

MCG 4322[A]

FSAE Design Dossier

FSAE 2

by

AbdalAziz AlGhoul (300005268)

Hasan Shahzad (300001167)

Hisham Ali (300010128)

Peter Saroufim (300015864)

Munir Alsafi (300013845)

University of Ottawa
Department of Mechanical Engineering
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Professor: Mihaita Matei
Design TA: Nathaniel Mailhot
Marking TA: Ahmed Taimah

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Chapter 1

Project Charter

1.1 Mandate

Formula SAE is a series of international competitions in which university teams compete to design and manufacture the best performing race cars. Our design team has been approached by a car manufacturer and contracted to develop a small electric Formula-style race car. The prototype must be sufficiently durable to successfully complete all the static and dynamic events at the Formula SAE competitions.

1.2 Requirements

The vehicle must only be powered by electrical motor(s), which must be connected to the accumulator through a motor controller. The braking system must act on all four wheels and the steering wheel must be mechanically connected to the front wheels.

1.3 Constraints

The maximum power drawn from the accumulator must not exceed 80 kW and the maximum voltage between any two points must not exceed 600 V DC. The wheels must be 203.2 mm or more in diameter and the suspension must have a wheel travel of at least 50mm.

1.4 Criteria

The design of the vehicle will focus on key areas such as performance, serviceability, safety, ergonomics, reliability, aerodynamics, efficiency and cost.

1.5 Parameterization Outline

The design of the vehicle is driven by the length and weight to be able to accommodate drivers of sizes ranging from 5th percentile female up to 95th percentile male. Accommodation will include driver position, driver controls, and driver equipment.

