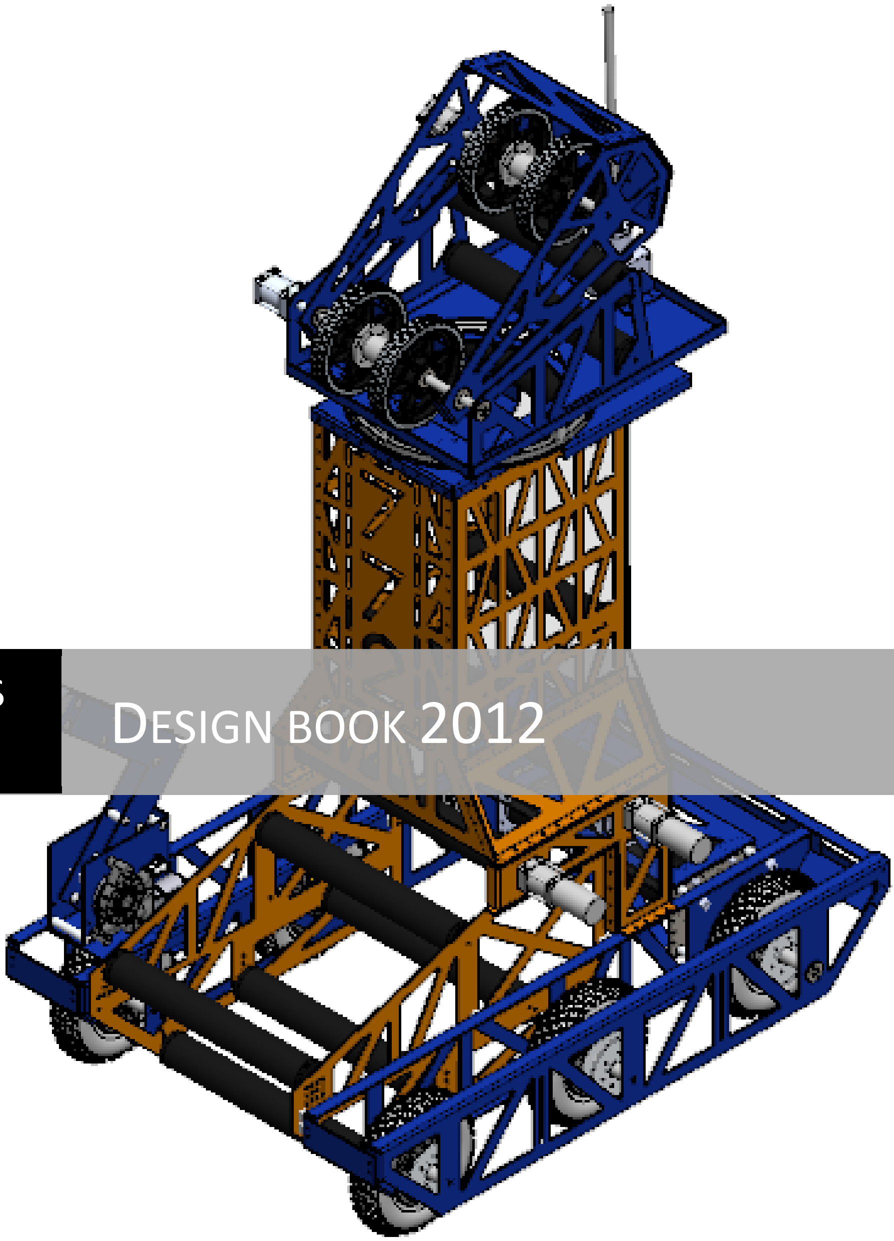
2012 FRC Season



SABRE BYTES
772

DESIGN BOOK 2012

Introduction

This book takes you through the process of how Team 772, Sabre Bytes, designed their 2012 *Rebound Rumble* robot, Droid. Here you will find reasons of why sub-assemblies (ex. Turret, chassis, etc) were designed the way they were, motor and electronic specification, part/assembly drawings, a calendar of the build season, and how we could improve the design/build process.

Why is Design Important?

This year Team 772 fully designed their robot in CAD software. The design software used was a donated version of *2011 SolidWorks Student Edition.* The process of designing is extremely helpful in FIRST and in Industrial settings for many reasons. First, designing helps the designer find issues in the robot assembly. The team can easily discover if a piece is interfering with something or if the motor won`t have enough speed or torque for its application. Second, with having a full design of your robot the build process will usually go faster, meaning more time for programming and driver practise. Design can be beneficial to your team because if you were to design a sheet metal robot, you could send the design to a sponsor or company that can cut the sheet metal for you, and bend it. Your team still has to make small parts that aren't made of sheet metal, but a lot of your robot is done and just needs to be assembled. This method was used for us this year, and it proved to be very beneficial. We designed the full robot before building, rather than "designing" and building at the same time.

Process of Designing

This year Team 772 used a process to design the robot. The different processes of designing were:

i. **Analyze and Strategize**

This step in the design process is where we understand everything about the game. The team figures out how we can score and what the different ways to score are. Then we try to strategize and understand how the game will be played. The reason we do this is to understand what our robot needs to be able to accomplish. This way we can build a robot to complete the tasks quickly and effectively.

ii. **Brainstorm**

Brainstorming is an essential part of the designing process. Here Team 772 started to think of ways to manipulate the ball, drive over the bump, get the bridge down, and shoot the ball accurately and quickly. Many ideas came out of the brainstorming section however it will be hard to list all of them, so I will list a few simple ideas. To pick up the balls we wanted something quick. The choices were mainly conveyor or pool noodle system. To drive over the bump we wanted to put pneumatic tires on and cut the front and back of the chassis to be able to just drive over. Other ideas consisted of ramps to push our robot up and lifting up wheels over the bump to drive over with ease. To push down the ramp the ideas consisted of, a ramp that pushed the bridge down when we drive into the bridge, and a poker that pushes the bridge down when we drive up to it. As a shooter we were choosing between a puncher and a double wheeled shooter. This can be a stressful part in the design process because there are so many ways to build your robot and trying to find the “perfect” one is nearly impossible.

iii. <u>Prototyping</u>

While in the prototyping stage the team makes quick mock-ups of the ideas we came up with in the brainstorming stage. This is an extremely important part of the design process because it helps the designers chose what the best way to make the robot is. During this step we found that the double wheeled shooter was the best way to go, because it could shoot the balls further and quicker and the punching shooter took too long to reload. We found that the conveyor system would work better because there is always contact with the ball while it is inside the robot.

iv. **<u>CAD Designing</u>**

With all the data collected from the first three steps the team can start to design the robot. With the assist of the program SolidWorks Team 772 made a full design of the robot for this year’s game. This process may take the longest and may take up the most time during the build season; however it will help make a team better at the engineering part of robotics, and make the actual building of the robot a lot quicker because you already know what needs to be made.

Team 772's Robot "Droid"

This section will describe the different sections of Team 772's 2012 robot. The individual sections include the Chassis, Bridge Lowering Device, Ball Collector/Tower Assembly, Turret Assembly, and the Shooter Assembly. A description of all the sections and how/why we chose this will be included.

Chassis:

the chassis was designed to be light weight, robust, and to drive over the center bump with ease. To accomplish these things we decided to make a sheet metal chassis to keep the weight down to a minimum. There are 0.75" flanges on the outer edges of the side plates where possible to make the chassis very robust. To accomplish going over the bump we decided to use 8" pneumatic wheels from AndyMark. This would make the center of the wheel equal to or higher than the bump. To make the chassis quick at turning the center wheels were lowered 1/8" so they could act as an axis. We chose to use "AM Shifting gearboxes" to make our robot have a lot of torque and a lot of speed.

Bridge Lowering Device:

to make a bridge lowering device driver friendly, easy to build and lightweight we chose to put a simple "L" shaped stick on a window motor. When the motor turns then the stick pushes down the bridge for our robot to simply drive up and onto the bridge. The driver would be able o easily lower and raise this making it really quick and easy to balance in the end game.

Ball Collector/Tower Assembly:

We knew our ball collector would need to be quick and effective at picking up balls from the floor. We also wanted to prevent balls from jamming inside our robot, which could stop us from scoring any more points during that match; we chose to use a "conveyor" type ball collector. This would ensure the ball is in contact with the rollers at all times. To do this we got ABS piping, outer diameter of 1.9", to hold the belting material. The belting material used to hold the balls is a Polyurethane Belt from McMaster-Carr. This belting is very grippy to ensure the balls do not slip or get stuck inside the robot. The ball collector is powered by two AndyMark 9015 Motors (found in the KoP) with a 71:1 reduction (spinning at 250RPM). It now takes between 2 and 3 seconds for the ball to reach the shooter.

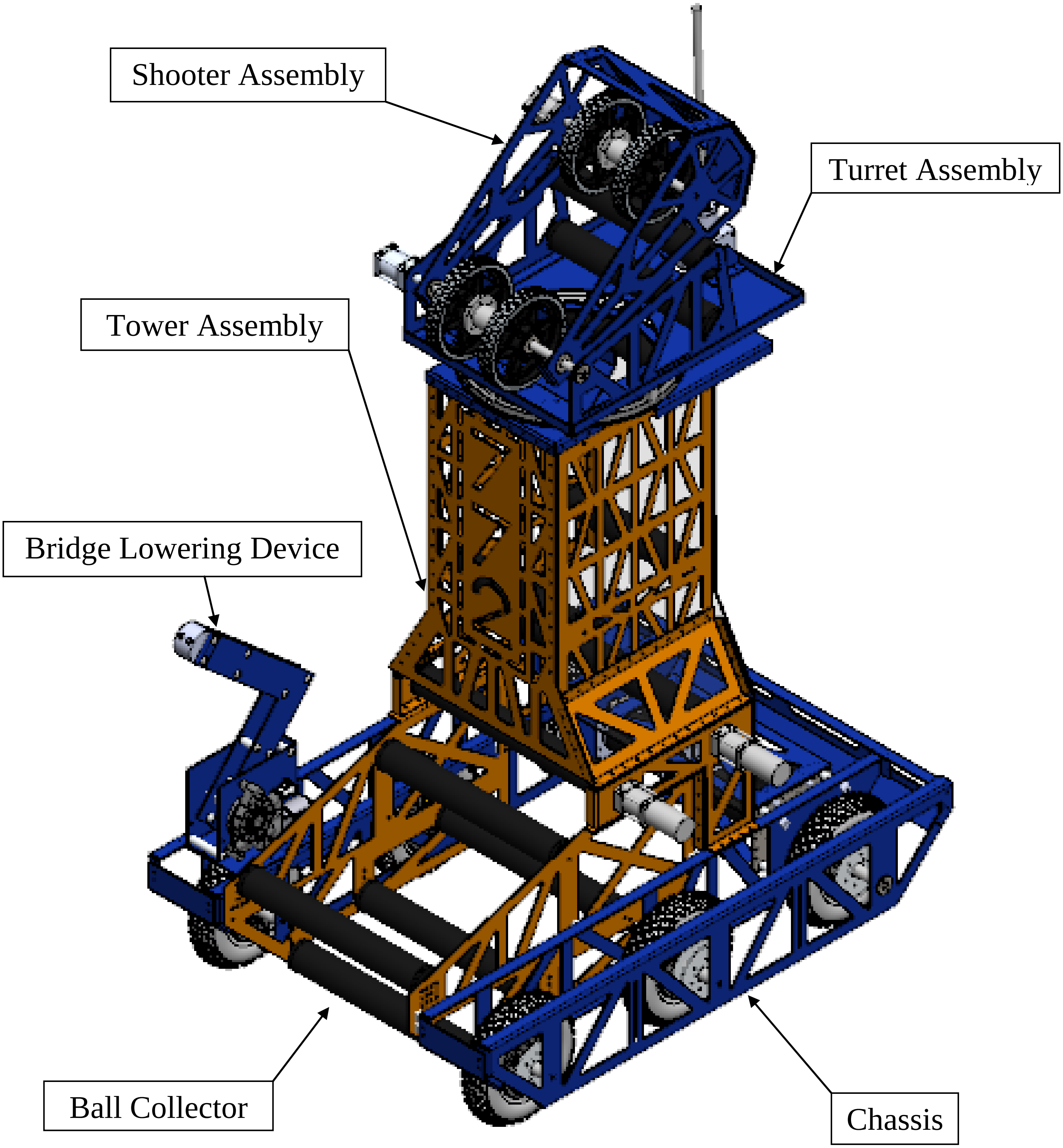
Turret Assembly:

To make the turret we wanted something that was able to turn at least 45^{o} each way to adjust our shooter without moving the whole robot. To do this we mounted everything on top of a "Lazy Susan Bearing" so it could easily move side to side. To turn it a motor was mounted on the back of the Robot, on a stationary point with a belt pulley set screwed on. The belt ran around the perimeter of the Lazy Susan Bearing and when the motor moved, it turned the shooter to aim at a target.

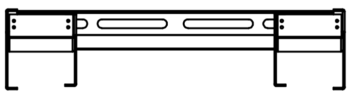
To change the shooter angle we decided to mount a lead screw onto a motor, A stationary hub for the lead screw was mounted into of the shooter. When the motor moves clockwise or counter-clockwise, the shooter increases or decreases.

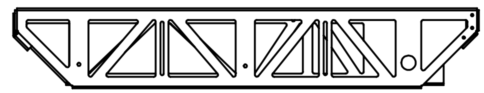
Shooter Assembly:

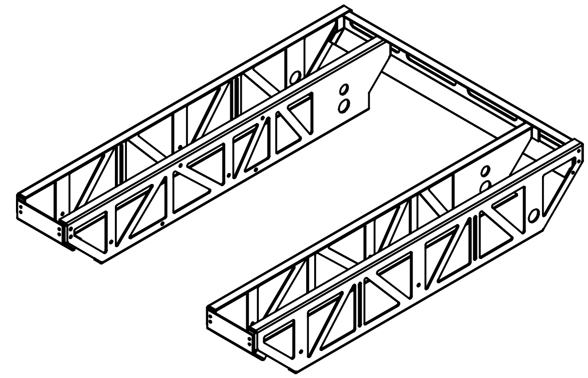
The shooter needed to be quick and accurate. To do this we chose to use a double sided shooter, meaning there is a pair of wheels on either side of the ball (top and bottom). These wheels are both powered by bane-bot motors in a 4:1 reduction. At top speed the shooter is extremely powerful and shoots the ball too far. So the speed of the shooter wheels can be dialed down to make closer shots.

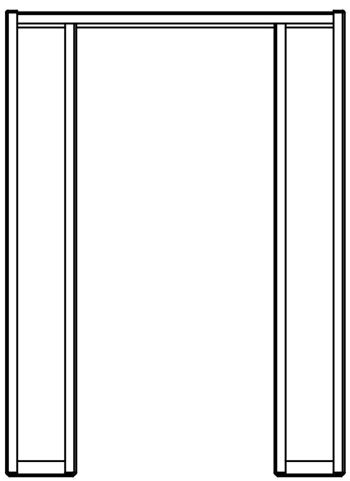

Shooter Assembly
Turret Assembly
Tower Assembly
Bridge Lowering Device
Ball Collector
Chassis

Abreviations for Parts							
SB-12 - <assembly> - <kind of part> - <location1> - <location2>							
SB	**12**	**Assembly**		**Kind of part**		**Locaton 1 or 2**	
Sabre Bytes	2012 season	C	CHASSIS	P	PLATE	F	FRONT
		T	TOWER	A	AXLE	B	BACK
		CT	COW TIPPER	S	SPACER	R	RIGHT
		TR	TURRET	M	MOTOR	L	LEFT
		S	SHOOTER	SP	SPROCKET	BT	BOTTOM
		R	ROBOT			T	TOP
		BC	BALL COLLECTOR			I	INSIDE
						O	OUTSIDE
						LS	LASY SUSAN
						S	SHOOTER
						HB	HUB MOUNT
						MM	MOTOR MOUNT
						BD	BALL DEFLECTOR









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2	Side Plate - L - O	1
3	Side Plate - B - O	1
4	Side Plate - L - I	1
5	Side Plate - R - I	1
6	Side Plate - F - O - L	1
7	Side Plate - F - O - R - 1	1

NEXT ASSY | USED ON
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COMMENTS:

SABRE BYTES FIRST 772

Chassis - Frame

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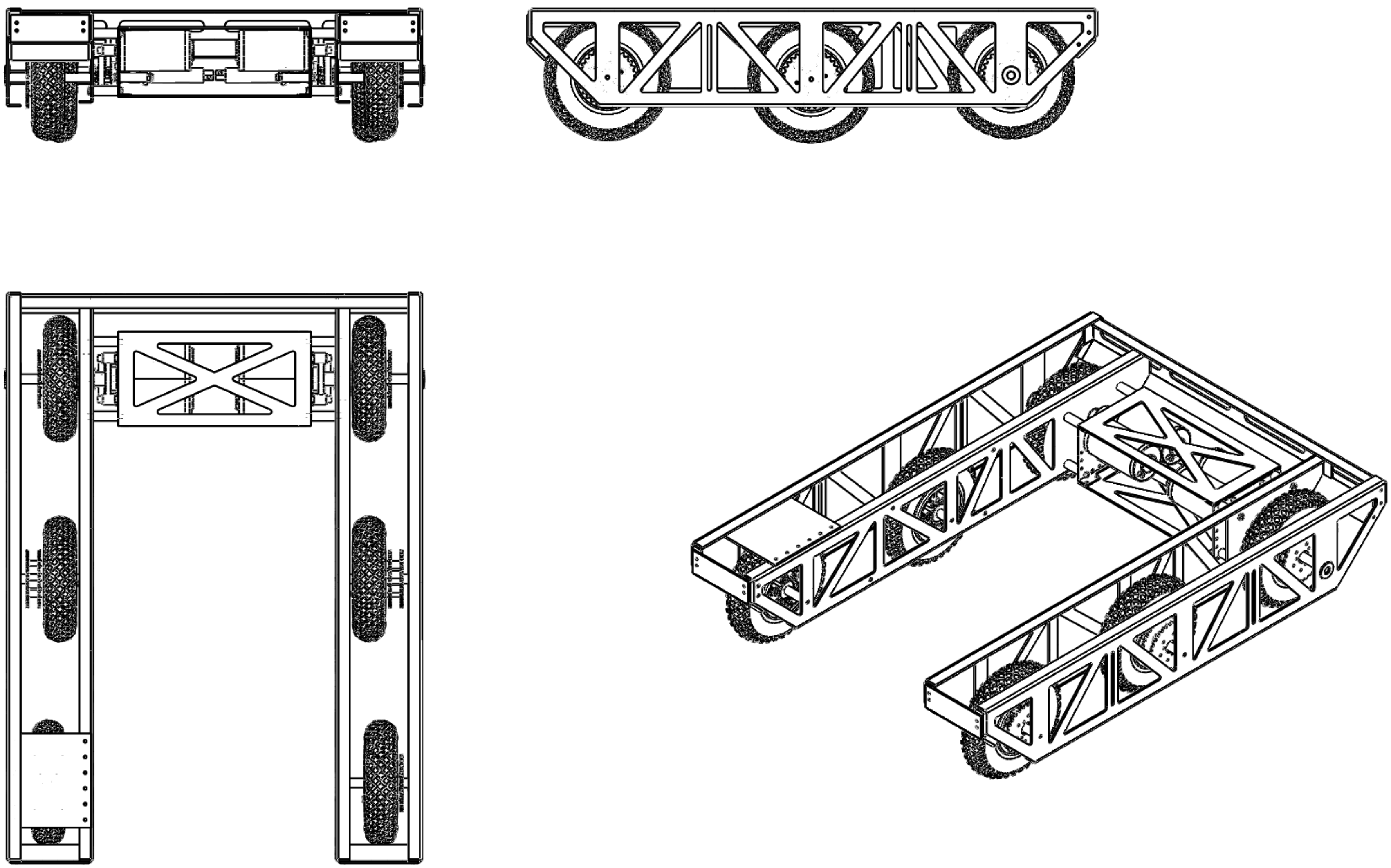

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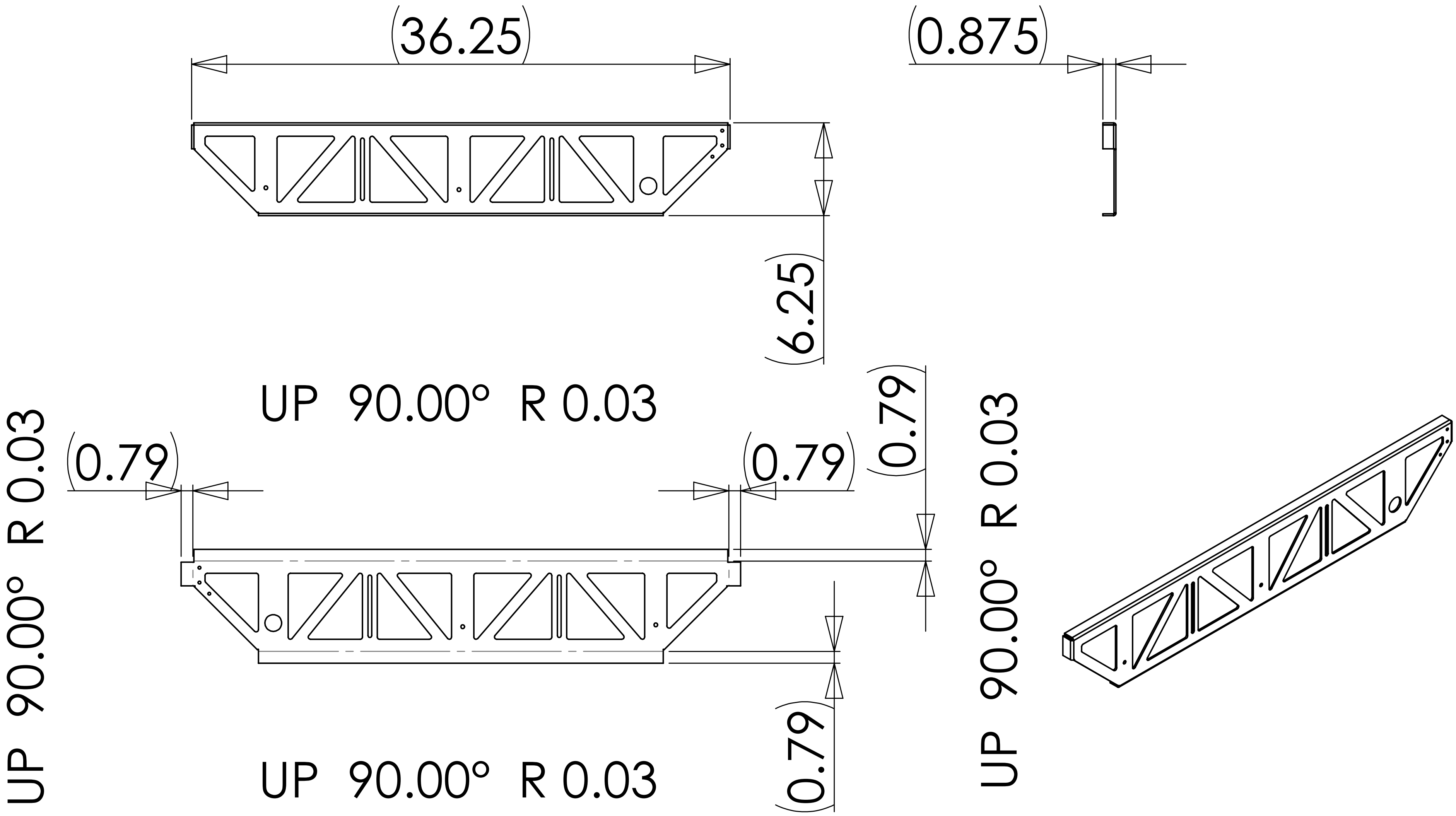
2	Side Plate - L - O	1
3	Side Plate - B - O	1
4	Side Plate - L - I	1
5	Side Plate - R - I	1
6	Side Plate - F - O - L	1
7	Side Plate - F - O - R - 1	1
8	Transmission Support	2
9	10-32_nylock_nut	12
10	10-32x2500_shcs	4
11	1-4-28_jam-nut	2
12	5-8-18_jam_nut	2
13	amshifter2_d02	2
14	amshifter2_d07	4
15	m-0405-dp_cylinder	2
16	amshifter2_d19	2
17	amshifter2_d03	2
18	r3 bearing	2
19	amshifter2_d08	2
20	0625x3125_roll_pin	2
21	4-40x0500_shcs	4
22	CIM motor	4
23	5-16_washer	8
24	10-32x0500_shcs	8
25	amshifter2_d12	4
26	2mmx2mmx14mm_key	4
27	8mm_spring_clip	4
28	10-32x3000_shcs	8
29	amshifter2_d04	8
30	AMShifter_d01	2
31	fr-6	2
32	fr-6-zz	2
33	amshifter2_d10	2
34	amshifter2_d13	2
35	amshifter2_d11	2
36	amshifter2_d06	2
37	amshifter2_d09	2
38	amshifter2_d14	2
39	67353805 washer	6
40	67501726 0925x100 roll pin	2
41	125x124x400_key	4
42	fr-8-zz	2
43	fr-6-zz_1	2
44	fr-6_1	2
45	r8 bearing	2
46	amshifter2_d05	2
47	fr-8-zz - 1	12
48	Tire	6
49	Valve	6
50	#4x1.00, Plastic Thread Rolling Screw, Pan Head, Cross Recessed, Zinc Plated (Plastic Applications)_	36
51	Hub	12
52	Sprocket Spacer	36
53	500-key-hub	2
54	30T - .875 bore	8
55	Sprocket Spacer - 0.625in	12
56	Axle	4
57	Plate - attachment	1
58	Transmission Plate	2



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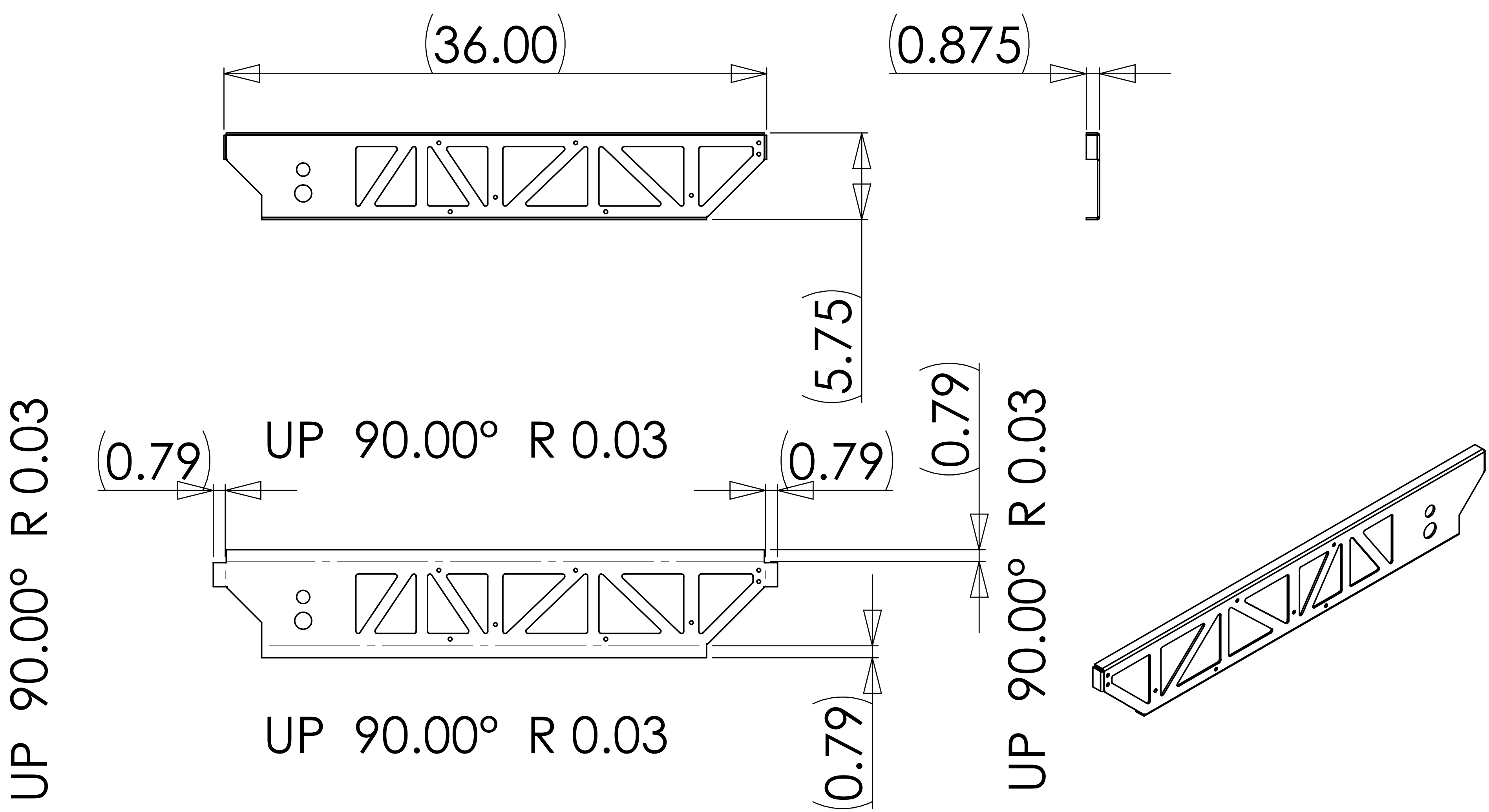

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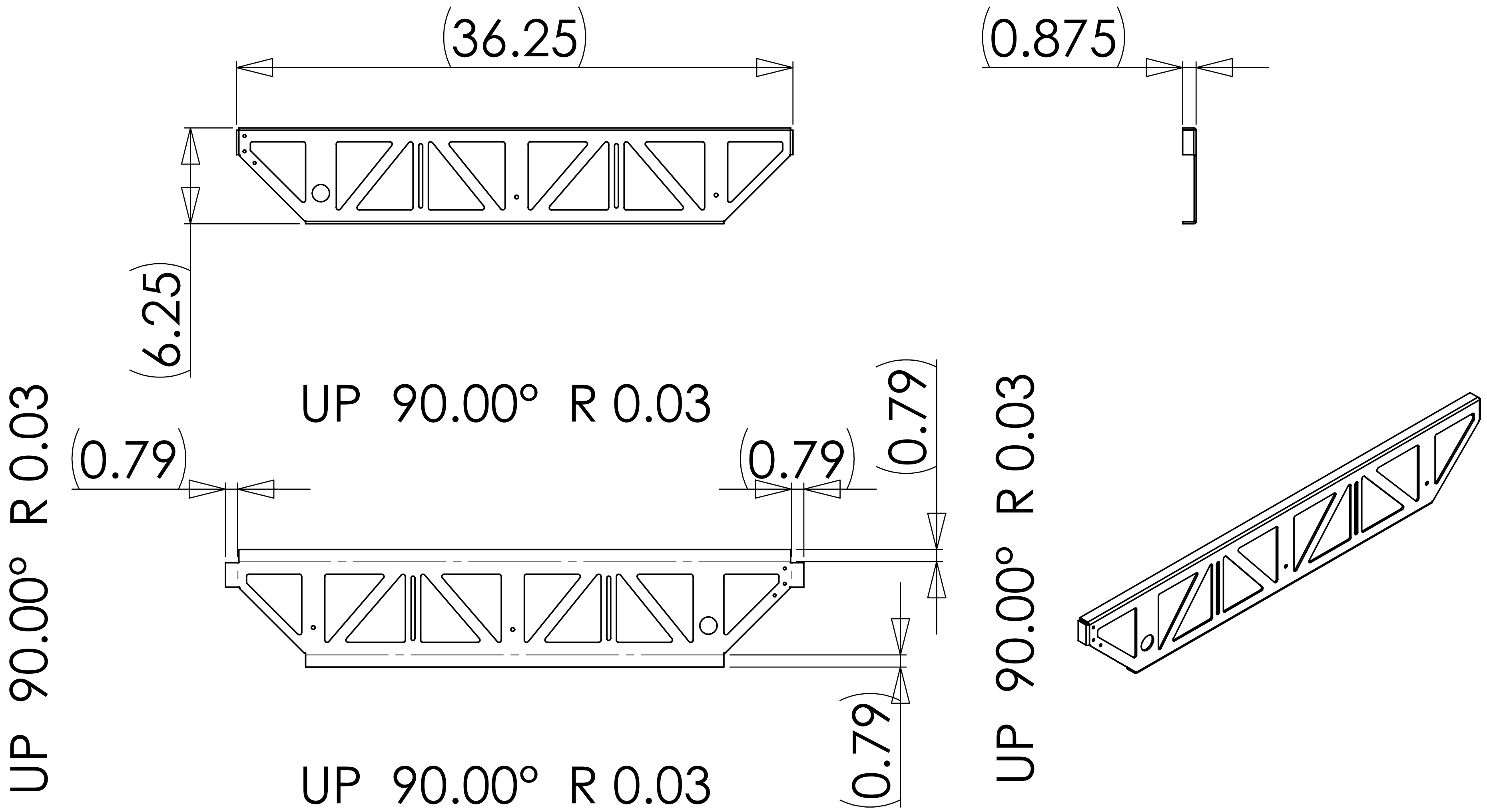

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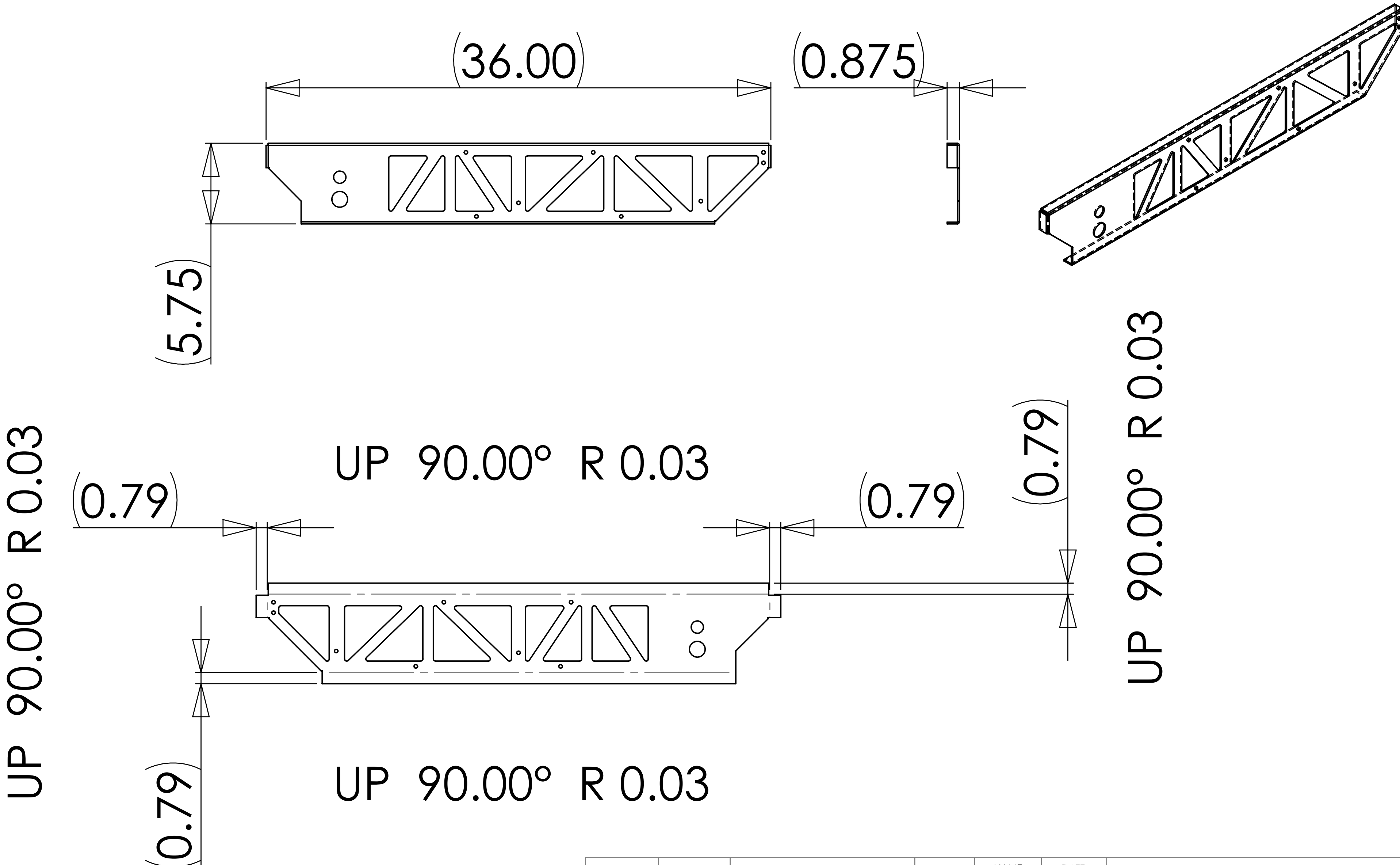

