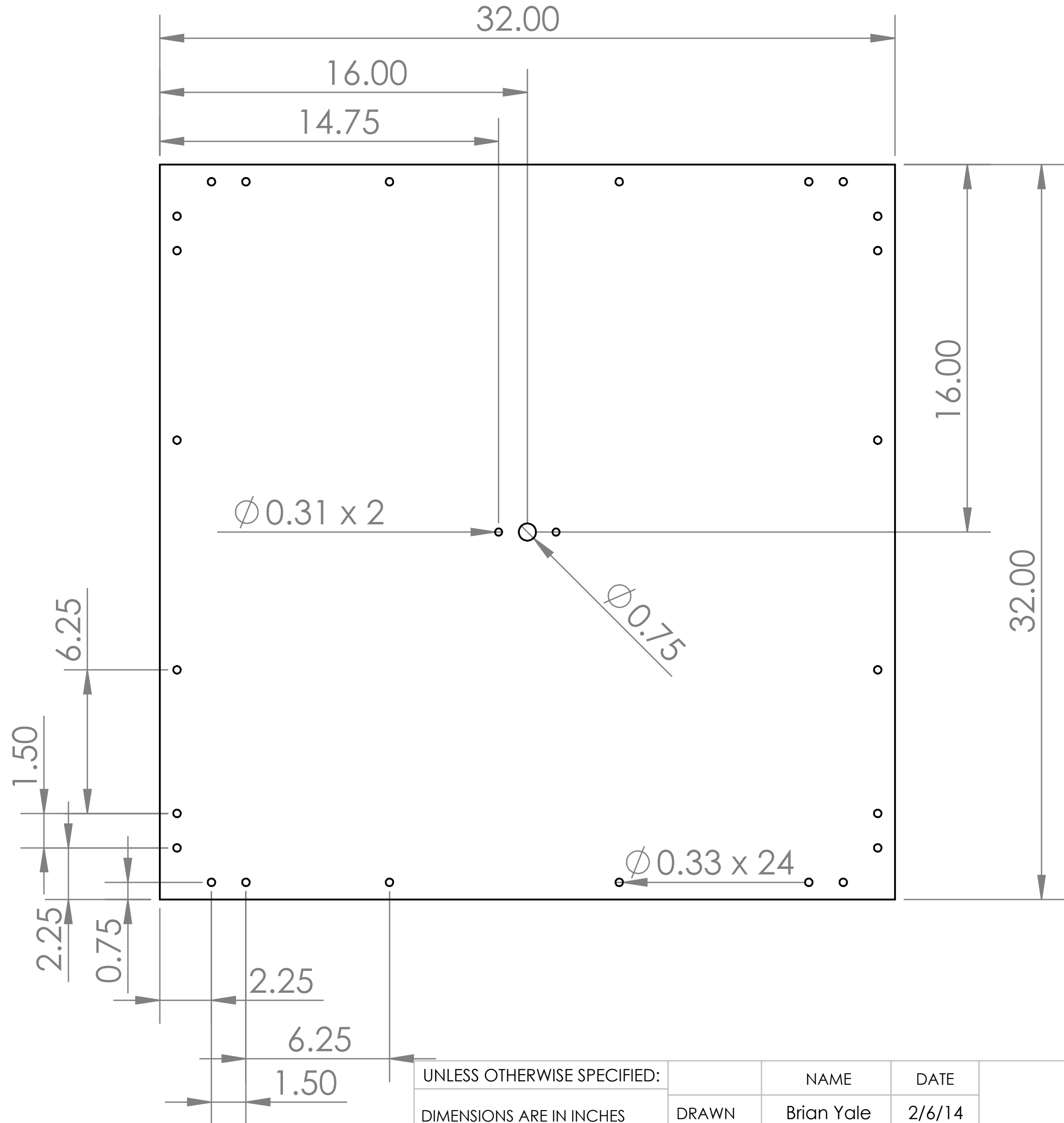
COMMENTS:

TITLE:
Frame Assembly

SIZE A | DWG. NO. 200 | REV 1

SCALE: 1:8 | SHEET 1 OF 1

5 4 3 2 1



UNLESS OTHERWISE SPECIFIED:

DIMENSIONS ARE IN INCHES

Tolerances:
Plate Dimensions: ±0.05 in.
Hole Locations: ±0.005 in.

Next Assy: 200

MATERIAL
1/4" Aluminum

DO NOT SCALE DRAWING

	NAME	DATE
DRAWN	Brian Yale	2/6/14
CHECKED	David Shelton	2/6/14

COMMENTS:

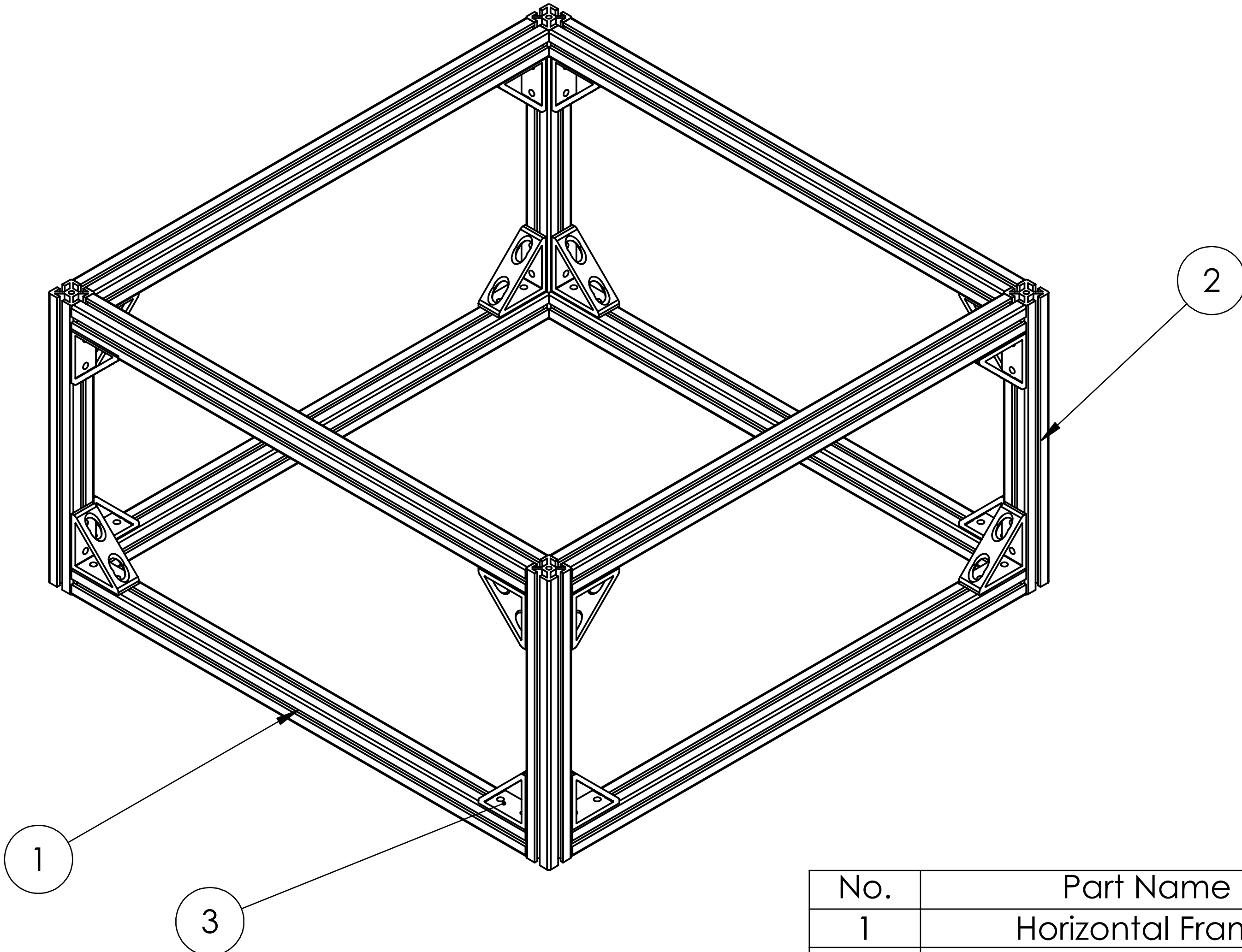
TITLE:

PC Side Housing - Bottom

SIZE	DWG. NO.	REV
A	201	1

SCALE: 1:8 SHEET 1 OF 1

5 4 3 2 1



No.	Part Name	Part Number	Qnty
1	Horizontal Frame	211	8
2	Vert. Frame - Bottom	212	4
3	Large Inside Corner Gusset	213	16

Note:
All inside corner gussets use 5/16" - 18 x 11/16" bolts and double T-nut from Tslot manufacturer.

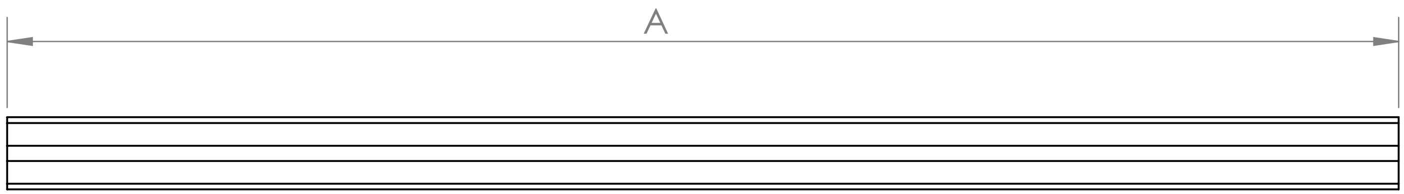
UNLESS OTHERWISE SPECIFIED:		NAME	DATE
DIMENSIONS ARE IN INCHES	DRAWN	Brian Yale	2/6/14
	CHECKED	David Shelton	2/6/14
Next Assy: 200	COMMENTS:		
MATERIAL Various			
DO NOT SCALE DRAWING			

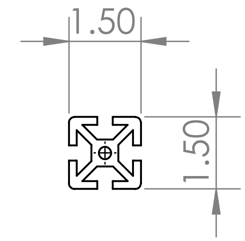
TITLE:
Bottom Frame Assembly

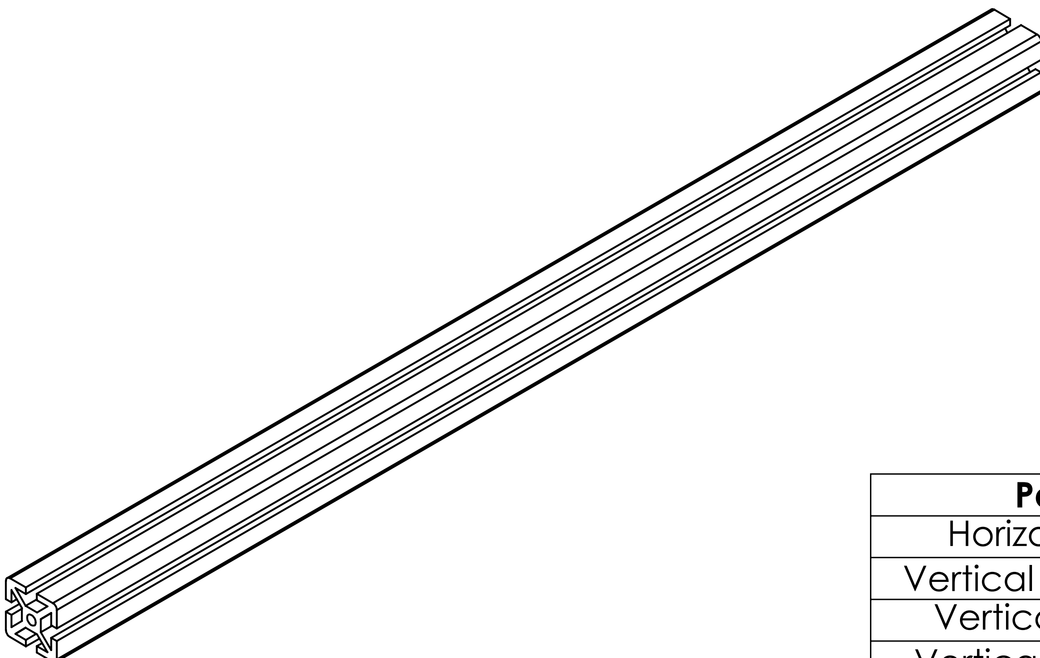
SIZE A | DWG. NO. 210 | REV 1

SCALE: 1:8 | SHEET 1 OF 1

5 4 3 2 1







Part Name	Part Number	Dimension 'A'
Horizontal Framing	211	29
Vertical Frame - Bottom	212	16
Vertical Frame - Top	221	7
Vertical Frame - Motor	231	13

UNLESS OTHERWISE SPECIFIED:

DIMENSIONS ARE IN INCHES

Tolerances:
Plate Dimensions: ±0.05 in.