Chapter 2

Design Solution

2.1 System Layout

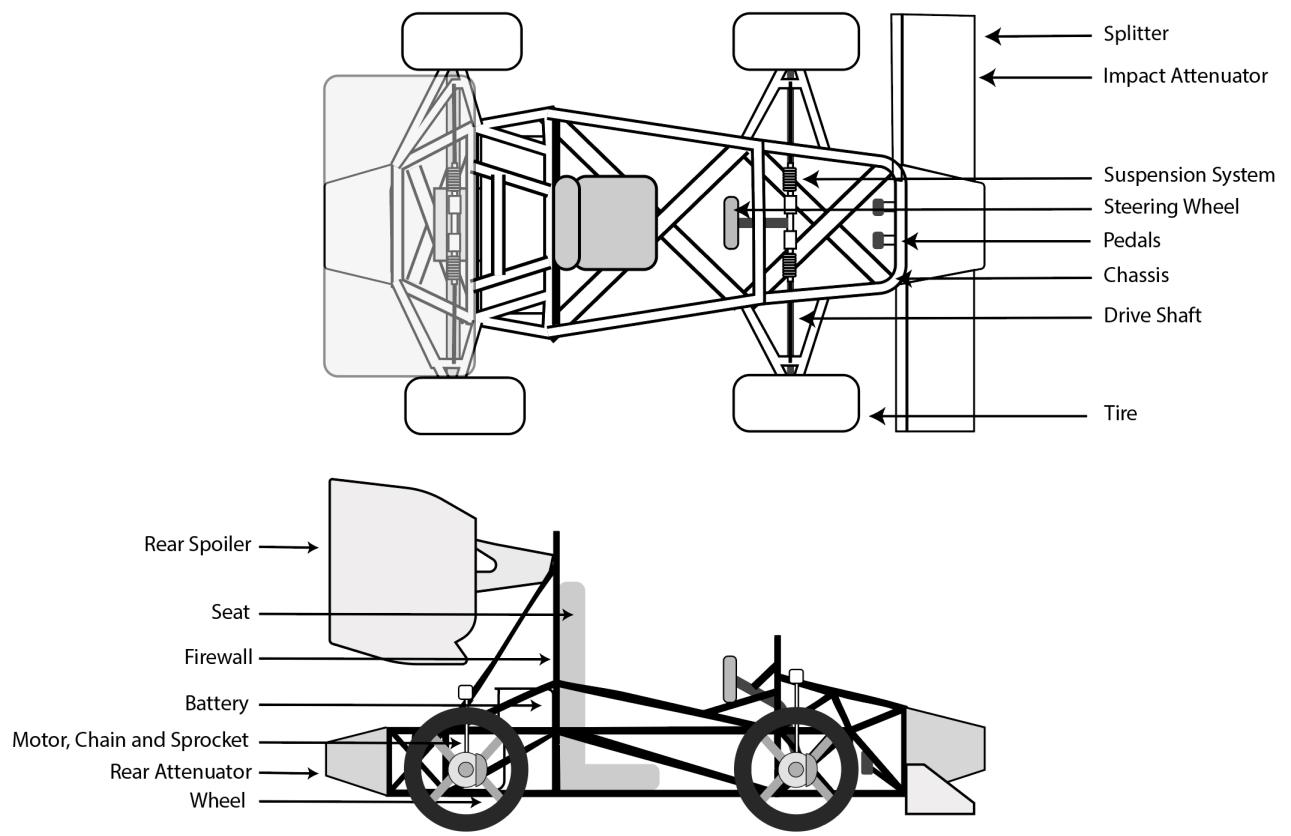


Figure 2.1: Updated System Layout of the Electric FSAE Vehicle

2.2 Detailed Drawings & Descriptions

2.2.1 Battery

The battery mounts, and mounting method to the chassis will be explored in this section.