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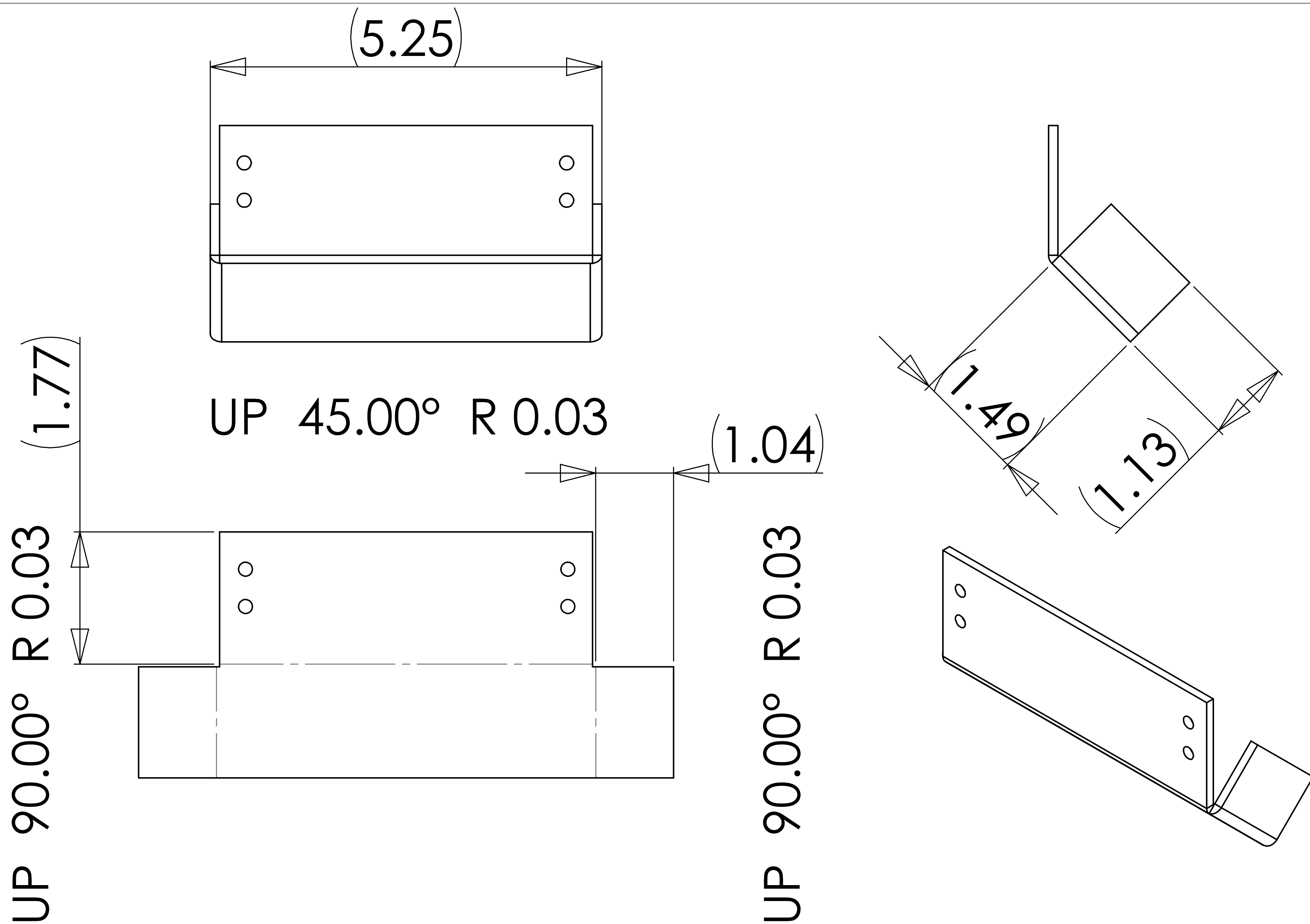

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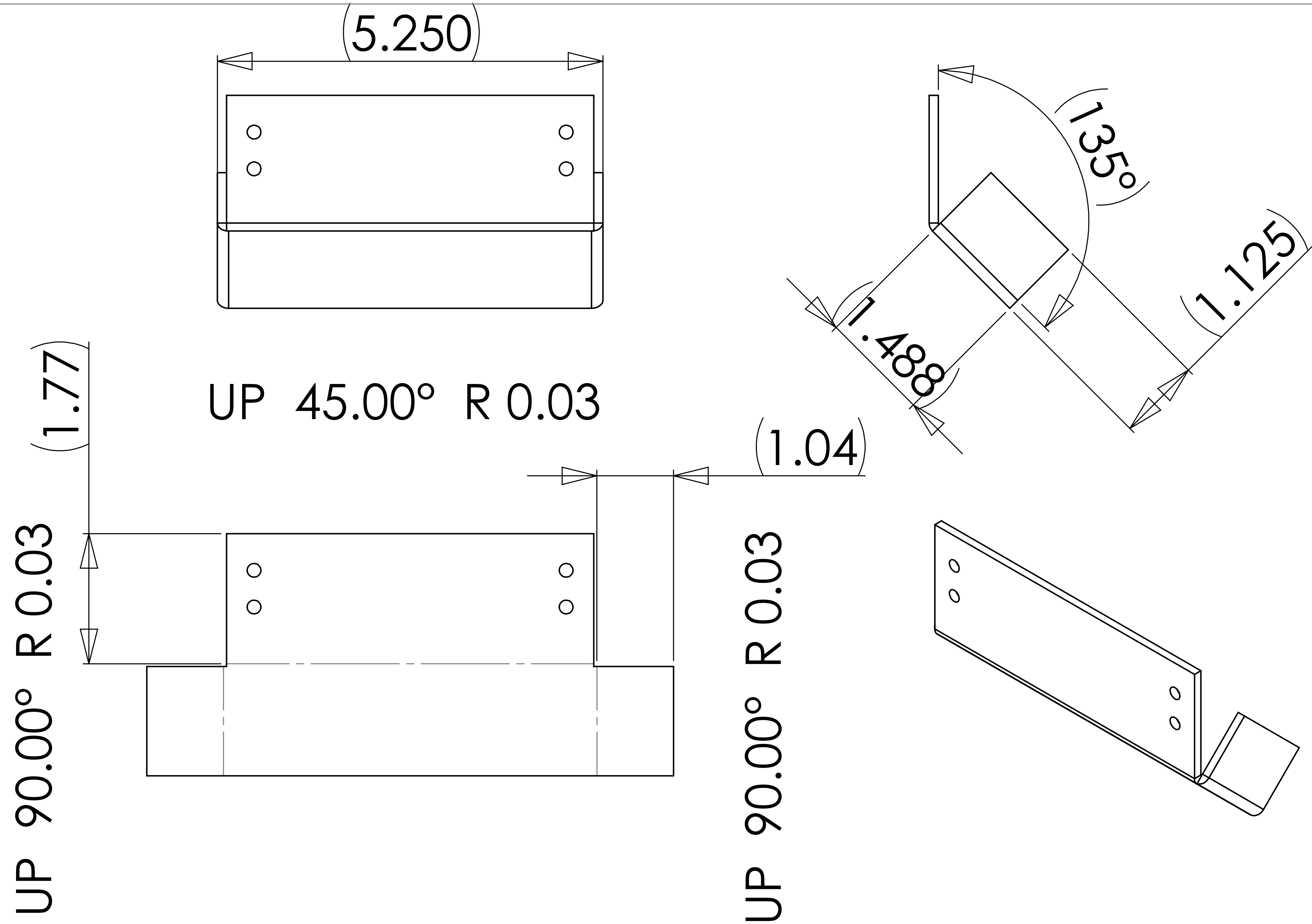

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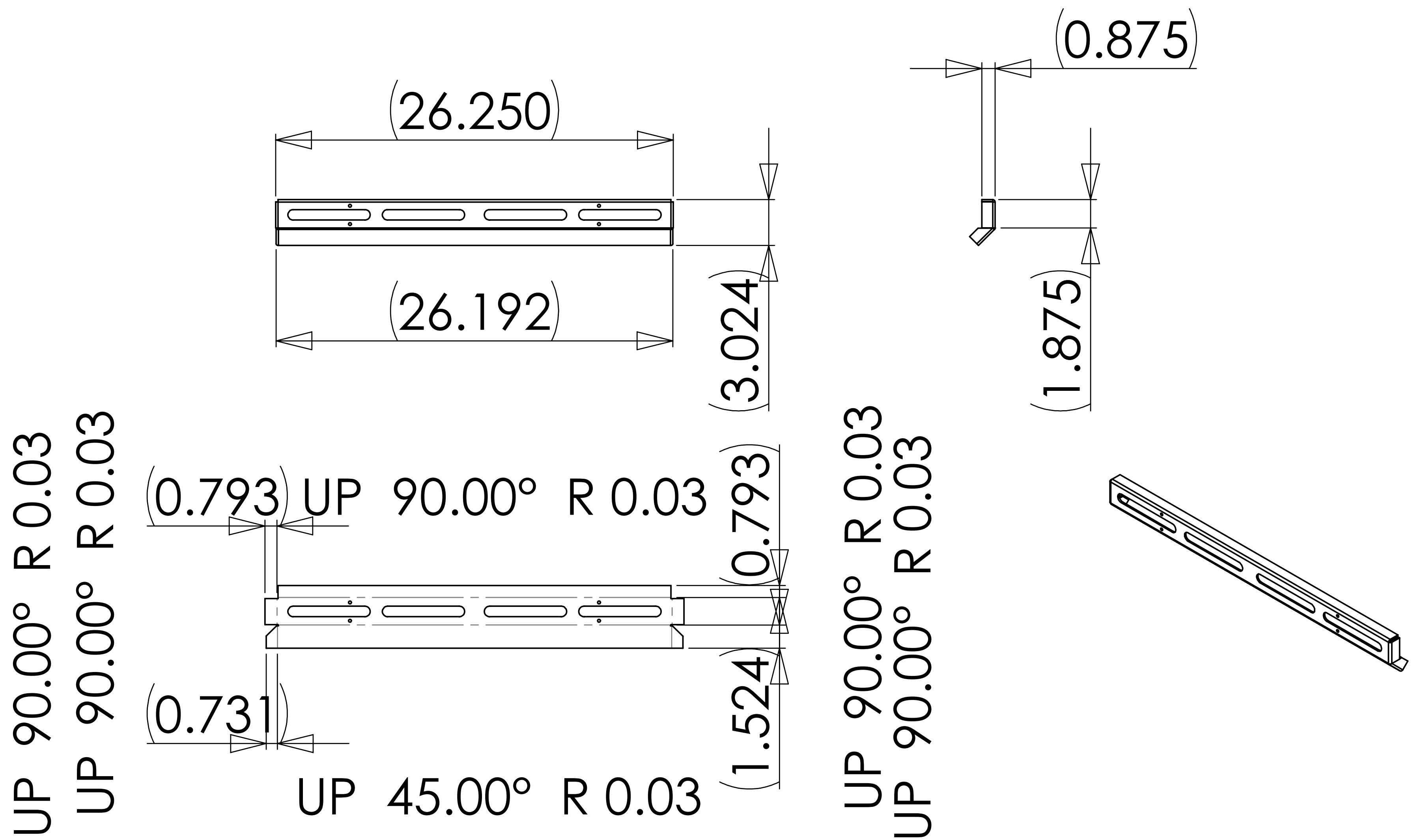

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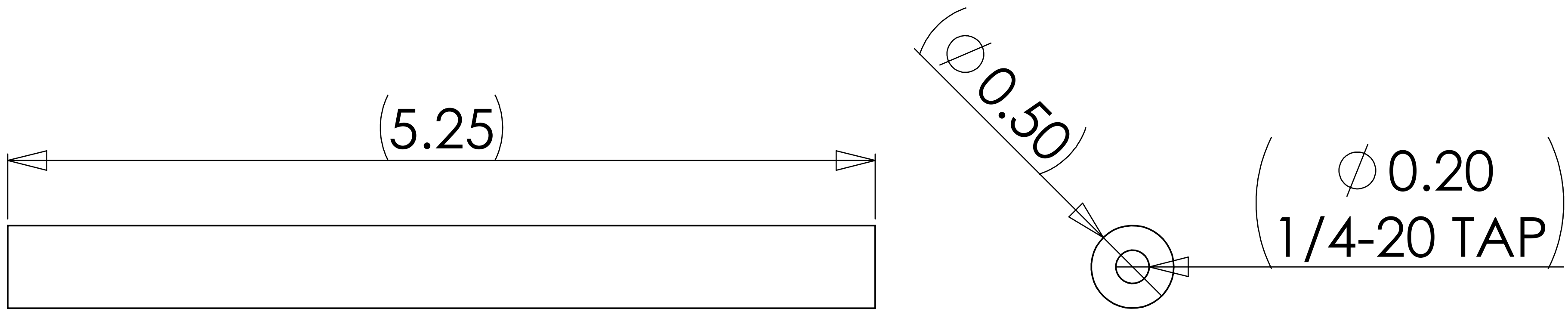

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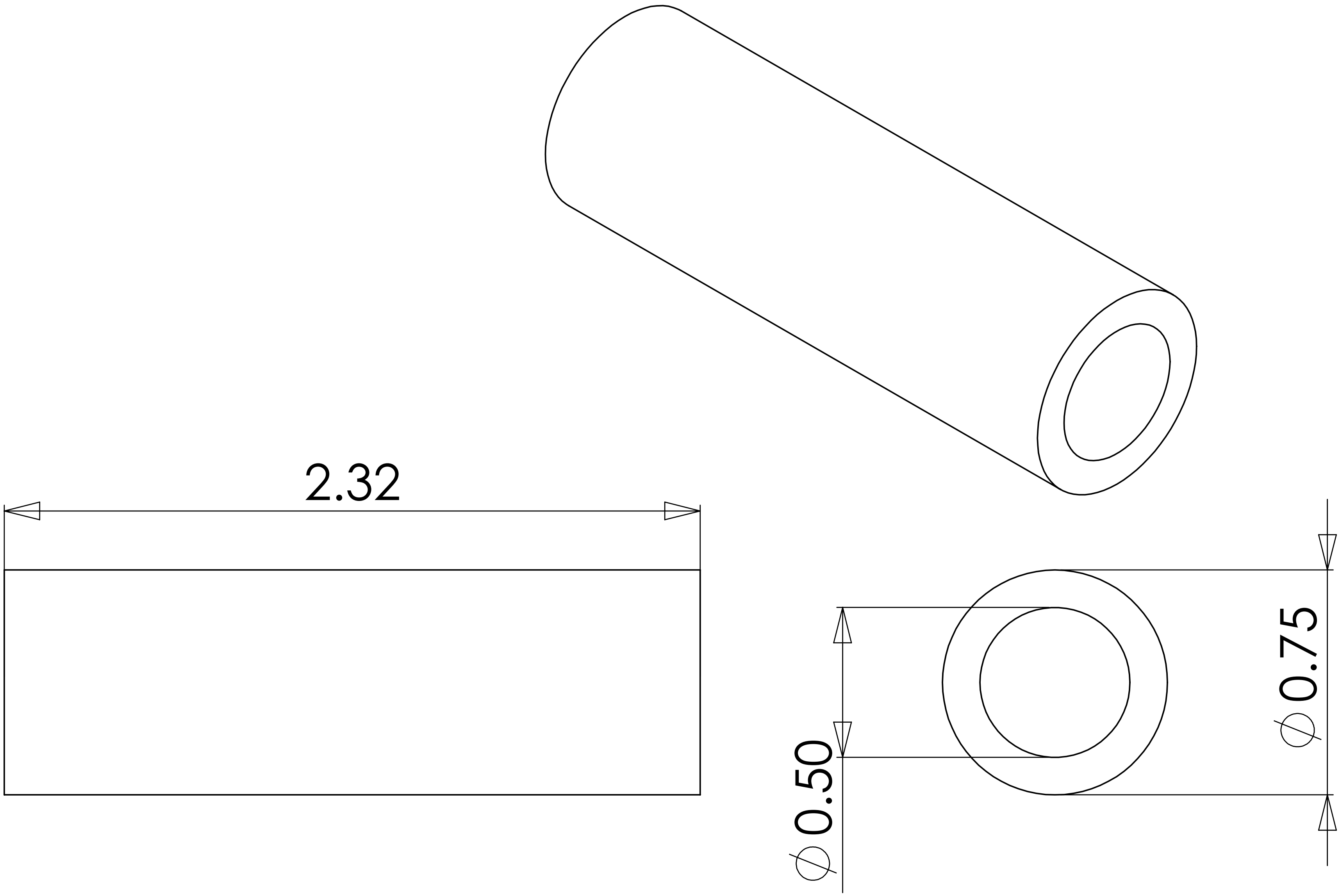

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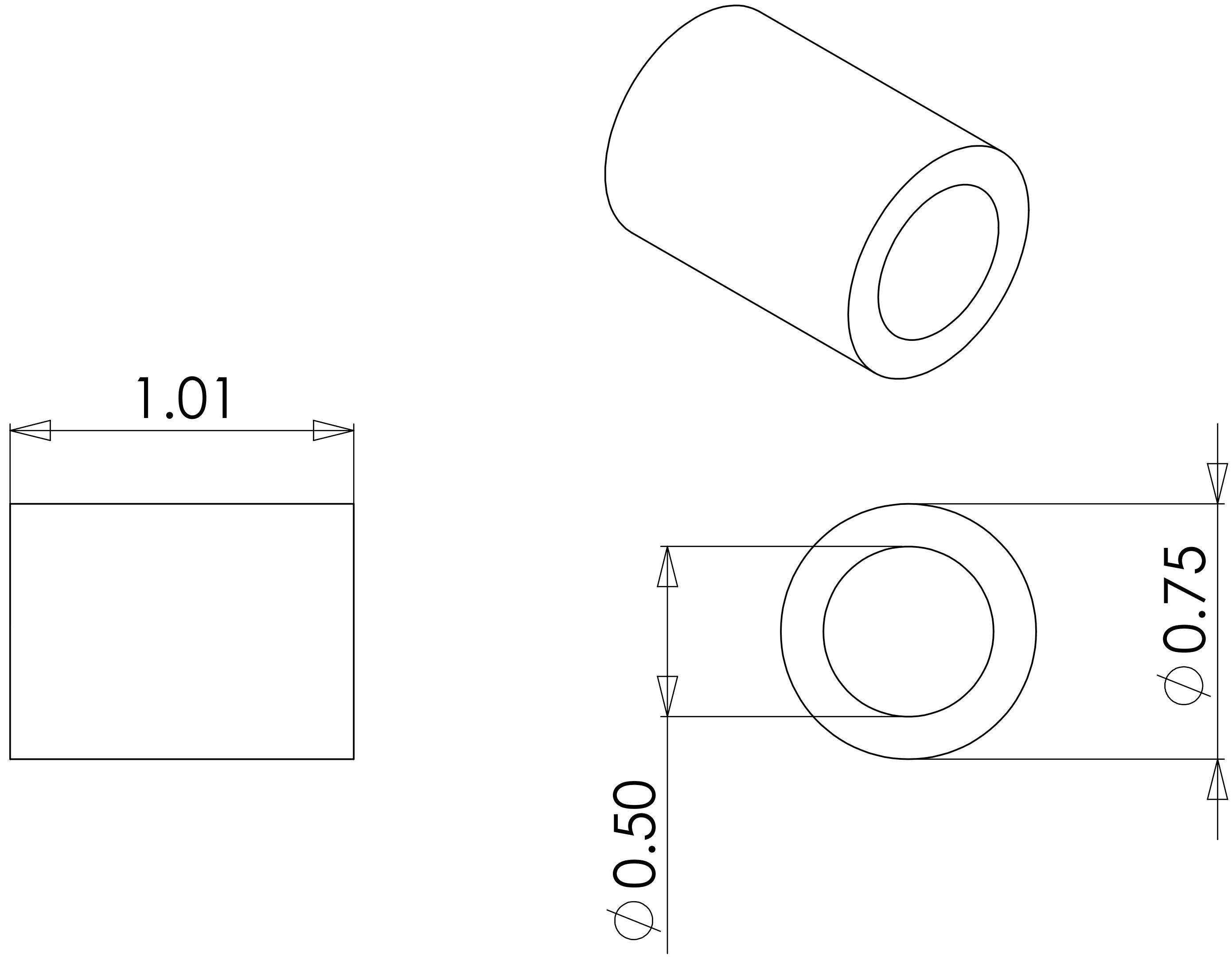

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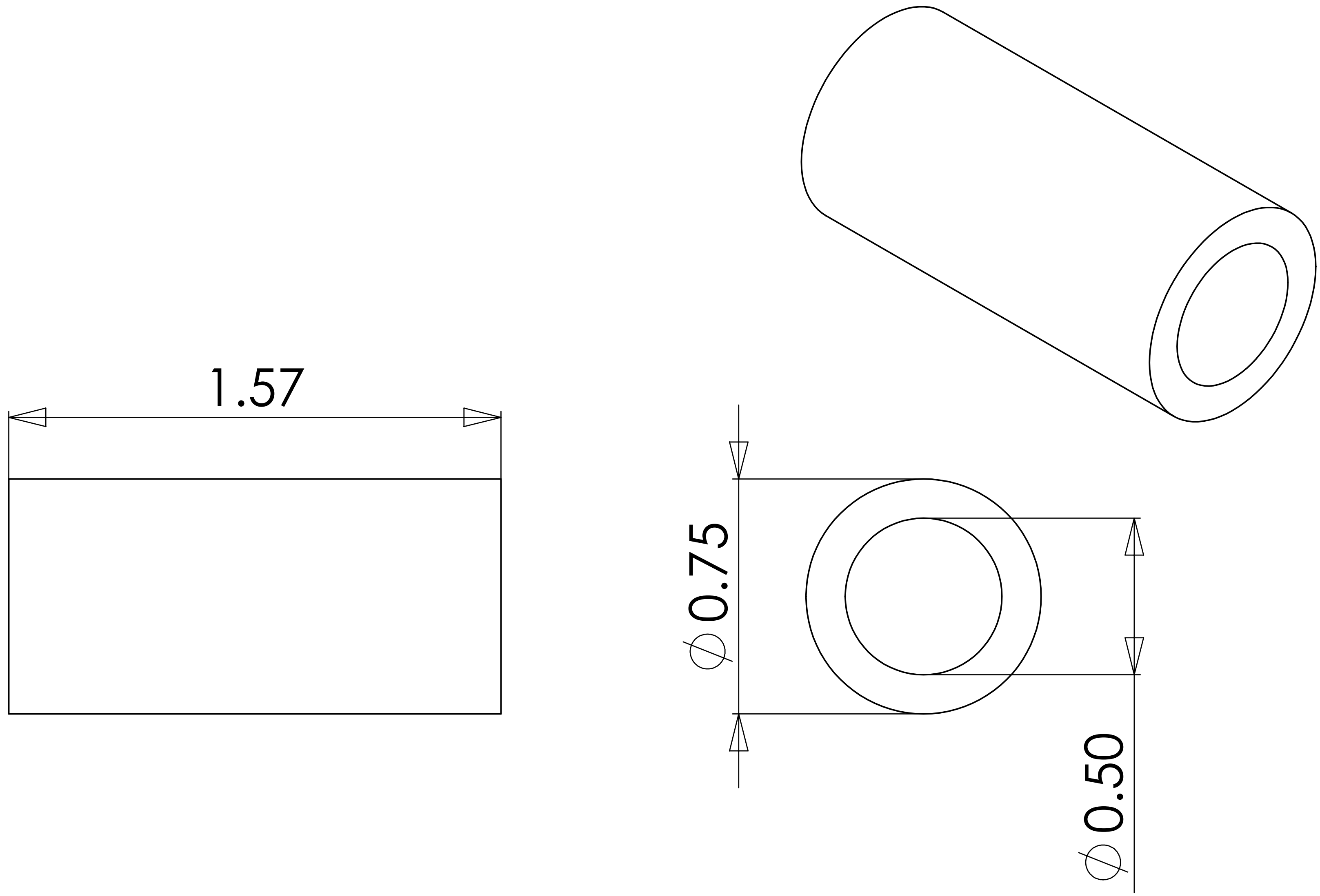

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Spacer - F - O

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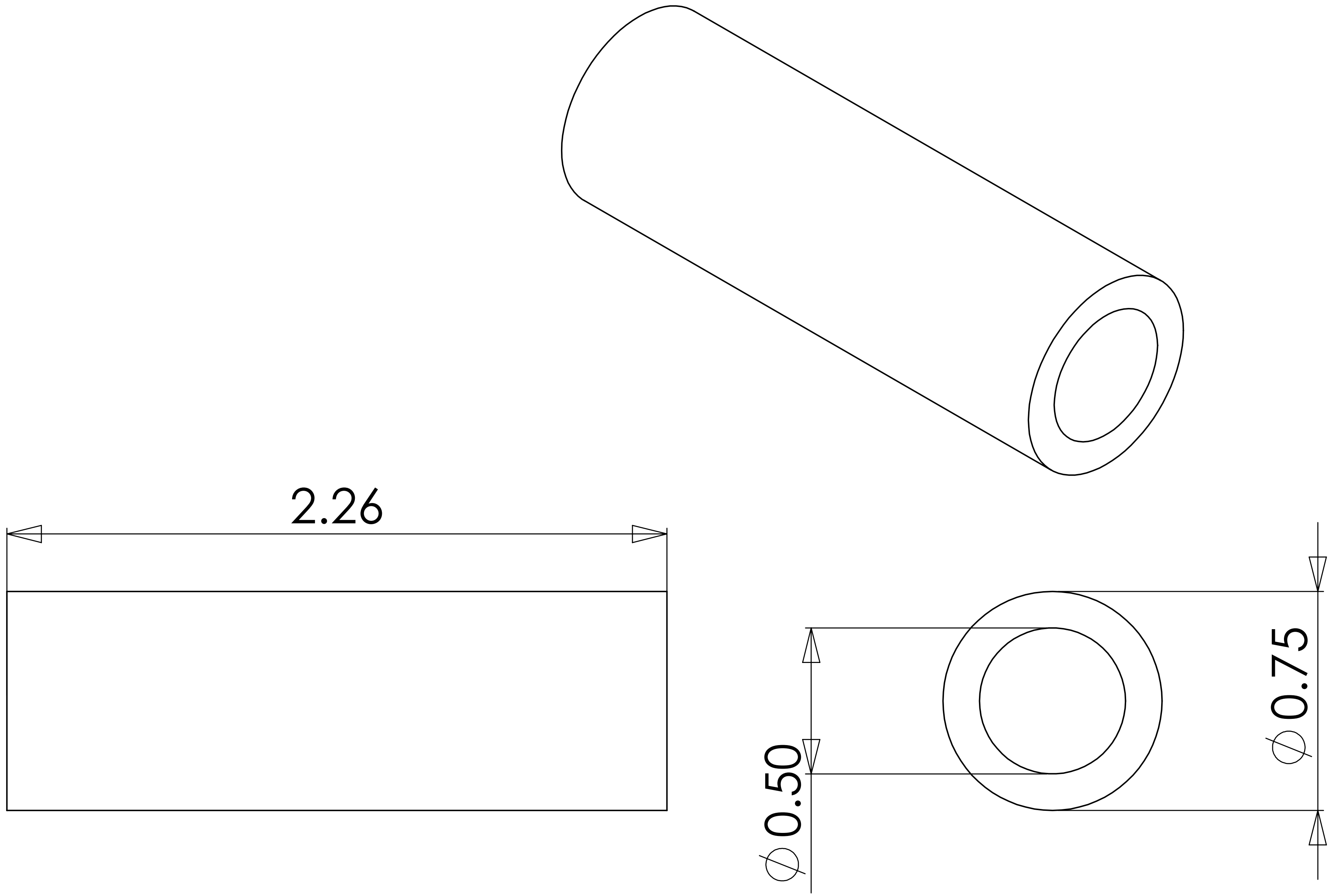

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SABRE BYTES FIRST 772

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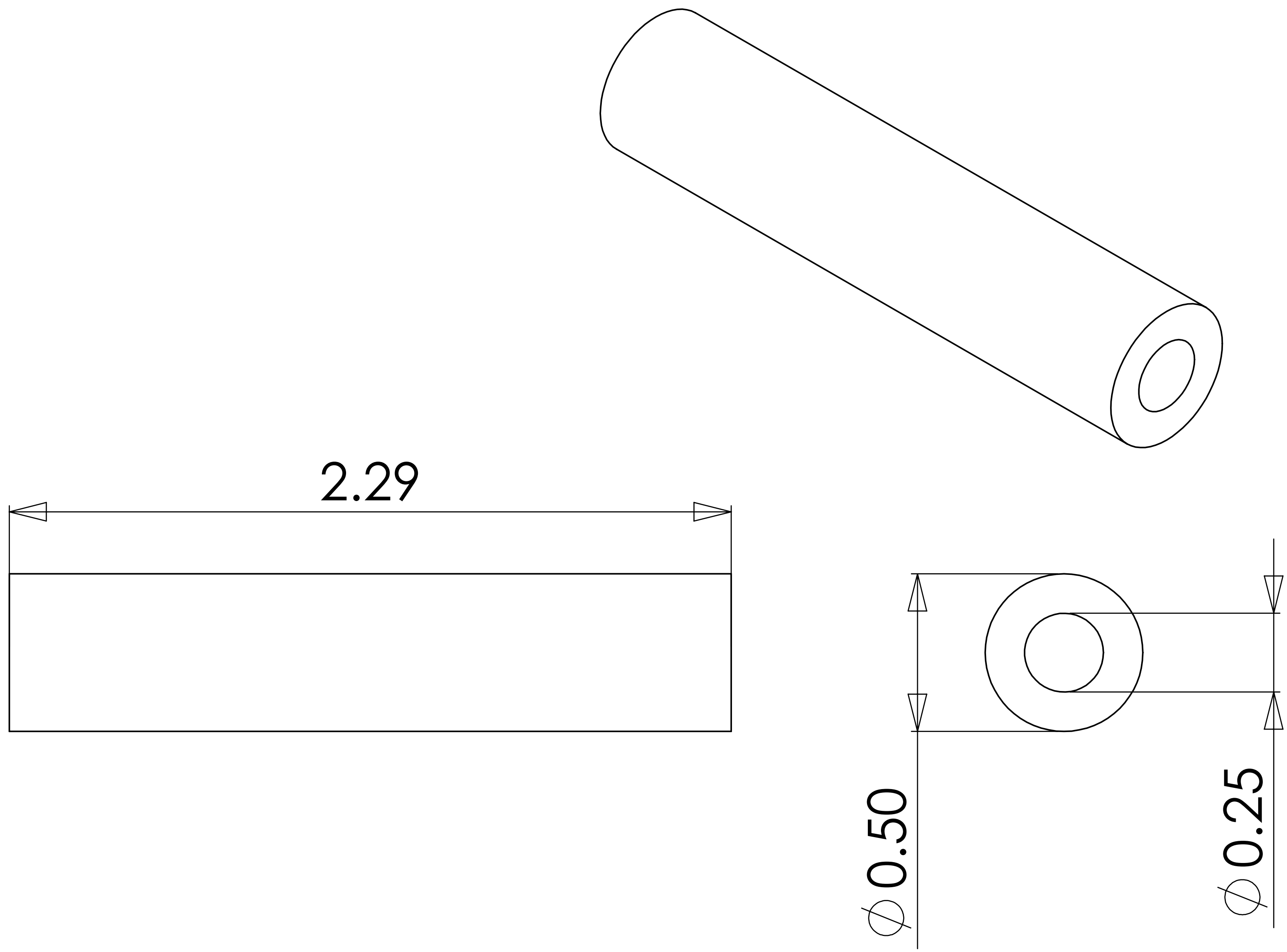

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Spacer - Side Plates

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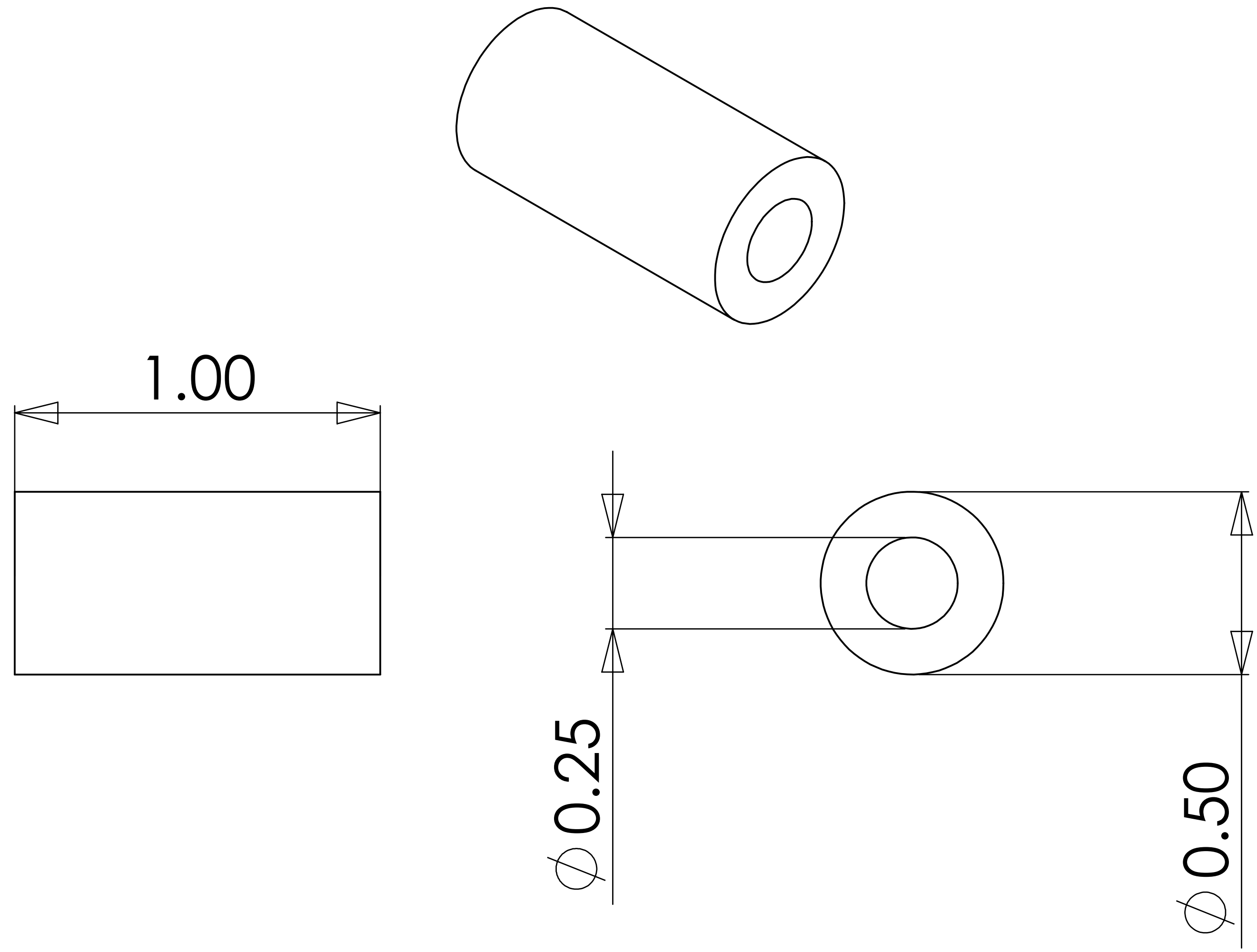
APPLICATION

SIZE A | DWG. NO. SB-12-CT-S-I | REV. 1

SCALE:2:1 | WEIGHT: | SHEET 1 OF 1



NEXT ASSY | USED ON
APPLICATION

DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±
ANGULAR: MACH ± BEND ±
TWO PLACE DECIMAL ±
THREE PLACE DECIMAL ±

MATERIAL --
FINISH --
DO NOT SCALE DRAWING

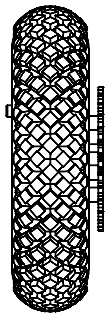
	NAME	DATE
DRAWN		
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

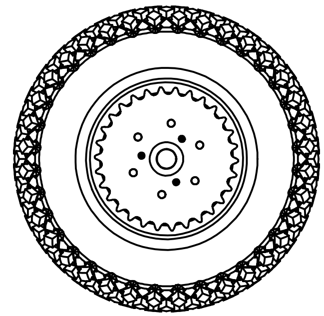
COMMENTS:

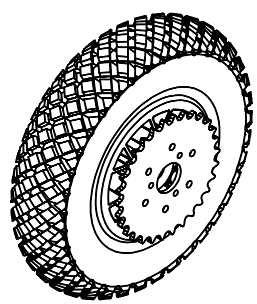
SABRE BYTES FIRST 772

Spacer - Middle

SIZE A | DWG. NO. SB-12-CT-S-M | REV. 1
SCALE:2:1 | WEIGHT: | SHEET 1 OF 1







ITEM NO.	PART NUMBER	QTY.
1	Tire	1
2	Valve	1
3	#4x1.00, Plastic Thread Rolling Screw, Pan Head, Cross Recessed, Zinc Plated (Plastic Applications)_	6
4	Hub	2
5	Sprocket Spacer	6
6	fr-8-zz - 1	2
7	30T - .875 bore	1

NEXT ASSY | USED ON
APPLICATION

DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±
ANGULAR: MACH ± BEND ±
TWO PLACE DECIMAL ±
THREE PLACE DECIMAL ±

MATERIAL --

FINISH --

DO NOT SCALE DRAWING

	NAME	DATE
DRAWN		
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

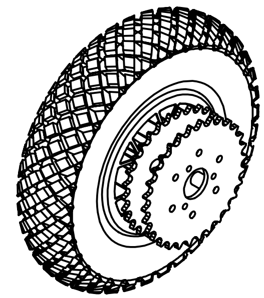
COMMENTS:

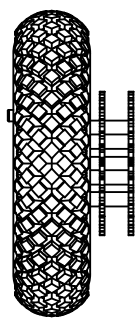
SABRE BYTES FIRST 772

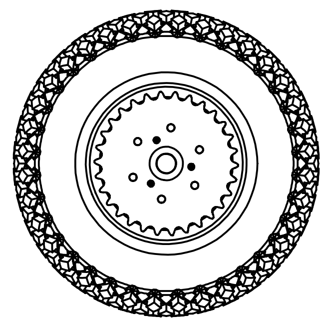
Pneumatic Wheel Front

SIZE A | DWG. NO. | REV. 1

SCALE:1:5 | WEIGHT: | SHEET 1 OF 1







ITEM NO.	PART NUMBER	QTY.
1	Tire	1
2	Valve	1
3	#4x1.00, Plastic Thread Rolling Screw, Pan Head, Cross Recessed, Zinc Plated (Plastic Applications)_	6
4	Hub	2
5	Sprocket Spacer	6
6	Sprocket Spacer - 0.625in	6
7	fr-8-zz - 1	2
8	30T - .875 bore	2

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NEXT ASSY | USED ON
APPLICATION

DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±
ANGULAR: MACH ± BEND ±
TWO PLACE DECIMAL ±
THREE PLACE DECIMAL ±

MATERIAL --
FINISH --
DO NOT SCALE DRAWING

	NAME	DATE
DRAWN		
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

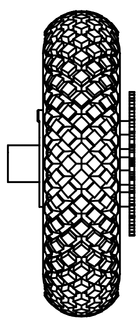
COMMENTS:

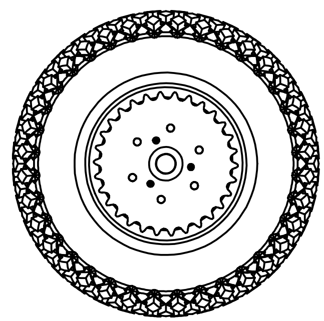
SABRE BYTES FIRST 772

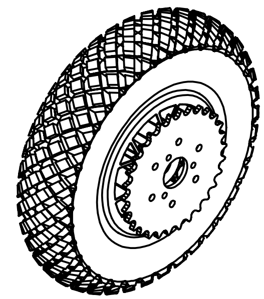
Pnuematic Wheel Middle

SIZE A | DWG. NO. | REV. 1

SCALE:1:5 | WEIGHT: | SHEET 1 OF 1







ITEM NO.	PART NUMBER	QTY.
1	Tire	1
2	Valve	1
3	#4x1.00, Plastic Thread Rolling Screw, Pan Head, Cross Recessed, Zinc Plated (Plastic Applications)_	6
4	Hub	2
5	Sprocket Spacer	6
6	fr-8-zz - 1	1
7	500-key-hub	1
8	30T - .875 bore	1