	NAME	DATE
DRAWN	Brian Yale	2/6/14
CHECKED	David Shelton	2/6/14

Next Assy: 200

MATERIAL
Aluminum

DO NOT SCALE DRAWING

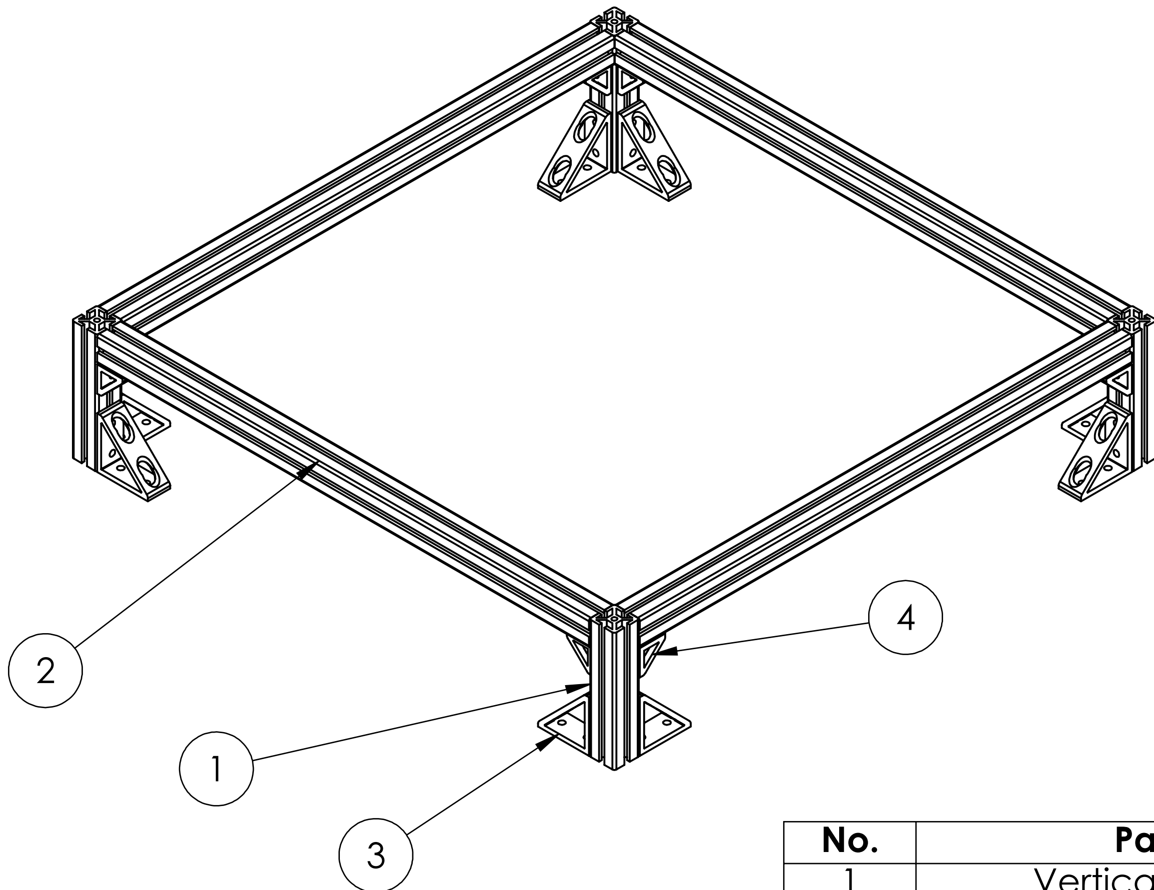
COMMENTS:

TITLE:
TSlot Framing

SIZE A | DWG. NO. Various | REV 1

SCALE: 1:4 | SHEET 1 OF 1

5 4 3 2 1



No.	Part Name	Part No.	Qnty
1	Vertical Frame - Top	221	4
2	Horizontal Framing	211	4
3	Large Inside Corner Gusset	213	8
4	Small Inside Corner Gusset	222	8

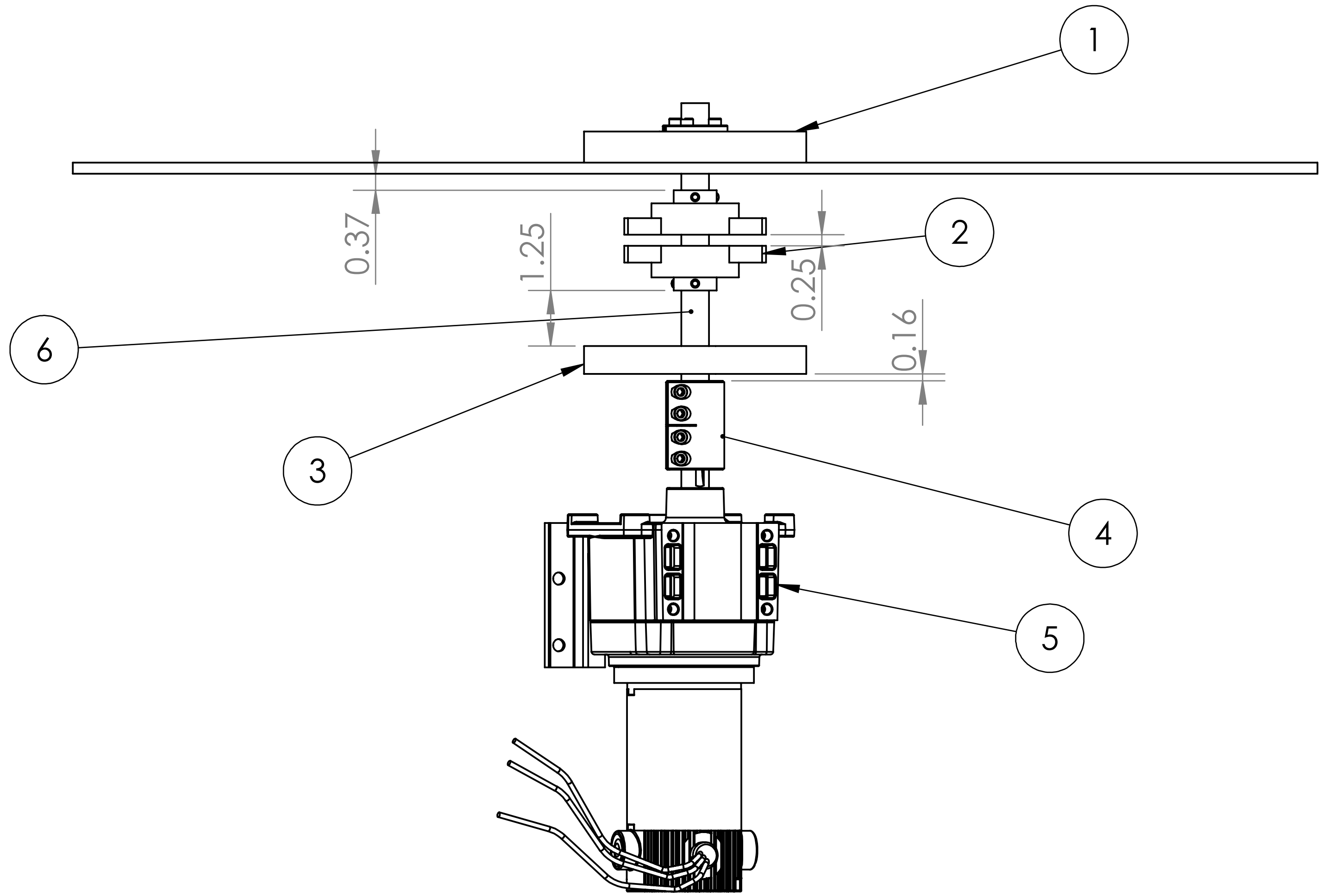
Note:
Small Inside Corner Gussets use 5/16" - 18 x 11/16" bolts with T-nut from Tslot manufacturer.
Large Inside Corner Gussets use 5/16" - 18 x 1" bolt to attach to bottom frame and 5/16" - 18 x 11/16" bolts to attach to vertical frame. Both with double T-nut.

UNLESS OTHERWISE SPECIFIED:		NAME	DATE
DIMENSIONS ARE IN INCHES	DRAWN	Brian Yale	2/6/14
	CHECKED	David Shelton	2/6/14
Next Assy: 200	COMMENTS:		
MATERIAL Various			
DO NOT SCALE DRAWING			

TITLE:
Top Frame

SIZE	DWG. NO.	REV
A	220	1
SCALE: 1:8		SHEET 1 OF 1

5 4 3 2 1



No.	Part Name	Part No.
1	Disk Assembly	310
2	Bearing	305
3	Pulser Wrap	304
4	Coupling	302
5	Motor	301
6	Shaft	303

UNLESS OTHERWISE SPECIFIED:

DIMENSIONS ARE IN INCHES

Tolerances:
Distance Dim's: ±0.05 in.

Next Assy: 100

MATERIAL Various

DO NOT SCALE DRAWING

	NAME	DATE
DRAWN	Brian Yale	2/6/14
CHECKED	David Shelton	2/6/14

COMMENTS:

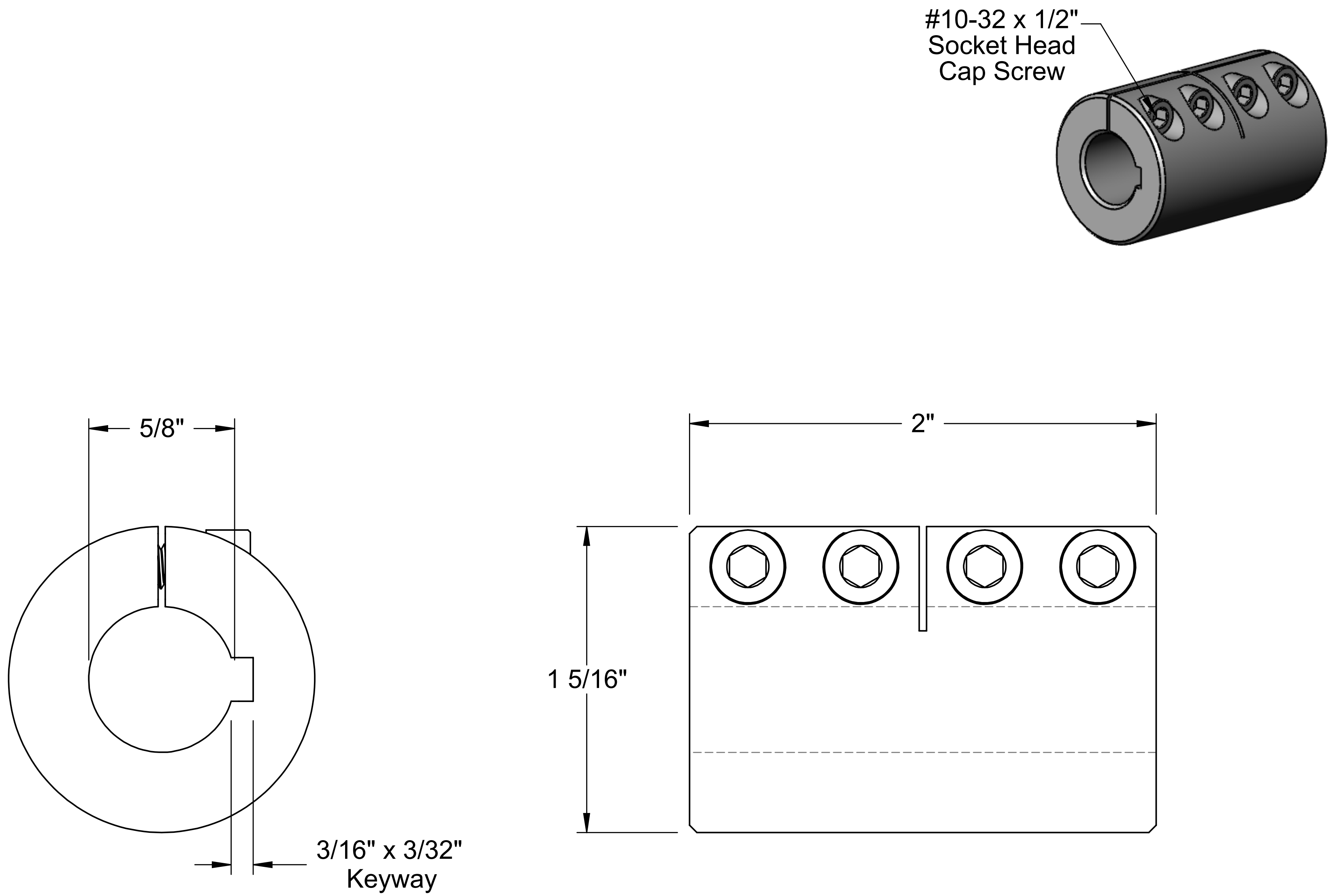
TITLE:

Drive Assy.