2.2.1.1 Subsystems

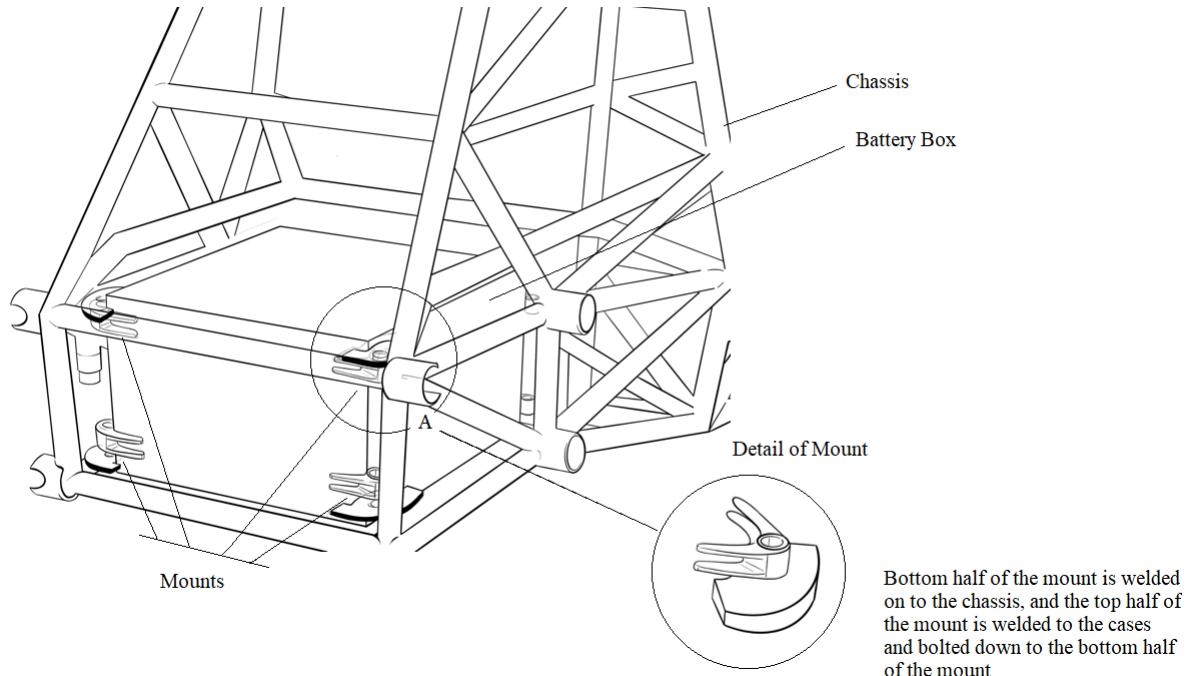


Figure 2.2: Isometric View of Battery Mounted to Chassis

Front View of Bottom Mounts Welded to Chassis Tubes

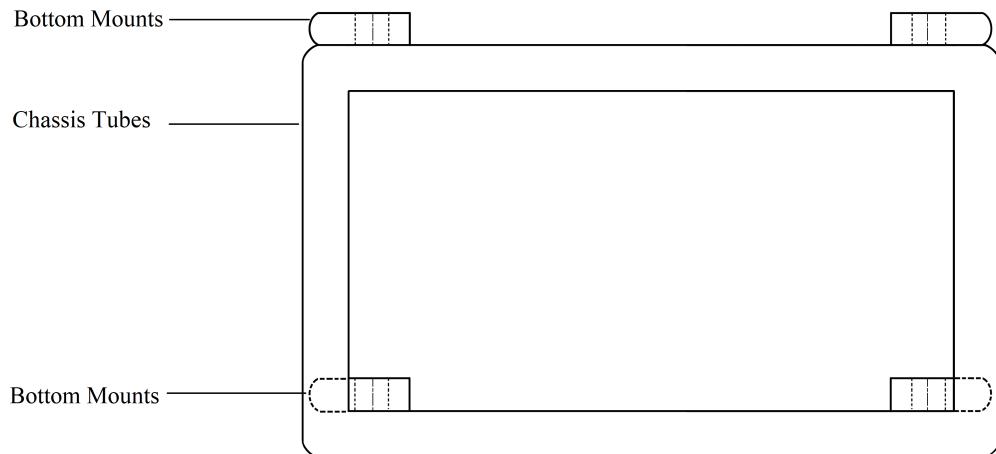


Figure 2.3: Front View of Bottom Mounts Welded onto Chassis

Top View of Bottom Mounts Welded to Chassis Tubes

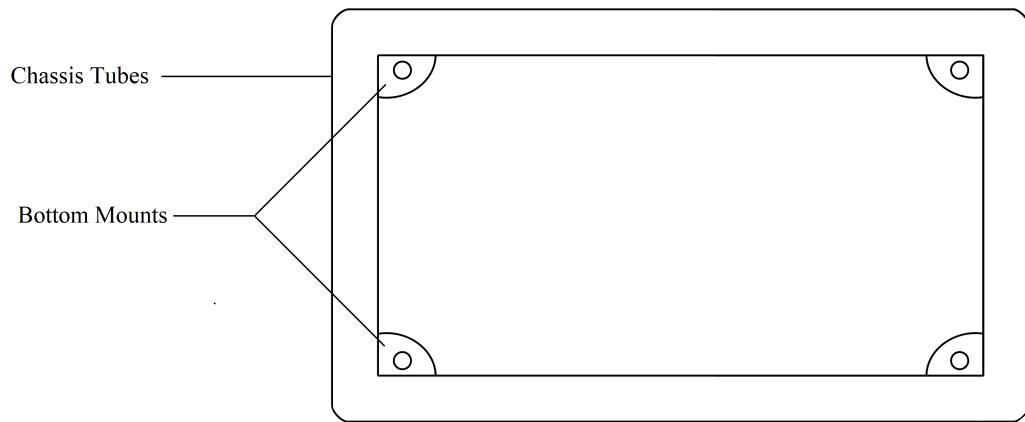


Figure 2.4: Top View of Bottom Mounts welded onto Chassis

Front View of Top Bracket welded onto Battery box, and fastened to Bottom Mount.