NEXT ASSY | USED ON
APPLICATION

DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±
ANGULAR: MACH ± BEND ±
TWO PLACE DECIMAL ±
THREE PLACE DECIMAL ±

MATERIAL --
FINISH --
DO NOT SCALE DRAWING

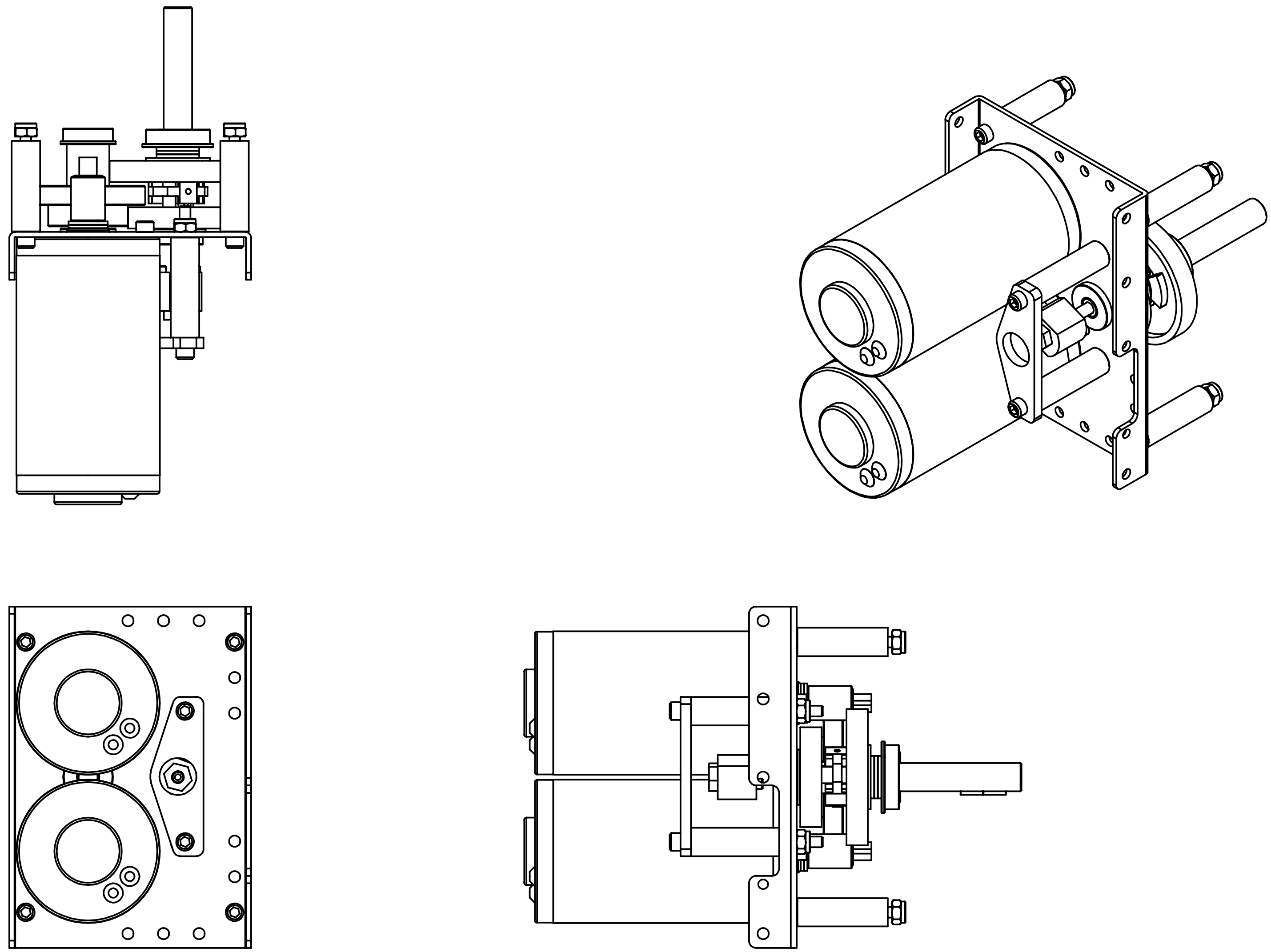
	NAME	DATE
DRAWN		
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

COMMENTS:

SABRE BYTES FIRST 772

Pneumatic Wheels Back

SIZE A | DWG. NO. | REV. 1
SCALE:1:5 | WEIGHT: | SHEET 1 OF 1



NEXT ASSY	USED ON
APPLICATION	

DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±
ANGULAR: MACH ± BEND ±
TWO PLACE DECIMAL ±
THREE PLACE DECIMAL ±

MATERIAL --

FINISH --

DO NOT SCALE DRAWING

	NAME	DATE
DRAWN		
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		
COMMENTS:		

SABRE BYTES FIRST 772

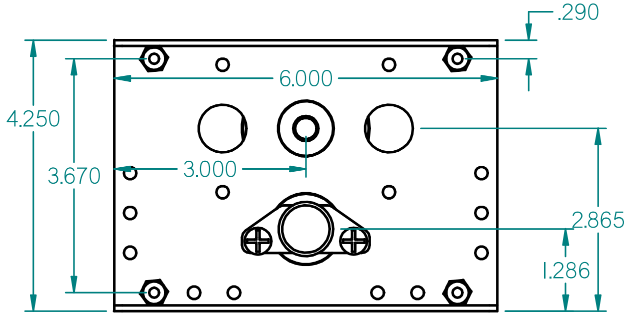
Transmission Gen2

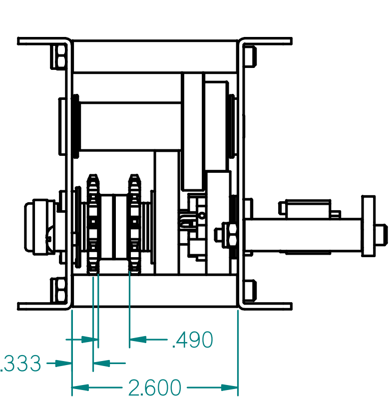
SIZE	DWG. NO.	REV.
A		1

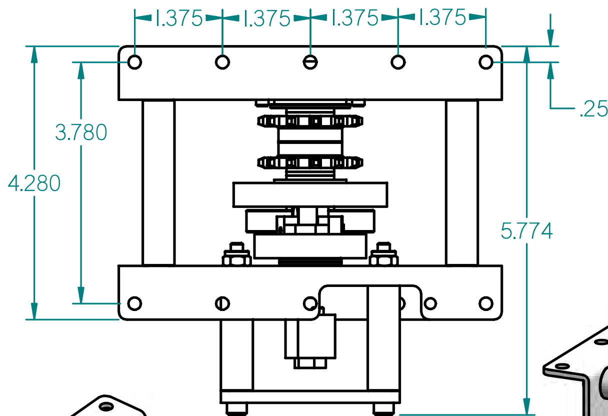
SCALE:1:3 | WEIGHT: | SHEET 1 OF 2

ITEM NO.	PART NUMBER	QTY.
1	10-32_nylock_nut	6
2	10-32x2500_shcs	2
3	1-4-28_jam-nut	1
4	amshifter2_d02	1
5	amshifter2_d07	2
6	amshifter2_d03	1
7	r3 bearing	1
8	amshifter2_d08	1
9	0625x3125_roll_pin	1
10	4-40x0500_shcs	2
11	CIM motor	2
12	5-16_washer	4
13	10-32x0500_shcs	4
14	amshifter2_d12	2
15	2mmx2mmx14mm_key	2
16	8mm_spring_clip	2
17	10-32x3000_shcs	4
18	amshifter2_d04	4
19	AMShifter_d01	1
20	fr-6	1
21	fr-6-zz	1
22	amshifter2_d10	1
23	amshifter2_d13	1
24	amshifter2_d11	1
25	amshifter2_d06	1
26	amshifter2_d09	1
27	amshifter2_d14	1
28	67353805 washer	3
29	67501726 0925x100 roll pin	1
30	125x124x400_key	2
31	fr-8-zz	1
32	fr-6-zz_1	1
33	fr-6_1	1
34	r8 bearing	1
35	amshifter2_d05	1

REVISION HISTORY			
REV	DESCRIPTION	DATE	APPROVED



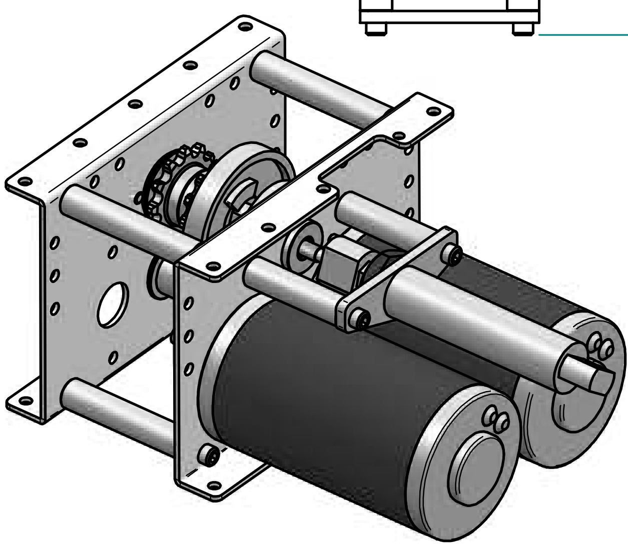




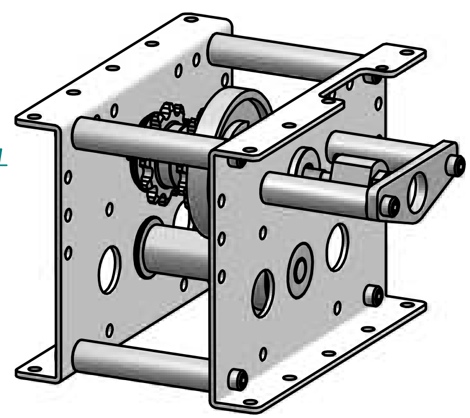
STANDARD GEARING:
All gears are 4140 steel, 20 dp, 14.5 p.a.
Ratio between High and Low gears: 2.56:1
Low Gear: 10.67:1
High Gear: 4.17:1

OPTIONAL "OUTPUT" GEARING
(available as optional parts)
Ratio between High and Low gears: 4:1
Low Gear: 10.67:1
High Gear: 2.67:1

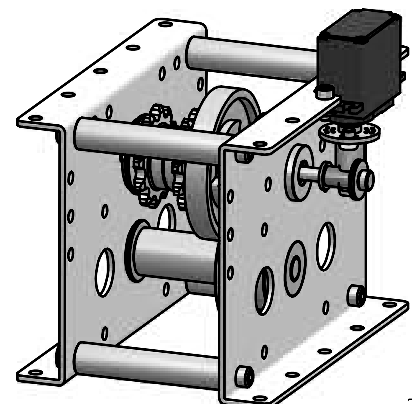
See http://www.andymark.biz/am-0001.html
for more information.



AM Shifter with two CIM Motors and 04-0.5-DP Bimba cylinder installed. Total weight: 9.0 pounds



AM Shifter with pneumatic setup.
Total weight: 3.5 pounds



AM Shifter with servo shifting setup.
Total weight: 3.5 pounds

NOTE:
The AM Shifter Gen. 2 is the same version as this Gen. 1 gearbox, except there are different side plates on the Gen. 2. These side plates were used for a larger motor provided to FRC teams in 2005-2007.

DRAWN	Andy Baker	01/04/10
MATERIAL		
QUANTITY		
HEAT TREAT		
FINISH		

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
ANGLES ±0.5°
2 PL ±0.01" 3 PL ±0.005"

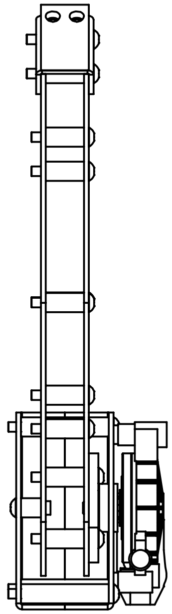
ANDYMARK.BIZ
STANDARD SOLUTIONS FOR COMPETITION ROBOTS

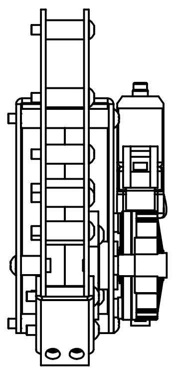
TITLE
AM SHIFTER

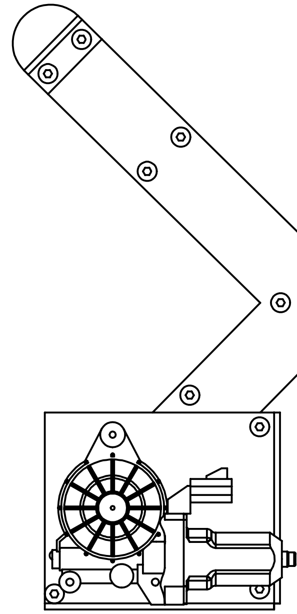
SIZE	DWG NO	REV
A3	AMSHIFTER-ASM.DFT	3

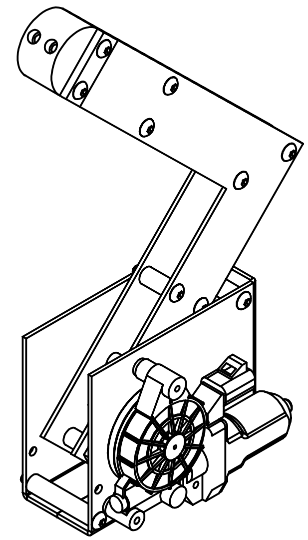
FILE NAME: amshifter-asm.dft

SCALE:	WEIGHT:	SHEET 1 OF 1









ITEM NO.	PART NUMBER	QTY.
1	Support - Window Motor	1
2	Spacer - Middle	10
3	Spacer - Side Plates	3
4	Cow Tipper - Stick	2
5	Side Plate - CT - L - O	1
6	Side Plate - CT - R - O	1
7	Plate - Support - F	1
8	Bolt - 14-20 x 1.75in - button head	4
9	Bolt - 14-20 x 1.5in - button head	6
10	Bolt - 14-20 x 2.75in - button head	3
11	ND Motor Left	1
12	nippondensogearcoupler2 0.5 in	1
13	Ski - Bottom	1
14	Bolt - 14-20 x 0.5in - button head	1

NEXT ASSY | USED ON
APPLICATION

DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±
ANGULAR: MACH ± BEND ±
TWO PLACE DECIMAL ±
THREE PLACE DECIMAL ±

MATERIAL --
FINISH --
DO NOT SCALE DRAWING

	NAME	DATE
DRAWN		
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

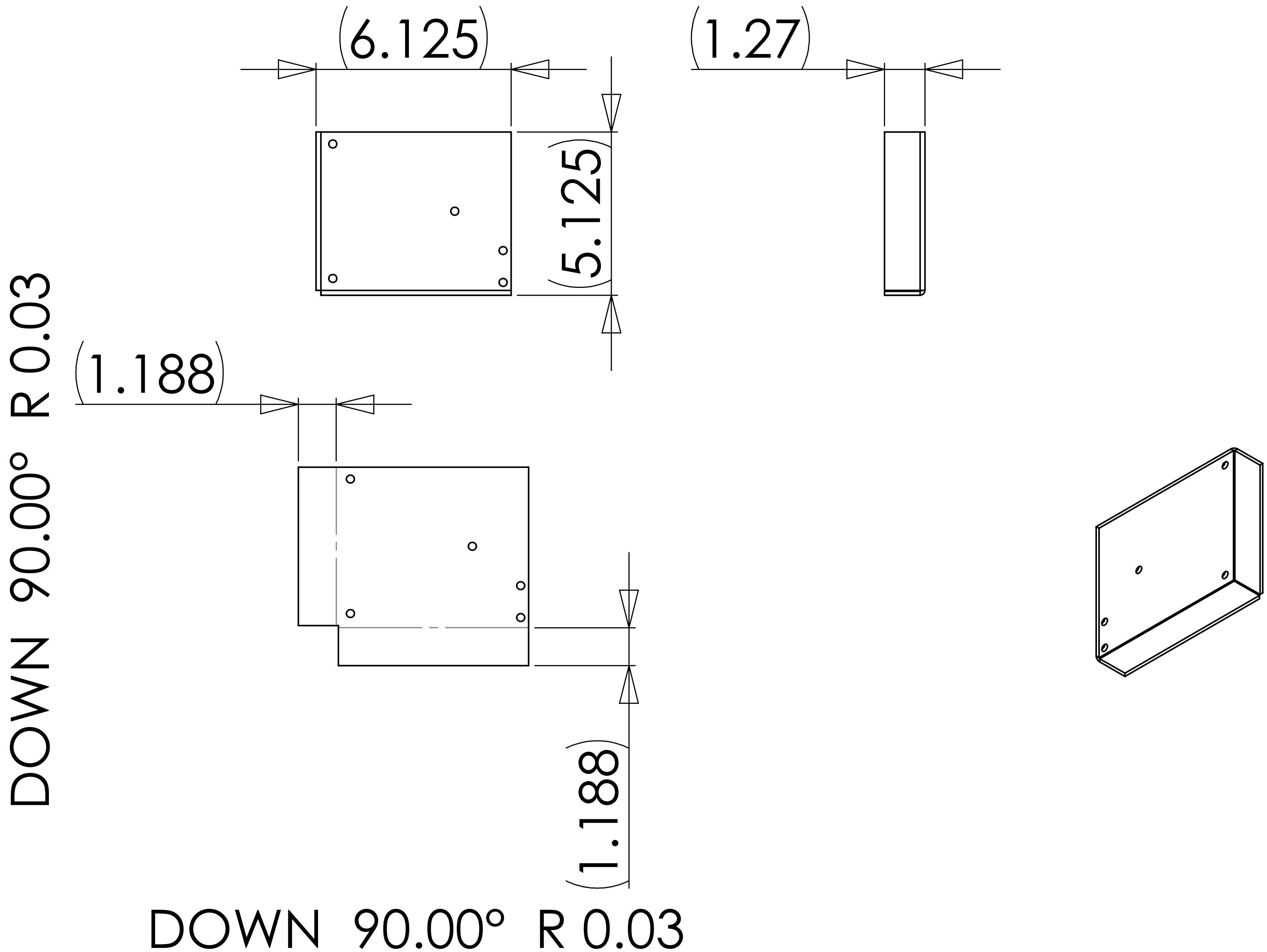
COMMENTS:

SABRE BYTES FIRST 772

Cow Tipper

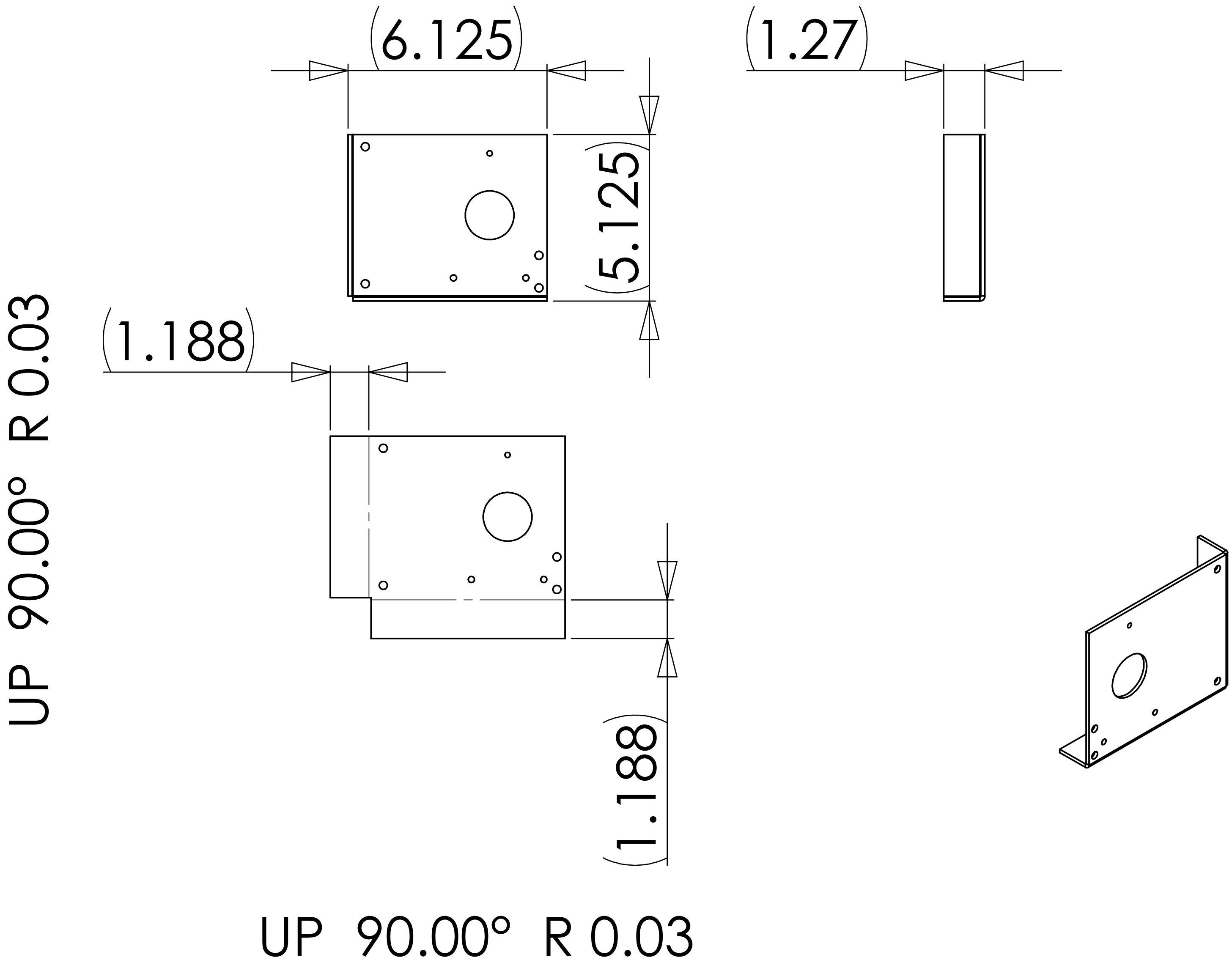
SIZE A | DWG. NO. | REV. 1

SCALE:1:5 | WEIGHT: | SHEET 1 OF 1



DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±		NAME	DATE	SABRE BYTES FIRST 772	
	DRAWN			Side Plate - CT - R - O	
	CHECKED				
	ENG APPR.				
	MFG APPR.				
MATERIAL --	Q.A.				
FINISH --	COMMENTS:			SIZE A DWG. NO. SB-12-CT-P-R	REV.
DO NOT SCALE DRAWING				SCALE:1:5 WEIGHT:	SHEET 1 OF 1

NEXT ASSY	USED ON
APPLICATION	



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NEXT ASSY	USED ON
APPLICATION	

DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±
ANGULAR: MACH ± BEND ±
TWO PLACE DECIMAL ±
THREE PLACE DECIMAL ±

MATERIAL --

FINISH --

DO NOT SCALE DRAWING

	NAME	DATE
DRAWN		
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

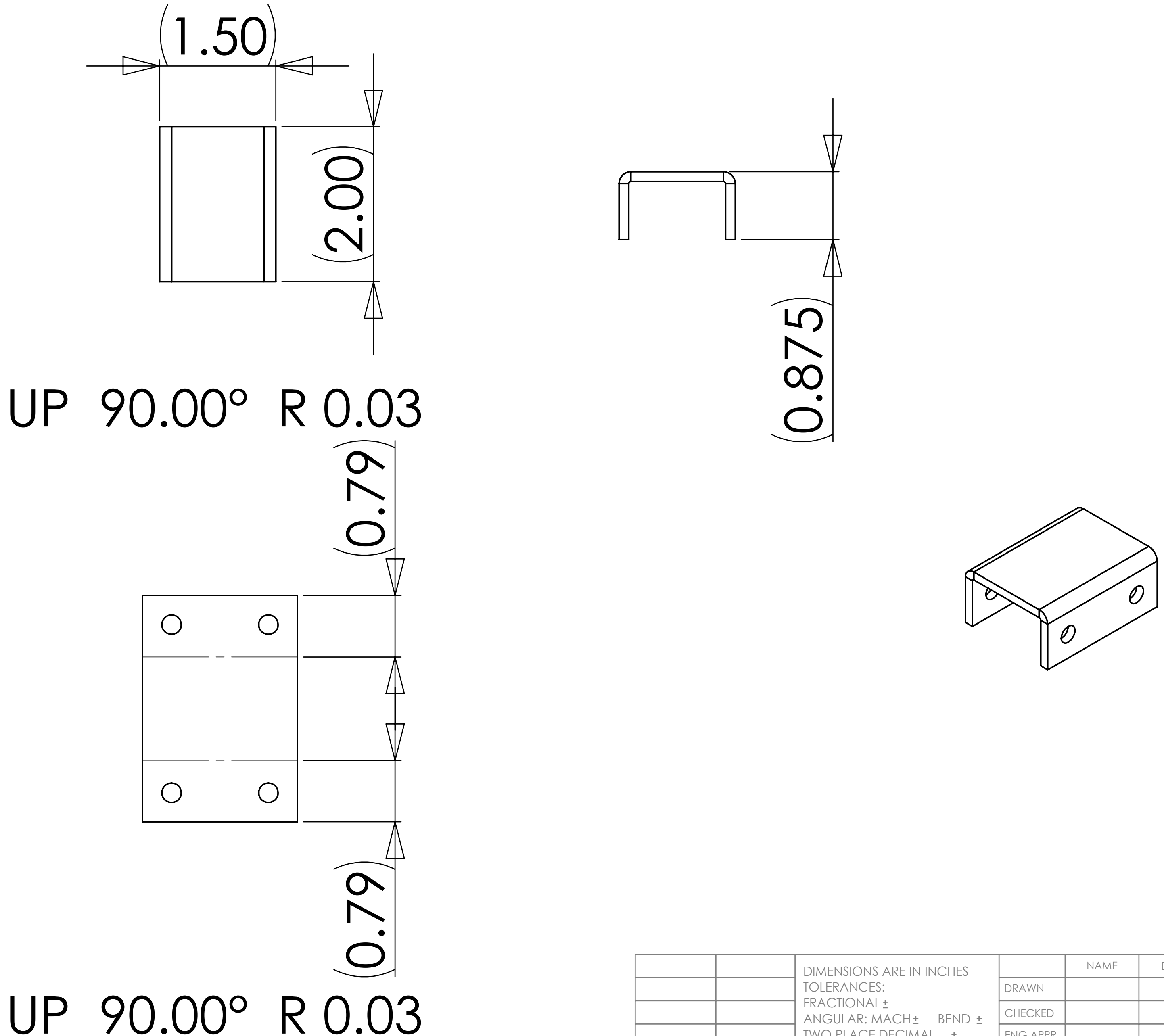
COMMENTS:

SABRE BYTES FRST 772

Side Plate - CT - L - O

SIZE	DWG. NO.	REV.
A	SB-12-CT-P-L	

SCALE:1:5 | WEIGHT: | SHEET 1 OF 1



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NEXT ASSY	USED ON
APPLICATION	

DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±
ANGULAR: MACH ± BEND ±
TWO PLACE DECIMAL ±
THREE PLACE DECIMAL ±

MATERIAL --

FINISH --

DO NOT SCALE DRAWING

	NAME	DATE
DRAWN		
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

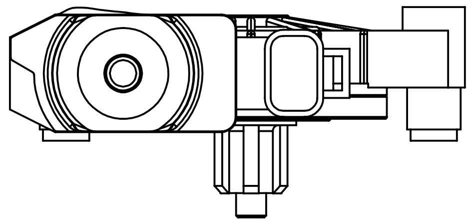
COMMENTS:

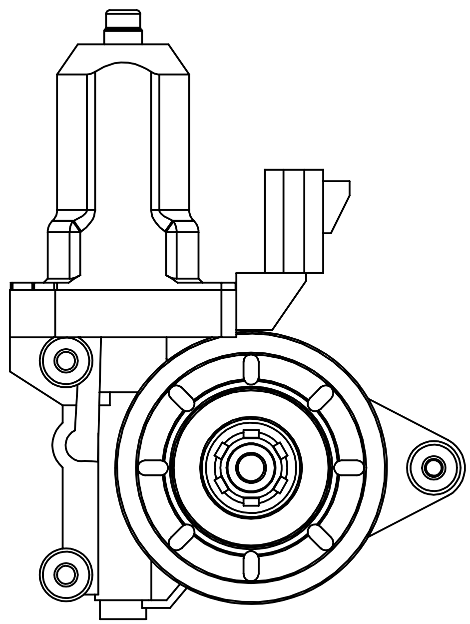
SABRE BYTES FIRST 772

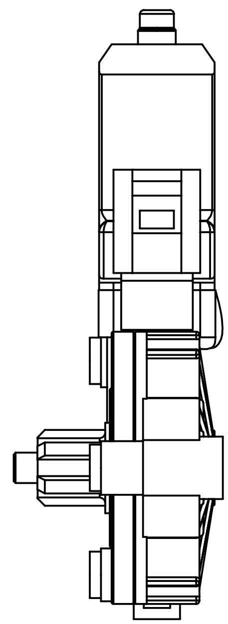
Plate - Support - F

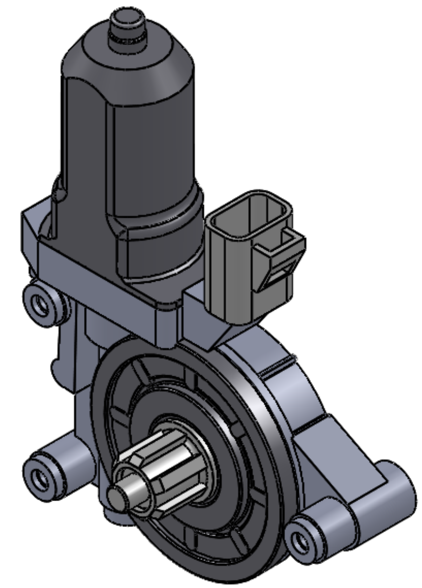
SIZE A | DWG. NO. SB-12-CT-P-F | REV.

SCALE:1:2 | WEIGHT: | SHEET 1 OF 1









DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±
ANGULAR: MACH ± BEND ±
TWO PLACE DECIMAL ±
THREE PLACE DECIMAL ±

	NAME	DATE
DRAWN		
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

COMMENTS:

MATERIAL
--

FINISH
--

NEXT ASSY	USED ON
APPLICATION	

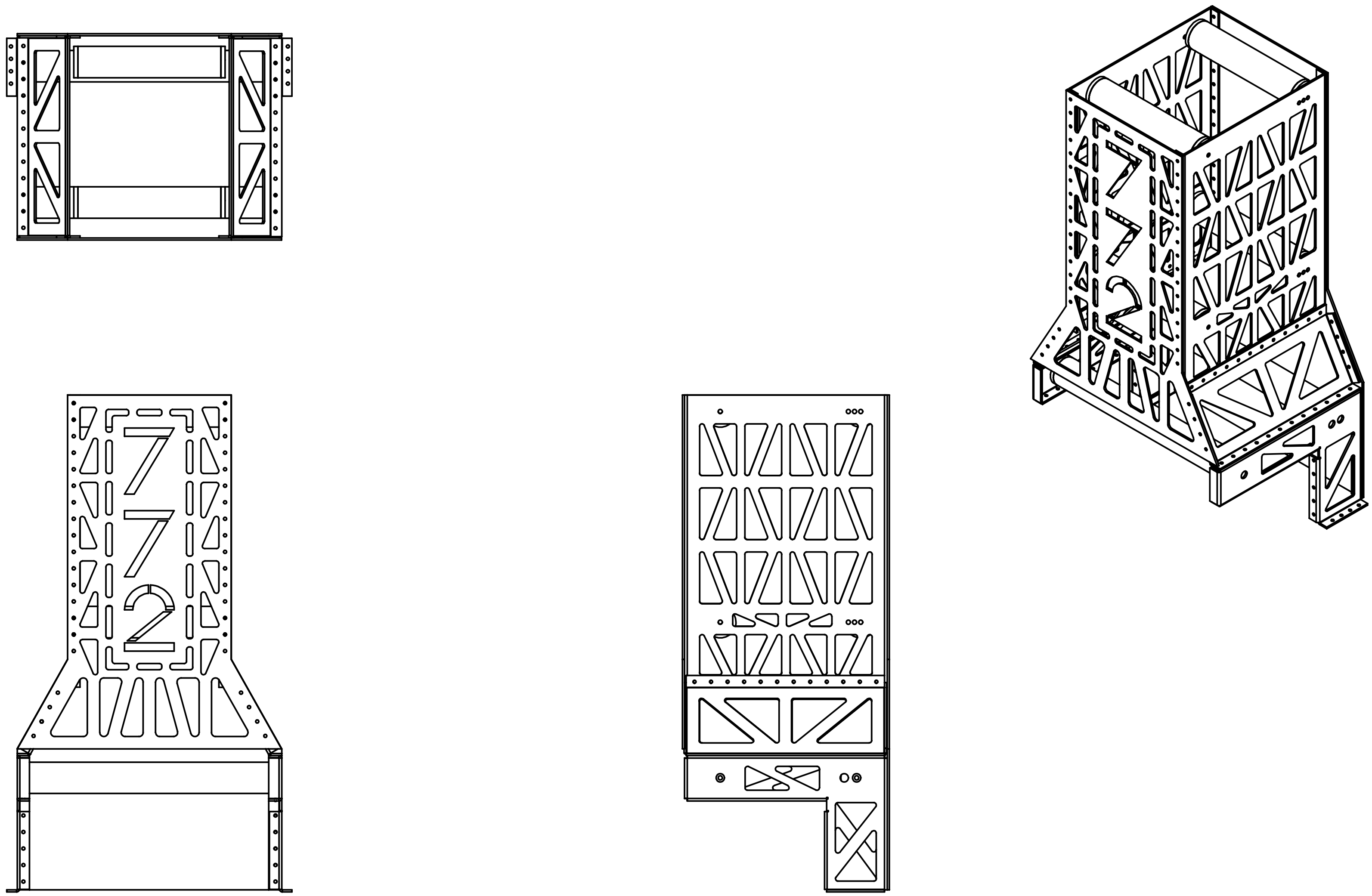
DO NOT SCALE DRAWING

SABRE BYTES FIRST 772

ND Motor Left

SIZE A | DWG. NO. | REV. 1

SCALE:1:2 | WEIGHT: | SHEET 1 OF 1



	NAME	DATE
DRAWN		
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		
COMMENTS:		

DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±
ANGULAR: MACH ± BEND ±
TWO PLACE DECIMAL ±
THREE PLACE DECIMAL ±

MATERIAL
--

FINISH
--

DO NOT SCALE DRAWING

NEXT ASSY | USED ON

APPLICATION

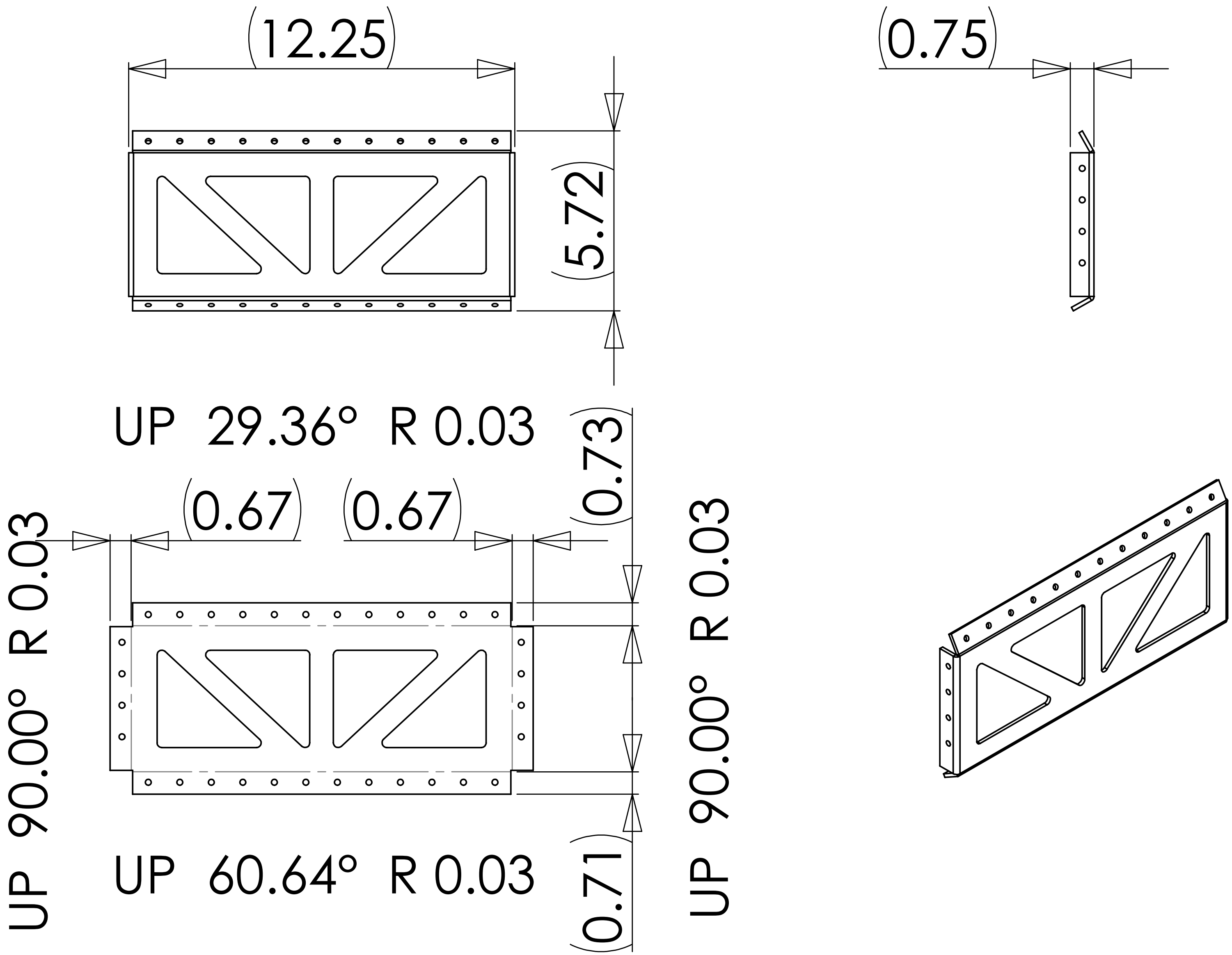
SABRE BYTES FIRST 772

Tower Assembly

SIZE A | DWG. NO. | REV. 1

SCALE:1:10 | WEIGHT: | SHEET 1 OF 2

ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	Side Plate - Right1 - Outside		1
2	Side Plate - Left - Outside		1
3	Side Plate - Front - Outside		1
4	Side Plate - Tower - Right - O		1
5	Side Plate - Tower - Left - O		1
6	Side Plate - Tower Funnel - Left - O		2
7	Side Plate - Back - Outside		1
8	Bushing		10
9	Roller Shaft - 1		2
10	Bushing - 1		2
11	Roller Shaft - 2		4