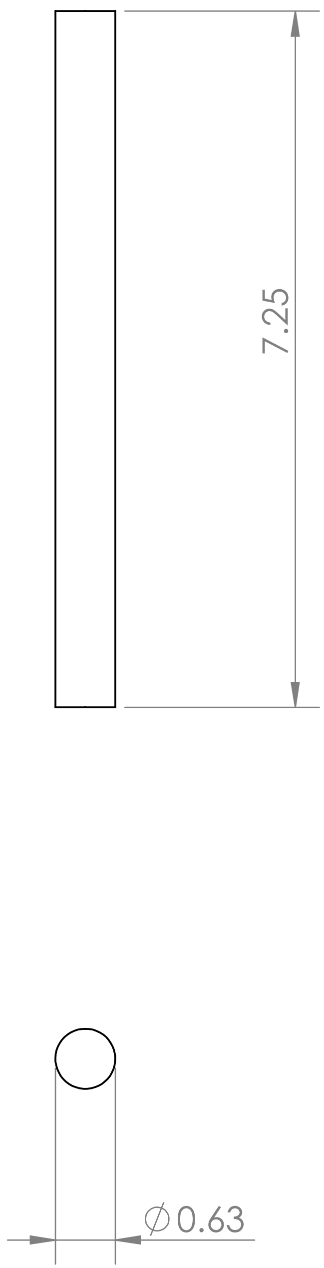
SIZE A | DWG. NO. 300 | REV 1

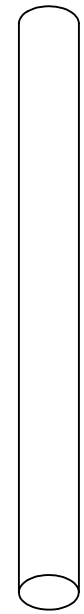
SCALE: 1:4 | SHEET 1 OF 1

5 4 3 2 1



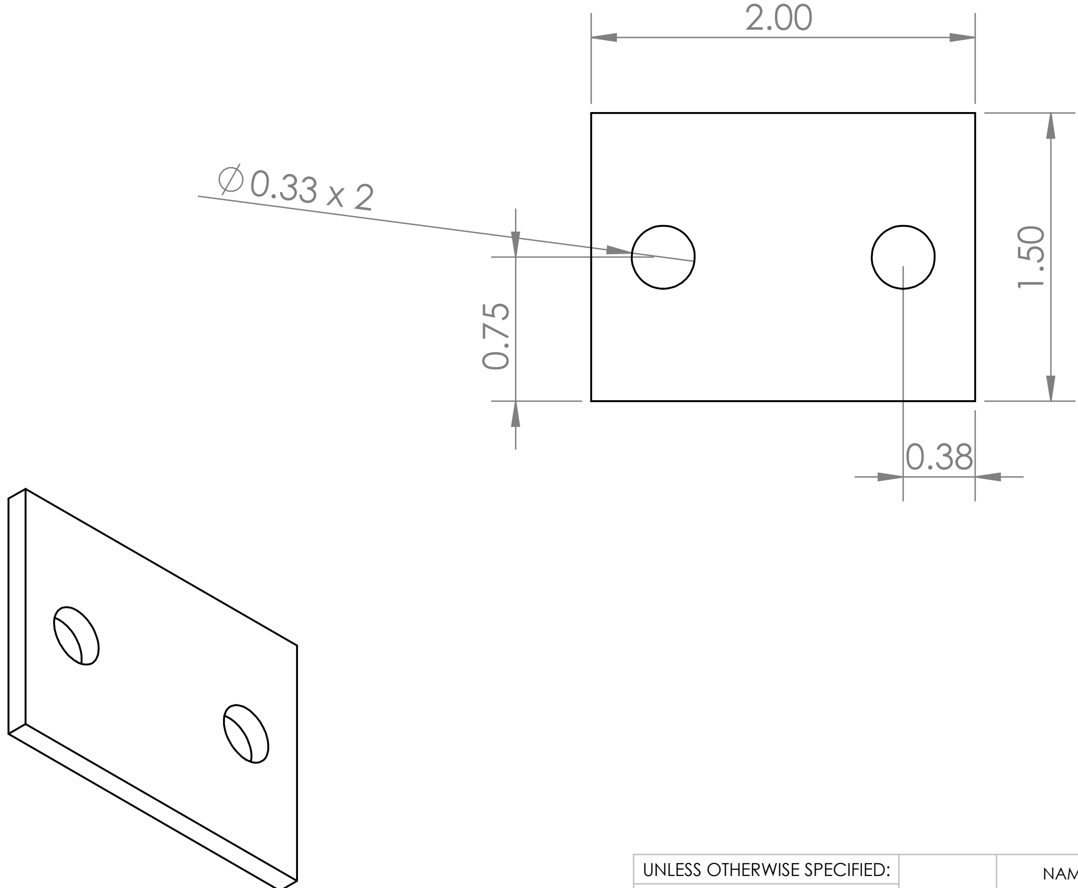
McMASTER-CARR® CAD	PART NUMBER	61005K133
http://www.mcmaster.com Information in this drawing is provided for reference only.	One-Piece Clamp-On Rigid Shaft Coupling	





UNLESS OTHERWISE SPECIFIED:		NAME	DATE	
DIMENSIONS ARE IN INCHES	DRAWN	Brian Yale	2/6/14	
Tolerances: Length: ±0.05 in.	CHECKED	David Shelton	2/6/14	TITLE: Shaft
Next Assy: 300	COMMENTS: Shaft will be keyed			SIZE A · DWG. NO. 303 · REV 1
MATERIAL 5/8" Steel				SCALE: 1:2 · SHEET 1 OF 1
DO NOT SCALE DRAWING				

5 4 3 2 1



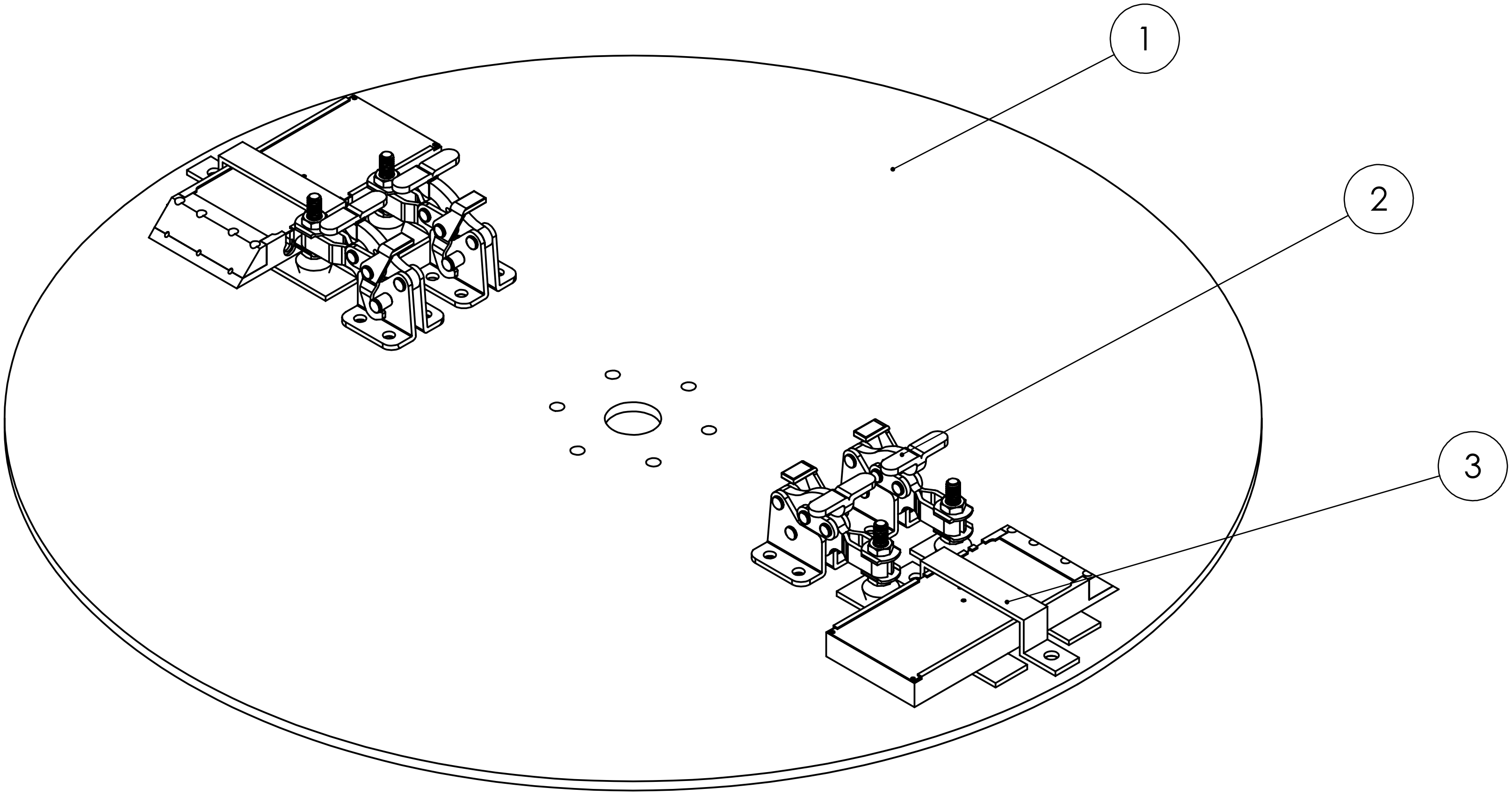
UNLESS OTHERWISE SPECIFIED:		NAME	DATE
DIMENSIONS ARE IN INCHES	DRAWN	Brian Yale	2/6/14
Tolerances: Size: ±0.05 in. Hole Location: ±0.005 in.	CHECKED	David Shelton	2/6/14
Next Assy: 300	COMMENTS:		
MATERIAL 1/8" Aluminum			
DO NOT SCALE DRAWING			

TITLE:

Speed Sensor Mount

SIZE	DWG. NO.	REV
A	309	1
SCALE: 1:1		SHEET 1 OF 1

5 4 3 2 1



No.	Part Name	Part No.	Qnty
1	Disk	311	1
2	Clamp	313	4
3	BLDS Bracket	314	2

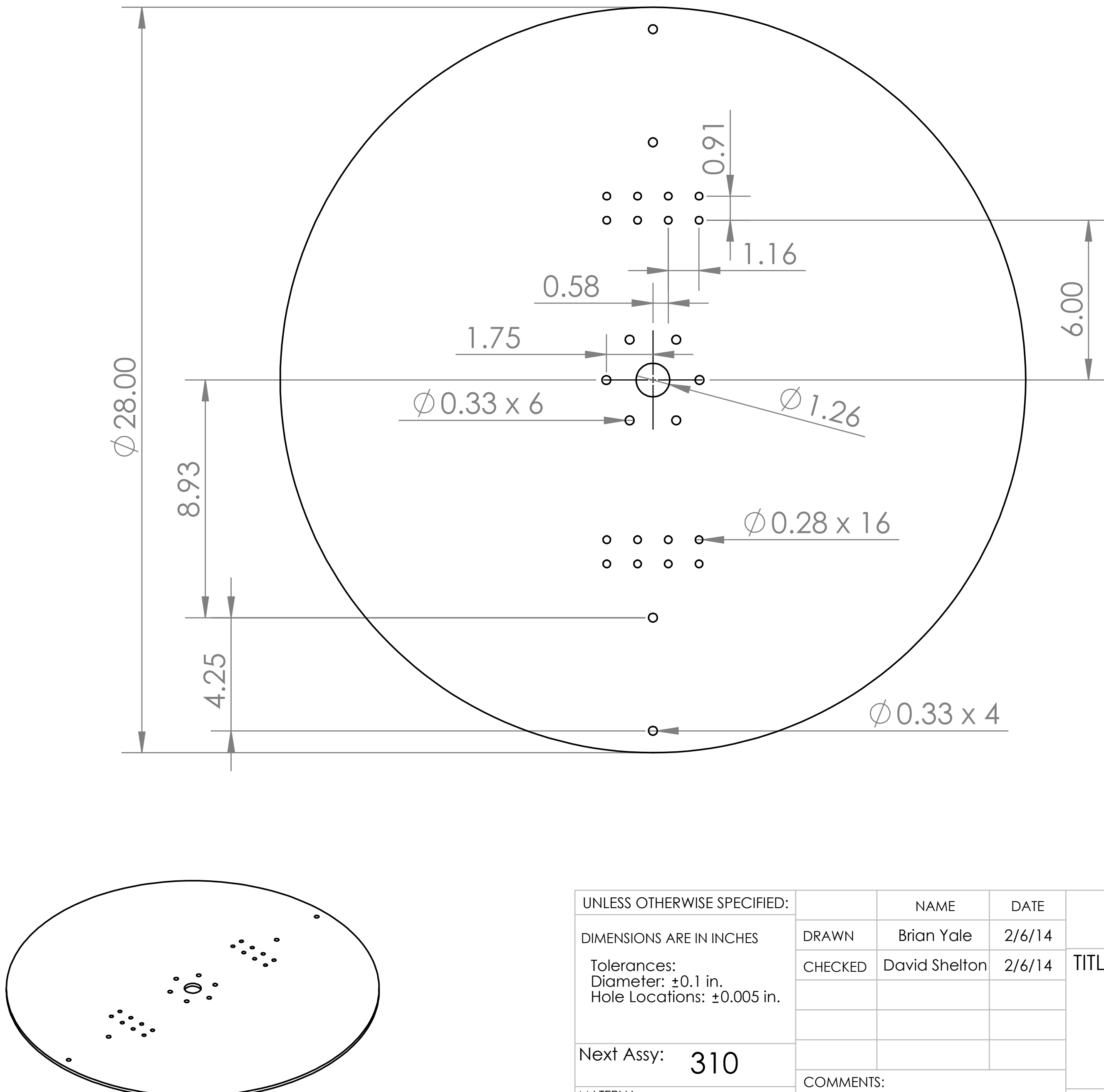
UNLESS OTHERWISE SPECIFIED:		NAME	DATE
DIMENSIONS ARE IN INCHES	DRAWN	Brian Yale	2/6/14
	CHECKED	David Shelton	2/6/14
Next Assy: 300	COMMENTS:		
MATERIAL Various			
DO NOT SCALE DRAWING			

TITLE:

Disk Assembly

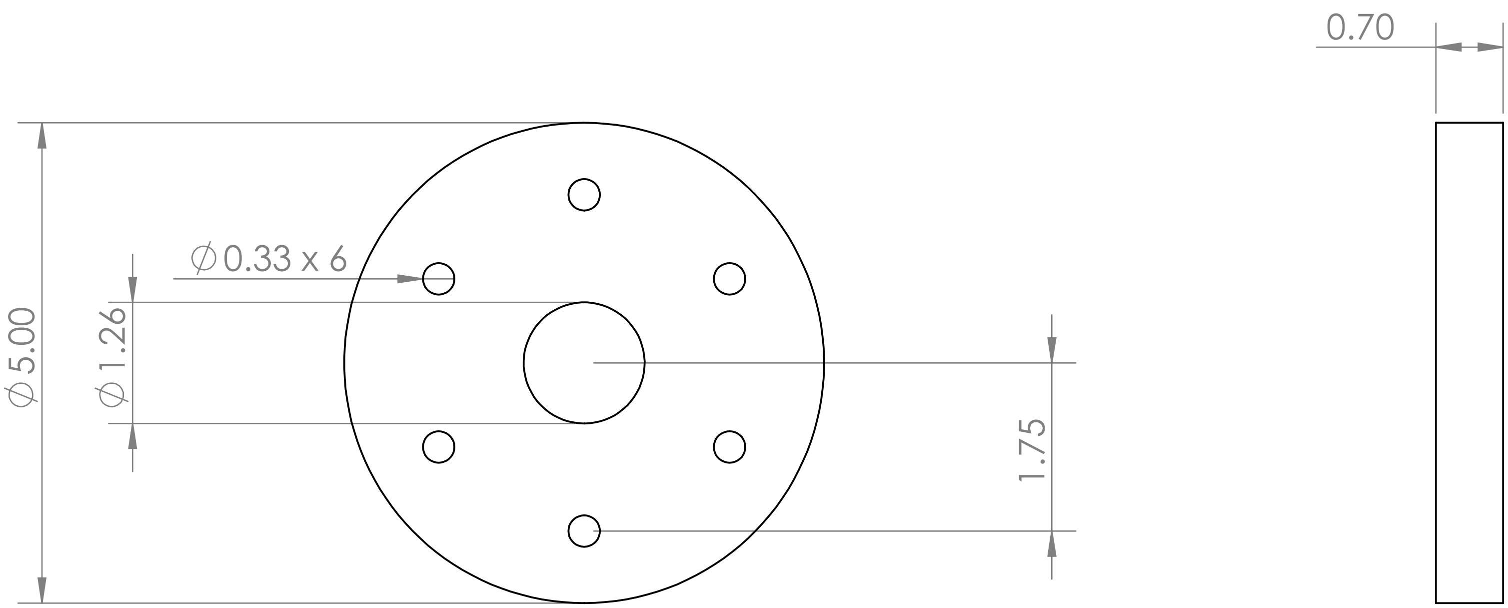
SIZE	DWG. NO.	REV
A	310	1
SCALE: 1:4		SHEET 1 OF 1