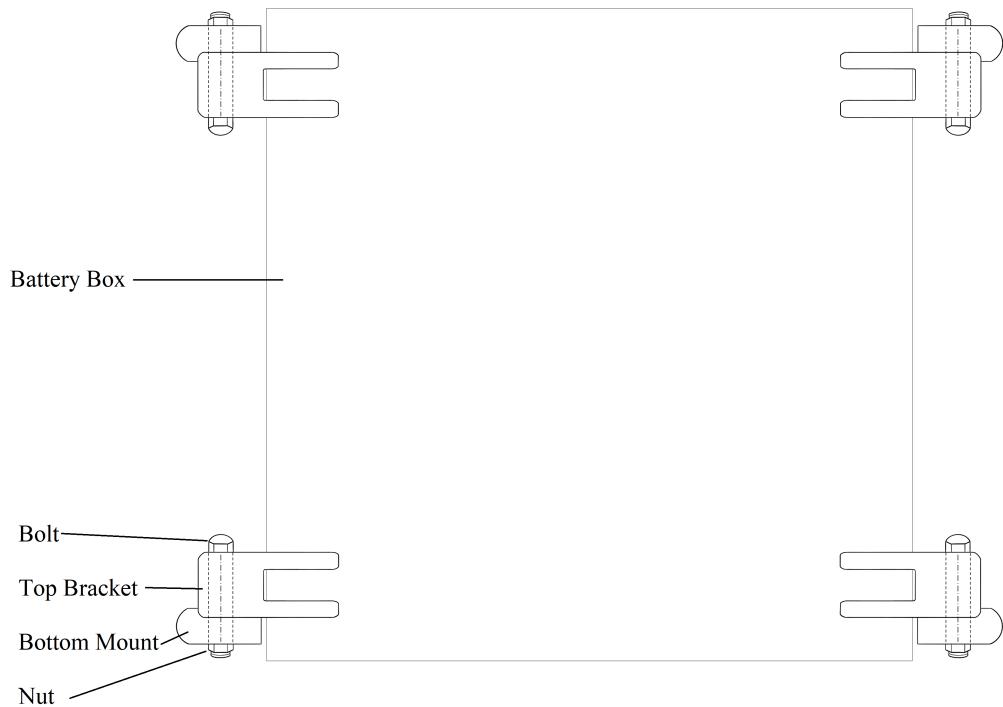


Figure 2.5: Front View of Top Bracket Welded on to the Battery Box

2.2.1.2 Components

Front and top views illustrating the battery mounting.