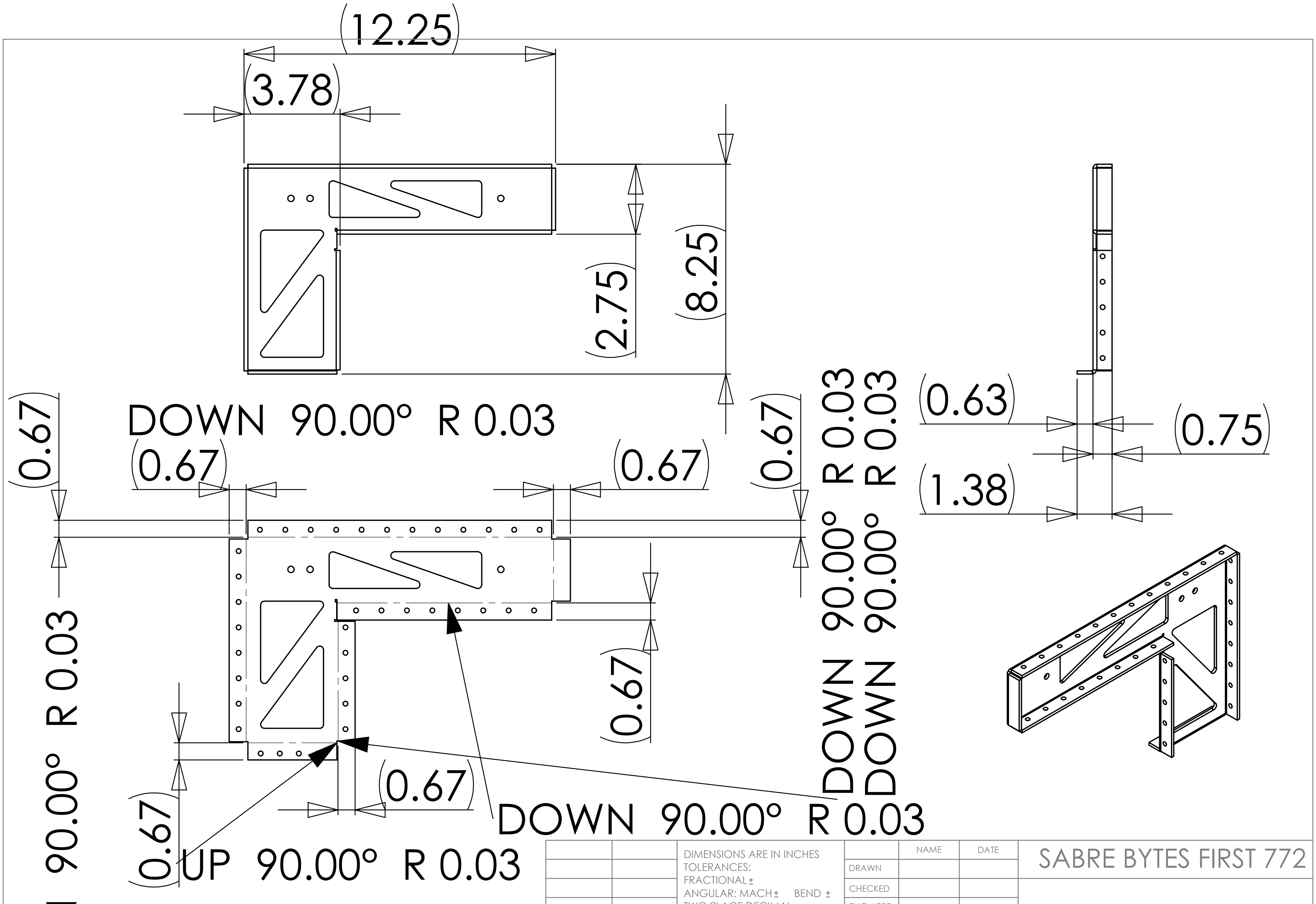
SABRE BYTES FIRST 772

Side Plate - Tower Funnel - Left - O

DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±		NAME / DATE
MATERIAL --	DRAWN	
FINISH --	CHECKED	
DO NOT SCALE DRAWING	ENG APPR.	
NEXT ASSY / USED ON	MFG APPR.	
APPLICATION	Q.A.	
	COMMENTS:	

SIZE A | DWG. NO. SB-12-T-P-M-L | REV. 1

SCALE:1:5 | WEIGHT: | SHEET 1 OF 1



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NEXT ASSY	USED ON
APPLICATION	

DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±
ANGULAR: MACH ± BEND ±
TWO PLACE DECIMAL ±
THREE PLACE DECIMAL ±

MATERIAL --

FINISH --

DO NOT SCALE DRAWING

	NAME	DATE
DRAWN		
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

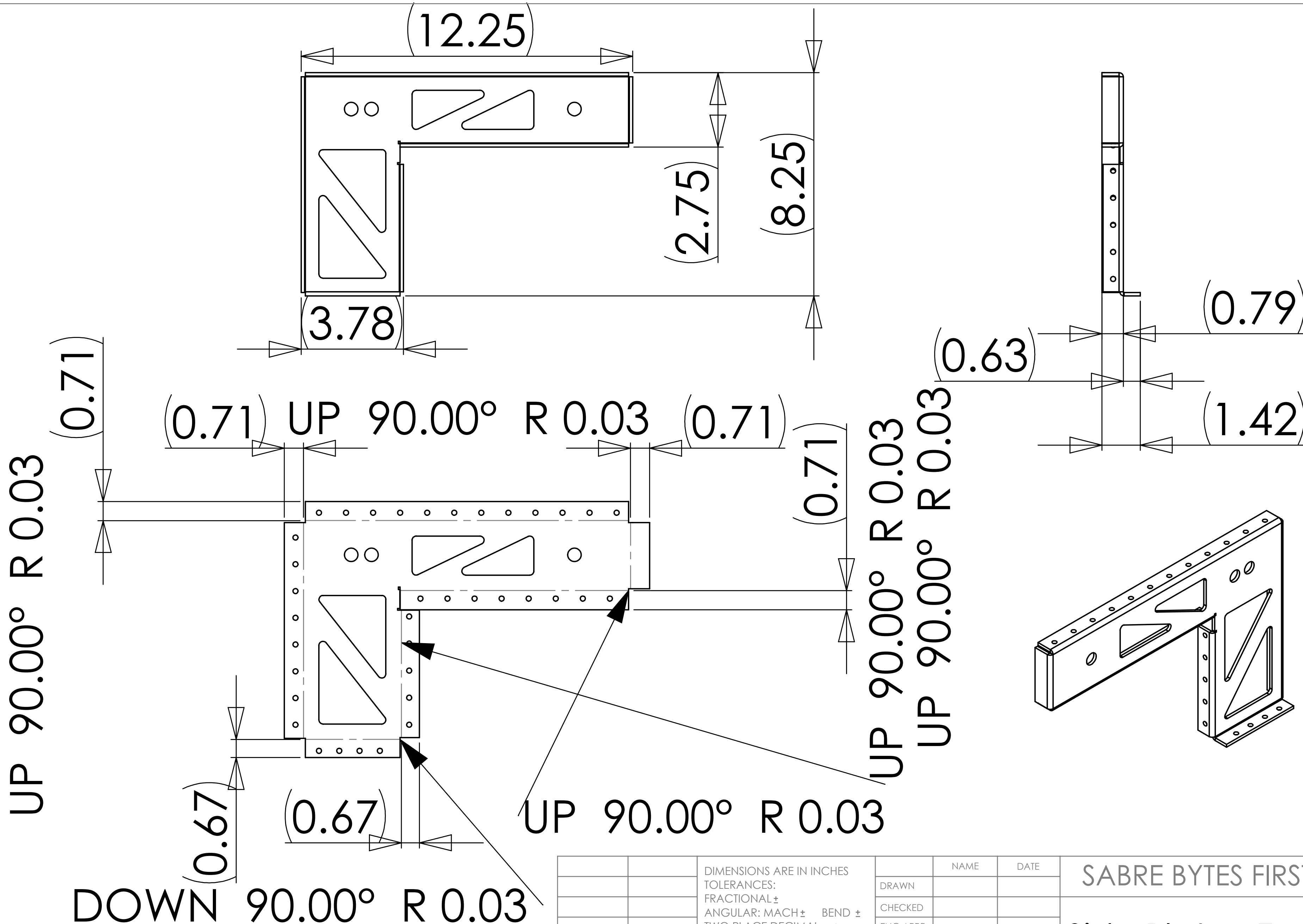
COMMENTS:

SABRE BYTES FIRST 772

Side Plate - Tower - Right - O

SIZE	DWG. NO.	REV.
A	SB-12-T-P-BT-R	1

SCALE:1:5 WEIGHT: SHEET 1 OF 1



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NEXT ASSY	USED ON
APPLICATION	

DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±
ANGULAR: MACH ± BEND ±
TWO PLACE DECIMAL ±
THREE PLACE DECIMAL ±

MATERIAL --

FINISH --

DO NOT SCALE DRAWING

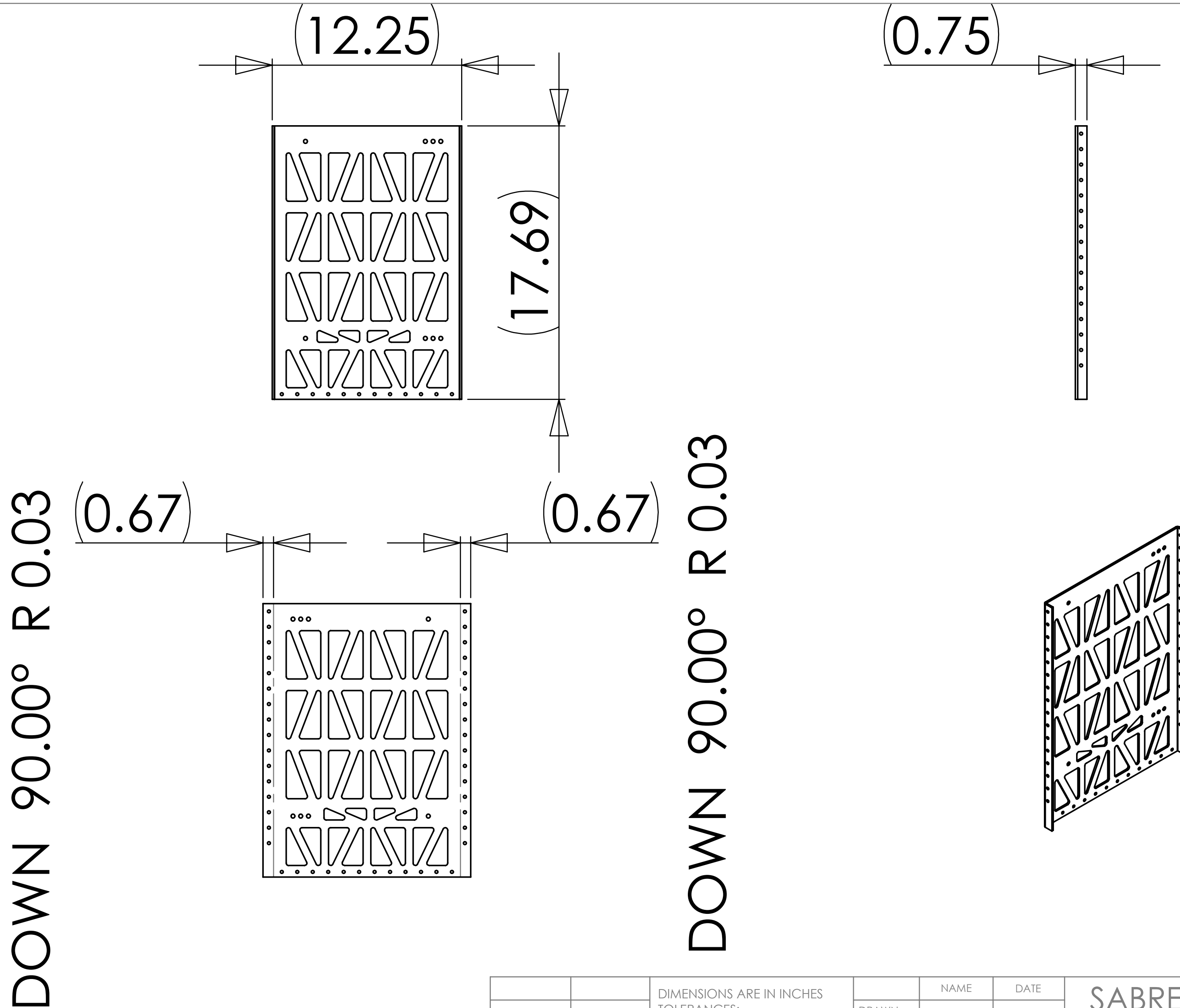
	NAME	DATE
DRAWN		
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		
COMMENTS:		

SABRE BYTES FIRST 772

Side Plate - Tower - Left - O

SIZE A | DWG. NO. SB-12-T-P-BT-L | REV. 1

SCALE:1:5 | WEIGHT: | SHEET 1 OF 1



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NEXT ASSY	USED ON
APPLICATION	

DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±
ANGULAR: MACH ± BEND ±
TWO PLACE DECIMAL ±
THREE PLACE DECIMAL ±

MATERIAL --

FINISH --

DO NOT SCALE DRAWING

	NAME	DATE
DRAWN		
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

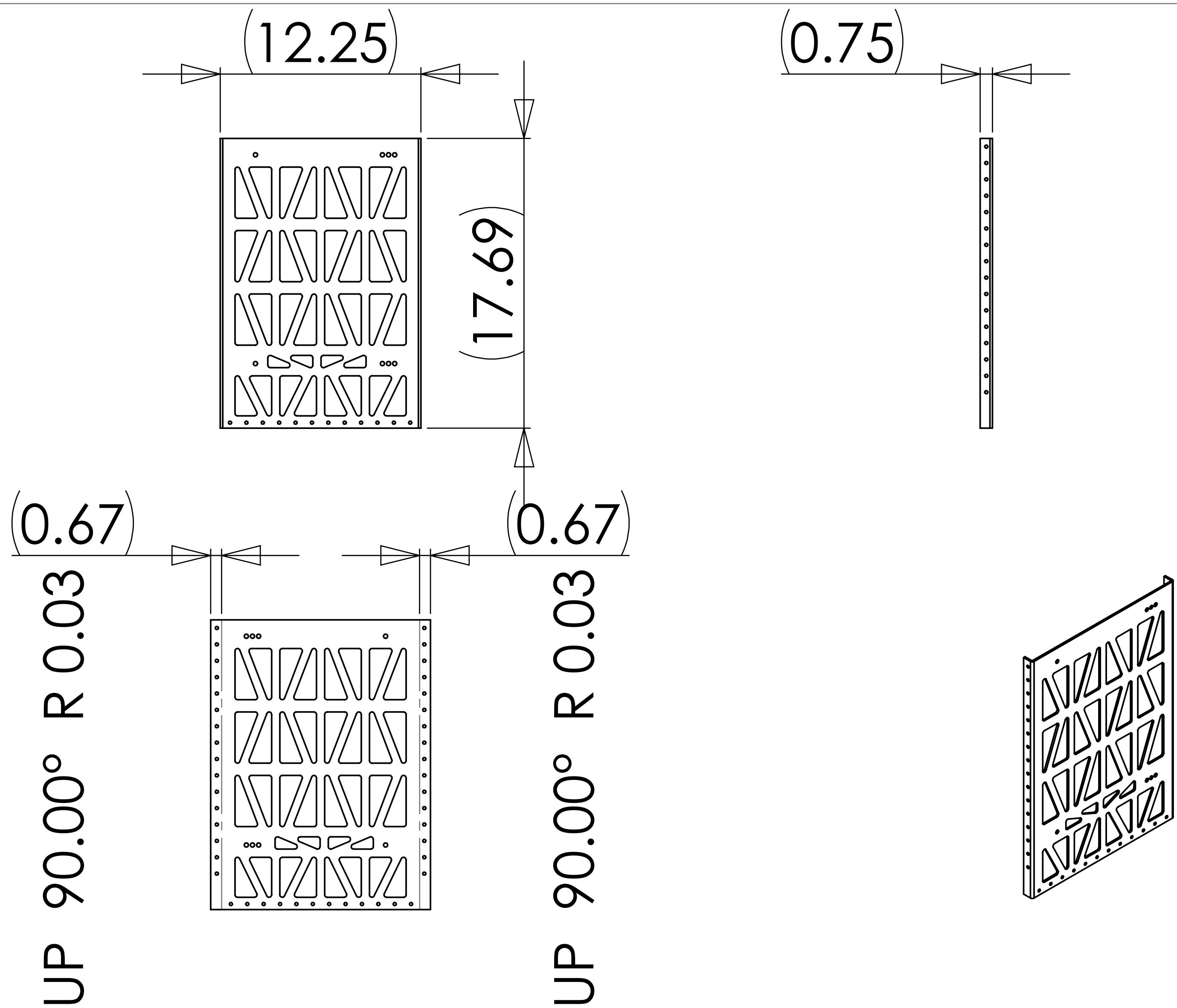
COMMENTS:

SABRE BYTES FIRST 772

Side Plate -Right1 - Outside

SIZE A | DWG. NO. SB-12-T-P-T-R | REV. 1

SCALE:1:10 | WEIGHT: | SHEET 1 OF 1



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NEXT ASSY | USED ON

APPLICATION

DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±
ANGULAR: MACH ± BEND ±
TWO PLACE DECIMAL ±
THREE PLACE DECIMAL ±

MATERIAL --

FINISH --

DO NOT SCALE DRAWING

	NAME	DATE
DRAWN		
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

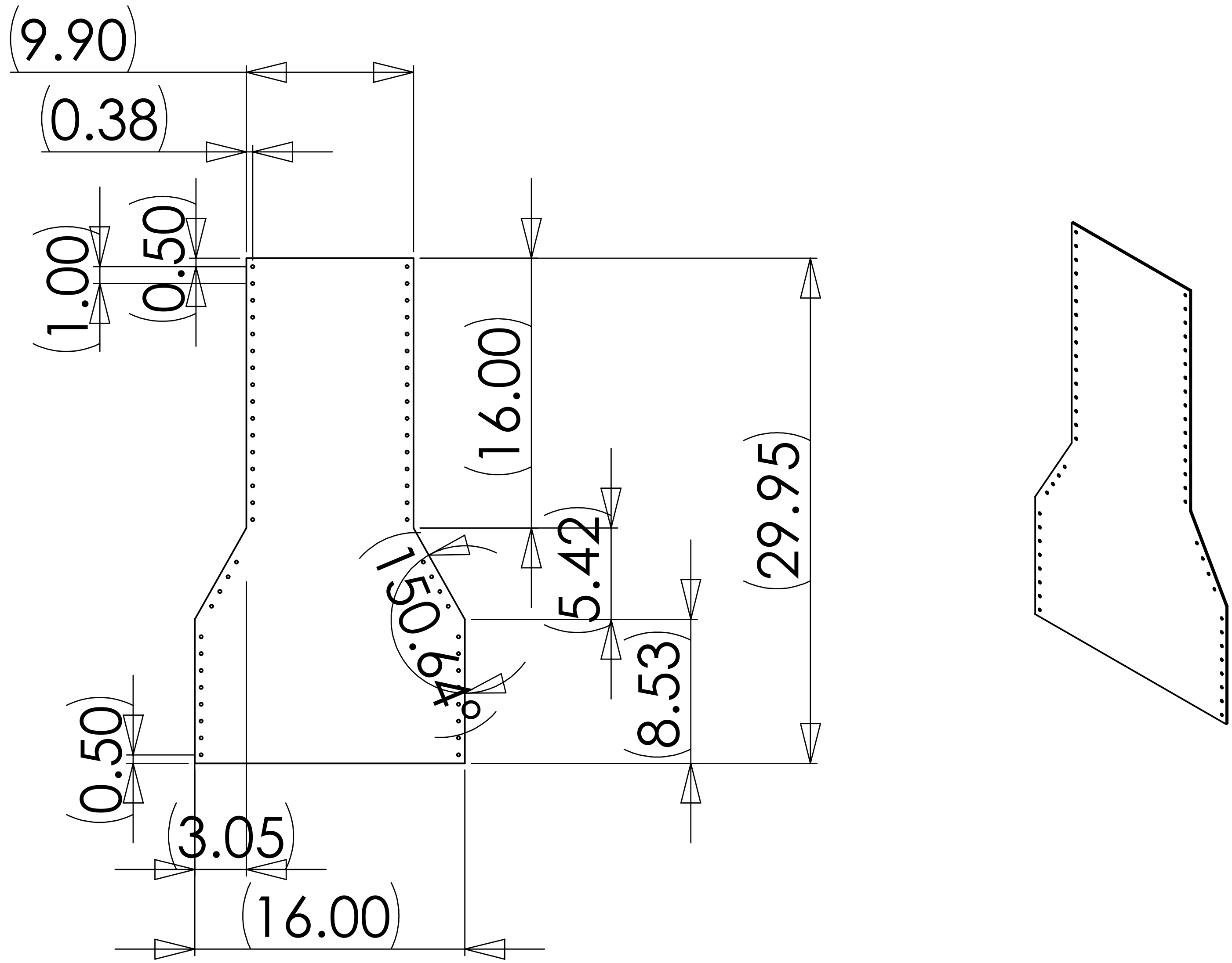
COMMENTS:

SABRE BYTES FIRST 772

Side Plate - Left - Outside

SIZE A | DWG. NO. SB-12-T-P-T-L | REV. 1

SCALE:1:10 | WEIGHT: | SHEET 1 OF 1



NEXT ASSY | USED ON

APPLICATION

DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±
ANGULAR: MACH ± BEND ±
TWO PLACE DECIMAL ±
THREE PLACE DECIMAL ±

MATERIAL --

FINISH --

DO NOT SCALE DRAWING

	NAME	DATE
DRAWN		
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

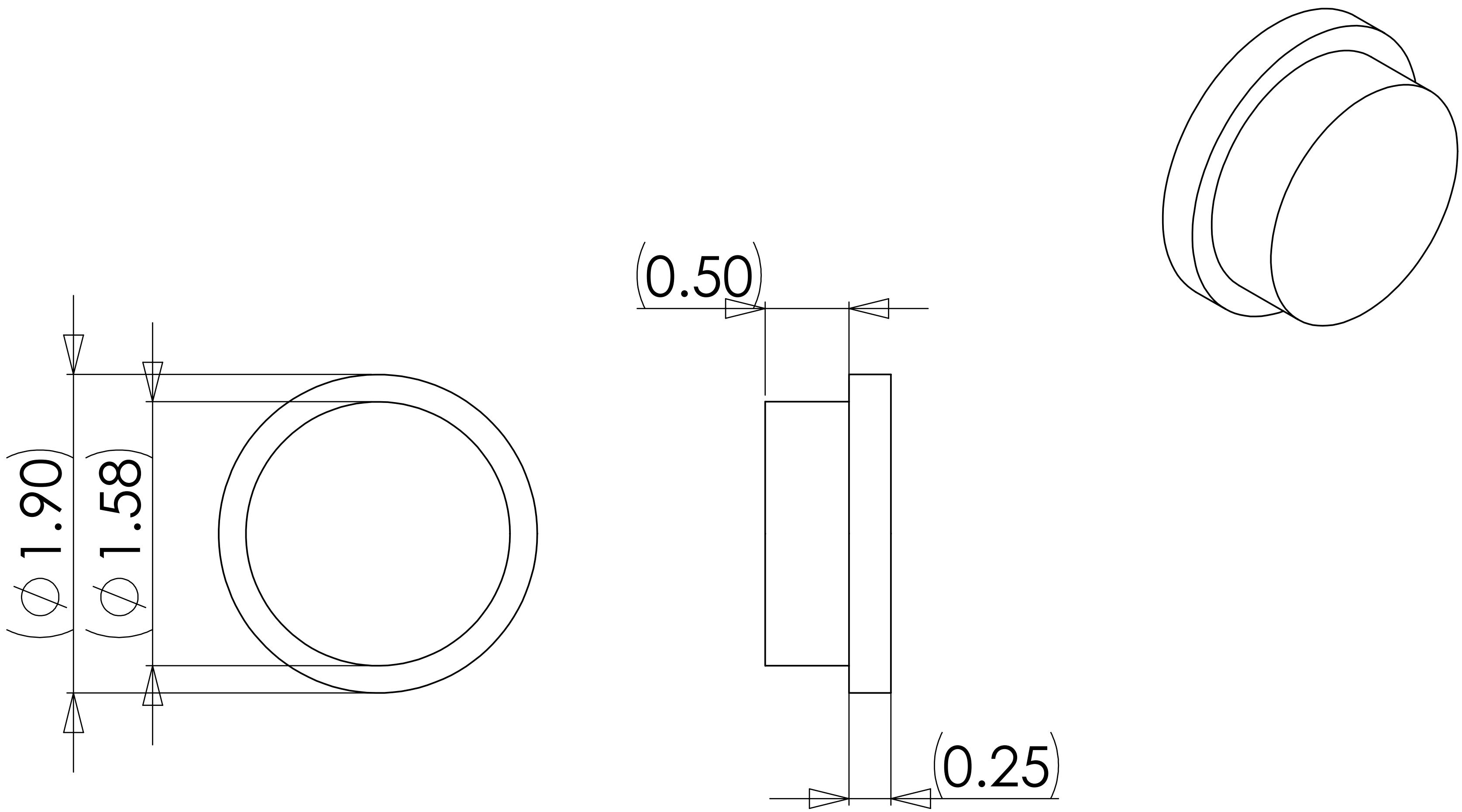
COMMENTS:

SABRE BYTES FIRST 772

SIDE PLATE - B - O
Electrical board

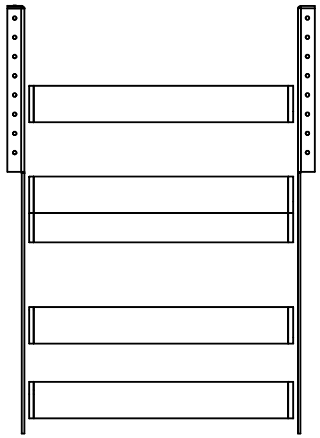
SIZE A | DWG. NO. | REV.

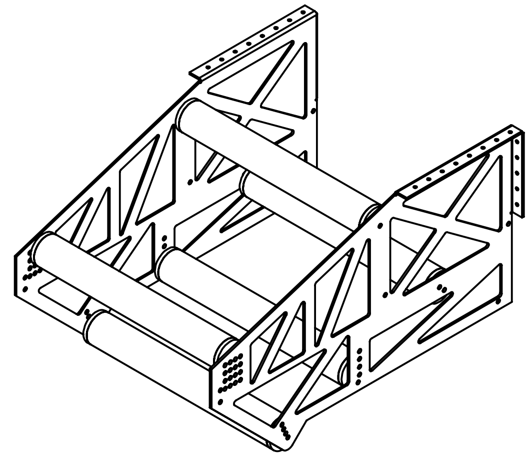
SCALE:1:10 | WEIGHT: | SHEET 1 OF 1

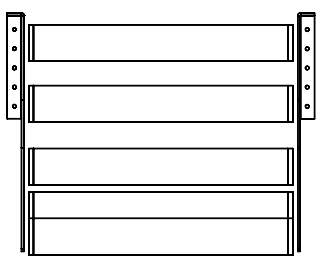


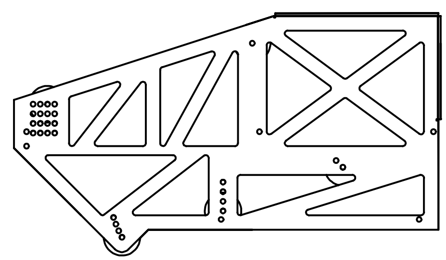
DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±		NAME	DATE	Sabre Bytes FIRST 772	
	DRAWN				
	CHECKED				
	ENG APPR.				
	MFG APPR.				
MATERIAL NYLON	Q.A.				
FINISH --	COMMENTS:			SIZE A	DWG. NO.	REV.
DO NOT SCALE DRAWING				SCALE:1:1	WEIGHT:	SHEET 1 OF 1

NEXT ASSY	USED ON
APPLICATION	









ITEM NO.	PART NUMBER	QTY.
1	Side Plate - Right - Inside	1
2	Side Plate - Left - Inside (2)	1
3	Roller Shaft	5
4	Bushing	10

NEXT ASSY | USED ON

APPLICATION

DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±
ANGULAR: MACH ± BEND ±
TWO PLACE DECIMAL ±
THREE PLACE DECIMAL ±

MATERIAL
--

FINISH
--

DO NOT SCALE DRAWING

	NAME	DATE
DRAWN		
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

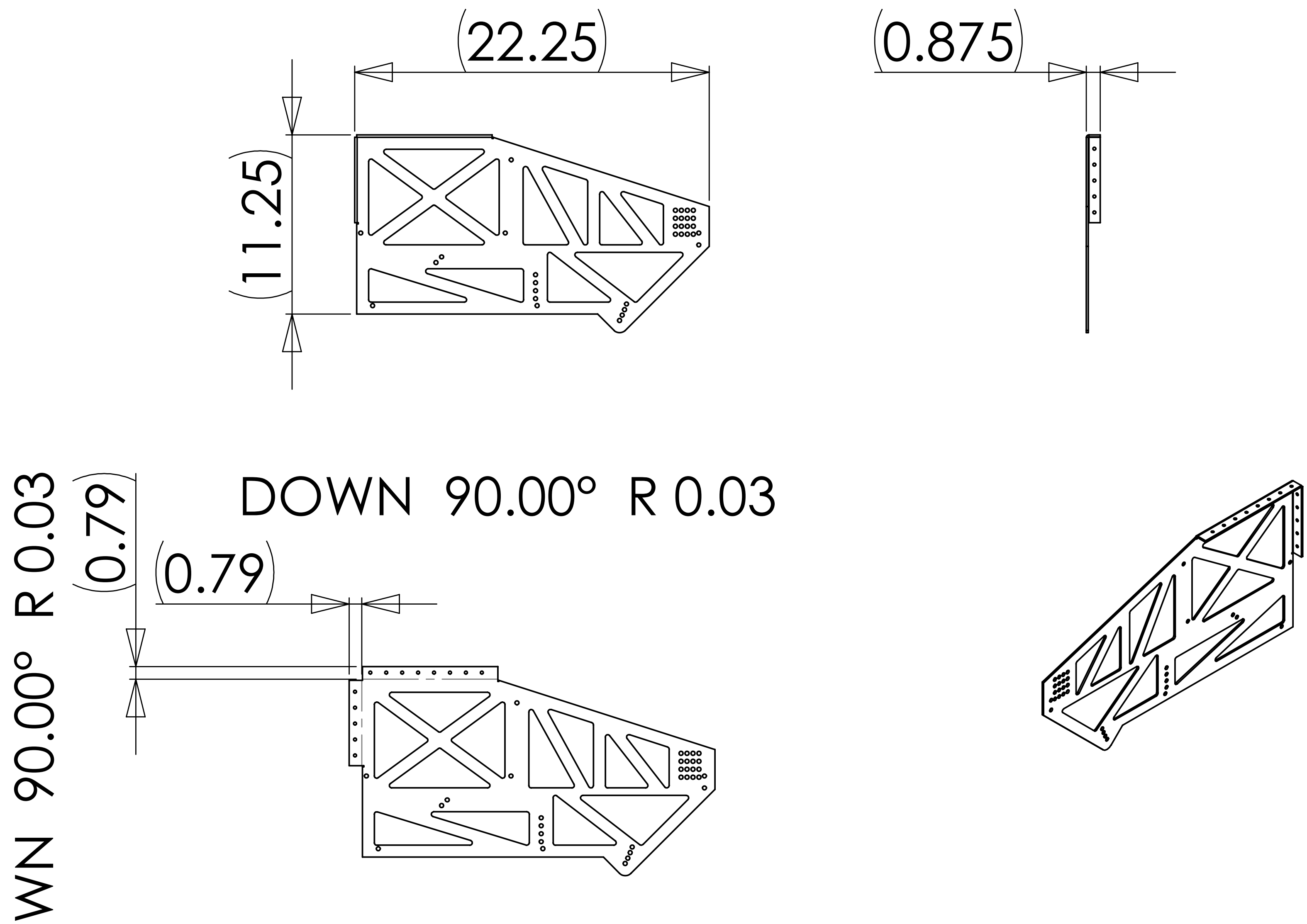
COMMENTS:

SABRE BYTES FIRST 772

Ball Collector

SIZE A | DWG. NO. | REV. 1

SCALE:1:10 | WEIGHT: | SHEET 1 OF 1



NEXT ASSY	USED ON
APPLICATION	

DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±
ANGULAR: MACH ± BEND ±
TWO PLACE DECIMAL ±
THREE PLACE DECIMAL ±

MATERIAL --

FINISH --

DO NOT SCALE DRAWING

	NAME	DATE
DRAWN		
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

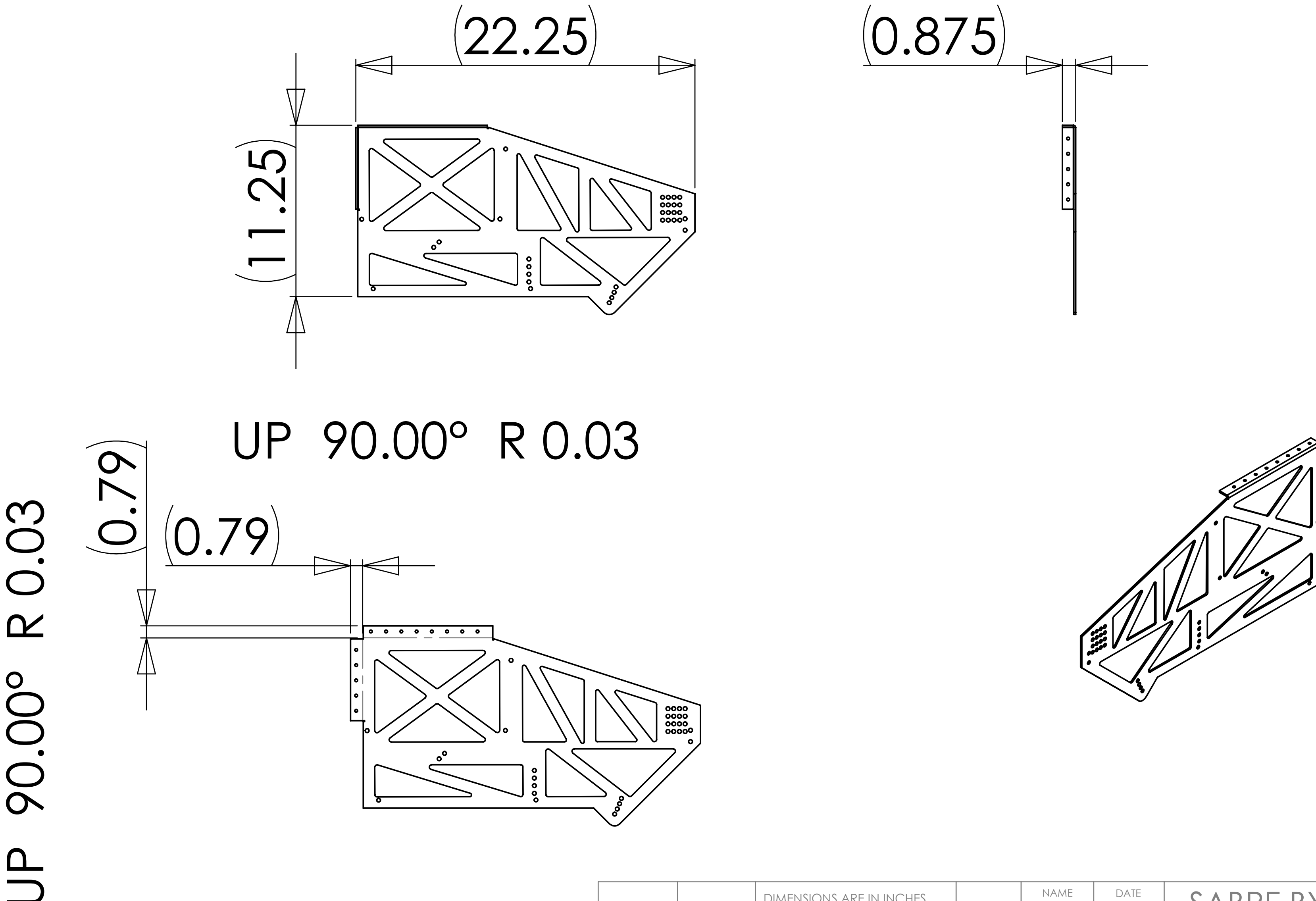
COMMENTS:

SABRE BYTES FIRST 772

Side Plate - Right - Inside

SIZE A | DWG. NO. SB-12-BS-S-B-R | REV. 1

SCALE:1:10 | WEIGHT: | SHEET 1 OF 1



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NEXT ASSY	USED ON
APPLICATION	

DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±
ANGULAR: MACH ± BEND ±
TWO PLACE DECIMAL ±
THREE PLACE DECIMAL ±

MATERIAL --

FINISH --

DO NOT SCALE DRAWING

	NAME	DATE
DRAWN		
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

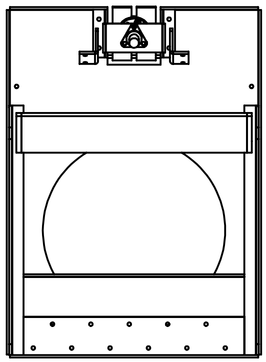
COMMENTS:

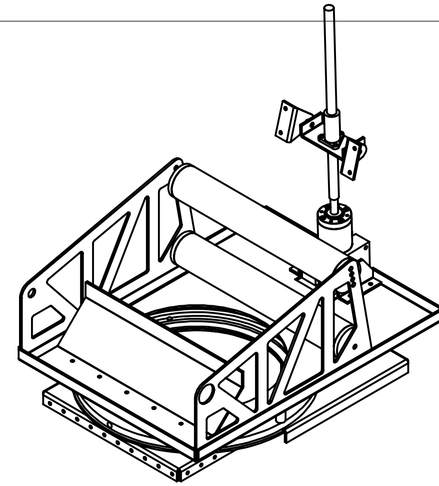
SABRE BYTES FIRST 772

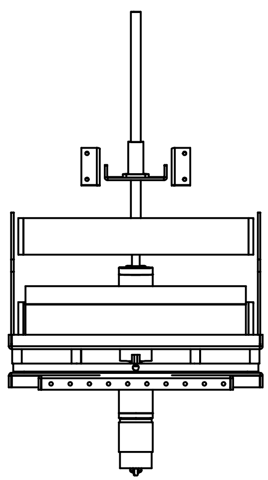
Side Plate - Left - Inside

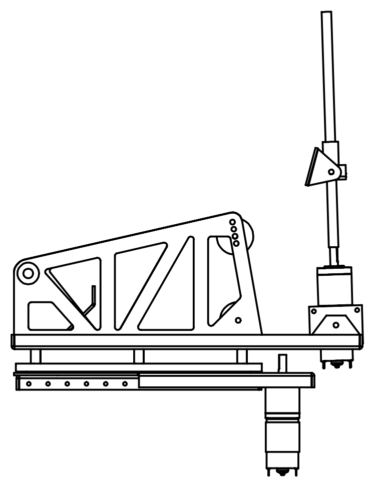
SIZE A | DWG. NO. SB-12-BC-P-B-L | REV. 1