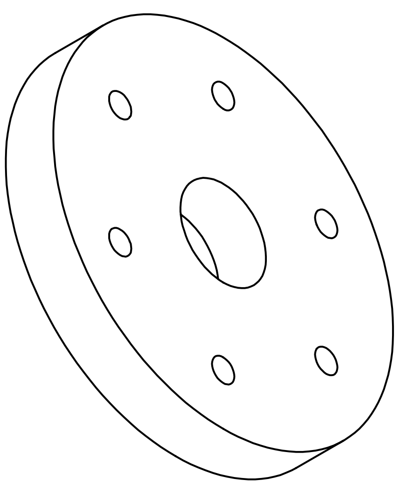
5 4 3 2 1



UNLESS OTHERWISE SPECIFIED:		NAME	DATE	
DIMENSIONS ARE IN INCHES	DRAWN	Brian Yale	2/6/14	
Tolerances: Diameter: ±0.1 in. Hole Locations: ±0.005 in.	CHECKED	David Shelton	2/6/14	TITLE: Disk
Next Assy: 310	COMMENTS:			
MATERIAL 1/4" Aluminum				SIZE A · DWG. NO. 311 · REV 1
DO NOT SCALE DRAWING				SCALE: 1:6 · SHEET 1 OF 1

5 4 3 2 1





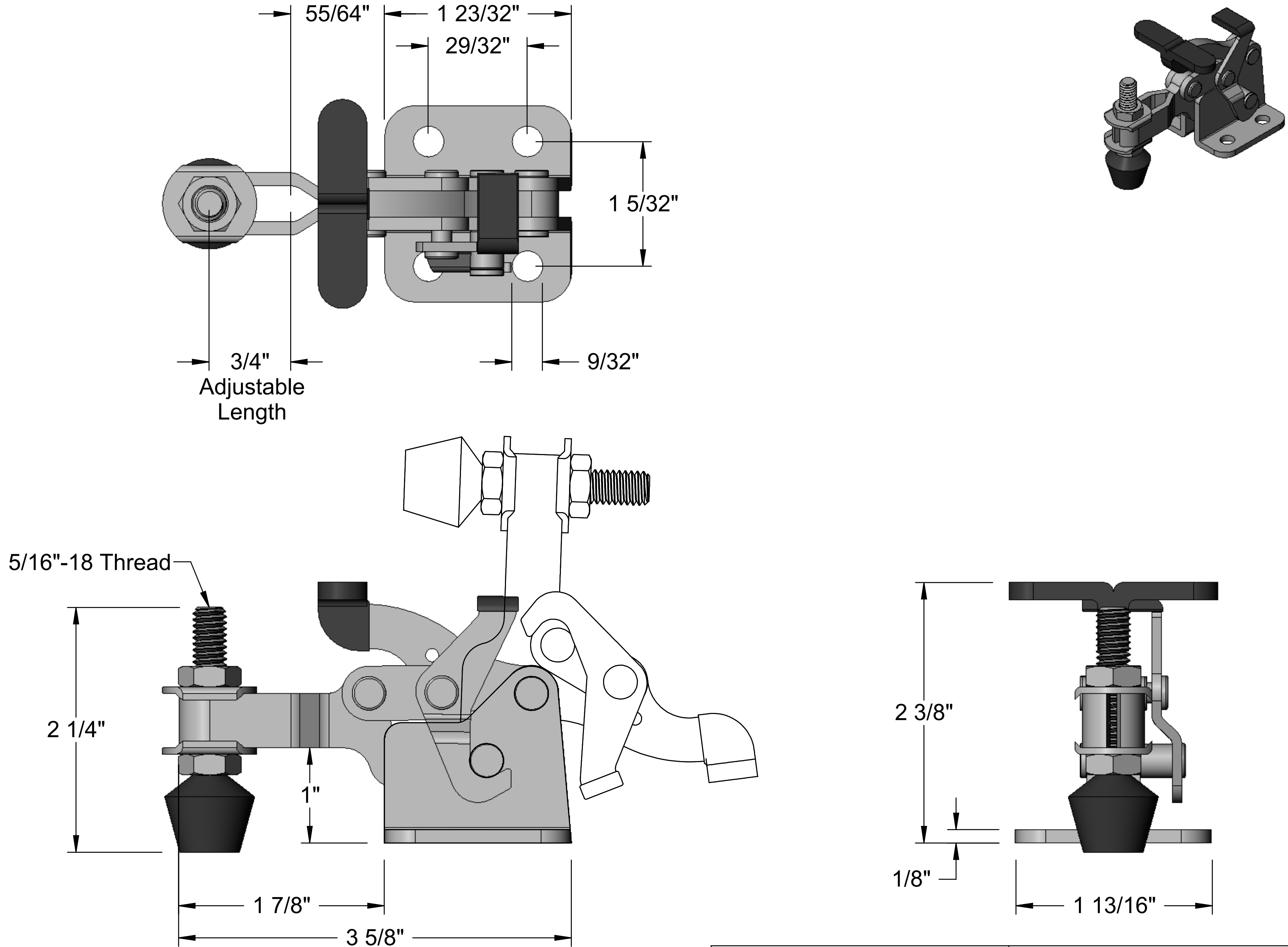
UNLESS OTHERWISE SPECIFIED:		NAME	DATE
DIMENSIONS ARE IN INCHES	DRAWN	Brian Yale	2/6/14
Tolerances: Size: ±0.05 in. Hole Locations: ±0.005 in.	CHECKED	David Shelton	2/6/14
Next Assy: 310	COMMENTS:		
MATERIAL Aluminum			
DO NOT SCALE DRAWING			

TITLE:

Hub

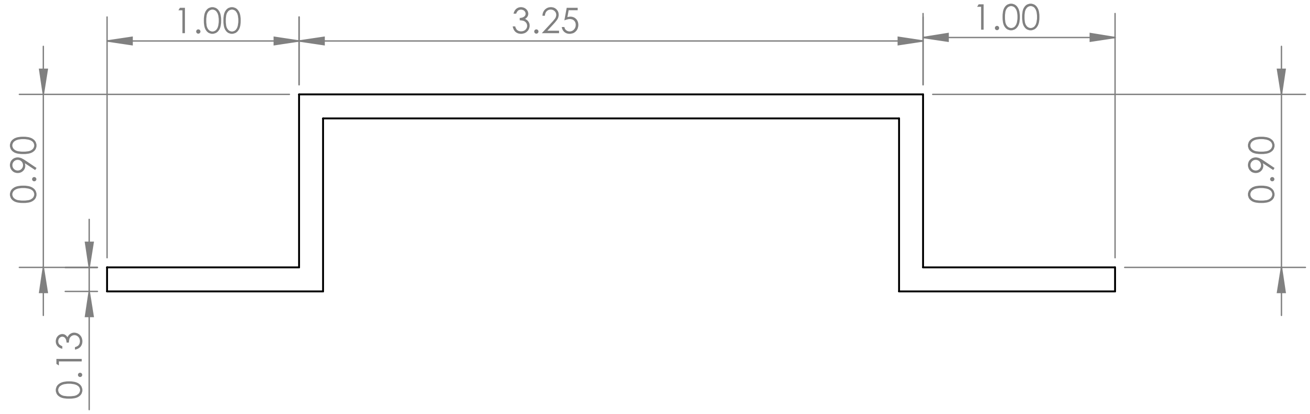
SIZE	DWG. NO.	REV
A	312	1
SCALE: 1:2		SHEET 1 OF 1

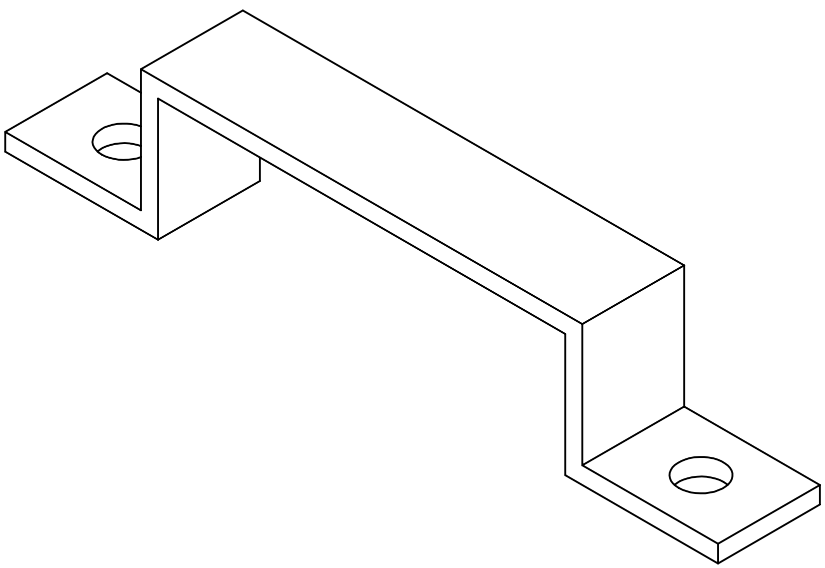
5 4 3 2 1



Clamp is supplied with both a metal and nonmarring holding screw.

McMASTER-CARR® CAD	PART NUMBER	4961A12
http://www.mcmaster.com © 2013 McMaster-Carr Supply Company Information in this drawing is provided for reference only.	Compact Hold-Down Toggle Clamp	





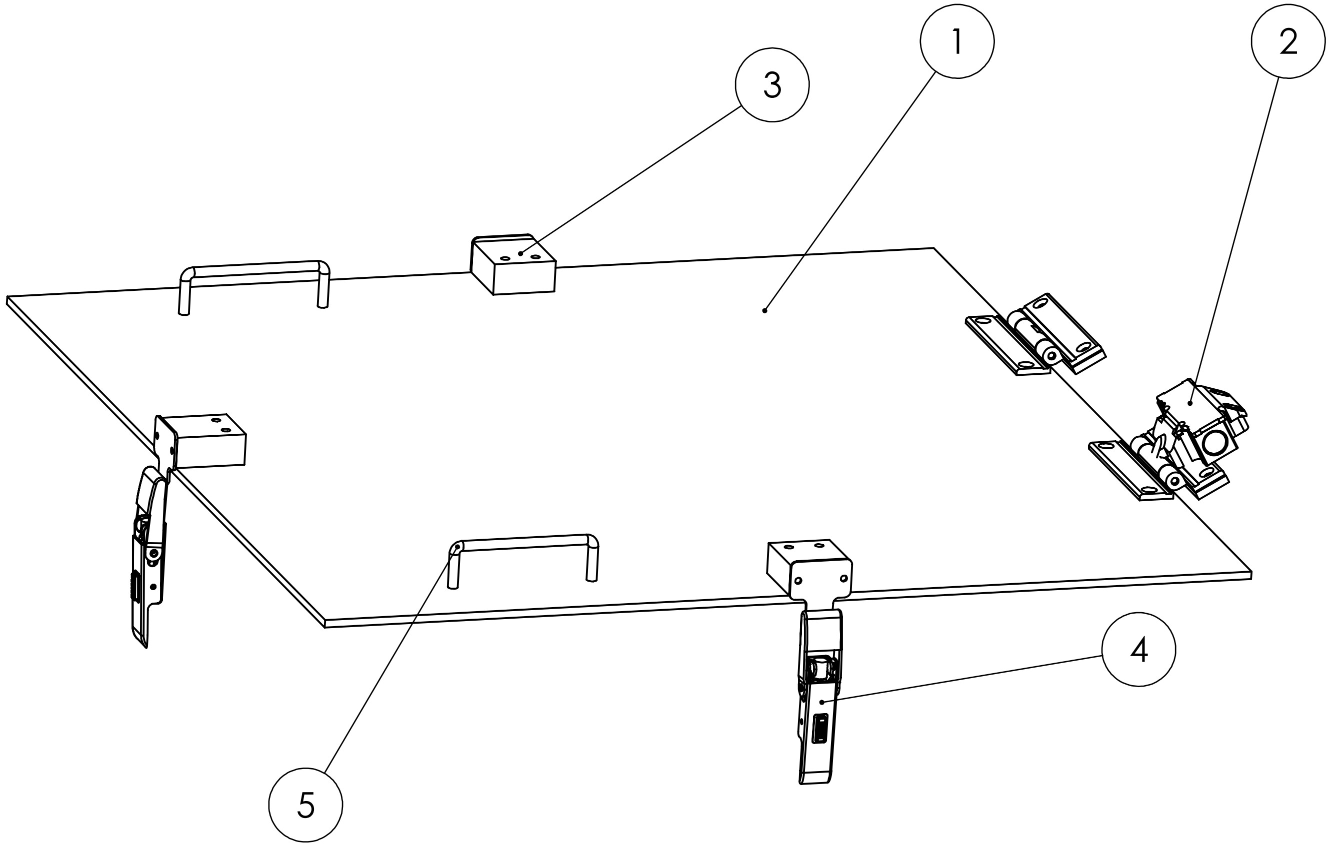
UNLESS OTHERWISE SPECIFIED:		NAME	DATE
DIMENSIONS ARE IN INCHES	DRAWN	Brian Yale	2/6/14
Tolerances: Size: ±0.05 in. Hole Locations: ±0.005 in.	CHECKED	David Shelton	2/6/14
Next Assy: 310	COMMENTS:		
MATERIAL 1/8" Aluminum			
DO NOT SCALE DRAWING			