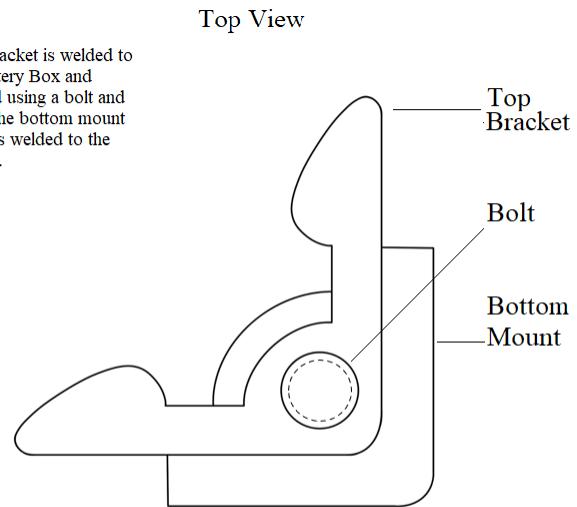


Figure 2.6: Top View of Mount

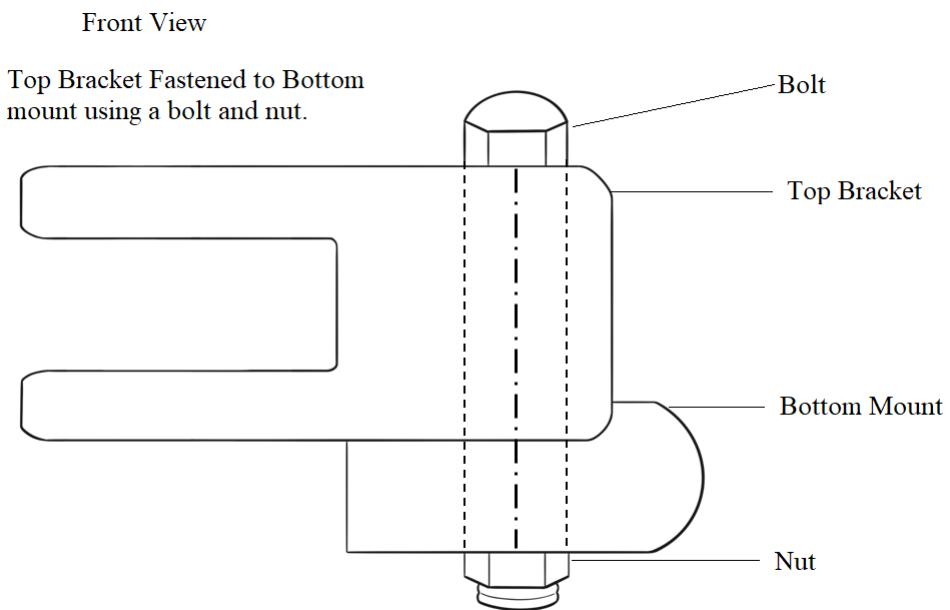


Figure 2.7: Front View of Mount

2.2.2 Aerodynamics

2.2.2.1 Subsystems