SCALE:1:10 | WEIGHT: | SHEET 1 OF 1









ITEM NO.	PART NUMBER	QTY.
1	Side Plate - Turret - top	1
2	Side Plate - Turret Mount	1
3	Side Plate - Base of turret	1
4	Side Plate - Shooter mount - Left	1
5	Side Plate - Shooter mount - Right2	1
6	Spacer - 1	6
7	18635A520	1
8	Bushing	4
9	Roller Shaft - 4	2
10	am-9014_2012	2
25	Ball defector	1
26	Side Plate - R	1
27	Side Plate - L	1
28	Motor support	2
29	Spacer - 2	2
30	Lead screw rod	1
31	Lead screw hub	1
32	Hub mount	1
33	Mount Axis	2

NEXT ASSY | USED ON
APPLICATION

DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±
ANGULAR: MACH ± BEND ±
TWO PLACE DECIMAL ±
THREE PLACE DECIMAL ±

MATERIAL --
FINISH --
DO NOT SCALE DRAWING

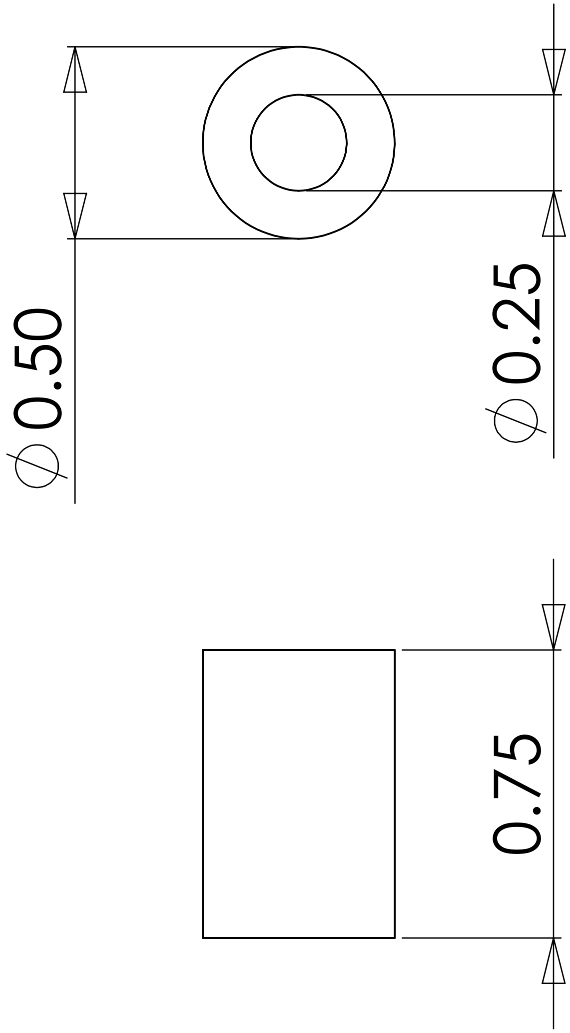
	NAME	DATE
DRAWN		
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

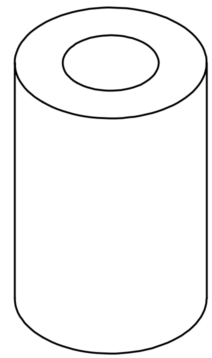
COMMENTS:

SABRE BYTES FIRST 772

Turret Assembly

SIZE A | DWG. NO. | REV. 1
SCALE:1:10 | WEIGHT: | SHEET 1 OF 1





NEXT ASSY	USED ON	
APPLICATION		

DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±
ANGULAR: MACH ± BEND ±
TWO PLACE DECIMAL ±
THREE PLACE DECIMAL ±

MATERIAL --

FINISH --

DO NOT SCALE DRAWING

	NAME	DATE
DRAWN		
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

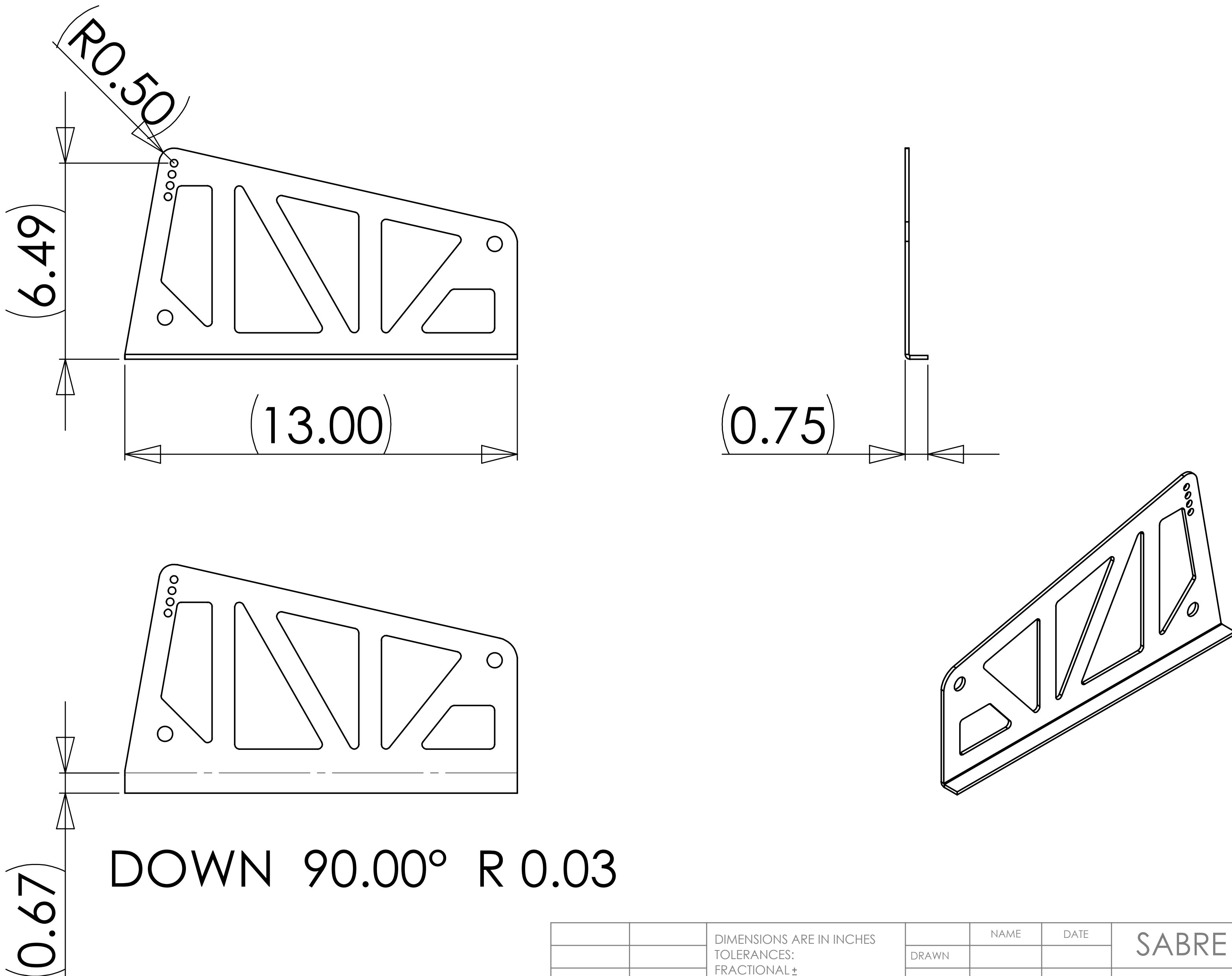
COMMENTS:

SABRE BYTES FIRST 772

Spacer - 1

SIZE	DWG. NO.	REV.
A	SB-12-TR-S-LS-S	1

SCALE:2:1 | WEIGHT: | SHEET 1 OF 1



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NEXT ASSY	USED ON
APPLICATION	

DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±
ANGULAR: MACH ± BEND ±
TWO PLACE DECIMAL ±
THREE PLACE DECIMAL ±

MATERIAL --

FINISH --

DO NOT SCALE DRAWING

	NAME	DATE
DRAWN		
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

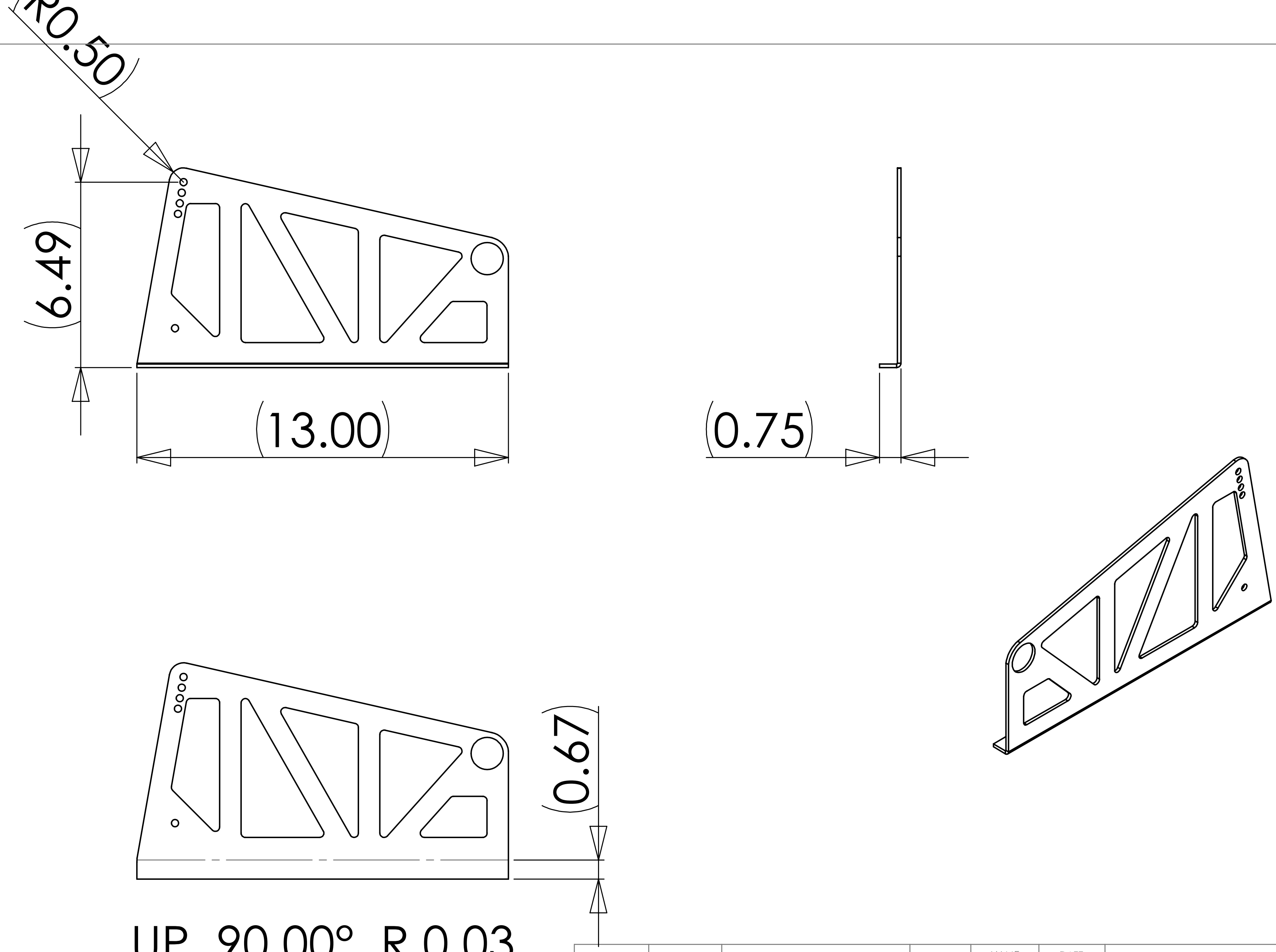
COMMENTS:

SABRE BYTES FIRST 772

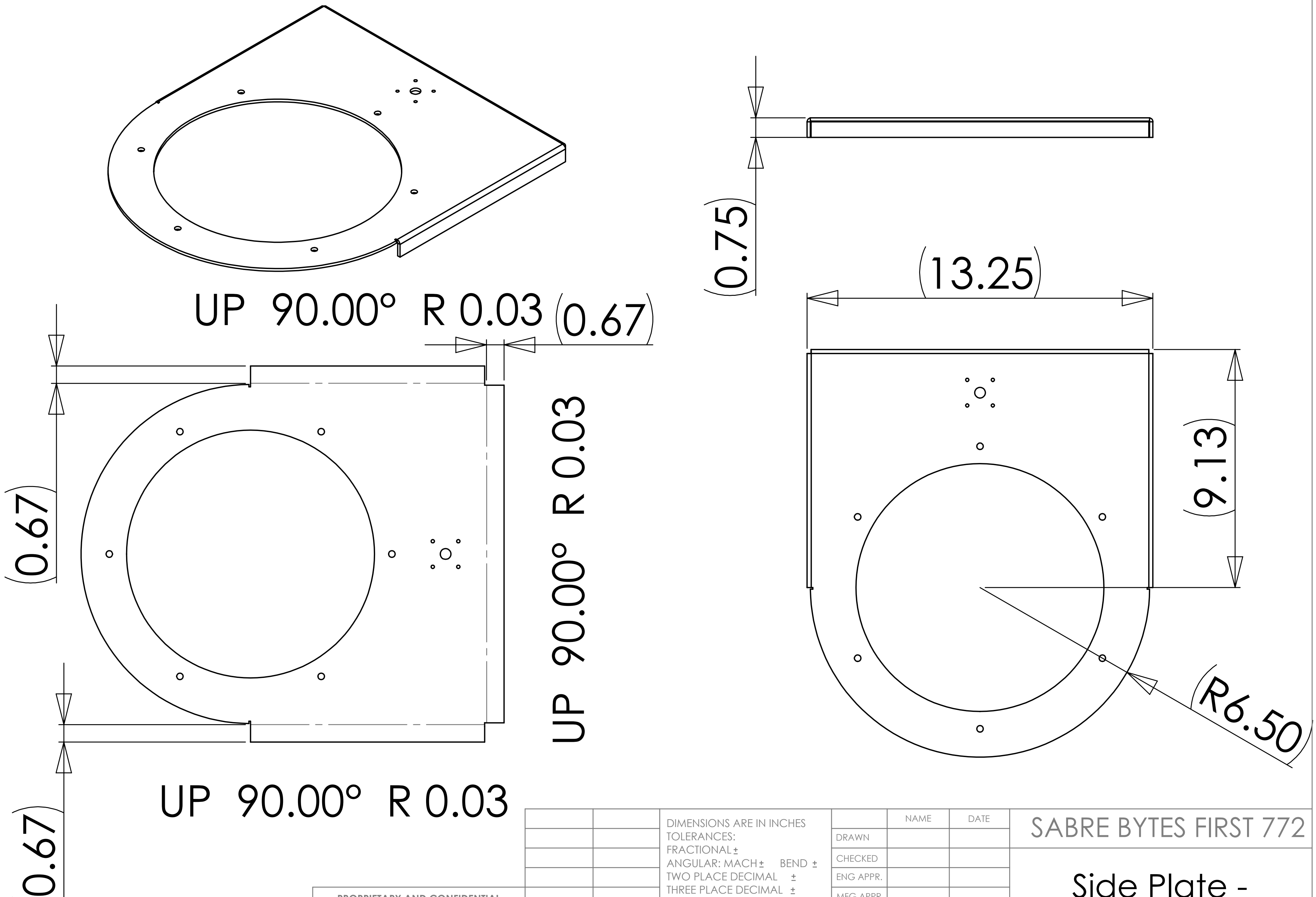
Side Plate - Shooter mount - rigth2

SIZE	DWG. NO.	REV.
A	SB-12-TR-P-R	1

SCALE:1:5 WEIGHT: SHEET 1 OF 1



		DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±		NAME	DATE	SABRE BYTES FIRST 772
			DRAWN			Side Plate - Shooter mount - Left
			CHECKED			
			ENG APPR.			
			MFG APPR.			
		MATERIAL --	Q.A.			
		FINISH --	COMMENTS:			SIZE A · DWG. NO. SB-12-TR-P-L · REV. 1
NEXT ASSY	USED ON					SCALE:1:5 · WEIGHT: · SHEET 1 OF 1
APPLICATION		DO NOT SCALE DRAWING				



NEXT ASSY	USED ON
APPLICATION	

DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±
ANGULAR: MACH ± BEND ±
TWO PLACE DECIMAL ±
THREE PLACE DECIMAL ±

MATERIAL --

FINISH --

DO NOT SCALE DRAWING

	NAME	DATE
DRAWN		
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

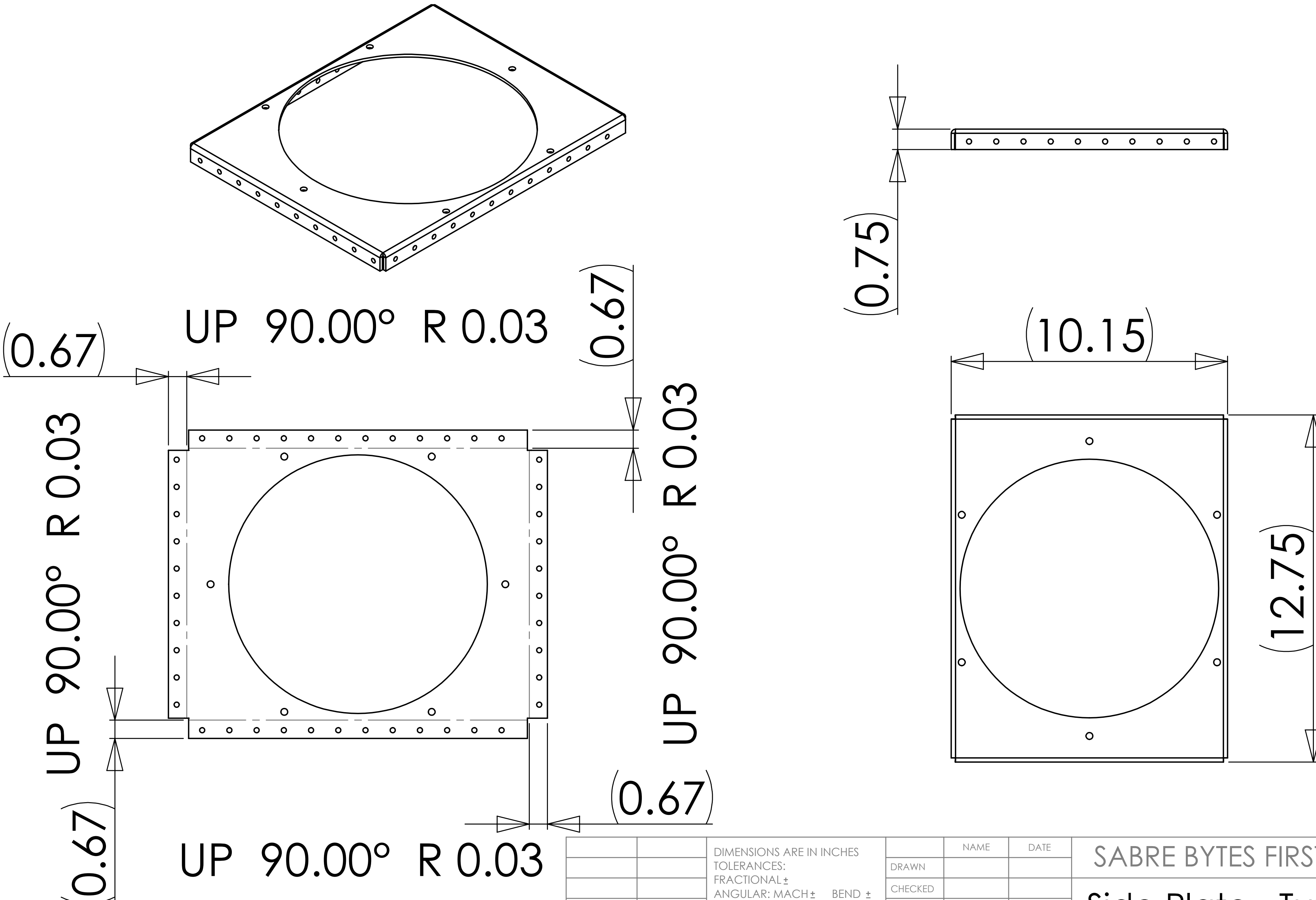
COMMENTS:

SABRE BYTES FIRST 772

Side Plate - Turret Mount

SIZE	DWG. NO.	REV.
A	SB-12-TR-P-B-O	1

SCALE:1:5 WEIGHT: SHEET 1 OF 1



SABRE BYTES FIRST 772

Side Plate - Turret - top

	NAME	DATE
DRAWN		
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

COMMENTS:

DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±
ANGULAR: MACH ± BEND ±
TWO PLACE DECIMAL ±
THREE PLACE DECIMAL ±

MATERIAL --

FINISH --

NEXT ASSY | USED ON

APPLICATION

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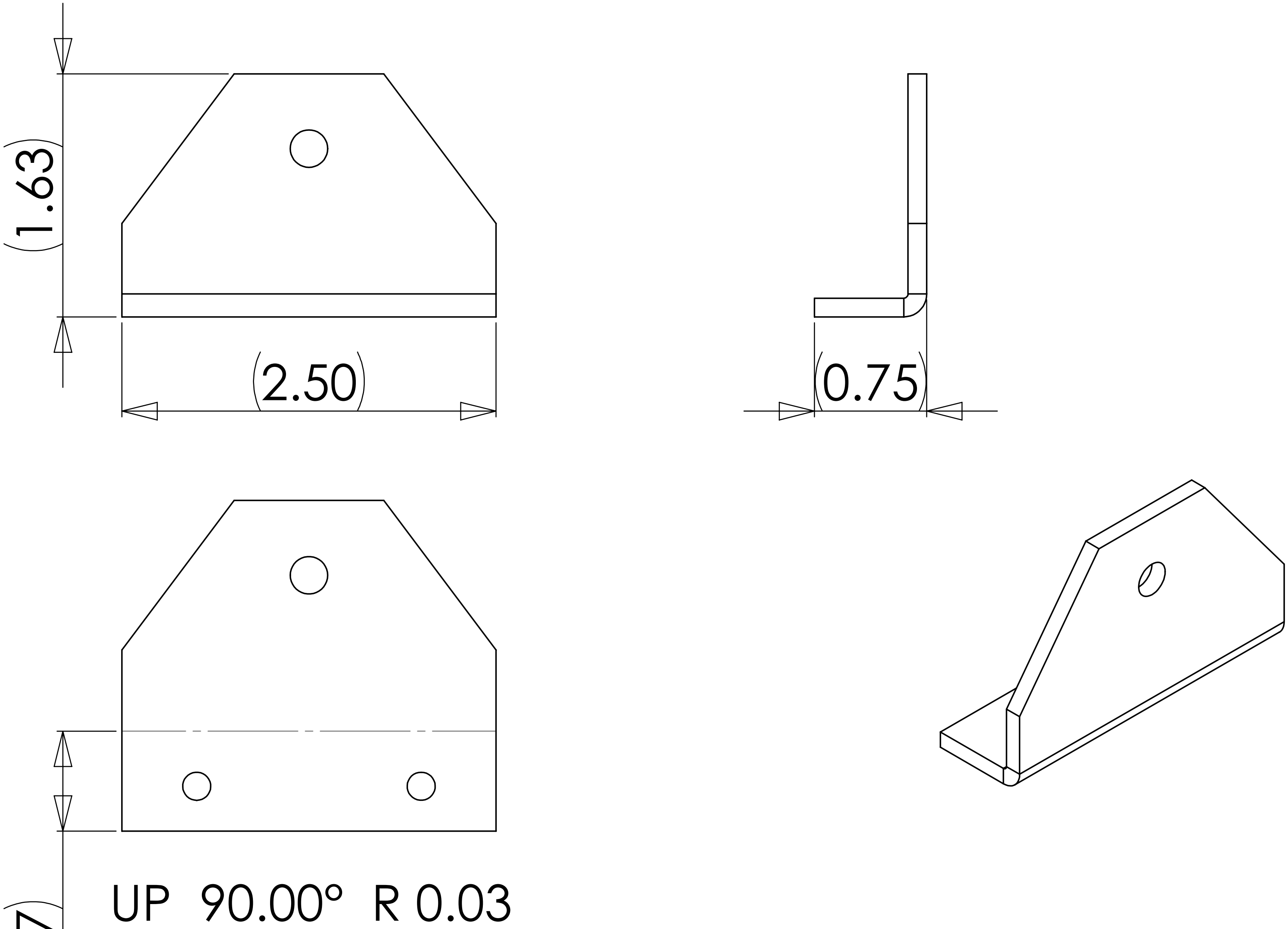
SIZE A | DWG. NO. SB-12-T-P-T | REV. 1

SCALE:1:5 | WEIGHT: | SHEET 1 OF 1



		DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±		NAME	DATE	SABRE BYTES FIRST 772
			DRAWN			
			CHECKED			Side Plate - R
			ENG APPR.			
			MFG APPR.			
		MATERIAL --	Q.A.			
		FINISH --	COMMENTS:			
NEXT ASSY	USED ON					SIZE A DWG. NO. SB-12-TR-P-MM-R REV. 1
APPLICATION		DO NOT SCALE DRAWING				SCALE:1:1 WEIGHT: SHEET 1 OF 1

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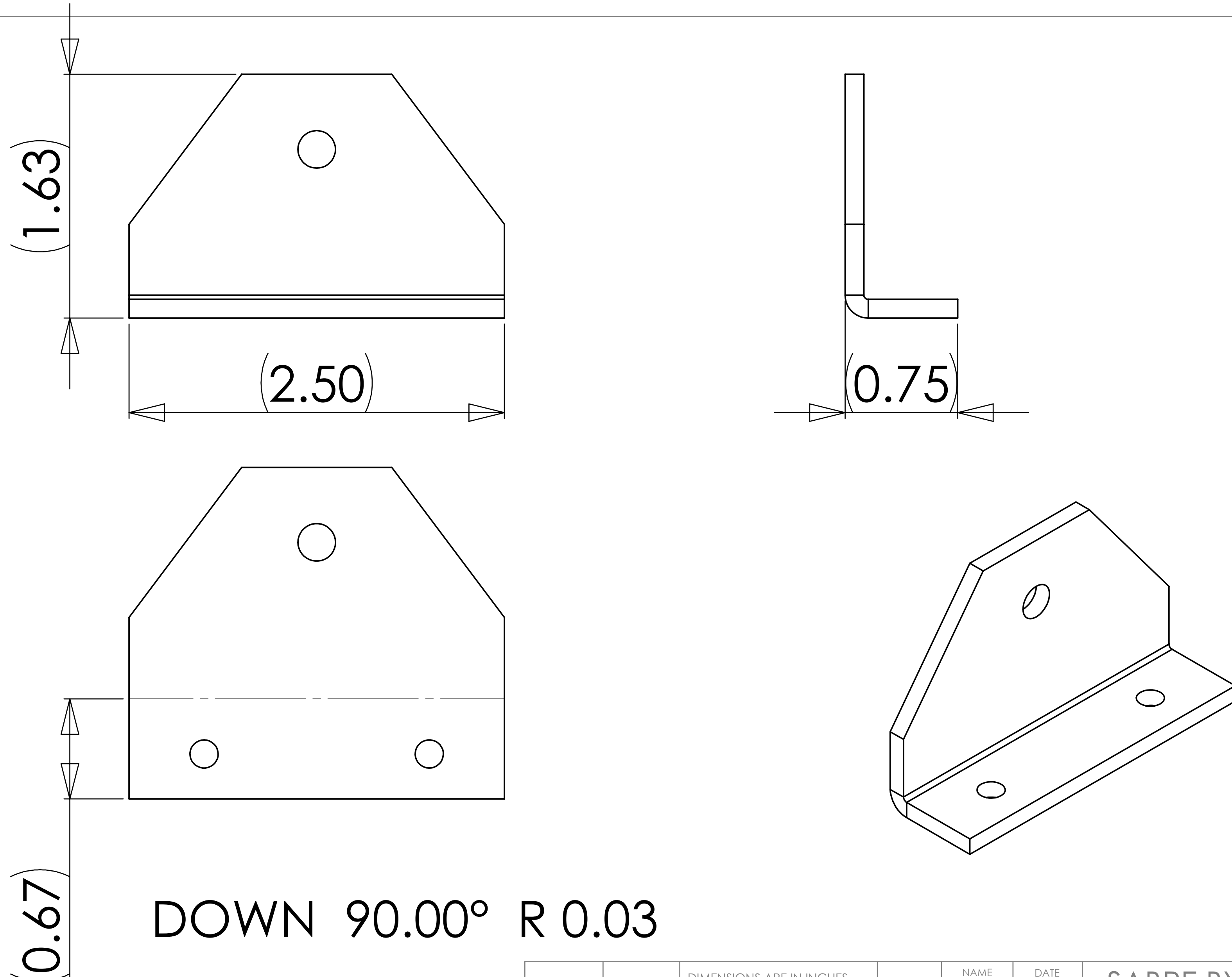


NEXT ASSY | USED ON
APPLICATION

DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±
ANGULAR: MACH ± BEND ±
TWO PLACE DECIMAL ±
THREE PLACE DECIMAL ±

MATERIAL --

FINISH --

DO NOT SCALE DRAWING

	NAME	DATE
DRAWN		
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

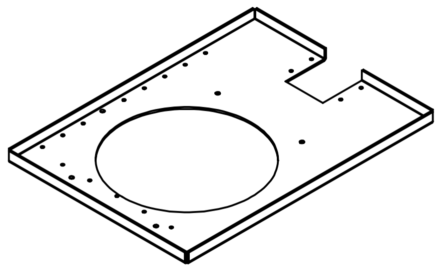
COMMENTS:

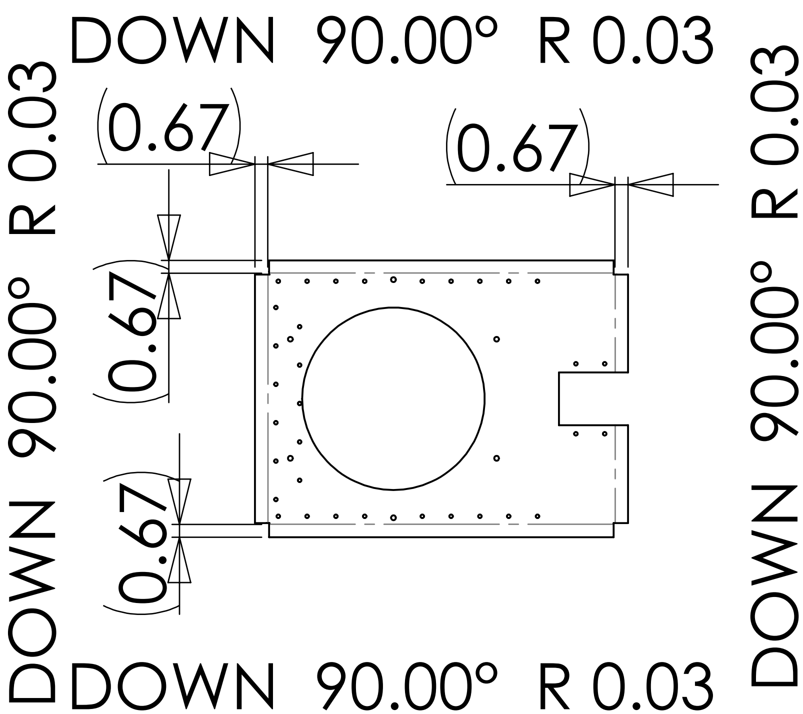
SABRE BYTES FIRST 772

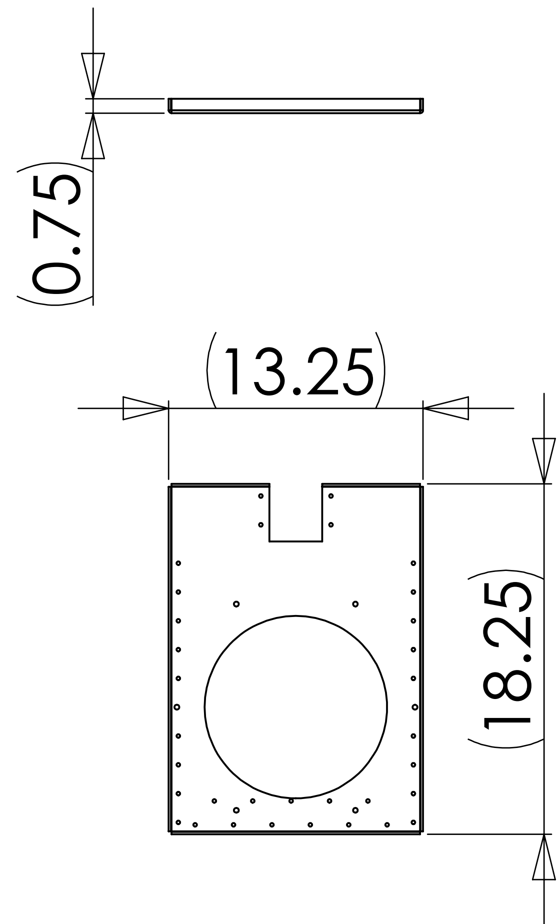
Side Plate - L

SIZE A | DWG. NO. SB-12-TR-P-MM-L | REV. 1

SCALE:1:1 | WEIGHT: | SHEET 1 OF 1







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NEXT ASSY	USED ON
APPLICATION	

DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±
ANGULAR: MACH ± BEND ±
TWO PLACE DECIMAL ±
THREE PLACE DECIMAL ±

MATERIAL --

FINISH --

DO NOT SCALE DRAWING

	NAME	DATE
DRAWN		
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

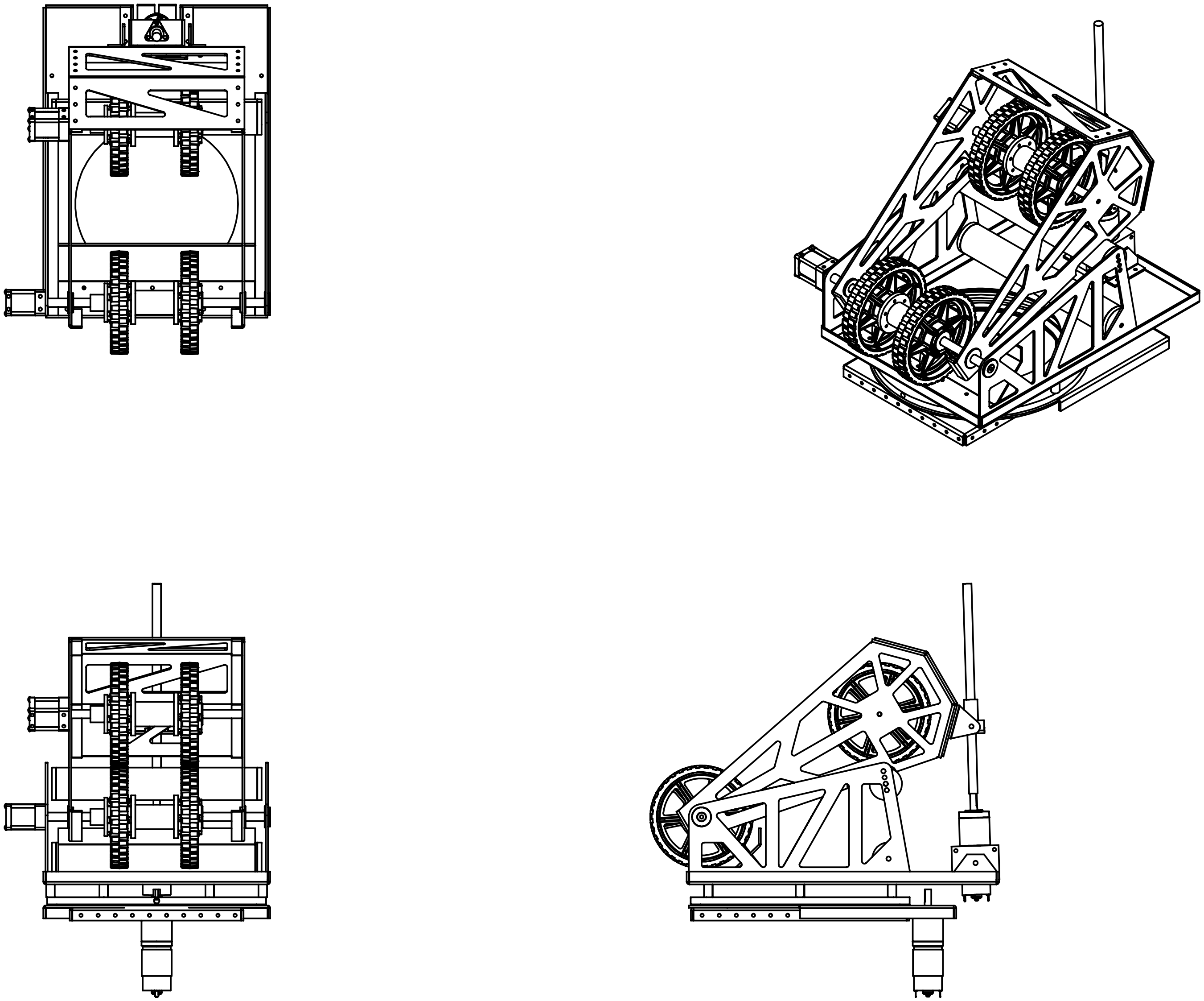
COMMENTS:

SABRE BYTES FIRST 772

Side Plate - Base of Turret

SIZE A | DWG. NO. SB-12-TR-P-BT-I | REV. 1

SCALE:1:10 | WEIGHT: | SHEET 1 OF 1



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APPLICATION	

DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±
ANGULAR: MACH ± BEND ±
TWO PLACE DECIMAL ±
THREE PLACE DECIMAL ±

MATERIAL
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FINISH
--

DO NOT SCALE DRAWING

	NAME	DATE
DRAWN		
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

COMMENTS:

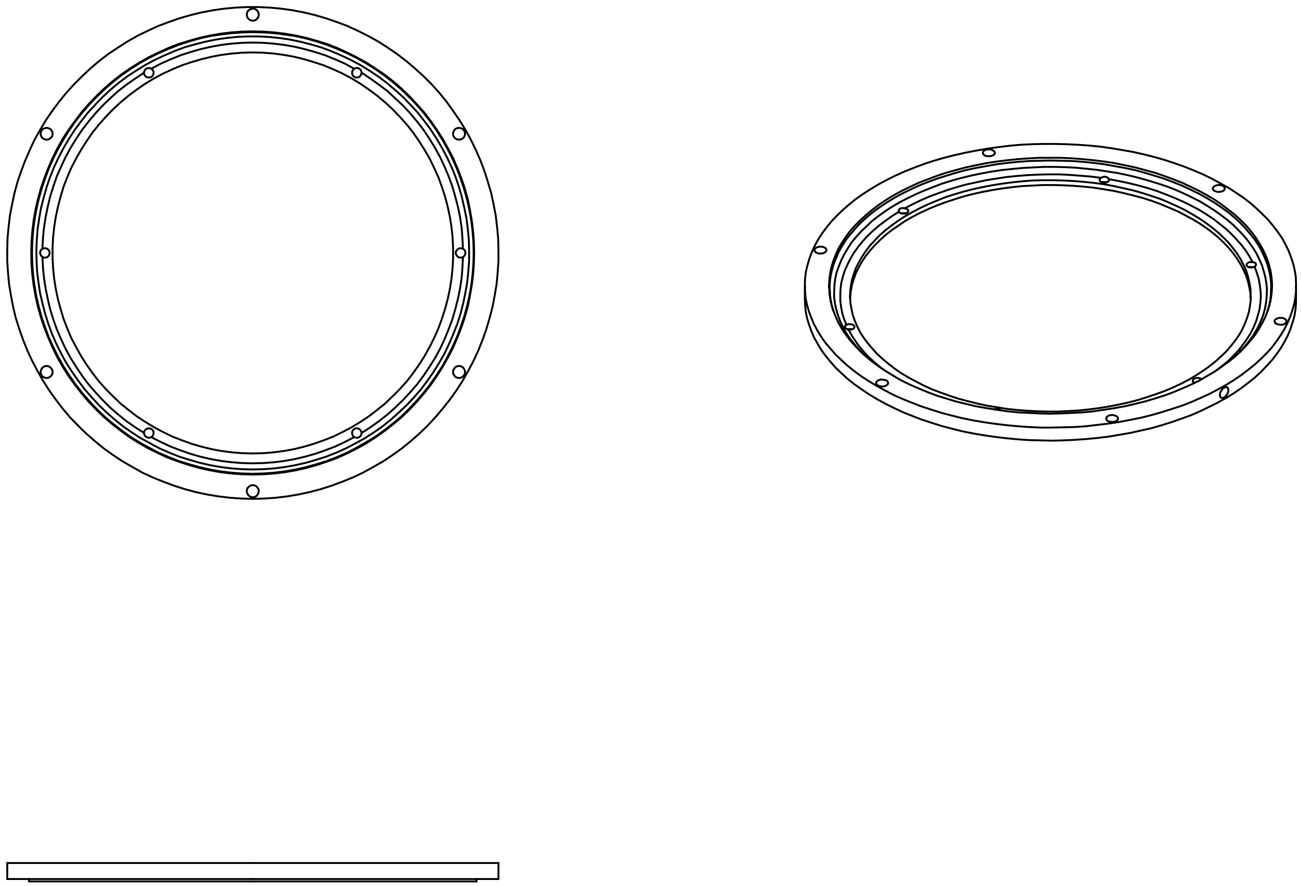
SABRE BYTES FIRST 772

Shooter/Turret

SIZE	DWG. NO.	REV.
A		1

SCALE:1:10 WEIGHT: SHEET 1 OF 2

ITEM NO.	PART NUMBER	QTY.
1	Side Plate - Turret - top	1
2	Side Plate - Turret Mount	1
3	Side Plate - Base of turret	1
4	Side Plate - Shooter mount - Left	1
5	Side Plate - Shooter mount - Right2	1
6	Spacer - 1	6
7	18635A520	1
8	Bushing	4
9	Roller Shaft - 4	2
10	am-9014_2012	2
11	Shooter - top cover	1
12	Side Plate - Shooter - L - O	1
13	Side Plate - Shooter - R - O - 1	1
14	Wheel Hub	2
15	6in 2008 FIRST Hub_1	4
16	6 HiGrip Tread_1	4
17	500-key-hub - 1	2
18	fr-8-zz - 2	5
19	Axle - 3	1
20	back - motor	2
21	cylindar-motor	2
22	bolt	8
23	cylinday 2	2
24	output-shaft	2
25	Axle 5	1
26	Ball defector	1
27	Side Plate - R	1
28	Side Plate - L	1
29	Motor support	2
30	Spacer - 2	2
31	Lead screw rod	1
32	Lead screw hub	1
33	Hub mount	1
34	Mount Axis	2



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APPLICATION	

DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±
ANGULAR: MACH ± BEND ±
TWO PLACE DECIMAL ±
THREE PLACE DECIMAL ±

MATERIAL --

FINISH --

DO NOT SCALE DRAWING

	NAME	DATE
DRAWN		
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

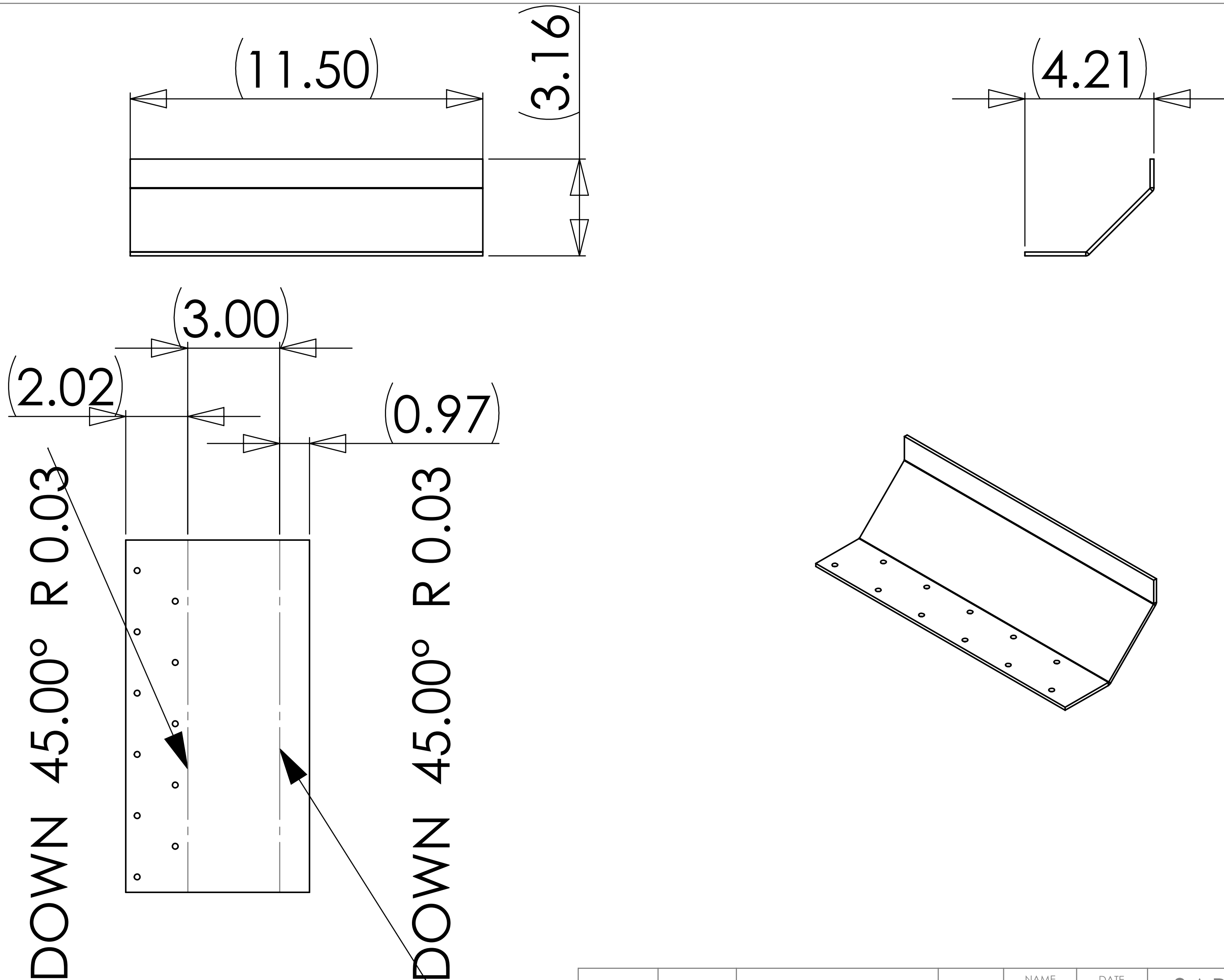
COMMENTS:

SABRE BYTES FIRST 772

Lazy Susan

SIZE A | DWG. NO. | REV. 1

SCALE:1:5 | WEIGHT: | SHEET 1 OF 1



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DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±
ANGULAR: MACH ± BEND ±
TWO PLACE DECIMAL ±
THREE PLACE DECIMAL ±

MATERIAL --

FINISH --

DO NOT SCALE DRAWING

	NAME	DATE
DRAWN		
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

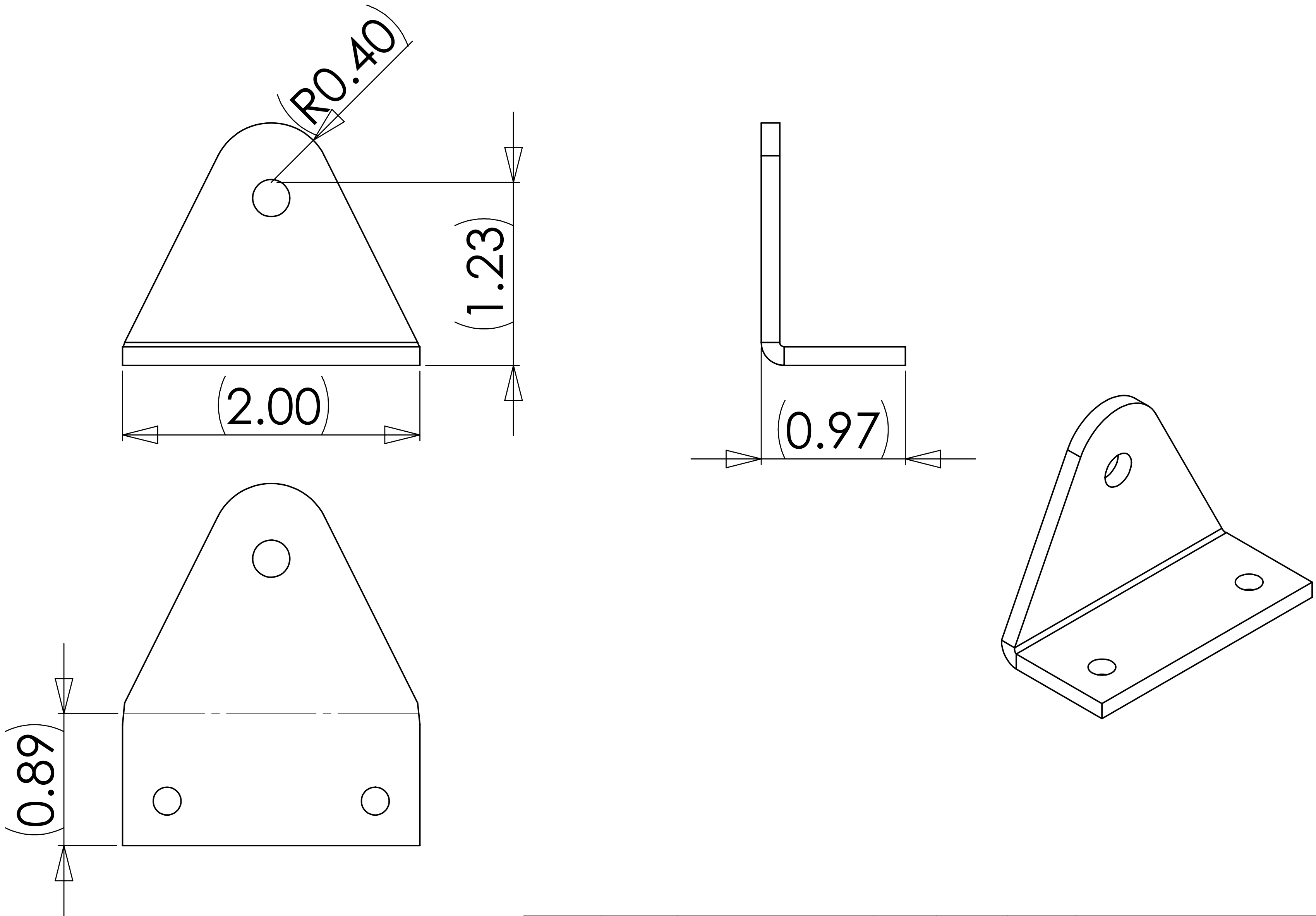
COMMENTS:

SABRE BYTES FIRST 772

Ball deflector

SIZE A DWG. NO. SB-12-TR-P-BD REV. 1

SCALE:1:5 WEIGHT: SHEET 1 OF 1



DOWN 90.00° R 0.03

NEXT ASSY | USED ON

APPLICATION

DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±
ANGULAR: MACH ± BEND ±
TWO PLACE DECIMAL ±
THREE PLACE DECIMAL ±

MATERIAL --

FINISH --

DO NOT SCALE DRAWING

	NAME	DATE
DRAWN		
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

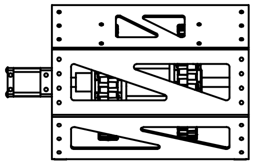
COMMENTS:

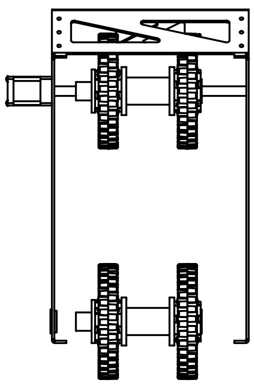
SABRE BYTES FIRST 772

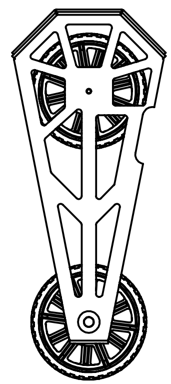
Mount Axis

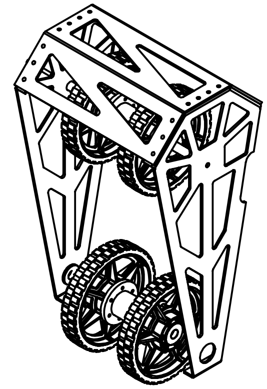
SIZE A | DWG. NO. SB-12-TR-P-S | REV. 1

SCALE:1:1 | WEIGHT: | SHEET 1 OF 1









ITEM NO.	PART NUMBER	QTY.
1	Shooter - top cover	1
2	Side Plate - Shooter - L - O	1
3	Side Plate - Shooter - R - O - 1	1
4	Wheel Hub	2
5	6in 2008 FIRST Hub_1	4
6	6 HiGrip Tread_1	4
7	500-key-hub - 1	2
8	fr-8-zz - 2	3
9	Axle - 3	1
10	back - motor	1
11	cylindar-motor	1
12	bolt	4
13	cylinday 2	1
14	output-shaft	1

DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±
ANGULAR: MACH ± BEND ±
TWO PLACE DECIMAL ±
THREE PLACE DECIMAL ±

MATERIAL --

FINISH --

DO NOT SCALE DRAWING

NEXT ASSY | USED ON

APPLICATION

	NAME	DATE
DRAWN		
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

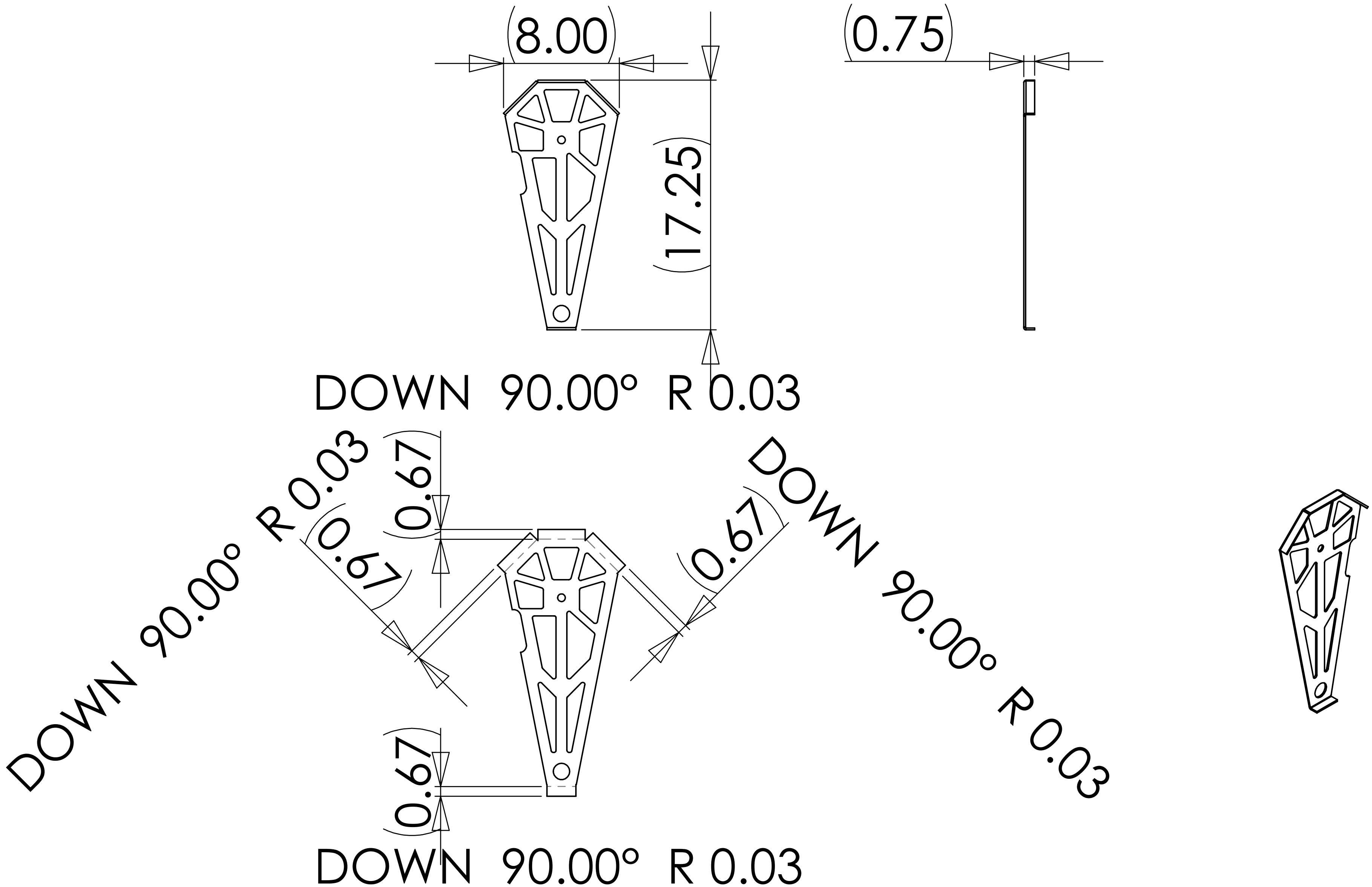
COMMENTS:

SABRE BYTES FIRST 772

Shooter Assmebly

SIZE A | DWG. NO. | REV. 1

SCALE:1:10 | WEIGHT: | SHEET 1 OF 1



NEXT ASSY	USED ON
APPLICATION	

DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±
ANGULAR: MACH ± BEND ±
TWO PLACE DECIMAL ±
THREE PLACE DECIMAL ±

MATERIAL --

FINISH --

DO NOT SCALE DRAWING

	NAME	DATE
DRAWN		
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

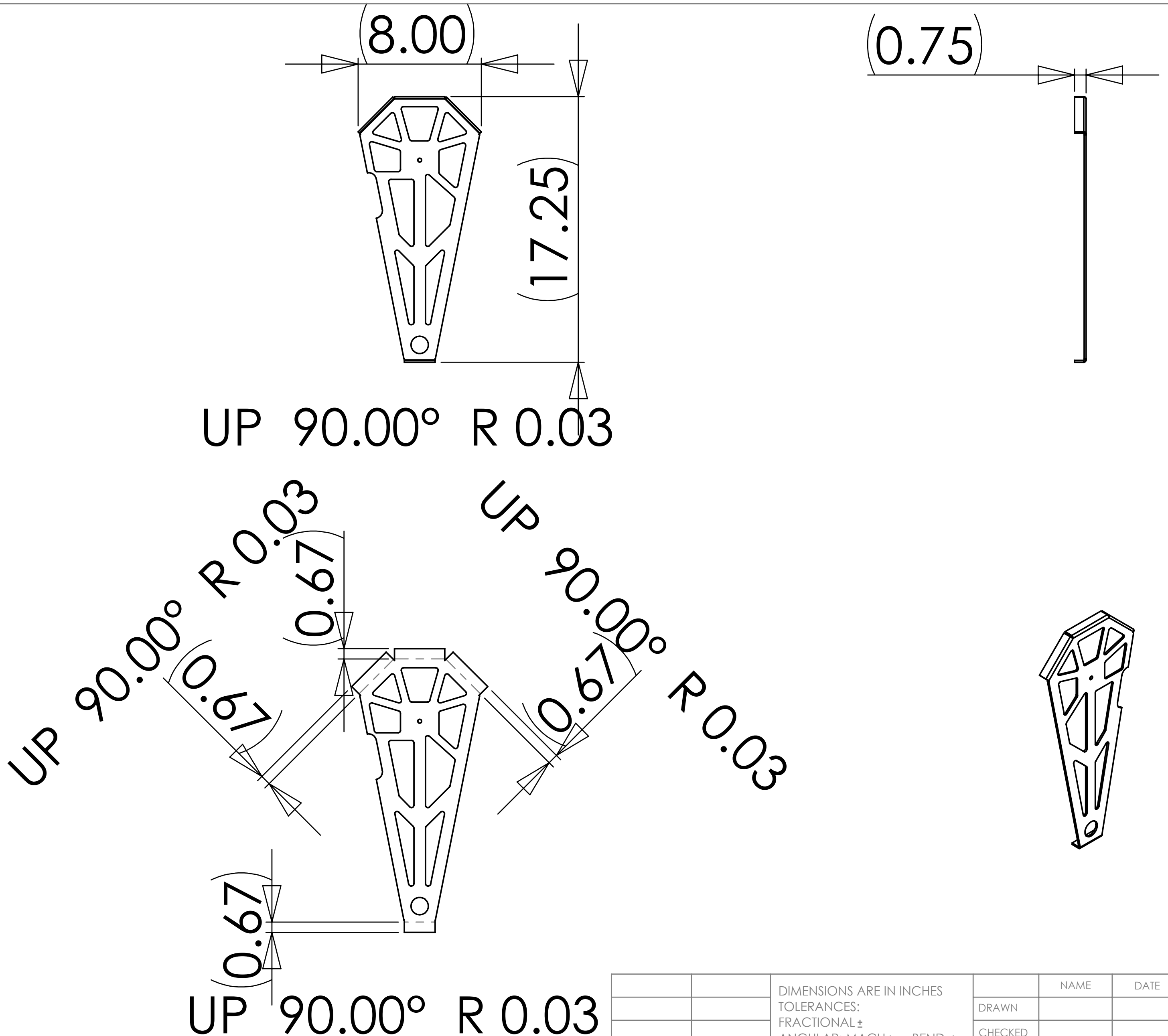
COMMENTS:

SABRE BYTES FIRST 772

Side Plate - Shooter - R - O

SIZE	DWG. NO.	REV.
A	SB-12-S-P-R	1

SCALE:1:10 WEIGHT: SHEET 1 OF 1



NEXT ASSY	USED ON
APPLICATION	

DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±
ANGULAR: MACH ± BEND ±
TWO PLACE DECIMAL ±
THREE PLACE DECIMAL ±

MATERIAL --

FINISH --

DO NOT SCALE DRAWING

	NAME	DATE
DRAWN		
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

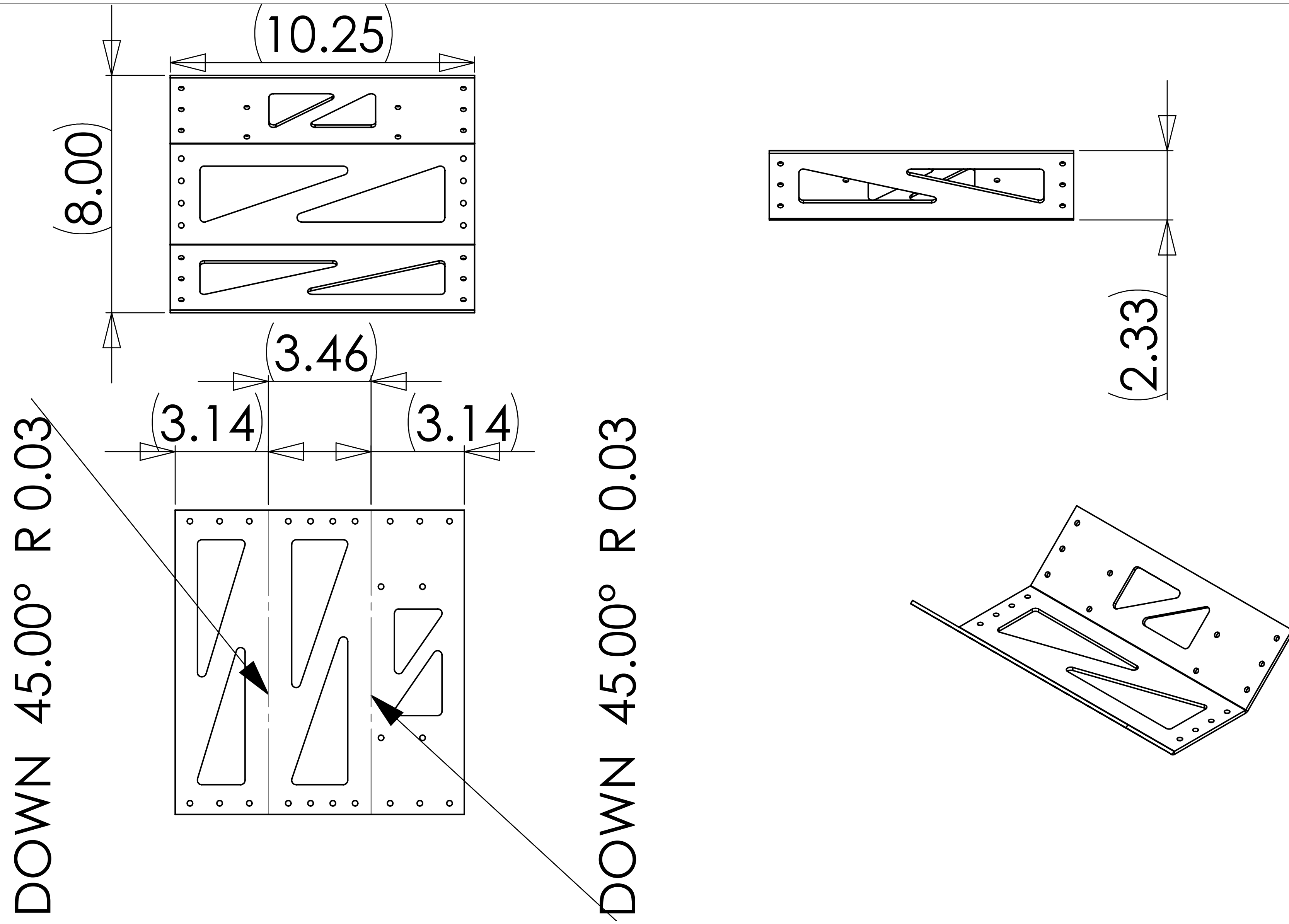
COMMENTS:

SABRE BYTES FIRST 772

Side Plate - Shooter - L - O

SIZE	DWG. NO.	REV.
A	SB-12-S-P-L-O	1

SCALE:1:10 WEIGHT: SHEET 1 OF 1



NEXT ASSY	USED ON
APPLICATION	

DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±
ANGULAR: MACH ± BEND ±
TWO PLACE DECIMAL ±
THREE PLACE DECIMAL ±

MATERIAL --

FINISH --

DO NOT SCALE DRAWING

	NAME	DATE
DRAWN		
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

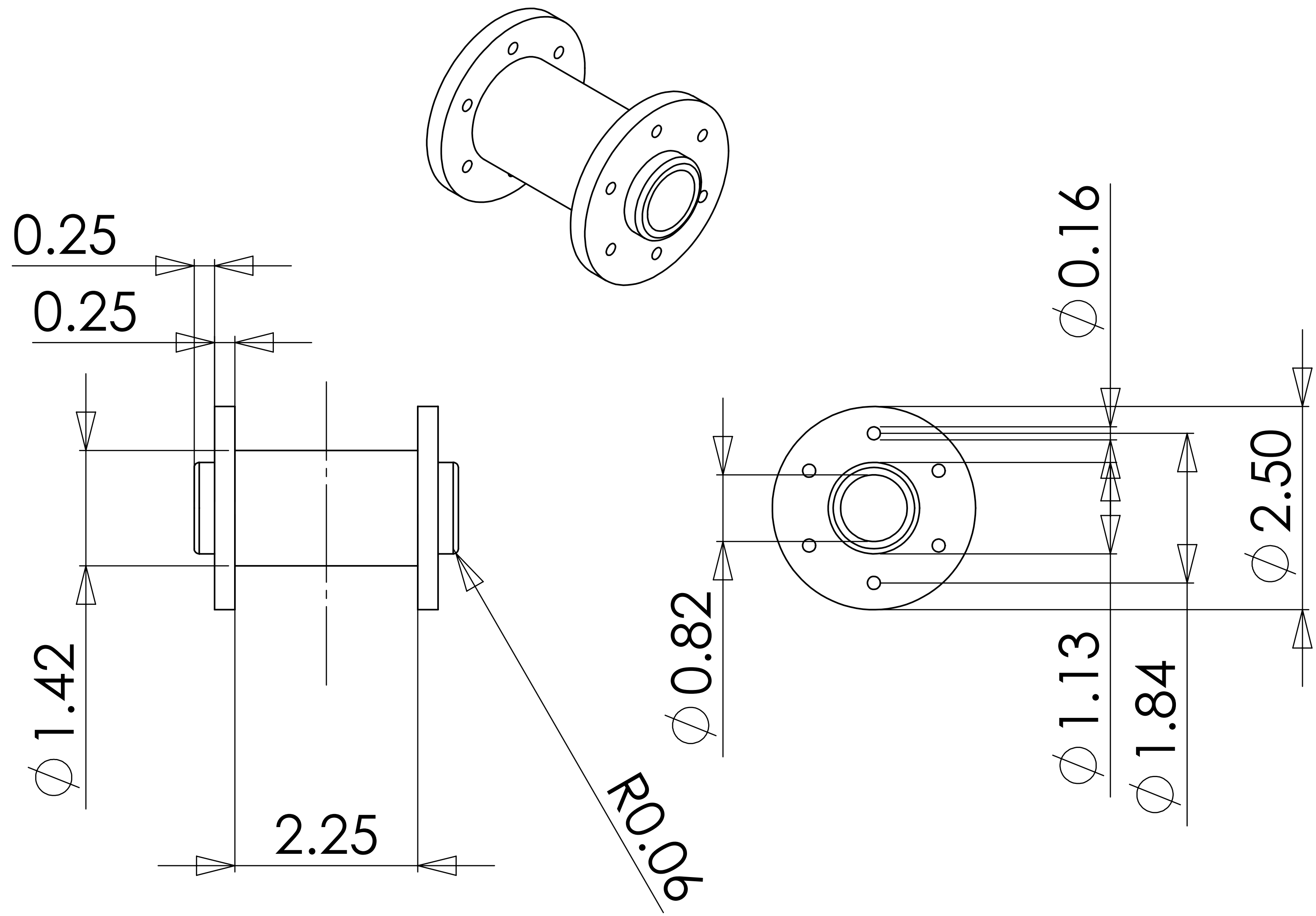
COMMENTS:

SABRE BYTES FIRST 772

Shooter - top cover

SIZE	DWG. NO.	REV.
A	SB-12-S-P-T-O	1

SCALE:1:5 | WEIGHT: | SHEET 1 OF 1



NEXT ASSY | USED ON

APPLICATION

DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±
ANGULAR: MACH ± BEND ±
TWO PLACE DECIMAL ±
THREE PLACE DECIMAL ±

MATERIAL --

FINISH --

DO NOT SCALE DRAWING

	NAME	DATE
DRAWN		
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

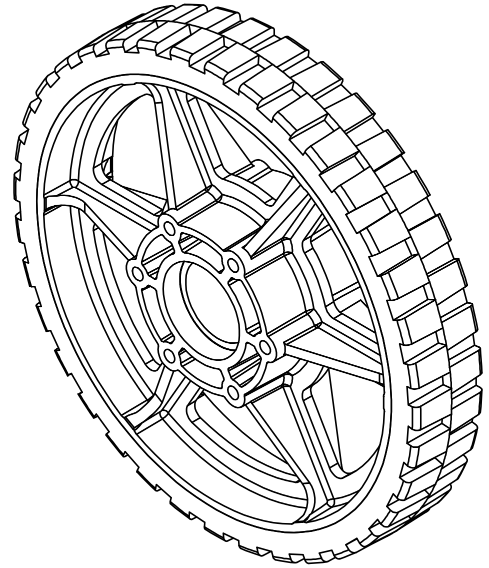
COMMENTS:

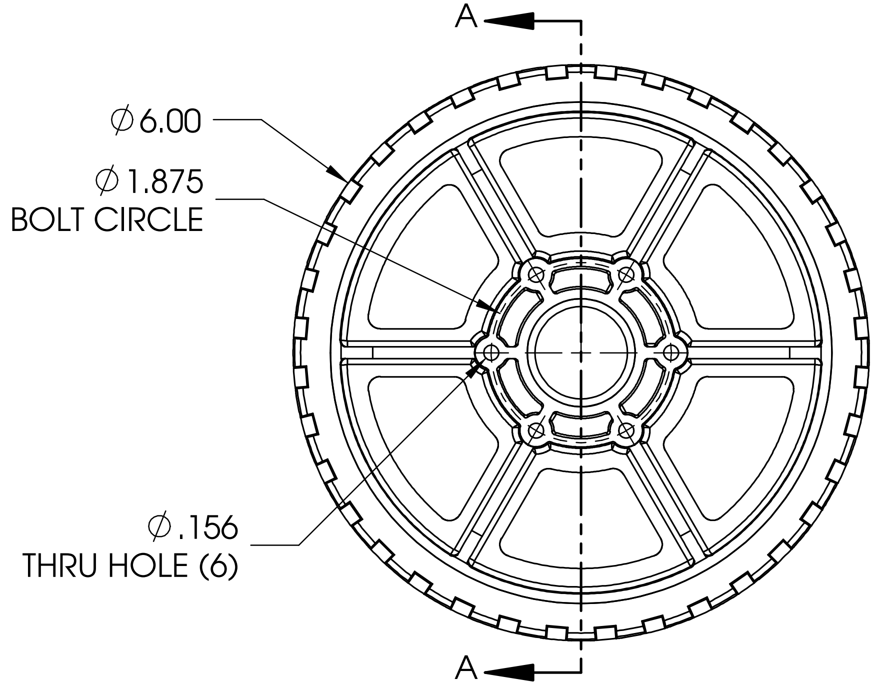
SABRE BYTES FIRST 772

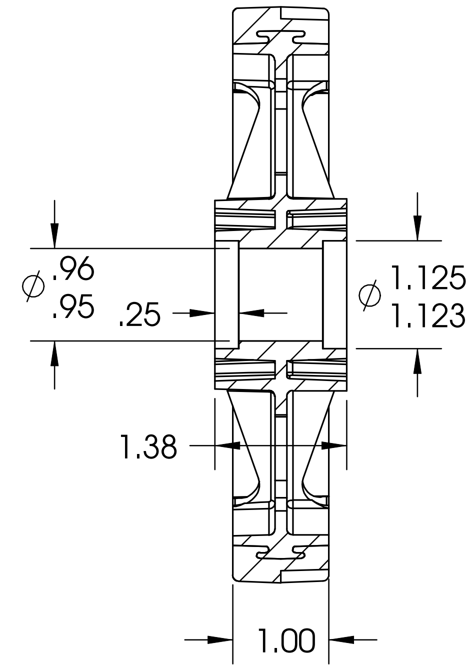
Wheel Hub

SIZE A | DWG. NO. | REV. 1

SCALE:1:2 | WEIGHT: | SHEET 1 OF 1







SECTION A-A
SCALE 1 : 2

PROPRIETARY AND CONFIDENTIAL

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NEXT ASSY	USED ON
APPLICATION	

UNLESS OTHERWISE SPECIFIED:

DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±
ANGULAR: MACH ± BEND ±
TWO PLACE DECIMAL ±
THREE PLACE DECIMAL ±

INTERPRET GEOMETRIC TOLERANCING PER:

MATERIAL
Polycarb and TPU

FINISH

DO NOT SCALE DRAWING

	NAME	DATE
DRAWN	MK	9-13-11
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

COMMENTS:

AndyMark Inc.

TITLE:
6 inch HiGrip Wheel

SIZE	DWG. NO.	REV
A	6-HiGrip-am-0940	1

SCALE: 1:4 WEIGHT: 0.5 SHEET 1 OF 1

5 4 3 2 1

Stellaris® Brushed DC Motor Control Module with CAN (MDL-BDC24)

Ordering Information

Product No.	Description
MDL-BDC24	Stellaris® Brushed DC Motor Control Module with CAN (MDL-BDC24) for Single-Unit Packaging
RDK-BDC24	Stellaris® Brushed DC Motor Control with CAN Reference Design Kit (includes the MDL-BDC24 module)

Figure 1. Brushed DC Motor Control Module

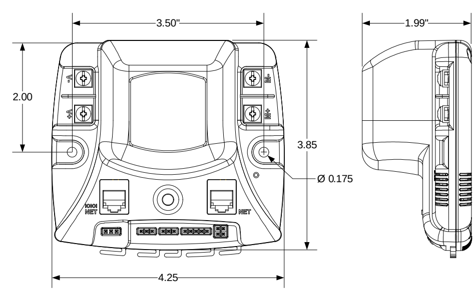


Figure 2. Mechanical Drawing

Contents

General Description

The MDL-BDC24 motor control module is a variable speed control for 12 V and 24 V brushed DC motors at up to 40 A continuous current. The motor control module includes high performance CAN networking as well as a rich set of control options and sensor interfaces, including analog and quadrature encoder interfaces.