TITLE:

BLDS Bracket

SIZE	DWG. NO.	REV
A	314	1
SCALE: 1:1		SHEET 1 OF 1

5 4 3 2 1



No.	Part Name	Part No.	Qnty
1	Lid	404	1
2	Safety Hinge	401	1
3	Latch Mount	406	3
4	Latch	405	3
5	Handle	407	2

Note:
Hinges mount with 5/16" - 18 x 1" bolts
Latches mount with 5 No. 10 machine screws each.
Latch mounts attach with with two 1/4" - 20 x 1.25" bots each

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES

	NAME	DATE
DRAWN	Brian Yale	2/6/14
CHECKED	David Shelton	2/6/14

Next Assy: 100

MATERIAL
Various

DO NOT SCALE DRAWING

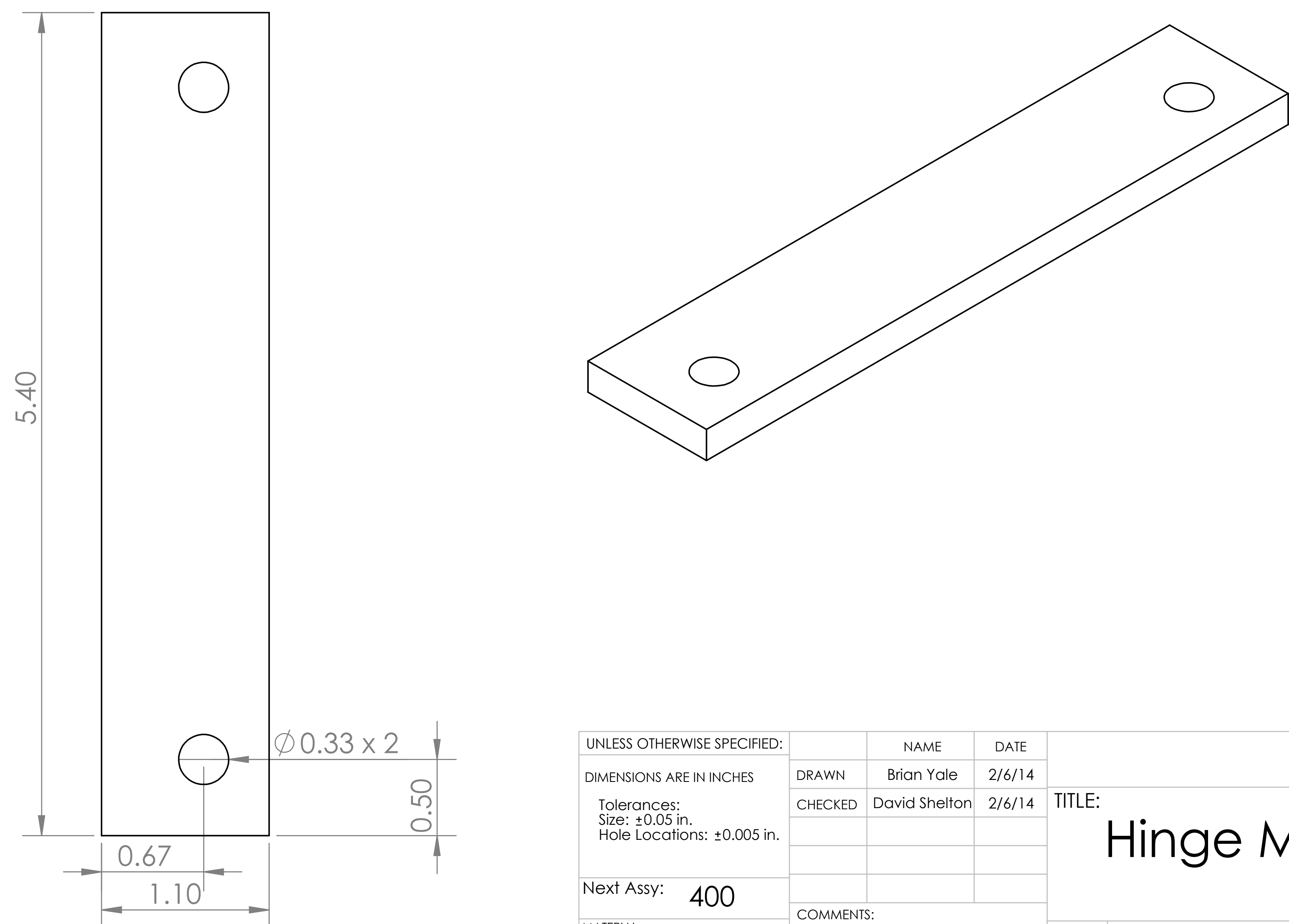
COMMENTS:

TITLE:
Lid Assembly

SIZE A | DWG. NO. 400 | REV 1

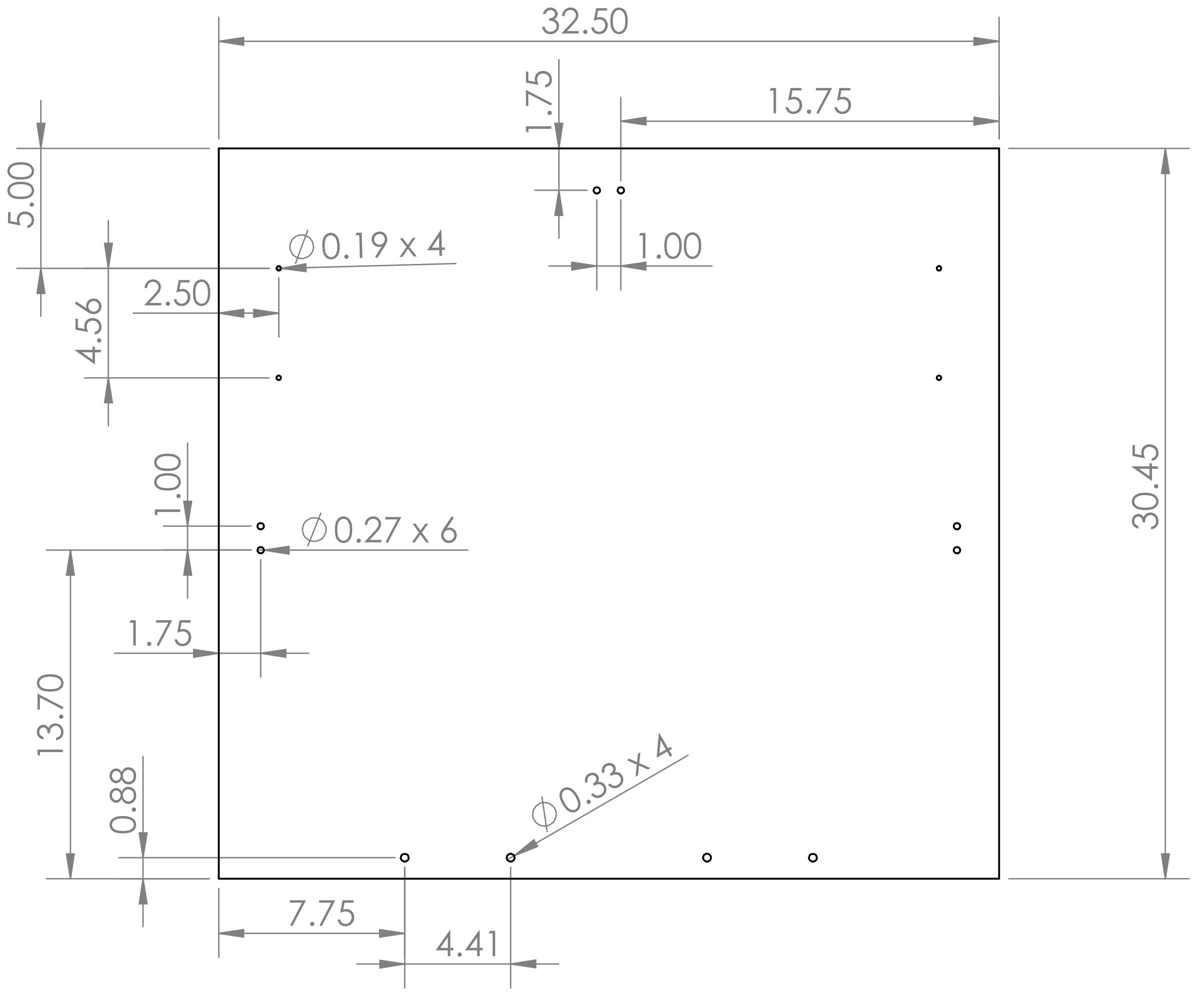
SCALE: 1:6 | SHEET 1 OF 1

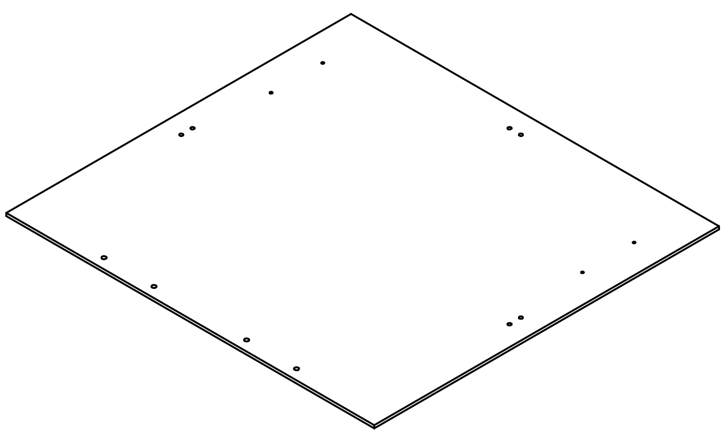
5 4 3 2 1



UNLESS OTHERWISE SPECIFIED:		NAME	DATE	
DIMENSIONS ARE IN INCHES Tolerances: Size: ±0.05 in. Hole Locations: ±0.005 in.	DRAWN	Brian Yale	2/6/14	TITLE: Hinge Mount
	CHECKED	David Shelton	2/6/14	
Next Assy: 400	COMMENTS:			
MATERIAL 1/4" Aluminum				SIZE A — DWG. NO. 403 — REV 1
DO NOT SCALE DRAWING				SCALE: 1:1 — SHEET 1 OF 1

5 4 3 2 1





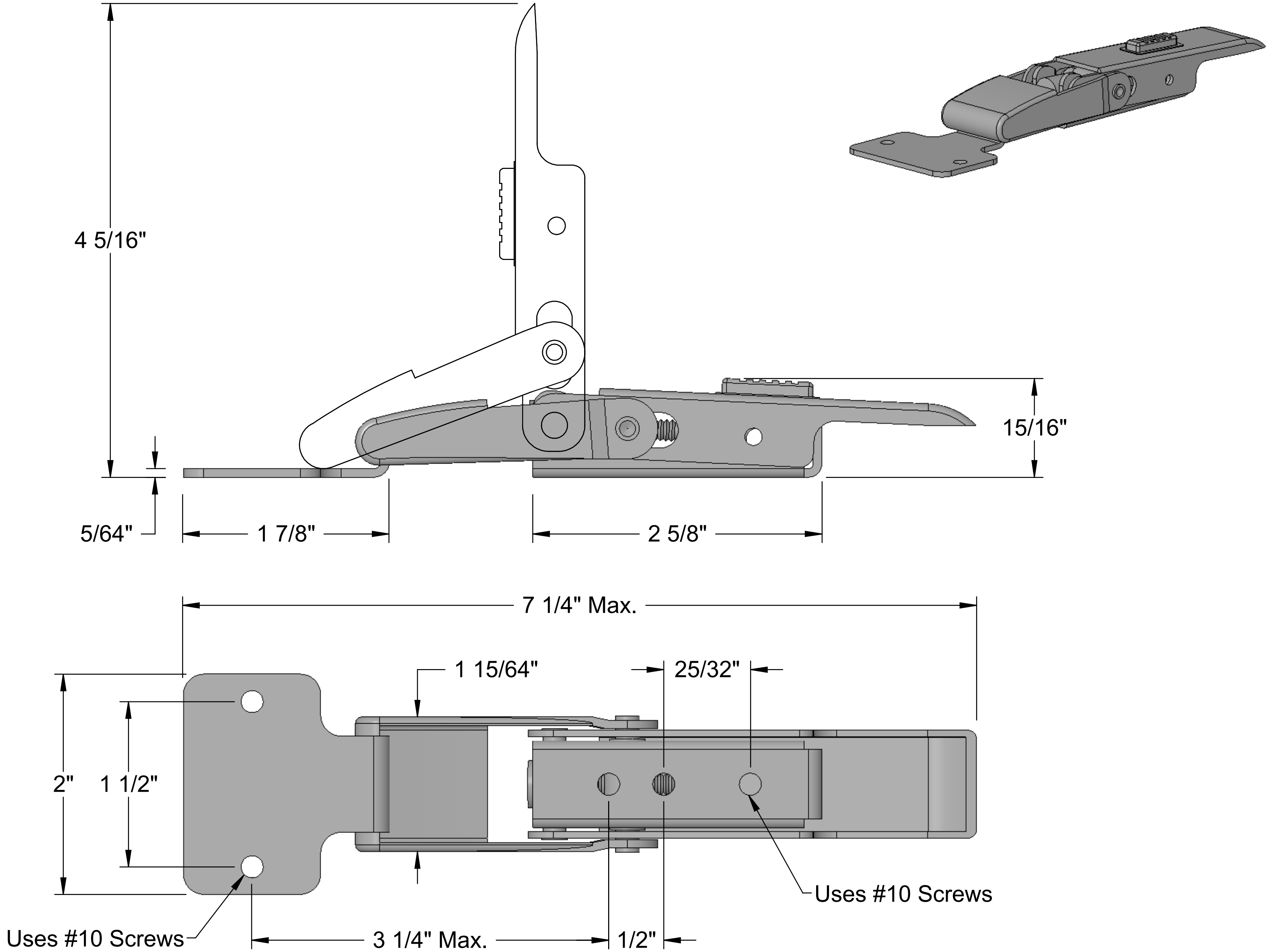
UNLESS OTHERWISE SPECIFIED:		NAME	DATE
DIMENSIONS ARE IN INCHES	DRAWN	Brian Yale	2/6/14
Tolerances: Size: ±0.05 in. Hole Locations: ±0.005 in.	CHECKED	David Shelton	2/6/14
Next Assy: 400			
MATERIAL 1/4" Polycarbonate	COMMENTS:		
DO NOT SCALE DRAWING			