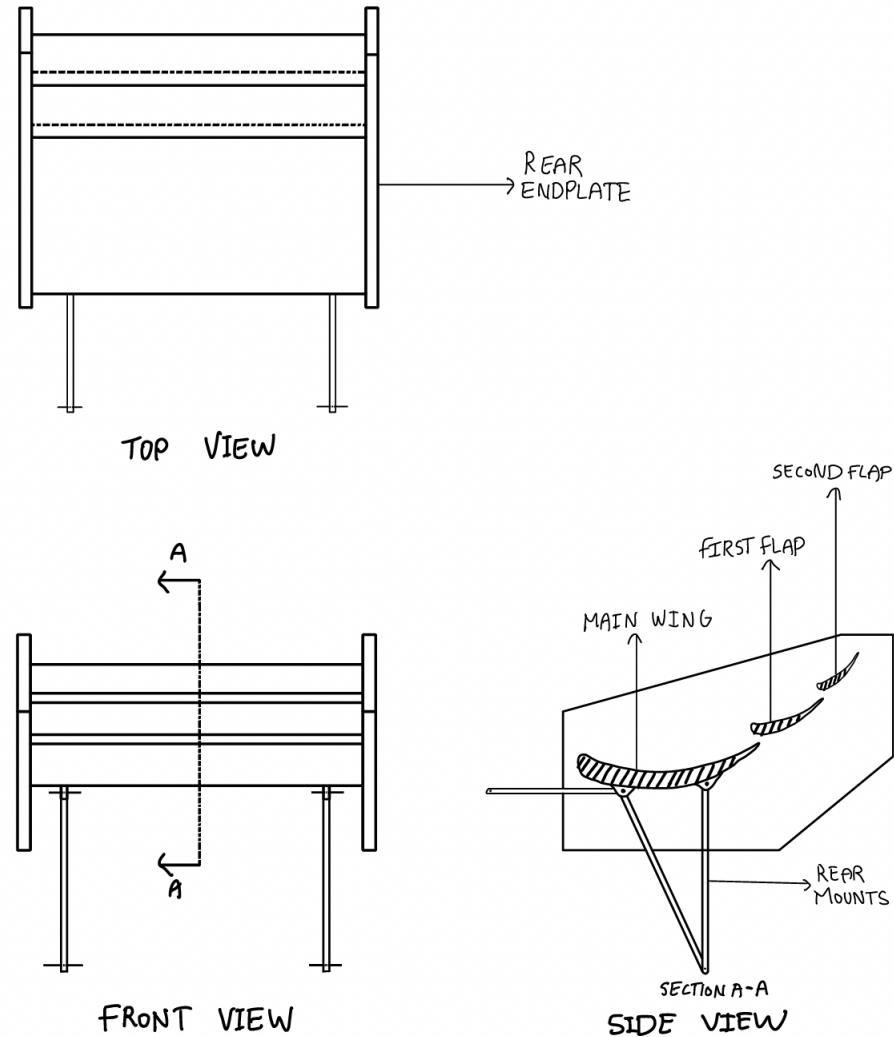


Figure 2.8: Front, side, and top views of the rear wing assembly

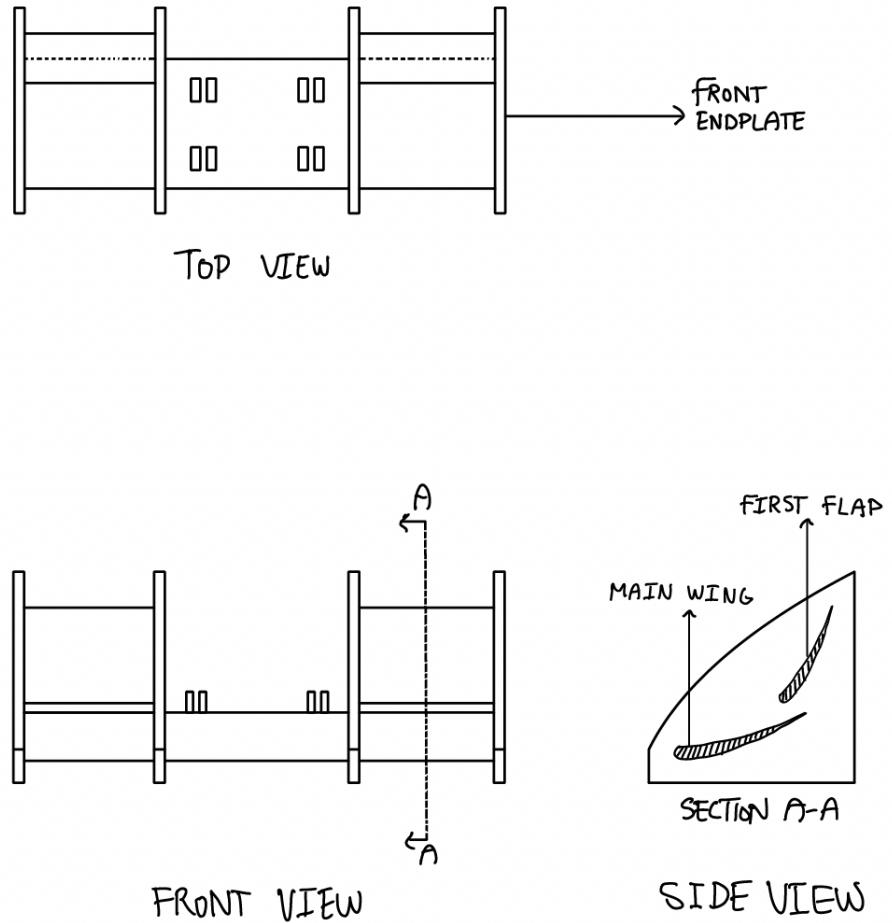
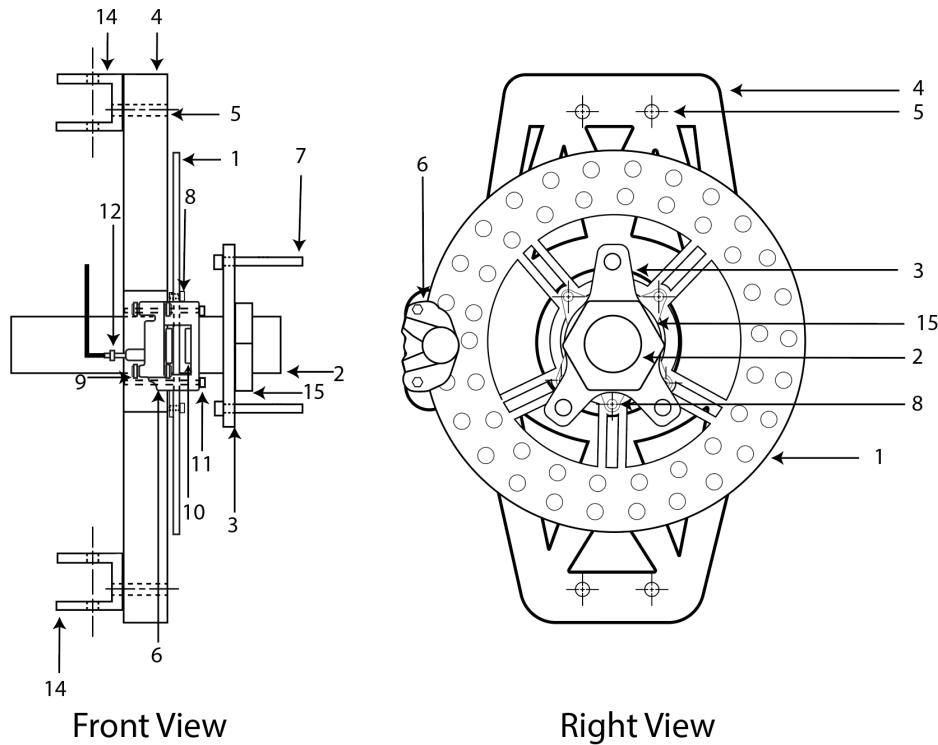