The high-frequency pulse width modulator (PWM) enables the DC motor to run smoothly and quietly over a wide speed range. The MDL-BDC24 uses highly optimized software and a powerful 32-bit Stellaris microcontroller to implement open-loop speed control as well as closed-loop control of speed, position, or motor current.

The MDL-BDC24 is a Stellaris reference design. The Brushed DC Motor Control Reference Design Kit (RDK) contains an MDL-BDC24 motor control module as well as additional hardware and software for evaluating CAN communication. After evaluating the RDK-BDC24, users may choose to either customize the parts of the hardware and software design or use the MDL-BDC24 without modification. For detailed circuit-level information and reference design kit details, see the *Brushed DC Motor Control Reference Design Kit (RDK) User's Manual* (available for download from www.ti.com/rdk-bdc24). Use the *MDL-BDC24 Getting Started Guide* if you are using the MDL-BDC24 without modification. Figure 2 shows the MDL-BDC24 motor control module from the top view.

Figure 2. MDL-BDC24 Motor Control Module

Overview

The MDL-BDC24 motor control board provides the following features:

- Controls brushed 12 V and 24 V DC motors up to 40 A continuous
- Controller Area Network (CAN) interface at 1 Mbit/s
- Industry-standard servo (PWM) speed input interface
- RS232 to CAN bridge
- Limit switch, encoder, and analog inputs
- Fully enclosed module includes cooling fan
- Flexible configuration options with simple source file modification
- Easy to customize—full source code and design files available

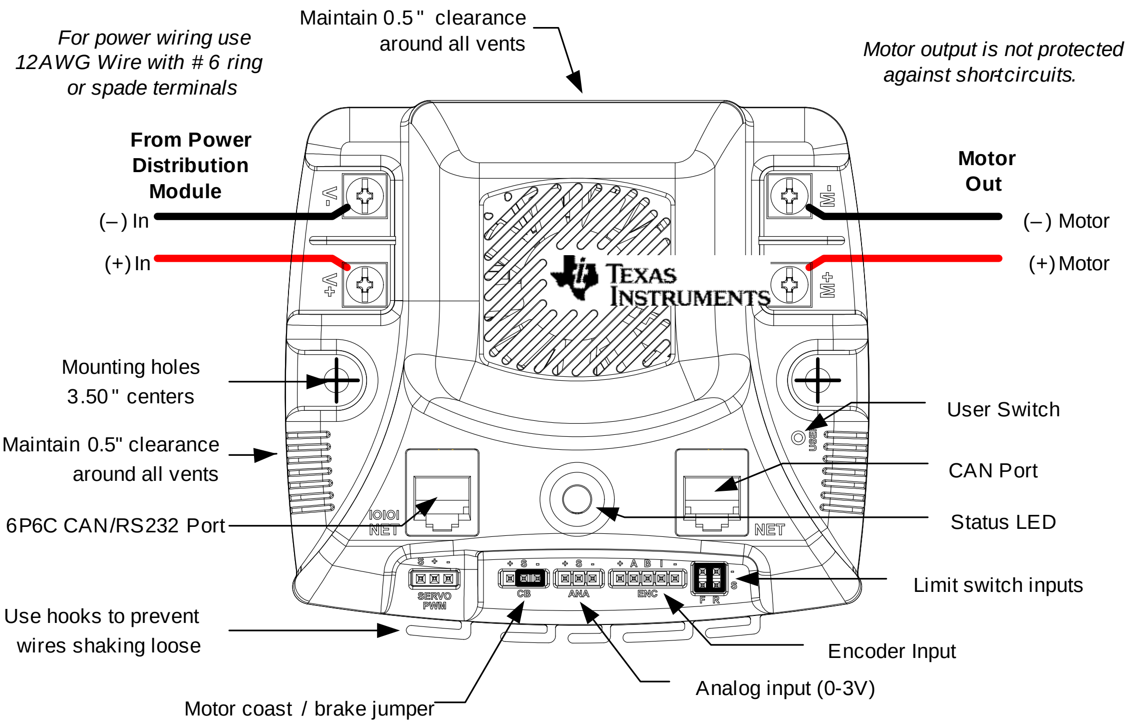
Detailed Features

This section describes the MDL-BDC24's features in detail:

- Quiet control of brushed DC motors
  - 15 kHz PWM frequency

- Three options for Speed control
  - Industry-standard R-C servo type (PWM) interface
  - Controller Area Network (CAN) interface
  - RS232 serial interface
- CAN communication
  - Multicast shared serial bus for connecting systems in electromagnetically noisy environments
  - 1M bits/s bit rate
  - CAN protocol version 2.0 A/B
  - Full configurability of module options
  - Real-time monitoring of current, voltage, speed, and other parameters
  - Firmware update
- RS232 serial communication
  - Bridges RS232 port to a CAN network
  - Directly interfaces to a PC serial port or National Instruments cRIO
- Automatic Output Ramp mode
- Status LED indicates Run, Direction, and Fault conditions
- Motor brake/coast selector
- Limit switch inputs for forward and reverse directions
- Quadrature encoder input (QEI)
  - Index input
  - 5 V supply output to encoder
- Analog input
  - Accepts 10 kΩ potentiometer or 0-3 V input
- Screw terminals for all power wiring
- Headers (0.1 inch pitch) for all control signals

Figure 3. Detailed Drawing of the MDL-BDC24 Motor Control Module



Operational Specifications

The following tables provide the operation specifications for the MDL-BDC24 motor control board.

WARNING – Do not exceed the maximum supply voltage of 30 V_{DC}. Doing so will cause permanent damage to the module.

Table 1. Power Supply

Parameter	Min	Typ	Max	Units
Supply voltage range (V_{IN})	5.5[a]	12/24	30	Vdc
Supply voltage absolute maximum	–	–	35[b]	Vdc
Supply current (motor off, fan off) (V_{IN} = 12 V)	–	35	–	mA
Supply current (motor off, fan on) (V_{IN} = 12 V)	–	105	–	mA
Under-voltage detect threshold	–	6.0	–	Vdc

a. Power supply requires $V_{IN} \geq 7.0\ V_{DC}$ to start up.
b. Exceeding this limit, even momentarily, will cause permanent damage.

Table 2. Motor Output

Parameter	Min	Typ	Max	Units
Motor voltage[a]	0	–	V_{IN}	V
Motor current - continuous	–	–	40	A
Motor current – for 2 seconds	–	–	60	A
Motor current – peak at starting	–	–	100	A
PWM frequency	–	15.625	–	kHz
PWM resolution	–	0.1	–	%
Output current for resistive loads[b]	–	–	30	A

a. The motor voltage is controlled by using a pulse-width modulated waveform.
b. The output current for resistive loads is continuous and the value shown is the maximum value.

Table 3. Environment

Parameter	Min	Typ	Max	Units
Operating temperature range	0	–	50	°C
Storage temperature range	-25	–	85	°C
Fan on temperature	–	42	–	°C
Fan off temperature	–	38	–	°C

Table 4. Servo-Style Speed Input

Parameter	Min	Typ	Max	Units
Minimum pulse width[a,b]	–	0.67		ms
Neutral pulse width[b]	–	1.5	–	ms
Maximum pulse width[b,c]	–	2.33	–	ms
Servo signal period	5.0125	–	29.985	ms
Valid pulse width range	0.5	–	2.50625	ms
Duty cycle range	–	–	50	%
Digital high-level input current	2	5	25	mA
Digital low-level input current	–	–	0.3	mA
Watchdog time-out	–	100	–	ms
Voltage isolation (servo+/- to other signals)[d]	–	–	40	V

a. Sets full-speed in reverse.
b. These are the default values. Pulse-width range can be calibrated for different values. See the servo PWM calibration procedure on page 13.
c. Sets full-speed in forward direction.
d. The servo input is optically isolated.

Texas Instruments

Table 5. Analog Input

Parameter	Min	Typ	Max	Units
Analog input voltage	0	–	3	V
Potentiometer value	–	10	–	kΩ
Potentiometer reference voltage (+ pin)[a]	2.9	3.0	3.1	V
Measurement resolution	–	10-bit	–	bits
Measurement rate	–	15.625	–	kHz

a. With 10 kΩ potentiometer connected.

Table 6. Voltage, Current, and Temperature Measurement

Parameter	Min	Typ	Max	Units
Temperature measurement accuracy	–	+/- 6	–	°C
Supply voltage measurement accuracy	–	+/- 0.3	–	V
Motor current measurement accuracy $\geq$ 8A	–	+/- 1	–	A
Motor current measurement accuracy $<$ 8A	–	+/- 2	–	A
Measurement resolution	–	10	–	bits
Measurement rate	–	15.625	–	kHz

Table 7. Brake/Coast Input

Parameter	Min	Typ	Max	Units
Digital low-level input voltage[a]	-0.3	–	1.3	V
Digital high-level input voltage[b]	2.0	3.3	5.0	V
Digital input pull-down resistor	–	200	–	kΩ
Response time	–	64	–	µs
Power on Pin 1 (3.3 V)	–	–	25	mA

a. Selects Brake mode.
b. Selects Coast mode.

Table 8. Quadrature Encoder Input (QEI)

Parameter	Min	Typ	Max	Units
Digital low-level input voltage[a]	-0.3	–	1.3	V
Digital high-level input voltage[a]	2.0	3.3	5.0	V
Digital input pull-up resistor	–	10	–	kΩ
Encoder rate[b]	DC	–	1	M
Encoder supply voltage	4.90	5.0	5.10	V

Texas Instruments

Table 8. Quadrature Encoder Input (QEI) (Continued)

Parameter	Min	Typ	Max	Units
Encoder supply current	–	–	100	mA

a. Applies to A, B, and Index inputs.
b. Measured in transitions per second.

Table 9. CAN Interface

Parameter	Min	Typ	Max	Units
Bit rate	0.0133[a]	1	1	Mbps
Recommended bus termination[b]	–	100	–	Ω
Absolute maximum CANH, CANL voltage	-27	–	40	V
Watchdog time-out	–	100	–	ms
Number of nodes per network[c] (protocol limit)	1	–	63	#
Number of nodes per network (physical limit)	1	–	16	#
Total cable length	–	–	20 6.1	ft m

a. Limited by fail-safe CAN transceiver SN65HVD1050.
b. Two terminations per network.
c. Must be a valid ID range.

Table 10. RS232 Interface

Parameter	Min	Typ	Max	Units
Baud rate	–	115,200	–	Baud
Format	–	8, n, 1	–	
Watchdog time-out	–	100	–	ms
RXD Absolute Maximum Voltage Range	-25	–	+25	V
TXD High-level output voltage	5	5.4	–	V
TXD Low-level output voltage	-5	-5.4	–	V
RXD Positive-going threshold	–	1.9	–	V
RXD Negative-going threshold	–	1.4	–	V

Table 11. Limit Switch Interface

Parameter	Min	Typ	Max	Units
Digital low-level input voltage[a]	-0.3	–	1.3	V
Digital high-level input voltage[b]	2.0	3.3	5.0	V
Pull-up resistor	–	10	–	kΩ

Table 11. Limit Switch Interface (Continued)

Parameter	Min	Typ	Max	Units
Response time	–	64	–	µs

a. Motor enabled state.
b. Motor disabled state.

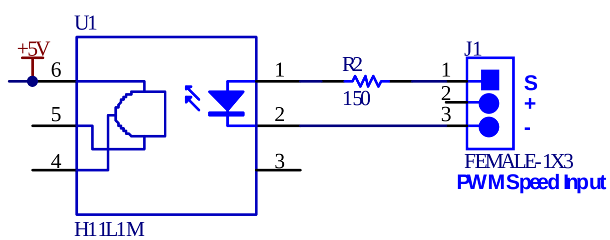
Servo-style PWM Input

The MDL-BDC24 incorporates support for speed and direction control using the standard servo-style interface found on many radio-control receivers and robot controllers. See the electrical specifications for default timing of this signal.

Electrical Interface

The Servo PWM input is electrically isolated from other circuits using an optocoupler. The MDL-BDC24 datasheet contains electrical specifications, including common-mode voltage limits, for the input stage.

Figure 4. MDL-BDC24's Servo PWM Input Stage



The on-board resistor (R2) has been selected to allow a signal of only a few volts to drive the optocoupler. At 3.3 V or more, it is advisable to add additional series resistance to limit the current into the LED. The PWM input stage is essentially a current-driven device, so the threshold for a logic high-level input is defined in milli-amps. Some recommended values for an external resistor are listed in Table 12.

Table 12. Recommended External Resistor Values

PWM Signal Level	External Series Resistor Value
2.5 V	0Ω (none)
3.0 V	0Ω - 150Ω
5.0 V	560Ω
12 V	2.2kΩ

Power Supply

The MDL-BDC24 is designed primarily for use with 12 V or 24 V sealed lead-acid batteries, although other power sources can be used as long as the voltage range is not exceeded. See the *Brushed DC Motor Control Reference Design Kit (RDK) User's Manual* for more detail.

NOTE: The MDL-BDC24 does not have reverse polarity input protection.

Motor Selection

The MDL-BDC24 operates 12 V or 24 V brushed DC motors. Typical motors include the BI802-001A model from CIM and the RS-555PH-3255 model from Mabuchi. Some very small DC motors or motors in lightly loaded applications may have a limited useful speed range. See the *Brushed DC Motor Control Reference Design Kit (RDK) User's Manual* for additional information on motor selection.

The MDL-BDC24 can also drive resistive loads with some de-rating to allow for increased ripple current inside the module.

Operating Modes

The MDL-BDC24 can be controlled using either the servo-style PWM input or the CAN interface. Table 13 compares the capabilities of the two control methods.

Table 13. Comparison of Control Methods

	Control Method	
	Servo-Style PWM Input	**CAN Interface**
Speed Control	Yes	Yes
Analog Position Control	No	Yes
Encoder Position Control	No	Yes
Configurable Parameters	No	Yes
Voltage, Current Measurement	No	Yes
Limit Switches	Yes	Yes
Coast/Brake Feature	Yes	Yes
Firmware Update	No	Yes

The MDL-BDC24 does support the simultaneous use of CAN for monitoring and the servo-style input for speed.

NOTE: See the *MDL-BDC24 Getting Started Guide* for additional calibration information.

Default Parameters

Table 14 lists the default configuration of the MDL-BDC24. Parameters can be modified using CAN commands or by modifying the software source code. Parameters changed using CAN commands are volatile and must be reloaded if power is cycled.

Table 14. Default Factory Configuration

Parameter	Default Value
Acceleration rate	Instantaneous change
Deceleration rate	Instantaneous change
Motor Control mode	Open-loop speed control using voltage

For additional information on parameters, see the *RDK-BDC24 Firmware Development Package User's Guide*.

Wiring

The MDL-BDC24 is controlled using either a servo-type PWM source, CAN bus, or RS232 interface. Figure 5 shows a typical, simple wiring arrangement with power, motor, PWM control, and optional limit-switch connections. Basic servo-style PWM control is enabled by default and does not require CAN configuration.

Figure 6 on page 11 shows an advanced wiring configuration using the CAN interface. Wiring for position sensing using both a position potentiometer and a quadrature encoder is detailed. Although two sensor types are shown, the MDL-BDC24 software supports control and monitoring of only one sensor at a time.

Figure 5. Basic Wiring with a Servo-Style Speed Command

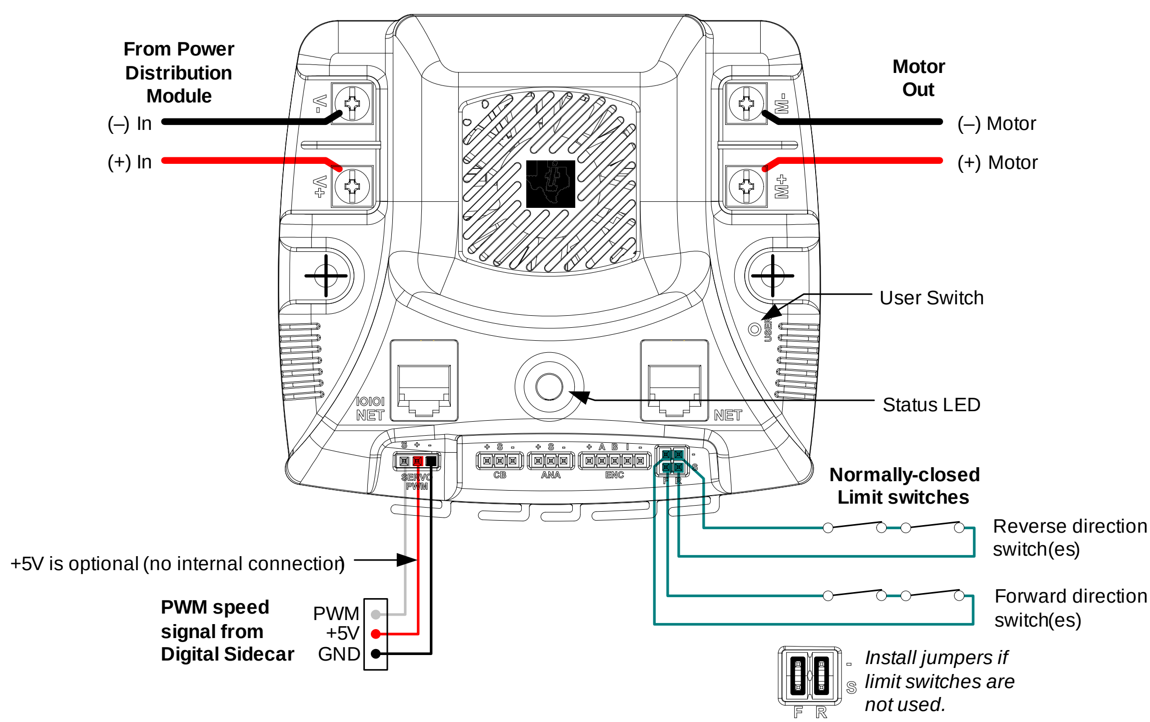
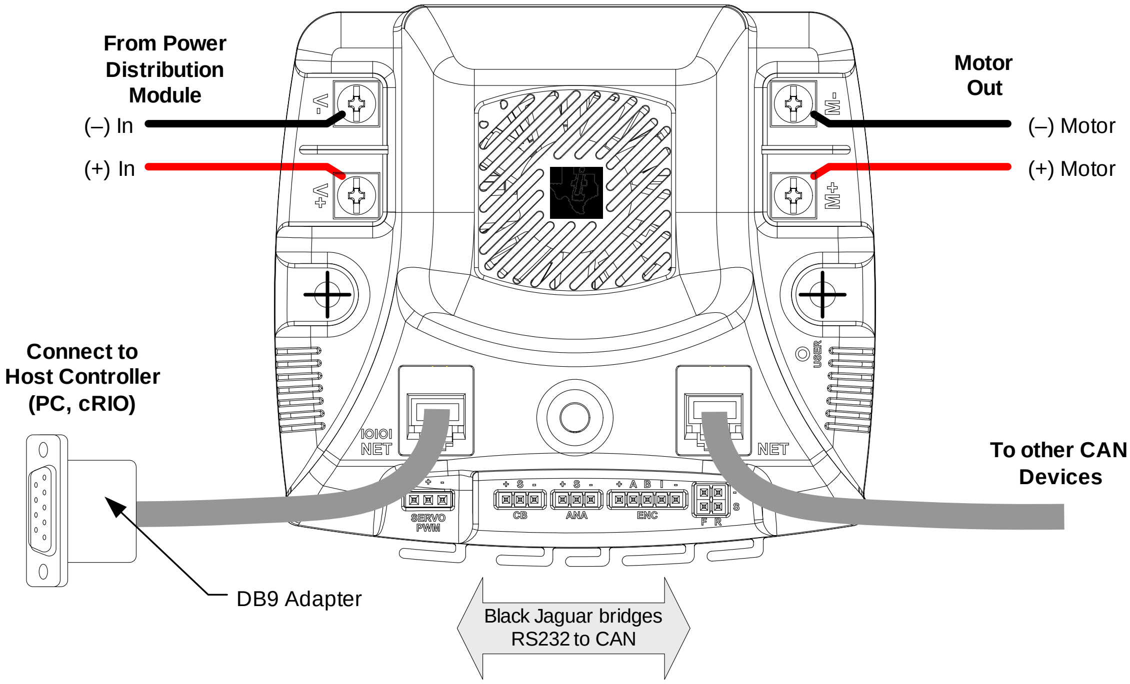


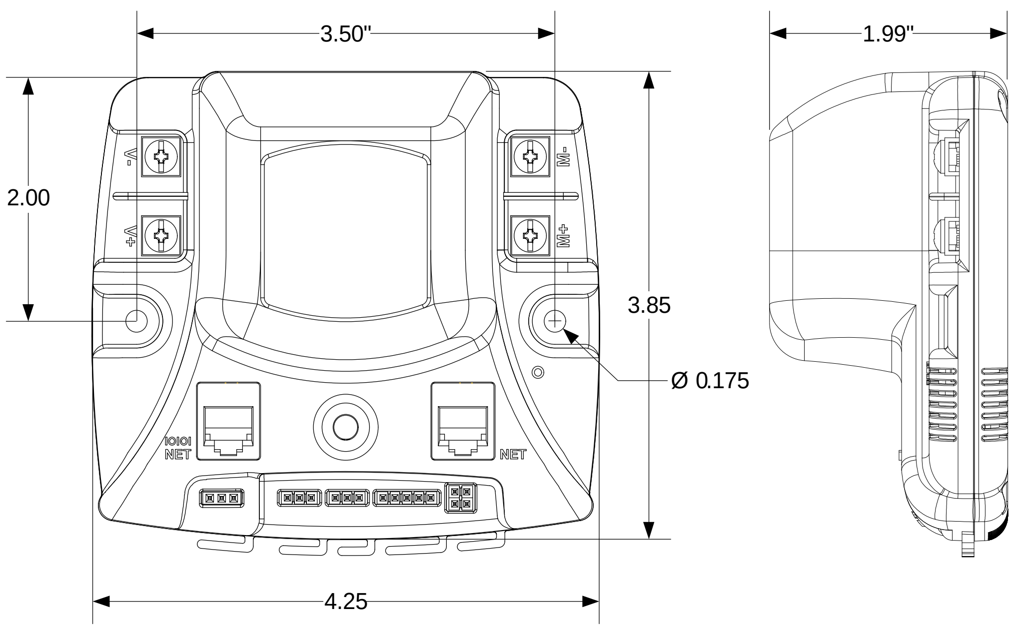
Figure 6. RS232/CAN-Based Control Wiring Diagram



Mechanical Details

Figure 7 shows the MDL-BDC24 physical dimensions. The module has two 0.175” (4.5 mm) diameter mounting holes as shown in Figure 7.

Figure 7. Mechanical Drawing



The MDL-BDC24 should be mounted so that the vents in the top and sides of the module are not restricted in any way. A clearance of ½ inch should be maintained around the module.

Status LED

Table 15 lists all of the LED status and fault codes for Normal Operating, Fault, and Calibration or CAN conditions. Fault information is prioritized, so only the highest priority fault will be indicated.

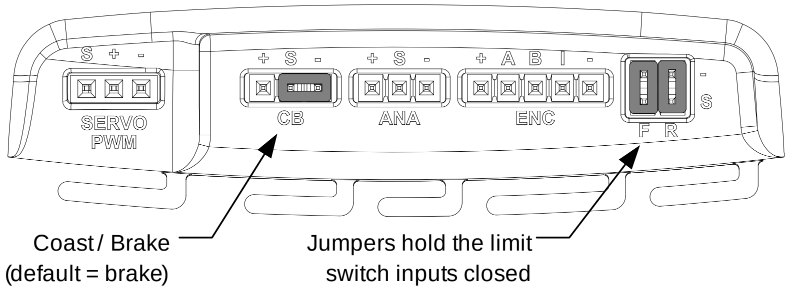
Table 15. Normal Operating Conditions

LED State	Module Status
Normal Operating Conditions	
Solid Yellow	Neutral (speed set to 0)
Fast Flashing Green	Forward
Fast Flashing Red	Reverse
Solid Green	Full-speed forward
Solid Red	Full-speed reverse
Fault Conditions	
Slow Flashing Yellow	Loss of servo or Network link
Fast Flashing Yellow	Invalid CAN ID
Slow Flashing Red	Voltage, Temperature, or Limit Switch fault condition
Slow Flashing Red and Yellow	Current fault condition
Calibration or CAN Conditions	
Flashing Red and Green	Calibration mode active
Flashing Red and Yellow	Calibration mode failure
Flashing Green and Yellow	Calibration mode success
Slow Flashing Green	CAN ID assignment mode
Fast Flashing Yellow	Current CAN ID (count flashes to determine ID)
Flashing Yellow	CAN ID invalid (that is, Set to 0) awaiting valid ID assignment

Jumper Settings

Figure 8 shows the factory-default jumper settings.

Figure 8. Default Factory Jumper Settings



Fault Detection

The MDL-BDC24 detects and shuts down the motor if any of the following conditions are detected:

- Power supply under-voltage
- Over temperature
- Over current
- Loss of CAN/RS232 or servo-style speed link
- Limit switch activated in the current direction of motion

The LED indicates a fault state during the fault condition and for three seconds after the fault is cleared (except for the limit switch and link faults, which are instantaneous).

Calibration

To accommodate variation in the timing of the supplied signal, the MDL-BDC24 has a calibrate feature that sets new values for full-forward, full-reverse, and points in between.

Follow these steps to initiate calibration:

1. Hold down the user switch for five seconds.
2. Set the controller to send a full-forward signal.
3. Set the controller to send a full-reverse signal.
4. Set the controller to send a neutral signal.

The MDL-BDC24 samples these signals and centers the speed range and neutral position between these limits.

See the *MDL-BDC24 Getting Started Guide* for complete calibration procedure information.

CAN Communication

The Controller Area Network (CAN) provides a powerful interface for controlling one or more MDL-BDC24 or MDL-BDC modules.

Protocol

The CAN protocol used by the MDL-BDC24 includes the following capabilities:

- Firmware update over CAN
- Read supply voltage, motor voltage, temperature, and current

- Set motor voltage or target position
- Set control mode to speed or position

Each MDL-BDC24 module on the CAN bus is accessed using an assigned ID number. The ID number defaults to 1, but can be changed by sending a CAN assign ID command to the bus.

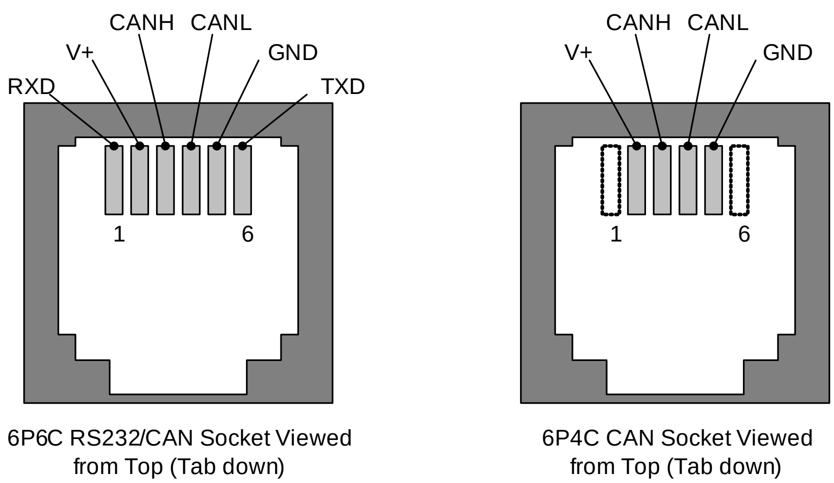
See the *RDK-BDC24 Firmware Development Package User's Guide* for complete protocol details.

Connectors

The MDL-BDC24 hasa 6P6C socket and a 6P4C socket for daisy-chaining CAN between modules using standard cables. The CAN signals on the two sockets are hard-wired to each other. Figure 9 shows the pin assignments of each connector.

Each end of the CAN network must be properly terminated. Terminator resistors can be between 100Ω and 120Ω. For more complex networks, 100Ω is recommended because it accelerates the return of differential signalling to a valid recessive state.

Figure 9. NET Connector Pin Assignments



RS232 Communication

The MDL-BDC24 supports a full set of network control and configuration functions over a standard RS232C serial interface. The command protocol is essentially the same as the protocol used on the CAN interface allowing the MDL-BDC24 to automatically bridge all commands between the RS232 and CAN interfaces.

RS232 signals are implemented on the left-side NET connector. See Figure 9 on page 14 for pin assignment information.

Coast/Brake Input

The Coast/Brake input selects the dynamic behavior of the motor controller when decelerating or stopping. In the coast setting, the MDL-BDC24 allows the current in the motor to decay slowly, providing a more gradual deceleration. In the brake setting, the MDL-BDC24 uses switching to oppose current generated by the motor which results in much faster deceleration.

The brake setting also provides some additional holding capability in the stopped position. However, it should not be regarded as a safety or mechanical brake of any sort.

By default, the brake input is set using a jumper. Network commands can override the jumper setting, allowing the control mode to be changed dynamically. An external control signal can be connected to provide the same capability. Table 7 on page 6 lists the electrical requirements of an external control signal.

Pin 1 of the brake/coast connector can supply a small amount of 3.3 V power to an external device, as long as the device is located adjacent to the MDL-BDC24 module. See Table 7 on page 6 for electrical limits.

Analog Input

The analog input accepts a 0-3 V sensor signal for implementing position control mode. Position control can also be implemented with a single- or multi-turn potentiometer. Potentiometers with continuous rotation are not supported. The MDL-BDC24 contains a built-in bias pin for use with 10kΩ potentiometers. If another potentiometer value or analog source is used, it must have a 0-3 V range.

If the P, I, and D parameters are positive (or zero), the MDL-BDC24 expects that a forward condition (+ voltage on White terminal, - voltage on Green) will generate an increasing voltage on the analog input.

If the P, I, and D parameters are positive (or zero), the MDL-BDC24 expects that a forward condition (+ voltage on White terminal, - voltage on Green) will generate a decreasing voltage on the analog input.

The analog input is not electrically isolated.

Table 5 on page 6 lists the electrical requirements of an external control signal.

Encoder Input

In position control mode, the MDL-BDC24 accepts position commands over the network, and then uses an internal PID controller to autonomously move the motor to the specified position.

The QEI software position count changes on each pulse of the Encoder A input. For example, a 360° movement of a 100 pulse-per-revolution (PPR) encoder will result in a 100-count change in the position value. PPR is sometimes referred to as the number of lines that an encoder has.

The relationship between the Encoder B input and the Encoder A input determines whether the position counter increments or decrements.

An edge on the Index ("I") input resets the position counter to zero.

The MDL-BDC24 supports a wide range of shaft encoders. Encoder electrical parameters are detailed in Table 8 on page 6.

If the P, I, and D parameters are positive (or zero), the MDL-BDC24 expects that a forward condition (+ voltage on White terminal, - voltage on Green) will generate increasing counts on the encoder interface. Increasing counts occur when the rising (or falling) edge of the A input leads the rising (or falling) edge of the B input.

If the P, I, and D parameters are negative (or zero), the MDL-BDC24 expects that a forward condition (+ voltage on White terminal, - voltage on Green) will generate decreasing counts on the encoder interface. Decreasing counts occur when the rising (or falling) edge of the B input leads the rising (or falling) edge of the A input.

The MDL-BDC24 can supply 5 V power to an encoder.

Limit Switch Inputs

Two limit switch inputs provide a method for immediate shut-down of the motor. The inputs expect typically-closed contacts - one for each direction of rotation. See Table 11 on page 7 for electrical specifications.

Firmware Update

The MDL-BDC24 firmware can be updated over CAN and RS232. The capability to update the MDL-BDC24 firmware can be added to most Host controllers by implementing the necessary protocol. If you are not developing a CAN host controller, the BDC-COMM application provides firmware update from a Windows PC. The BDC-COMM application can be downloaded from www.ti.com/bdc-comm.

For additional information on the firmware update procedure, see the *MDL-BDC24 Getting Started Guide*.

Additional Information

The following documents are available for download at www.ti.com/stellaris:

- *MDL-BDC24 Getting Started Guide*, Publication number MDL-BDC-GSG
- *BDC-COMM User's Guide*, Publication number MDL-BDC24-SW-UG
- *RDK-BDC24 Firmware Development Package User's Guide*, Publication number SW-RDK-BDC-UG
  - Part of the StellarisWare® source code library
- *Stellaris® Brushed DC Motor Control Module with CAN (MDL-BDC24) User's Manual*, Publication number RDK-BDC-BDC24-UM
  - Schematics and Bill-of-Materials (BOM)
  - Detailed functional description
  - Firmware update, configuration, and operation using the RDK-BDC24 test application
- *Stellaris® Brushed DC Motor Control Module with CAN (MDL-BDC24) Readme First*
  - A step-by-step guide to using the reference design kit (RDK-BDC24)

Spike is an H-Bridge relay module custom designed for Robotics applications. The most common use of Spike is to drive small motors in Forward, Reverse or Off. Spike can also be used to turn ON or OFF solenoids and lights. Spike takes input power from a 12V battery (labeled 12V, GND) and provides two outputs (labeled M+, M-). M+ and M- are typically connected to a motor. The unit is controlled via a three-wire interface, which connects to the Innovation First Robot Controller. Spike has a 20A integrated fuse to help protect the unit and it has an indicator to show status.

WARNING. BEFORE APPLYING POWER:

1. Ensure that there is not a short circuit on the output. A short circuit will destroy Spike.

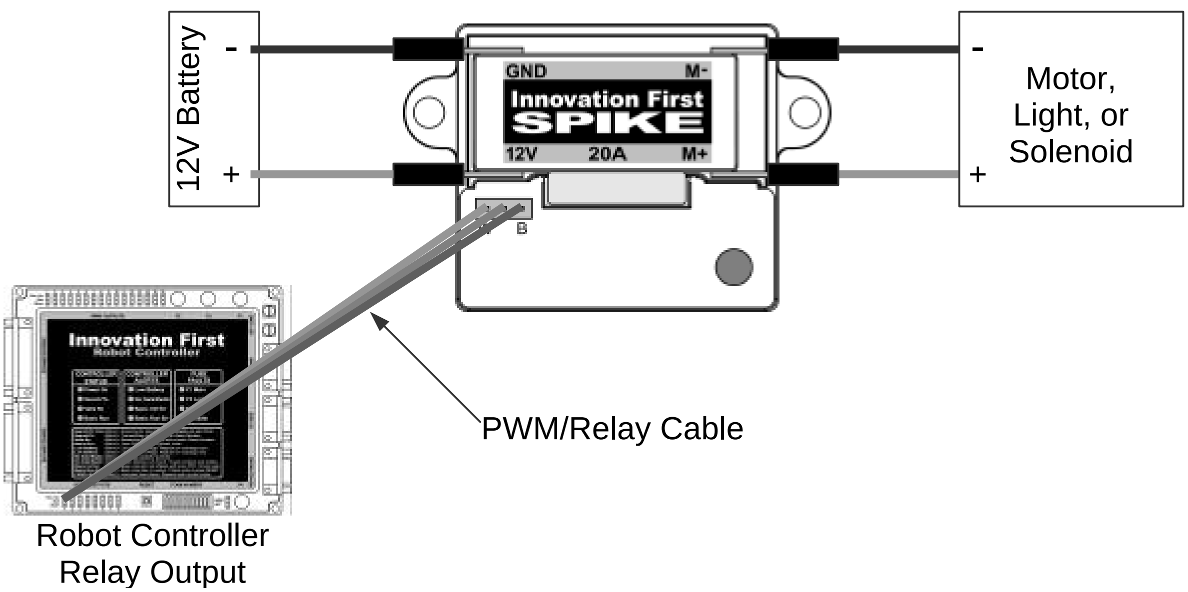


Figure 1: Spike Blue Wiring to One Motor, Light, or Solenoid

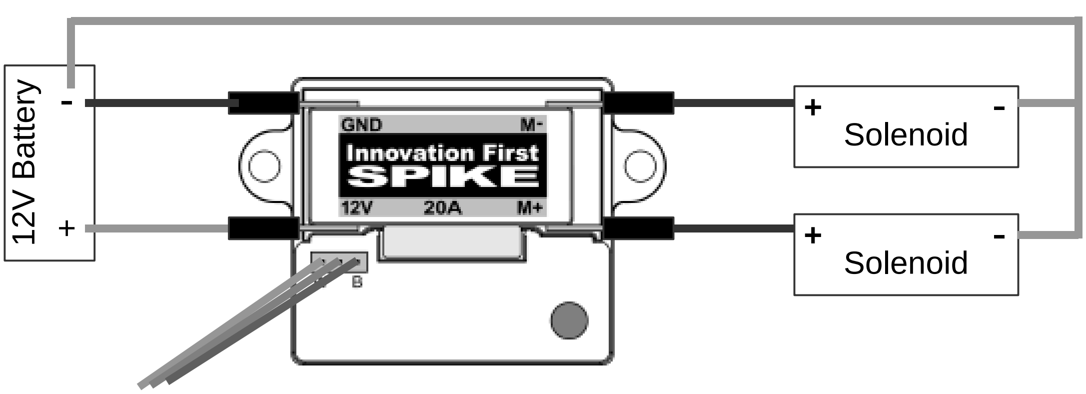


Figure 2: Spike Blue Alternate Wiring for Two Solenoids

Motor and Solenoid Wiring

The two motor connections can be wired to either of the relay outputs. M+, and M- are only labeled to indicate the polarity of the output versus the control signal and Spike's indicator. If your motor turns opposite of the direction desired, swap the wires connected to M+ and M-. The table below shows the corresponding output versus the control signal and the indicator.

Table 1: Spike Blue P-BASIC software control, Spike output, Motor function

INPUTS		OUTPUTS			
Fwd	Rev	M+	M-	Indicator	Motor Function
0	0	GND	GND	Orange	OFF / Brake Condition (default)
1	0	+12v	GND	Green	Motor rotates in one direction
0	1	GND	+12v	Red	Motor rotates in opposite direction
1	1	+12v	+12v	Off	OFF / Brake Condition

Notes:

1. 'Brake' refers to the dynamic stopping of the motor due to the shorting of the motor inputs. This condition is not optional when going to an off state.
2. The INPUT Fwd and Rev are described in the Programming section on page3.

One or Two Solenoid Wiring

The Spike Relay Module can be used to control solenoids. The easiest method of connection is to wire one side of the solenoid to M+, and the other wire to the ground (GND) side of the Battery. When the relay is sent a Forward (Indicator Green) command, the solenoid will be activated. The same can be done with the M- connector to control another solenoid or the opposite direction of a double solenoid (see Figure 2 on page 1).