TITLE:

Lid

SIZE	DWG. NO.	REV
A	404	1
SCALE: 1:8		SHEET 1 OF 1

5 4 3 2 1



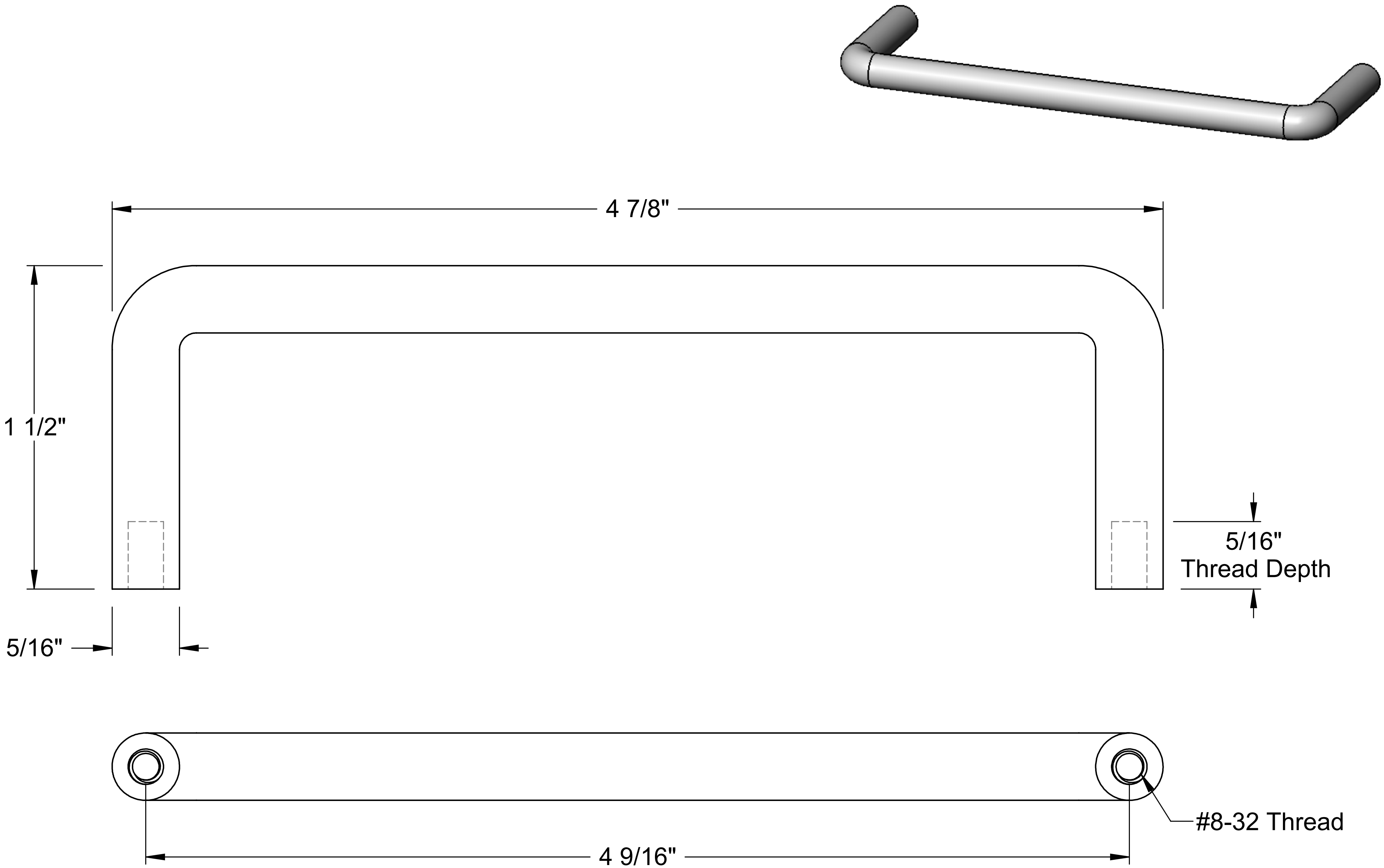
Latch Distance Adjustable from 1 11/16" - 2"

McMASTER-CARR® CAD

PART NUMBER 6200A36

http://www.mcmaster.com

Nonlocking Adjustable Draw Latch with Safety Catch



McMASTER-CARR® CAD

PART NUMBER **1568A69**

http://www.mcmaster.com

Dull Anodized Finish Extruded Aluminum Pull Handle

Appendix C – Bill of Materials

- Overall Bill of Materials
- Hardware Bill of Materials
- Tslot Cut Lenghts

Assembly	Part	Supplier	Manuf. Part No.	Assem Part No.	Size	Quantity	Cost (each)	Cost (total)
Frame - Tslots								
TS15-15	Horizontal Framing	Tslots (Futura Industries)	650005	211	29" long	14	16.58	232.12
	Vertical Framing (top)	Tslots (Futura Industries)	650005	221	7" long	4	4	16
	Vertical Framing (bottom)	Tslots (Futura Industries)	650005	212	16" long	4	9.15	36.6
	Motor Support Framing	Tslots (Futura Industries)	650005	231	13" long	2	7.74	15.48
	4 Hole Corner Gussets	Tslots (Futura Industries)	653169	213	n/a	36	6.75	243
	2 Hole Corner Gussets	Tslots (Futura Industries)	653165	222	n/a	8	4.59	36.72
	Harware	Various (see harware B.O.M.)	Varioius (see harware B.O.M.)	Varioius (see harware B.O.M.)	n/a	n/a	n/a	487.72
							Assembly Cost	1067.64
Housing								
	PC Sides - Bottom (1/4")	Tap Plastics	n/a	101	32"x16"	2	110.22	220.44
	PC Sides - Top (1/4")	Tap Plastics	n/a	102	32"x7"	2	48.22	96.44
	PC Front - Bottom (1/4")	Tap Plastics	n/a	103	32.5"x16"	1	113.67	113.67
	PC Front and Back - Top (1/4")	Tap Plastics	n/a	104	32.5"x7"	2	49.73	99.46
	Expanded Steel Back - Bottom	McCarthy Tank and Steel	n/a	105	32"x16"	1		
	Al Divider (1/4")	McCarthy Tank and Steel	n/a	201	32"x32"	1	97	97
	PC Lid (1/4")	Tap Plastics	n/a	404	32"x32"	1	220.44	220.44
	Latch	McMaster Carr	6200A36	405	n/a	3	33.86	101.58
	Handle	McMaster Carr	1568A69	407	n/a	2	4.2	8.4
	Hardware	Tslots (Futura Industries)	651129	n/a	n/a	64	0.65	41.6
							Assembly Cost	999.03
Drive								
	Motor	Bison	011-336-2005	301	n/a	1	527	527
	Controller	Bison	170-113-0003	301b	n/a	1	239	239
	Shaft	McMaster Carr	6117K33	303	24" Long	1	4	4
	Keyless Bushing	Fenner Drives	B-LOC B106 5/8"	306	n/a	1	30.25	30.25
	Bearing	FYH USA	BLF202-10J	305	n/a	2	10	20
	Coupling	McMaster Carr	61005K133	302	5/8" Bores	1	48.78	48.78
	Hub	n/a	n/a	312	5" Diameter			
	Clamps	McMaster Carr	4961A12	313	n/a	2	36.9	73.8
	Disk	McCarthy Tank and Steel	n/a	311	28" diameter	1	97	97
							Assembly Cost	1039.83
Speed Sensor								
	Sensor	Electro-Sensors	906 Hall Effect Speed Sensor	307	n/a	1	105	105
	Pulser	Electro-Sensors	Split Collar Pulser Wrap	304	n/a	1	250	250
	Tachometer	Electro-Sensors	AP1000 Digital Tachometer	307b	n/a	1	335	335
							Assembly Cost	690
Safety Interlock								
	Hinge Lever Style Switch	Schmersal USA	TESZ1102/45	401/402	n/a	1	150	150

Total Cost 3946.5

Hardware Bill of Materials							
Assembly	Location	Part Name	Manufacturer	Manufacturers Part No.	Quantity	Cost	Total Cost
Bottom Frame							
	Holds Frame Together	Four Hole Corner Gusset	Tslots	653169	16	6.75	108
	Bolts for Previous	5/16-18 x 11/16" FBHSCS & Dbl Econony T-Nut	Tslots	651141	32	1.58	50.56
Top Frame							
	Holds Top frame to Bottom Frame	Four Hole Corner Gusset	Tslots	653169	8	6.75	54
	Bolts for Previous	SS 5/16-18 x 1" BHSCS-Washer & Economy T-Nut	Tslots	651266	32	1.3	41.6
	Holds Top of Top Frame Together	Two Hole Corner Gusset	Tslots	653165	8	4.6	36.8
	Bolts for Previous	5/16-18 x 11/16" FBHSCS & Economy T-Nut	Tslots	651129	16	0.65	10.4
	Divider Bolts	5/16-18 x 11/16" FBHSCS & Economy T-Nut	Tslots	651129	8	0.65	5.2
	Hinge Bolts						
Motor Mount							
	Holds Motor Mount Togeter	Four Hole Corner Gusset	Tslots	653169	12	6.75	81
	Bolts for Previous	5/16-18 x 11/16" FBHSCS & Dbl Econony T-Nut	Tslots	651141	24	1.58	37.92
	Bolts For Motor	1/4-20 x 5/8" BHSCS	Tslots	651023	4	0.24	0.96
	T-Nuts for Motor	15 S Zinc Economy T-Nut 1/4-20 Center Hole	Tslots	651322	4	0.28	1.12
	Bolts for Speed Sensor	5/16-18 x 5/8" BHSCS w/ Washer & Economy T-Nut	Tslots	651190	2	0.64	1.28
Bottom Housing							
	Holds Housing To Frame	5/16-18 x 11/16" FBHSCS & Economy T-Nut	Tslots	651129	30	0.65	19.5
	Latch Bolts	10-24x7/16" Alloy Steel Button Head Socket Cap Screw	McMaster Carr	91255A235	1	9.58	9.58
	Latch Nuts	10-24 Machine Screw Hex Nut	McMaster Carr	90480A011	1	1.72	1.72
Top Housing							
	Holds Housing To Frame	5/16-18 x 11/16" FBHSCS & Economy T-Nut	Tslots	651129	24	0.65	15.6
Lid							
	Handle Bolts	8-32 x 1/2" Alloy Steel Button Head Socket Cap Screw	McMaster Carr	91255A194	1	12.48	12.48

Part Name	Part Number	Length	Quantity
Horizontal Framing	211	29	14
Vertical Framing - Top	221	7	4
Vertical Framing - Bottom	212	16	4
Vertical Framing - Motor Mount	231	13	2

Appendix D – Data Sheets

- Bison Motor
- Bison Tight Drive
- Keyless Bushing
- Speed Sensor
- Tachometer
- Pulser Wrap
- Bearing

336 Series PMDC 90V/130V 5/8'' shaft

011-336-2005: $527.00

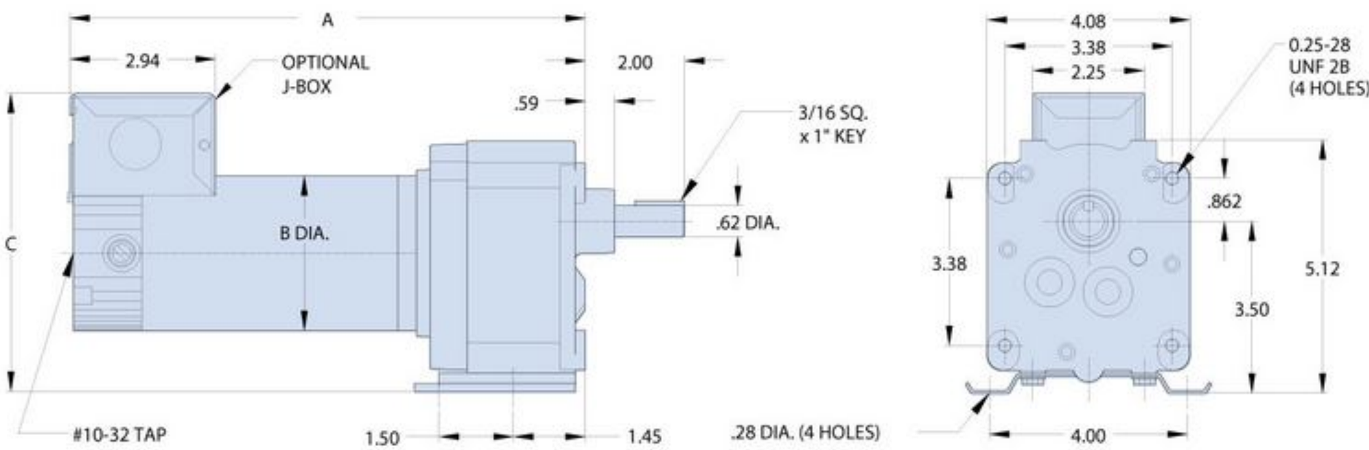
QUICK SPECS

Stock	ISIS	**Voltage (V)**	90-130
Input HP	1/8	**Torque (in-lbs)**	20
Amps	1.3	**Approx Weight**	13
OHL	200	**Ratio:1**	5
Stages	2	**Speed (RPM)**	360
Voltage	90-130	**Speed 130V**	360

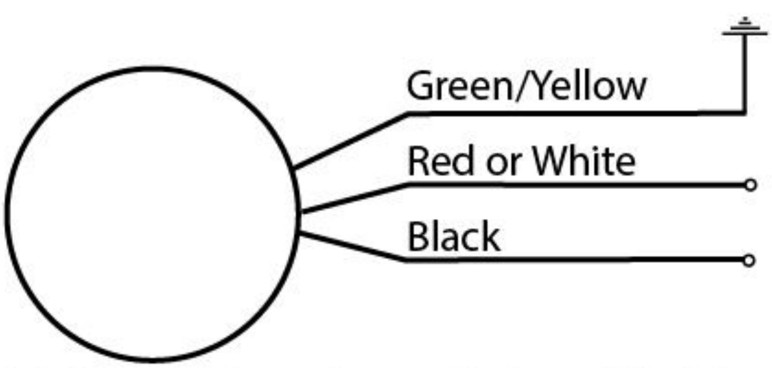
Specifications

Stock	ISIS
Voltage (V)	90-130
Input HP	1/8
Torque (in-lbs)	20
OHL	200
Ratio:1	5
Stages	2
Voltage	90-130
Input Watts	93
CE	No
CSA	No
ROHS	Yes
CuRus	No
IP Rating	IP43
Insulation Class	F
Duty Cycle	Continuous

Schematics / Wiring Diagrams



HP	A	B	C
1/20	8.53	2.58	5.60
1/8	10.34	3.13	6.02
1/4	12.27	3.38	6.23



To Reverse, interchange Red and Black leads.
Note: Some motors have white and black leads.