Figure 2.9: Front, side, and top views of the front wing assembly

2.2.3 Brakes

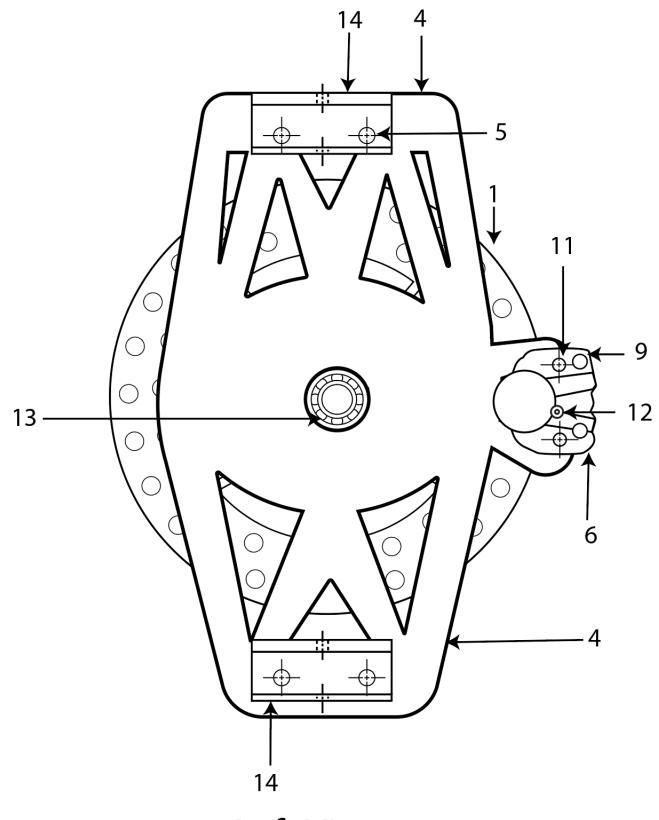
2.2.3.1 Subsystems



1	Rotor
2	Spindle
3	Wheel Hub
4	Wheel Knuckle
5	Knuckle Mounting Hole
6	Caliper
7	Lug Bolts
8	Rotor to Wheel Assembly Mount
9	Caliper Sliding Pin
10	Brake Pad
11	Caliper Mounting Bolt
12	Brake Line Input
13	Axle Bearing
14	Suspension and steering Knuckle Mount
15	Spindle Nut

Figure 2.10: Front and Right view of the wheel hub and brake assembly

1	Rotor
2	Spindle
3	Wheel Hub
4	Wheel Knuckle
5	Knuckle Mounting Hole
6	Caliper
7	Lug Bolts
8	Rotor to Wheel Assembly Mount
9	Caliper Sliding Pin
10	Brake Pad
11	Caliper Mounting Bolt
12	Brake Line Input
13	Axle Bearing
14	Suspension and steering Knuckle Mount
15	Spindle Nut