Table 2: Spike Blue P-BASIC software control, Spike output, Solenoid function

INPUT		OUTPUTS			
FWD	REV	M+	M-	Indicator	Solenoid Function
0	0	GND	GND	Orange	Both Solenoids OFF (default)
1	0	+12v	GND	Green	Solenoid connected to M+ is ON
0	1	GND	+12v	Red	Solenoid connected to M- is ON
1	1	+12v	+12v	Off	Both Solenoids ON

Note:

1. The INPUT Fwd and Rev are described in the P-BASIC Programming section on page3.

P-BASIC Programming for Spikes

The Robot Controller is supplied with a "Default" program in order to help get the robot up and running quickly. Refer to the Control System Users Manual for a description of the default control for relays. If more sophisticated control of the robot is desired, then a custom program, known as the user program, must be written. The source code for the default program, "Default Program.bsx" is available at www.innovationfirst.com/FIRSTRobotics.

Tables 1 and 2 on page 2 refer to the INPUT signals Fwd and Rev. These are aliases that are assigned in the P-BASIC code that you will set to either a '0' (OFF) or a '1' (ON) in the program section of the code depending on the function you wish to accomplish.

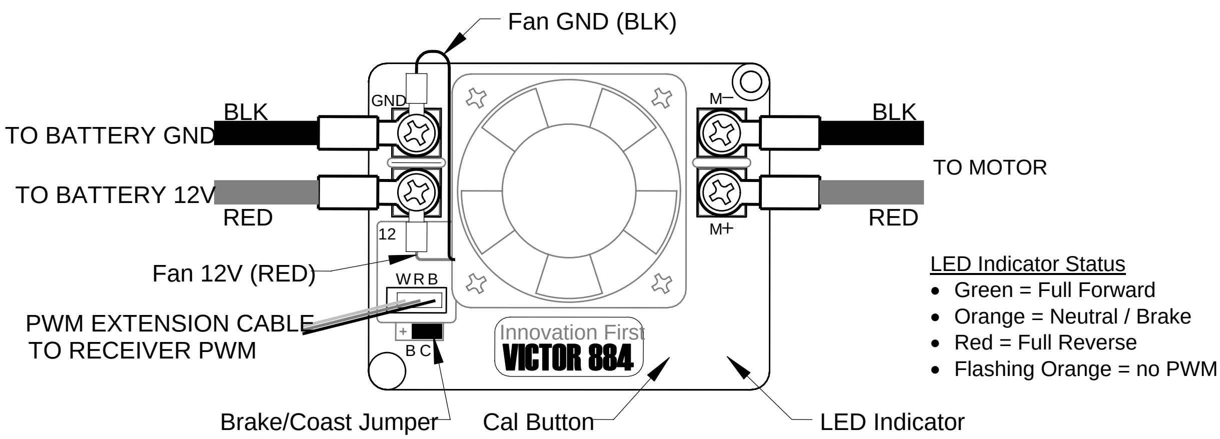
Below is the default code alias (variable) assignments made for each relay output on the Robot:

```
'---------- Aliases for each RC Relay outputs -------------------------------
'  Below are aliases for the relay outputs located on the Robot Controller.

relay1_fwd  VAR RelayA.bit0
relay1_rev  VAR RelayA.bit1
relay2_fwd  VAR RelayA.bit2
relay2_rev  VAR RelayA.bit3
relay3_fwd  VAR RelayA.bit4
relay3_rev  VAR RelayA.bit5
relay4_fwd  VAR RelayA.bit6
relay4_rev  VAR RelayA.bit7

relay5_fwd  VAR RelayB.bit0
relay5_rev  VAR RelayB.bit1
relay6_fwd  VAR RelayB.bit2
relay6_rev  VAR RelayB.bit3
relay7_fwd  VAR RelayB.bit4
relay7_rev  VAR RelayB.bit5
relay8_fwd  VAR RelayB.bit6
relay8_rev  VAR RelayB.bit7
```

The following are several examples for controlling the Relays. Refer to the default code for more examples.

```
'---------- Relay Control Examples -----------------------------------------
RelayA = 0              'sets Relays 1-4 OFF
RelayB = 0              'sets Relays 5-8 OFF

relay1_fwd = 1          'Relay 1 is always Forward (M+ is 12V, M- is GND)
relay2_rev = 0          'Relay 2 is always Reverse (M- is 12V, M+ is GND)
relay3_fwd = p1_sw_top  'Port 1 Top Button = Relay 3 Forward
relay3_rev = p1_sw_trig 'Port 1 Trigger Button = Relay 3 Reverse
relay4_fwd = rc_sw1     'Relay 4 is Fwd when Robot Controller SW1 is closed
```

The Victor speed controllers are specifically engineered for robotic applications. The high current capacity, low voltage drop, and peak surge capacity make the Victor ideal for drive systems while its braking options and precise control meet the demanding needs of arms and lift systems. This controller safely handles the high continuous current draws and extreme current surges produced by Competition robots. The innovative FET switching architecture and an integral cooling fan ensures cool FET junction temperatures. The low voltage drop and high switching speed ensures the motor receives maximum power, providing significant improvements in acceleration, direction changes, and lifting torque. The LED indicator will be GREEN in 'full-forward' condition, RED in 'full-reverse' and ORANGE while in neutral.



Wiring Guidelines

1. The fan must be wired so it is always ON when the Victor is ON.
2. Attach the fan wires and connect to the appropriate voltage.
3. The input and output wires should be 10AWG wire minimum and firmly connected to ensure low voltage drop and minimal temperature rise.
4. Use circle lugs designed for your wire size. The lug should have a hole designed for a #6 or #8 screw. If the center hole is too large, (#10 or larger) inadequate mechanical contact may result in excessively high resistance and temperature rise.
5. Check all lug connection after crimping and soldering. You should not be able to pull the lug off the wire with your hands.
6. Once the input and output wires are firmly connected, tie the wires using tie straps within 2" of the Victor. This will ensure the wires do not move and loosen the connections.

WARNING: BEFORE APPLYING POWER:

1. **Ensure the input connections are not reversed. Connecting 12V and GND backwards will destroy the unit.**
2. **Ensure that there is not a short circuit on the output. A short circuit will destroy the unit.**
3. **Ensure there is a circuit breaker either inline with the 12V power input to the speed controller, or inline with the motor. Use an appropriate circuit breaker for your application to ensure that long term exposure to a stalled motor (high currents) will not overheat the Victor.**

PWM Connection

You will need (1) PWM extension cable or PWM Signal Driver.

1. Use a PWM Signal Driver to ensure the signal from your receiver is Victor compatible if you are not using an IFI Control System.
2. The male PWM cable connector connects to the speed controller. The Victor housing is design to provide a firm connection. Trim the shroud corners slightly if necessary for insertion into the Victor.
3. The PWM extension cable should be installed with the black wire towards the fan.
4. Standard Radio Controlled PWM connectors are fragile. Use caution when inserting and removing the PWM cable so the contacts on both connectors are not damaged.

Mounting Guidelines

You will need (2) #4 or #6 screws.

1. The Victor can be installed in any orientation.
2. The speed controller must have adequate space above the fan for airflow, a minimum of 2 inches.
3. Do not over-tighten the mounting screws through the speed controller. A snug connection will hold the speed controller in place without crushing the case.

Calibration Instructions

The Victor is pre-calibrated to values compatible with an IFI Control System and re-calibration is not needed. You can re-calibrate to achieve 'full forward/reverse' from your joystick movement if necessary.

NOTE: While in calibration mode, the Victor will record the max PWM value detected as 'full forward', the min PWM value as 'full reverse', and 'neutral' will be the PWM value recorded at the release of the Cal button. The following steps will guide.

User Calibration:

1. Power ON the speed controller.
2. Press and hold the Cal button. After a moment, the LED indicator on the Victor will begin alternating between RED and GREEN to indicate a cal mode.
3. While continuing to hold the Cal button, move the joystick to the maximum and minimum positions. This can be done in any order and as many times as desired.
4. While continuing to hold the Cal button, return the joystick to center (neutral position).
5. Release the Cal button.
6. A flashing GREEN indicator confirms a successful calibration.
7. A flashing RED indicator denotes an unsuccessful calibration.

An unsuccessful calibration occurs when either:

a) Insufficient joystick travel was detected in forward and/or reverse.
b) The trim tab is too far from center.

Resetting Calibration to Factory Pre-calibration:

1. Power OFF the speed controller.
2. Press and hold the Cal button.
3. While continuing to hold the Cal button, Power ON the speed controller.
4. A flashing GREEN indicator denotes calibration is reset. Release the Cal button.

Brake / Coast Configuration

The Brake / Coast jumper is used to set the speed controller's action during a neutral condition. The Brake provides significant resistance to motor rotation and is recommended for motors driving linkages and arms that can be back-driven by gravity or other external forces.

The speed controller checks the status of the jumper approximately 60 times per second. This allows the user to change from brake to coast during operation. A limit switch may be connected to the jumper connector instead of the jumper. The limit switch can be triggered by various means including the use of a servo.

Brake / Coast Guidelines: Reference Diagram

1. The jumper should always be installed. If you lose the jumper, a standard computer jumper will work.
2. The Coast condition (Jumper on Inner two Pins) sets the output to an open circuit during neutral.
3. The Brake condition (Jumper on Outer two pins) sets the output to a short across the motor leads during neutral.

Troubleshooting

Indication: No ORANGE indicator on power up.
Problem: Input power issue or joystick trim tab off center.
Possible Solutions:

1. Disconnect PWM cable.
2. If indicator blinks ORANGE, the PWM value that was being received is either between 'neutral' and 'full forward', or between 'neutral' and 'full reverse'. Check joystick trim tab to ensure the controller is not in a partial forward or a partial reverse condition. If no change, check that the joystick and receiver channels match.
3. If indicator remains off, check +V or GND connections for voltage and proper polarity.

Indication: Flashing ORANGE indicator on power up.
Problem: No PWM signal.
Possible Solutions:

1. Ensure the transmitter and receiver are powered ON.
2. The PWM cable may be improperly connected. Check wire color-coding at each end. Check that the connector is not off a pin at the receiver end.
3. Check for a good PWM signal by connecting a known good servo to the PWM extension cable. If the servo does not move, this can indicate either:
   a) a faulty receiver
   b) an improperly connected cable
   c) a bad PWM extension cable

Note: The servo requires that 5V be present on the center pin of the PWM cable. This connection is not required for the Victor.

Indication: Flashing RED indicator after calibration.
Problem: Calibration Failed.
Possible Solutions:

1. Inadequate travel in forward or reverse. Repeat the calibration procedure and move the joystick further forward and/or further reverse.
2. The joystick trim tab is NOT centered. Neutral cannot be extremely far from center.

Indication: No power output from the speed controller although the indicator LED works.
Problem: Possible internal damage.
Possible Solutions:
If the indicator on the Victor is operating properly and there is no output, the Victor may be internally damaged. This condition is typically caused by a short circuit on the output or there has been an over-current condition to caused a failure.
Check the following:

1. Ensure the indicator is changing between ORANGE, RED and GREEN with joystick movement.
2. Disconnect the motor and check the output (M+ to M-) with a voltmeter. The meter should read between $\pm$ Battery voltage with corresponding full range joystick movement.

If the indicator is working properly and the outputs are not working properly, the speed controller is probably damaged. The final test to determine if the Victor is damaged is to replace it with another Victor.

Indication: No power output from the speed controller and the indicator does NOT work.
Problem: No input power or possible internal damage.
Possible Solutions:
If the indicator on the Victor is not operating properly and there is no output, the Victor may be internally damaged. This condition is typically caused by no input power or a reverse polarity on the input.
Check the following:

1. Disconnect the output wires.
2. Ensure the indicator on the Victor will not illuminate at any joystick position.
3. Check the input at the Victor (+BATTERY to GND) with a voltmeter.

If the indicator is not working properly and the input is good, the speed controller is probably damaged. The final test to determine if the Victor is damaged is to replace it with another Victor.

CAUTION: Prior to replacing a potentially damaged speed controller, ensure that the wires connected to the output are not shorted and the input is not reversed. Also verify that neither of the motor output leads are shorted to the chassis of the motor and/or the robot.

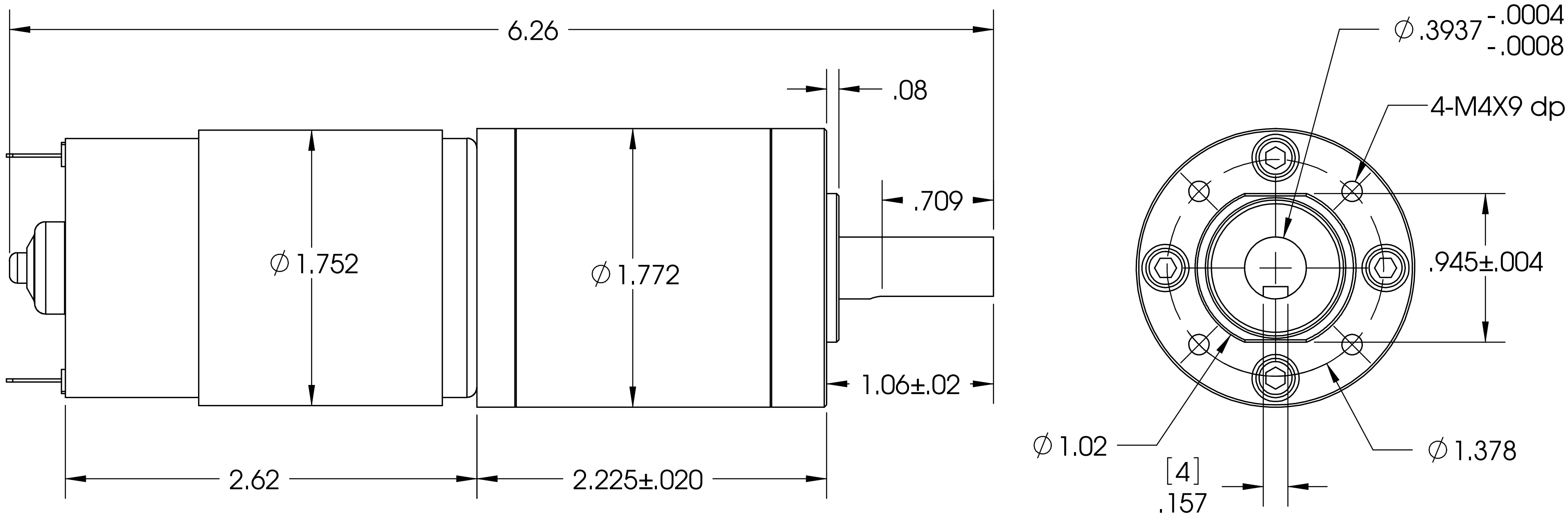
APPENDIX A: Document Version History

Date Code	Changes
1-26-05	Revised Brake/Coast Section
9-25-06	Revised Brake/Coast Section

Make	Part Number	Max Power (W)	Stall Torque (oz-in)	Free Speed (rpm)	Free Current (A)	Stall Current (A)	Notes
AndyMark	am-0912	180.83	60.7	16000	1.2	63.8	
AndyMark	am-0914	48.50	3101	84	0.6	22	
BaneBots	M3-RS395-12	48.05	16.65	15500	0.5	15	
BaneBots	M5-RS550-12 M5-RS550-12-B	253.52	70.55	19300	1.4	85	
BaneBots	M7-RS775-12	83.05	61.1	7300	1.1	30	
BaneBots	M7-RS775-18	273.03	112.8	13000	1.8	86.7	
CIM	FR801-001	340.11	344	5310	2.7	133	
Denso	262100-3030 (Right)	23.48	1501.1	84	1.8	18.6	
Denso	262100-3040 (Left)	23.48	1501.1	84	1.8	21	
Denso	AE235100-0160	18.16	18.4	5300	1	7	Pinion: 12 tooth, 20°PA, 0.75 module
Fisher Price	00801-0673	291.59	75.4	20770	0.82	108.7	Gearbox: 112:1 Reduction
Fisher Price	00968-2719	172.37	57.5	16100	2	63	Motor from 2010 KOP
Fisher Price	00968-9015	185.02	63.7	15600	1.25	70	Motor from 2011 KOP
Fisher Price	00968-9012	172.82	59.5	15600	1	63.5	
Fisher Price	00968-9013	209.26	67.3	16700	2	75	Motor from 2012 KOP
Keyang	16627960	24.55	1883.44	70	0.5	20	
Nippon-Denso	E6DF-14A365-BB	22.30	1302	92	2.8	24.8	
Nippon-Denso	E6DF-14A366-BB	22.30	1302	92	2.8	24.8	
VEX	276-2177 (high speed)	4.00	134.4	160	0.15	3.6	At 7.2 Volts
VEX	276-2177 (standard)	4.00	215	100	0.15	3.6	At 7.2 Volts

Geared Motor Specifications

Rated Voltage	12 VDC
No Load Current (A)	<= 1.30
No Load Speed (rpm)	84 +/- 10%
Rated Load Torque (kgf.cm)	15
Rated Current (A)	<= 4.0
Rated Load Speed (rpm)	63 +/- 10%



		UNLESS OTHERWISE SPECIFIED:
		DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±
		INTERPRET GEOMETRIC TOLERANCING PER:
		MATERIAL
NEXT ASSY	USED ON	FINISH
APPLICATION		DO NOT SCALE DRAWING

	NAME	DATE
DRAWN	MK	11-10-11
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		
COMMENTS:		

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AndyMark Inc.

TITLE:

PG-71 Gear Motor

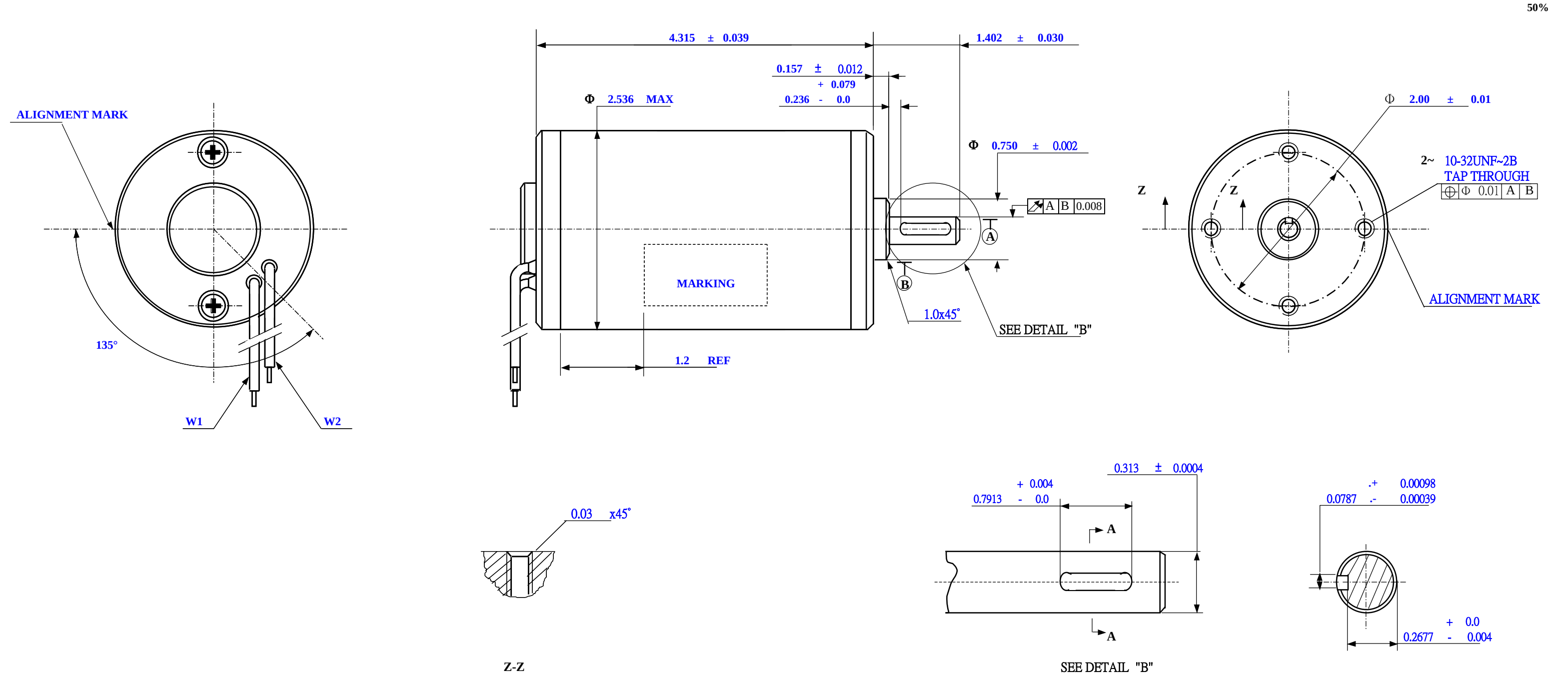
SIZE A | DWG. NO. PG-71 | REV

SCALE: 1:1 | WEIGHT: | SHEET 1 OF 1

5 4 3 2 1

MODEL NO.	FR801-001	CUSTOMER P/N		ISSUED BY	CIM	ISSUED TO	FIRST ROBOTICS	DATE	10/13/2004

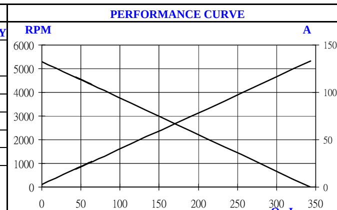
50%



TYPICAL PERFORMANCE @ 12 Vdc	TORQUE Oz-In	SPEED RPM (±10%)	CURRENT A MAX	POWER Wo	EFF'CY %
FREE LOAD	0	5310	2.7	0	0%
NORMAL LOAD	64.0	4320	27	205	63%
@MAX EFFICIENCY	45.0	4614	19.8	154	65%
@MAX POWER	171.7	2655	67.9	337	41%
@STALL	343.4	0	133.0	0	0%

HIPOT: 600 Vac/0.5 mA/1 sec
INSULATION RESISTANCE: > 10.0 M Ohm MIN
INSULATION CLASS: B

PERFORMANCE CURVE



GENERAL FEATURES

(1) LEAD WIRE: AWG#14 UL#1015,105°

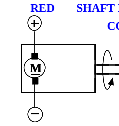
	LENGTH	STRIP LENGT	COLOR
W1	18.0 ± 0.5	0.5 ± 0.04	RED
W2	18.0 ± 0.5	0.5 ± 0.04	BLACK

(2) FINISHING:HOUSING POWDER GLOSS BLACK COA'
(3) END-PLAY 0.005 ~ 0.02
(4) CONSTRUCTION: TENV.

SPECIAL FEATURES

1) DUTY CYCLE:INTERMITTENT, CCW 3 MINUTES ON 2 SECOND
CW 3 MINUTES ON 30 MINUTES @64.0 OZ-IN,
2) LIFE:1000 CYCLES MINIMUM .

WIRING & ROTATION



ROTATION: REVERSIBLE

MARKING

CIM
FIRST ROBOTICS
FR801-001
12Vdc
MMDDYY

NO.	REVISIONS	DRAWN	CHECKED	DATE
B1	from 0.0789±0.00047,rev to B	s b Bu	JQ.He	10/13/04
B	Keyway width changed to 0.0789+0.00098/-0.00039	s b Bu	JQ.He	10/13/04
A	Rejigger key form,rev. to A.	HAN.L	JQ.He	8/9/04

NO.	REVISIONS	DRAWN	CHECKED	DATE

CUSTOMER APPROVAL

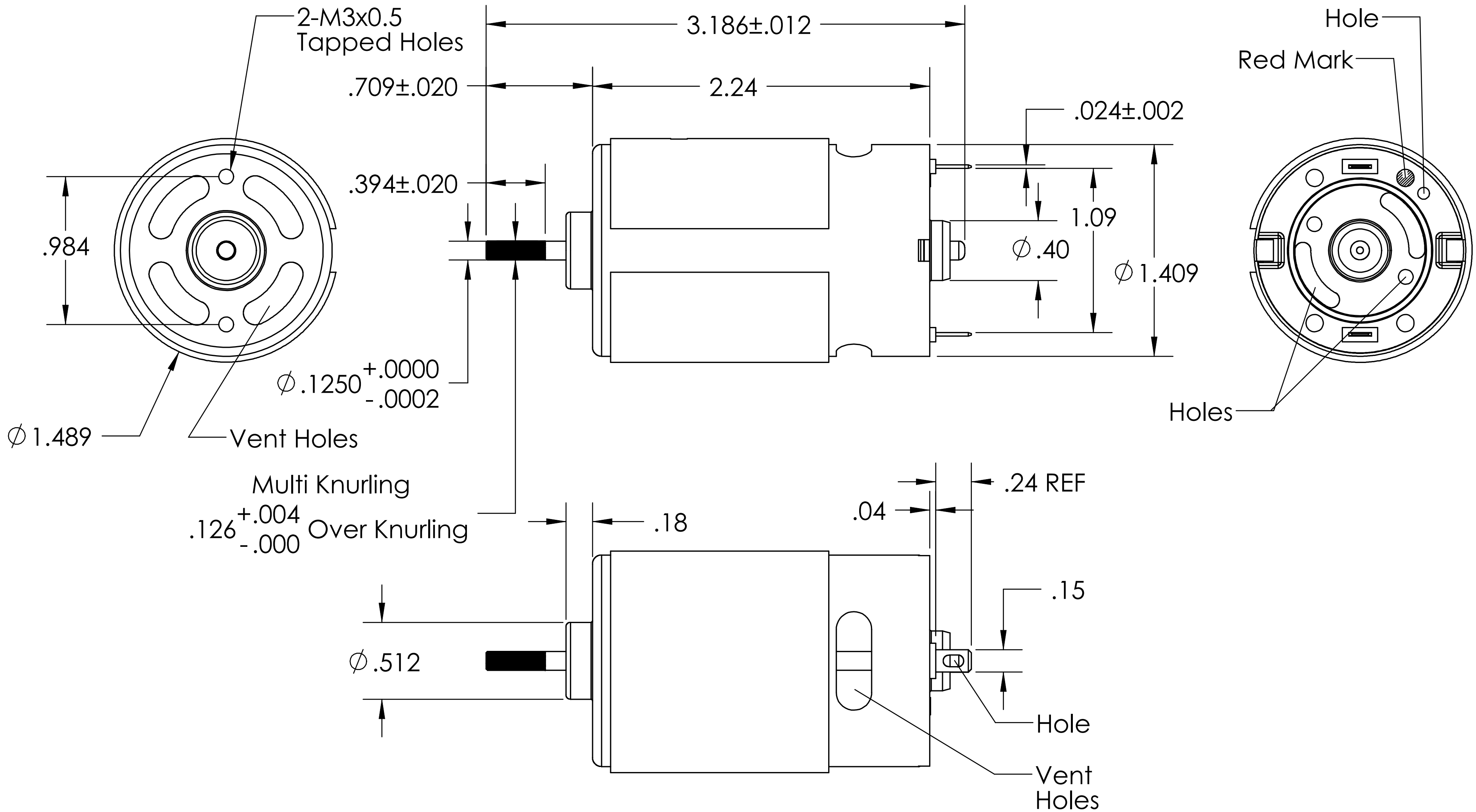
FIRST ROBOTICS
APPROVAL :

DATE :

UNSPECIFIED TOLERANCE		
DECIMAL		ANGLE
2 PLACE	3 PLACE	
± 0.008	± 0.005	± 1°
DESIGNED	QI. JX	8/9/2002
DRAWN	QI. JX	8/9/2002
CHECKED		
APPROVAL		

UNIT	INCH	REV.	B
TITLE	MOTOR SPECIFICATIONS		
MODEL NO.	FR801-001		
DRAWING NO.	CAD- FR1-01A		
CUSTOMER P/N			
SERIES	2510BA08ZZa		

CCL Industrial Motor Limited (CIM)
捷和工業電機有限公司



		UNLESS OTHERWISE SPECIFIED:		NAME	DATE
		DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±	DRAWN	MK	11-11-11
			CHECKED		
			ENG APPR.		
			MFG APPR.		
		INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.		
		MATERIAL	COMMENTS:		
NEXT ASSY	USED ON	FINISH			
APPLICATION		DO NOT SCALE DRAWING			

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AndyMark Inc.

TITLE:

AM-0912 Motor

SIZE	DWG. NO.	REV
A	AM-0912	
SCALE: 1:1	WEIGHT:	SHEET 1 OF 1

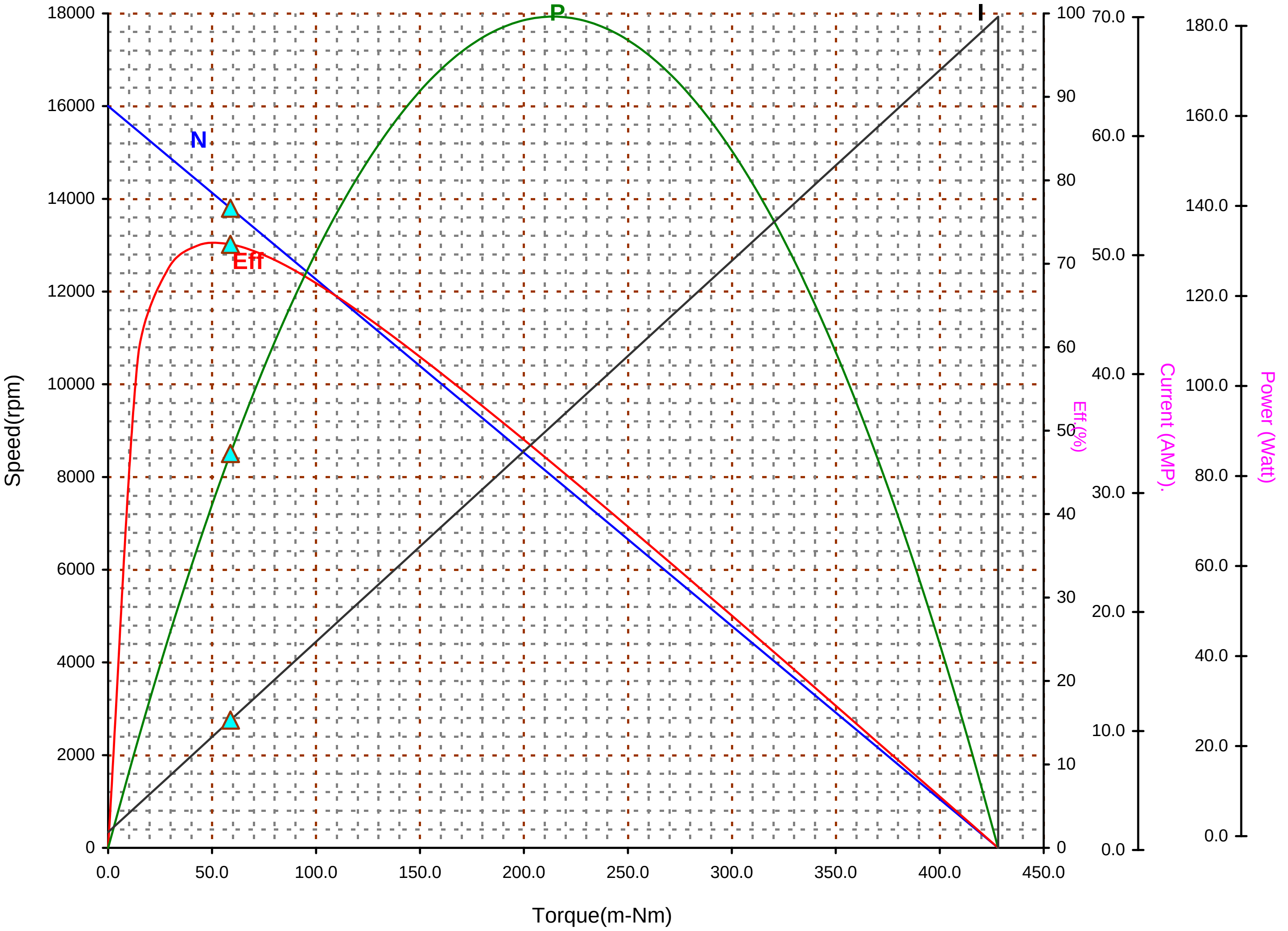
5 4 3 2 1

Chiaphua Components
Group of Companies

http://www.cclmotors.com

Project No : DB-30F-2005
Proposal No:
Winding : 0.00 - 0
Motor test reference no : (CCW)

Operator : JACKY
Date : 2011/11/10



Performance (In an ambient temperature of 25 -30 C)
Motor tested rapidly to prevent significant temperature rise.

At a constant voltage of	**12.00**	Volts
With a circuit resistance	0.000	Ohms

AT No Load

Speed :	16000	Rpm
Current:	1.200	Amp

At stall (Extrapolated)

Torque :	428.073	m-Nm
Current:	63.745	Amp

At maximum efficiency

Efficiency :	72.50	%
Torque :	51.647	m-Nm
Speed :	14070	Rpm
Current :	8.746	Amp
Output :	76.095	Watts

At maximum power

Torque :	214.036	m-Nm
Speed :	8000	Rpm
Current :	32.473	Amp
Output :	179.311	Watts

Characteristics

Torque Constant :	6.844	m-Nm/Amp
E.M.F Constant :	6.844	mV/rad/sec
Dy. Resistance :	0.188	Ohms
Motor Regulation:	37.377	Rpm/m-Nm

Calculation

At Torque Level:			At Fan:		
Torque:	58.860	m-Nm	Torque:		m-Nm
Speed:	13800	Rpm	Speed:		Rpm
Current:	9.800	Amp	Current:		Amp
Efficiency:	72.33	%	Efficiency:		%
Output:	85.061	Watts	Output:		Watts

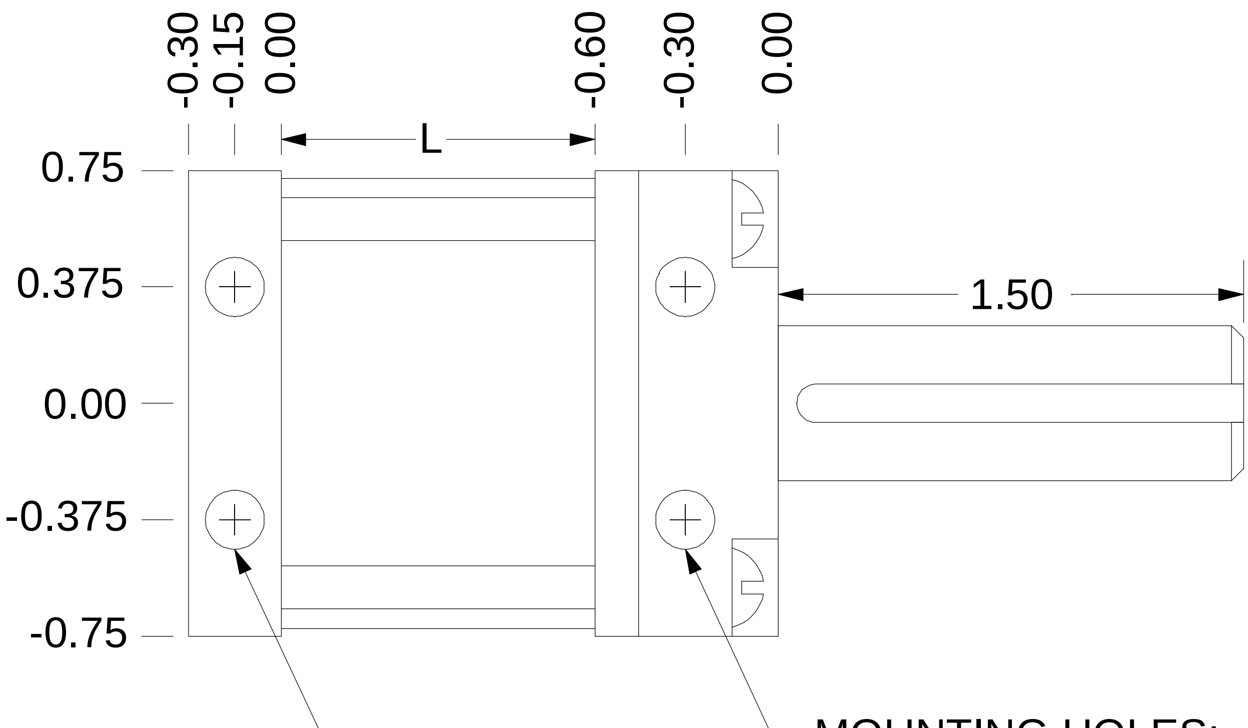
COMPUTER PRINT-OUT
NORMINAL MOTOR CURVE
Performance and characteristics are measured based on limited motor sample only

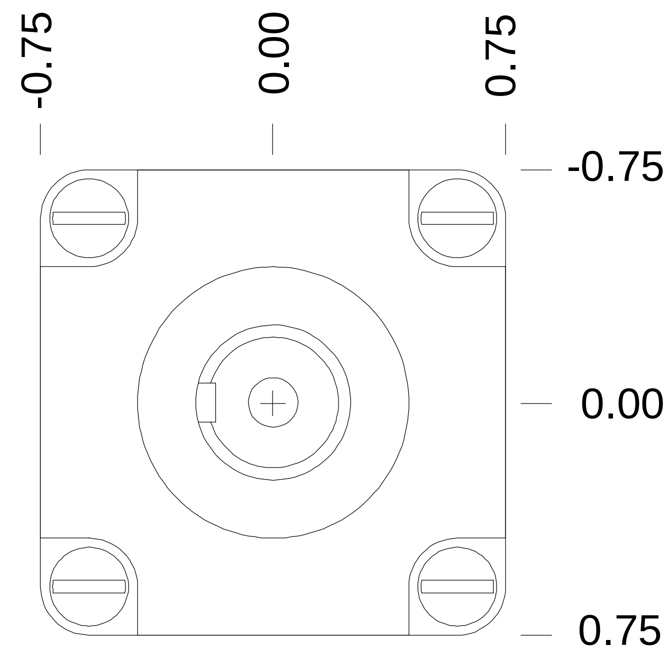
BANEBOTS P60 GEARBOX
PRELIMINARY

RINGGEAR LENGTH (L)
- 1 STAGE: 0.60
- 2 STAGE: 1.00
- 3 STAGE: 1.40
- 4 STAGE: 1.80

(TOTAL LENGTH = RINGEAR LENGTH + 0.90)

STANDARD SHAFT:
4140 HARDENED STEEL
0.500 DIAMETER
0.125 KEYWAY TO SHAFT END
#10-32 END TAP, 0.300 MIN DEPTH





MOUNTING HOLES:
#10-32
8TOTAL
4 TOP, 4 BOTTOM
0.30 MIN DEPTH

ALL DIMENSIONS INCHES
NO HIDDEN LINES SHOWN

PRELIMINARY
11 JAN 09

Iteration #	Description of what changed	Why did it change?
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		