PMDC Motors

Tight Drive

1/8 HP, 90 VDC, 2.5 AMPS, FIELD INSTALLED

Designed to be easily field mounted on Bison PMDC motors, the speed control is mounted within an aluminum extrusion for superior heat dissipation. A simple knob provides a convenient on-off switch. Three adjustable potentiometers provide settings for minimum RPM, maximum RPM, and current limit. A pre-wired three foot long cord with plug is provided for use with 115V, 60 Hz.

- Simple Mounting and Assembly. Allows the drive to start working for you in the field as quickly as possible
- Easy Operation. Speed is controlled with a simple on/off potentiometer in conjunction with current limit, min. speed, and max. speed settings
- All Metal Enclosure. Durable aluminum housing with steel cover plates disperses heat more efficiently
- Includes Power Cord with Plug. Three foot power cord is included with a NEMA 5-15P plug for use with 115VAC 60Hz
- More Consistent Speed Under All Loads. SCR circuitry provides much more consistent speed throughout the motor's rated torque
- Specifications. Up to 2.5 AMPS (1/8 HP @ 90VDC)

1 Item(s) Show 20 per page

Sort By Name

Product Number	Stock	Mounting Style	HP Rating	Output Current (amps)	Input Voltage	Output Voltage VDC	Control Type
170-113-0003	ISIS	TightDrive	1/8	2.5	115 VAC	90 VDC	SCR

B-LOC.

B-LOC B106 5/8"

Product #T602010

RATING Write | View

The B-LOC B106 Series 5/8" Keyless Bushing provides a high capacity, zero-backlash shaft to hub connection for shafts measuring 5/8" in diameter by means of a mechanical interference fit and transmits up to a maximum of 55 ft lbs of torque.

Download CAD File
View 3D Model
Email This Page
Print This Page

Description | Specifications | Reviews | Additional Information

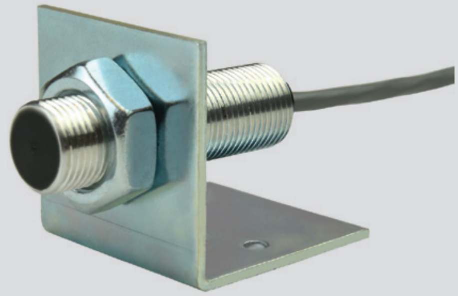
- **Series:** B106
- **Axial Movement:** No
- **Bore Tolerance:** 1.262"
- **Compliancy:** RoHS
- **Component Bore Diameter:** 1.26"
- **Hub Pressure:** 8007
- **Installation Torque:** 3.5 ft lb
- **Internal/ External:** Internal
- **Material:** Steel
- **Metric/Inch:** Inch
- **Releasing/ Locking:** Locking
- **Screw Size:** M4 x 12
- **Self-Centering:** Yes
- **Shaft Diameter:** 5/8"
- **Shaft Tolerance:** 0.623
- **Taper:** Single
- **Thrust:** 2096

Reliable Products
Trustworthy People

906 Hall Effect
Shaft Speed Sensors

Key Features

- Square-wave pulse frequency output, NPN open-collector
- Zero speed operation with no signal loss
- 5-24 VDC powered
- Non-contact, large gap distance sensing
- Simple to install and set up
- Bidirectional (quadrature) options
- Works with Electro-Sensors magnetic pulser discs / wraps
- Optional Mounting Bracket Assembly and Mounting Magnet



Description

Model 906 Hall Effect sensors are water resistant and suitable for industrial applications, including environments where dirt, dust, grease, or moisture are present.

The quadrature (bidirectional) option has two sensors and is designed for applications requiring both speed and direction information.

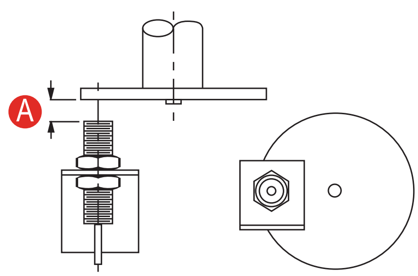
Principle of Operation

These speed sensors use magnet-sensing Hall Effect IC's to produce a digital pulse signal to interface with speed switches, tachometers, counters, signal conditioners, or PLC's. Hall Effect sensors provide true zero speed operation with square-wave output and immunity to electrical noise.

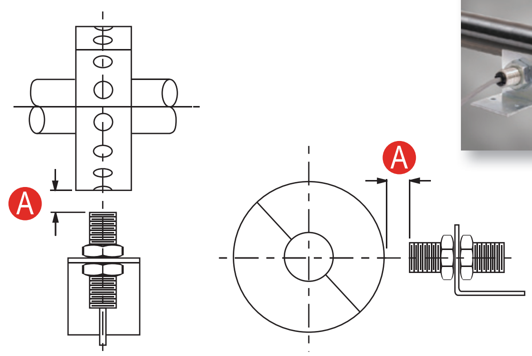
A pulser disc or split collar pulser wrap with embedded magnets is mounted on the monitored shaft. As the shaft rotates, the magnets pass in front of the sensor causing the sensor to switch high and low, thus producing a digital pulse output. The sensors provide a digital square wave signal with a 50/50 duty cycle when used with pulse generators that have evenly spaced magnets of alternating polarity, such as the Electro-Sensors Model 255 Pulser Disc.

The recommended gap distance between the sensor and pulse generator is 1/4 inch +/- 1/8 inch (Represented by A in the figures below). The gap flexibility makes the sensors tolerant of vibration, shaft run-out, misalignment, and industrial environments.

906 with Pulser Disc



906 with Pulser Wrap



906 Hall Effect

Product	
Supply	5-24 VDC @ 10 mA
Output Type	NPN Open Collector
Operating Frequency	0 Hz to 20 KHz
Current Sink	25 mA maximum
Operating Temperature	-40° F to +140° F -40° C to +60° C
Gap Distance	3/8" ± 1/8"
Distance to Input Device	1,500 feet maximum
Cable (22AWG)	906: 3-conductor shielded 906 Quadrature: 4-conductor shielded
Wiring Code	906: Red = Supply, Clear = Common, Black = Signal 906 Quadrature: Red = Supply, White = Common, Black = Signal A, Green = Signal B
Threads	3/4"–16 UNF threads

Specifications subject to change without notice.

Ordering

906 sensors come with a standard "L" bracket for mounting

Model	Part Number
906 AL[1] Body, 10' PVC Cable - Standard	775-000500
906 SS[2] Body, 10' PVC Cable	775-000400
906 Quadrature, AL Body, 10' PVC Cable	775-000504
906 AL Body, 10' Teflon[3] Cable	775-000502
906 SS Body, 50' PVC Cable	775-000405
906 AL Body, 50' PVC Cable	775-000511
906 Quadrature, SS Body, 10' PVC Cable	775-000404
906 Quadrature, AL Body, 50' PVC Cable	775-000509
906 AL Body, 50' Teflon Cable	775-000514
906 Quadrature, SS Body, 50' PVC Cable	775-000409
906 SS Body, 100' PVC Cable	775-000410
906 Quadrature, SS Body, 100' PVC Cable	775-000414
906 SS Body, 10' Teflon Cable	775-000503
906 AL Body, 100' PVC Cable	775-000505
906 PVC Body, 10' PVC Cable	775-000506
906 Quadrature, AL Body, 10' Teflon Cable	775-000507

(continued into next column)

906 Quadrature, AL Body, 50' Teflon Cable	775-000508
906 Quadrature, AL Body, 100' PVC Cable	775-000510
906 SS Body, 50' Teflon Cable	775-000515
906 Quadrature, AL Body, 100' Teflon Cable	775-000516
906 AL Body, 100' Teflon Cable	775-000518
906 SS Body, 100' Teflon Cable	775-000519

1 *Aluminum*
2 *Stainless Steel*
3 *Teflon is a High Temperature Cable*

906 Hall Effect Standard System

• Shaft Speed Pulse Generator

These are the most popular system components. Many other options are available.

System Options	Part Number
Standard 255 Nylon Pulser Disc, 4" Diameter, 16 Magnets	700-000200
Split Collar Pulser Wrap (PVC, Aluminum, Stainless Steel)	Custom (See Website)

Easy Mounting Options	Part Number
EZ-3/4in Bracket Assembly	810-000040
MM-1.25 Mounting Magnet (must use with EZ-3/4in Bracket Assembly)	810-000060

EZ-3/4in Option (includes 8 PPR Pulser Disc in housing)

MM-1.25 Mounting Magnet Option (must be used with EZ-3/4in)

Customization

If one of our standard products does not meet your specifications, please call one of our applications specialists. Many of our products can be customized to fit specific needs.

Additional Information

See the 906 / 907 Hall Effect Sensors Installation and Operating Manual for complete details, specifications, and programming instructions.

AP1000 Digital Tachometer

Tachometers, Counters & Displays

Key Features

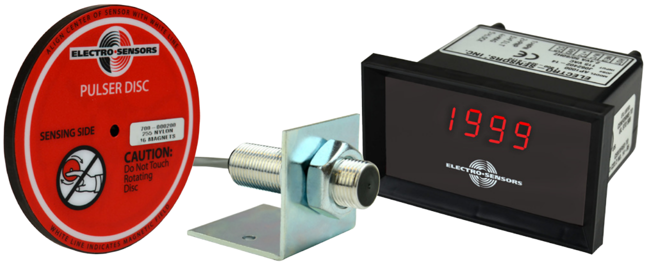
- Displays rate from 0-9,999 or time-in-process
- Field programmable, panel-mount meter
- Easy-to-read, high efficiency LED display
- Optional explosion proof enclosure
- Optional NEMA 4X or NEMA 12 enclosure kit
- 115, 230 VAC (50-60 Hz) and 12, 24 VDC power options
- ETL approved to applicable UL and CSA standards

Description

The AP1000 Digital Tachometer combines accuracy and reliability in a rugged, compact housing. The AP1000 is completely field programmable, and offers simple set up and calibration for use in a wide variety of monitoring and process control applications.

Principle of Operation

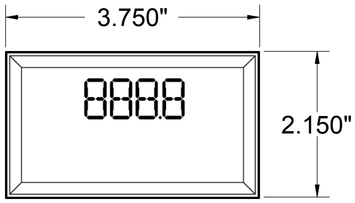
A standard system includes the AP1000 tachometer, a shaft-end mounted pulser disc or split collar pulser wrap, and a Hall Effect Sensor. The pulser generates an alternating magnetic field that is picked up by the large gap, non-contact sensor, which transmits this signal as a digital pulse to the AP1000 via a 3-conductor shielded cable. The AP1000 translates this signal into Hertz or other desired programmable user units such as RPM, FPM, GPM, or TIP (Time-in-Process) and displays them on the front panel LEDs.



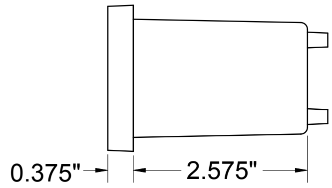
Standard System with: AP1000, 906 Speed Sensor, 255 Pulser Disc

Dimensions

Front View



Side View



Options: Protective Enclosures

NEMA 4X Model

Enclosure Kits - NEMA

NEMA 4X - Model 725-003700
- 10x8x6, Fiber Glass
- Swing Out Door and Window

NEMA 12 - Model 725-000004
- 8x6x6, Steel

Explosion Proof
- Model 305-001600

UL Listings:
- Class I, Div I, Class B, C, D
- Class II, Div I, Class E, F, G
- Class III, Div I, Type 4

AP1000 Digital Tachometer

Tachometers, Counters & Displays

Specifications

Product	
Input Power Voltage Optional Voltages	115 VAC, 60 Hz 230 VAC, 24 VDC, 12 VDC
Input Signal Type	NPN open collector, PNP, magnetic pickup, logic level
Pull-up	2.2K Ohms
Frequency Range	0.01 Hz – 9,999 Hz
Sensor Supply	10 VDC at 50 mA max
Display Type	0.3" height segmented LED

Resolution	4 Digits
Accuracy	±1 Digit
Physical/Environmental Enclosure	Noryl 255
Tachometer Operating Temperature	0° C to +70° C*
Storage Temperature	-65° C to +70° C
Tachometer Mounting	Panel mount

** Contact Electro-Sensors for higher temperature ranges*
Specifications subject to change without notice.

Ordering

Model	Part Number
AP1000, 115 VAC	800-082000
AP1000, 230 VAC	800-082001
AP1000, 12 VDC	800-082002
AP1000, 24 VDC	800-082003
AP1000, 12 VDC High Intensity Display	800-082004

Enclosure Options	Part Number
Explosion Proof Enclosure	305-001600
NEMA 4X Enclosure Kit	725-003700
NEMA 12 Enclosure Kit	725-000004

AP1000 Standard System

- Speed Sensor
- Shaft Speed Pulse Generator

These are the most popular system components. Many other options are available.

System Options	Part Number
906 Hall Effect Speed Sensor	775-000500
907 XP Hall Effect Speed Sensor (Explosion Proof)	775-000600
Standard 255 Nylon Pulser Disc, 4" Diameter, 16 Magnets	700-000200
Split Collar Pulser Wrap (PVC, Aluminum, Stainless Steel)	Custom (See Website)

Customization

If one of our standard products does not meet your specifications, please call one of our applications specialists. Many of our products can be customized to fit specific needs.

Additional Information

See the AP1000 Installation and Operating Manual for complete details, specifications, and programming instructions.

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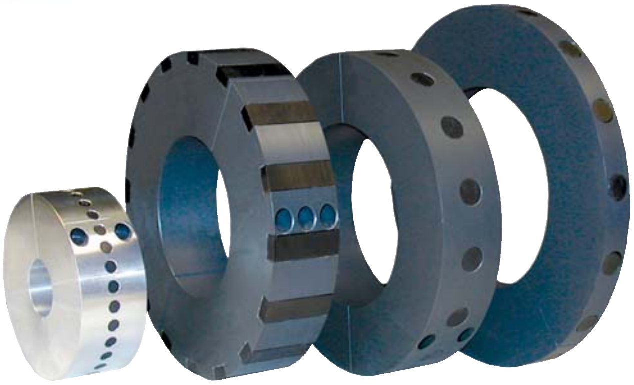


Split Collar Pulser Wraps

Custom made for your application, built to your specifications

- No machinery tear-down required for mounting
- Five types of wraps fit most applications
- Custom number of pulses per revolution
- PVC, aluminum, or stainless steel
- High temperature wraps available

Product Information

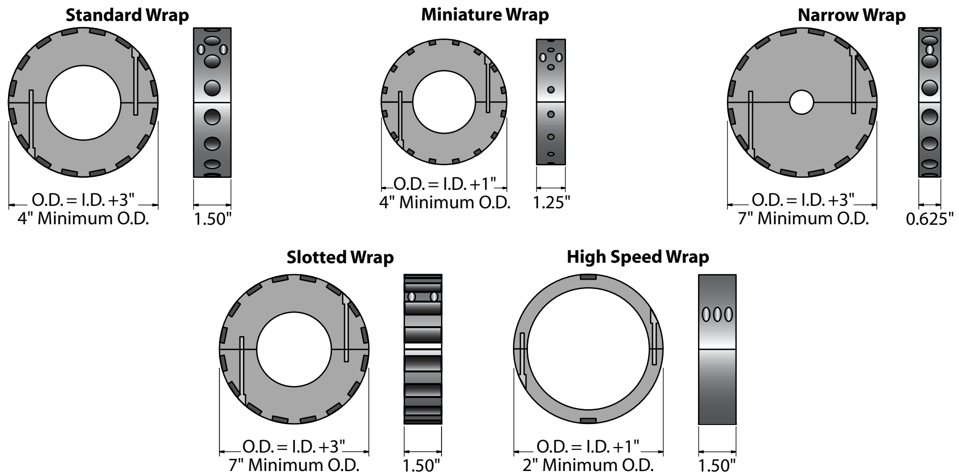
Description

Pulser Wraps are PVC, aluminum, or stainless steel split collars with magnets mounted on the outside circumference. The magnets serve as targets for Hall-Effect and Magnetoresistive sensors that switch when exposed to magnetic fields. All wraps are custom machined to the diameter of the monitored shaft and are split into halves. This splitting process allows the wrap to clamp tightly onto the shaft without tearing down any equipment to install them. The halves are secured around the shaft with recessed Allen-head socket screws supplied. Pulser Wraps provide magnetic targets that are strong enough to allow large gap distances (up to 1/2-inch) between the wrap and the sensor. The wrap and sensor system forgives slight misalignment of the sensor, machinery vibration, dirty, wet, or greasy environments, and shaft end-play.

Special Wraps

Wraps purchased for use with standard Electro-Sensors systems are typically provided with 16 magnets of alternating polarity. Using a standard Hall-Effect sensing system, this provides 8 pulses per revolution from the sensor. Special wraps can be provided to suit particular application requirements. This often includes adding magnets to the wraps to increase the number of pulses per revolution generated by the sensing system. Adding magnets will usually require an increase in the outside diameter of the wrap. Standard and miniature wraps are typically selected when more magnets are required because the magnets may be added without large increases in the ouside diameter, particularly if the 1/4" diameter magnets are used. Wraps can be manufactured from PVC, aluminum, or stainless steel, and have the option of a keyway where required. **Steel inserts can be substituted for magnets when using proximity or mag sensors.** An Electro-Sensors Application Specialist can assist in the design of wraps to meet specific or special needs.

Dimensional Drawings



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Free Catalog and Application Assistance
1-800-328-6170
Visit Us Online:
www.electro-sensors.com

Installation

Pulser Wraps are custom manufactured to fit the shaft they will be mounted on. When the wrap is shipped, four Allen-head cap screws hold the two halves of the wrap together. These screws must be removed so that the wrap is in two halves. **Place the halves around the shaft, reinsert the screws and torque them evenly to 5 foot pounds.** After installation, a small gap between the two halves is normal.

To correctly specify the size, type and material of wrap you require, please answer the following questions and forward the information to the sales department at Electro-Sensors. Please review the specifications and differences between the various wraps before submitting this information.

Before ordering, please check all wrap dimensions carefully. Wraps are custom made and are non-returnable items.

1. Exact shaft diameter (in inches)____________________
2. Type of wrap____________________ (Standard, Miniature, Narrow, Slotted, High Speed)
3. Max shaft RPM____________________
4. Wrap material____________________ (PVC, Aluminum, Stainless Steel)
5. Ambient temperature____________________
6. Are there corrosive elements present?____________________
7. Additional application information____________________

You can also contact an Electro-Sensors application specialist for assistance:
Toll-Free: 800-328-6170 • 952-930-0100 • sales@electro-sensors.com

The formulas below show the maximum number of magnets that can be mounted on the Standard or Miniature Wraps with respect to magnet diameter and the outside diameter of the Wrap.

1/2" Magnets

$$\frac{(\text{Wrap Outside Diameter} - 1/2") \times 3.14}{0.65}$$

1/4" Magnets

$$\frac{(\text{Wrap Outside Diameter} - 1/2") \times 3.14}{0.35}$$

Specifications • Split Collar Pulser Wraps

All Wraps - Temperature Range

PVC Material .... -40°C to +60°C (-40°F to +150°F)
Aluminum Material .... -40°C to +150°C (-40°F to +302°F)
Stainless Steel........ -40°C to +150°C (-40°F to +302°F)

Consult factory for higher temperature ranges.

Wrap Types

Standard - Under 3,000 rpm

Width .... 1-1/2"
Inside diameter........ Custom to shaft size
Outside diameter .... I.D. + 3"
Min. outside diameter .... 4"
Material........ PVC std., aluminum optional
Standard magnet size .... 1/2" diameter
Standard no. of magnets .... 16 (8 or 16 pulses/revolution)

Miniature - Under 3,000 rpm

Width .... 1-1/4"
Inside diameter........ Custom to shaft size
Outside diameter .... I.D. + 1"
Minimum outside diameter .... 4"
Material........ PVC std., aluminum optional
Standard magnet size .... 1/4" diameter
Standard no. of magnets .... 16 (8 or 16 pulses/revolution)

Narrow - Under 3,000 rpm

Width .... 5/8"
Inside diameter........ Custom to shaft size
Outside diameter .... I.D. + 3"
Minimum outside diameter .... 7"
Material........ PVC std., aluminum optional
Standard magnet size .... 1/2" diameter
Standard no. of magnets .... 16 (8 or 16 pulses/revolution)

Slotted - Under 3,000 rpm

Width .... 1-1/2"
Inside diameter........ Custom to shaft size
Outside diameter .... I.D. + 3"
Minimum outside diameter .... 7"
Material........ PVC std., aluminum optional
Standard magnet size .... 1/2" x 1-1/2" bar
Standard no. of magnets .... 16 (8 or 16 pulses/revolution)

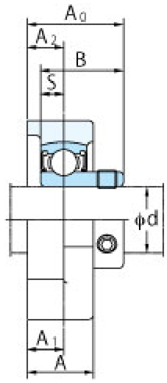
High Speed - Over 3,000 rpm

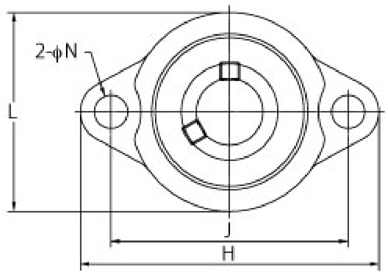
Width .... 1-1/2"
Inside diameter........ Custom to shaft size
Outside diameter .... I.D. + 1"
Minimum outside diameter .... 2"
Material........ Aluminum
Standard magnet size .... 1/2" diameter
Standard no. of magnets .... 2 (1 or 2 pulses/revolution)

Specifications subject to change without notice.

ES-102 Rev F

BLF202-10J





Specifications	
Housing Number	LF203
Bearing Number	SB202-10
Shaft Size	5/8 in
Bolt Size	M6 1/4 in
Weight	0.25 kg 0.55 lb
Locking Style	Set Screw Locking

Dimensions	
H	81 mm 3-3/16 in
L	52 mm 2-1/16 in
A	18 mm 23/32 in
J	63.5 mm 2-1/2 in
N	8 mm 5/16 in
A1	9.5 mm 3/8 in
A2	9.5 mm 3/8 in
A0	25.5 mm 1 in
B	22 mm 0.866 in
S	6 mm 0.236 in

Basic Load Rating	
Cr	9.55 kN 2147 lbf
Cor	4.8 kN 1079 lbf
Factor fo	13.2

Appendix E – References

Bison Motor Specs: www.bisongear.com

Bearing Specs: www.fyhbearings.com

Coupling, Latch, Handle Specs: www.mcmaster.com

Tslot Specs – www.tslots.com

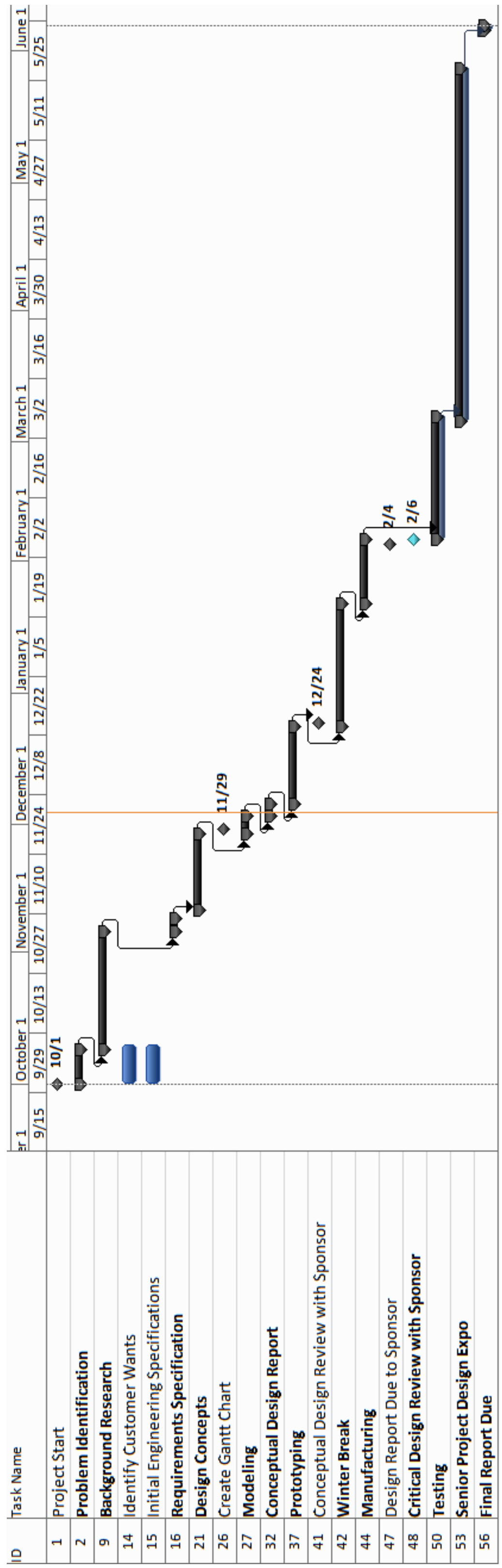
Polycarbonate Specs: www.tapplastics.com

Bushing Specs: www.fennerdrives.com

Safety Hinge Specs: www.schmersalusa.com

Speed Sensor Specs: www.electro-sensors.com

Appendix F - Gantt Chart



Appendix G – Final Budget

Part	Anticipated Cost	Actual Cost
Tslot Extrusions	$543.20	$0.00
Tslot Brackets	$279.72	$0.00
Tslot Hardware	$529.32	$0.00
Polycarbonate	$530.01	$937.00
Aluminum Divider	$97.00	$60.00
Latches	$101.58	$101.58
Handles	$8.40	$8.40
Motor	$527.00	$527.00
Controller	$239.00	$239.00
Shaft	$4.00	$6.00
Keyless Bushing	$30.25	$30.25
Bearings	$20.00	$25.00
Coupling	$48.78	$50.00
Hub	$0.00	$60.00
Clamps	$73.80	$73.80
Disk	$97.00	$220.00
Sensor	$105.00	$105.00
Pulser	$250.00	$250.00
Tachometer	$335.00	$335.00
Safety Interlock	$150.00	$0.00
Emergency Stop	$50.00	$0.00
Extra Expenses	$0.00	$50.00
Total	$4,019.06	$3,078.03