Left View

Figure 2.11: Left view of the wheel hub and brake assembly

2.2.3.2 Components

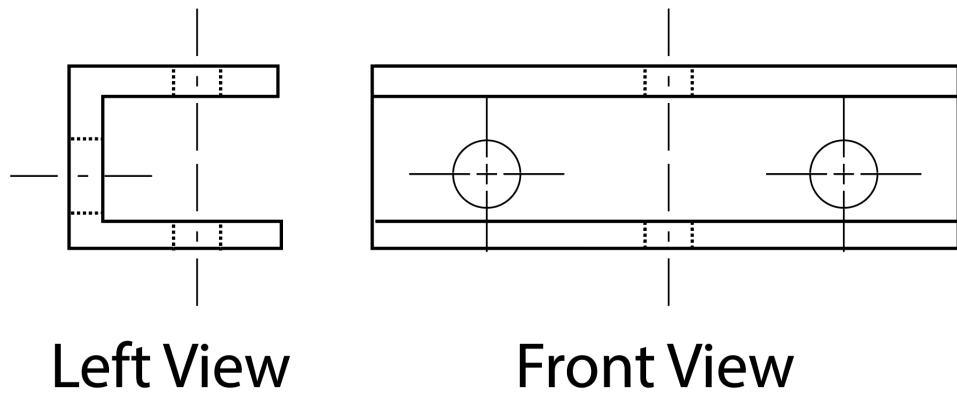
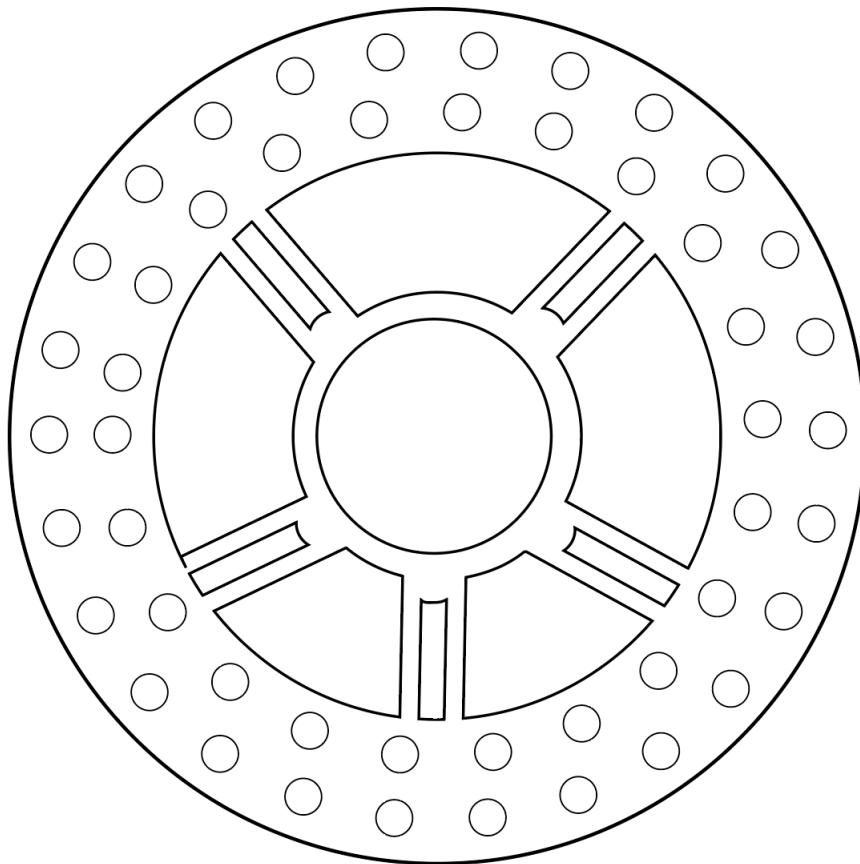


Figure 2.12: Suspension and Steering Knuckle Mount



Front View

Figure 2.13: Brake Rotor

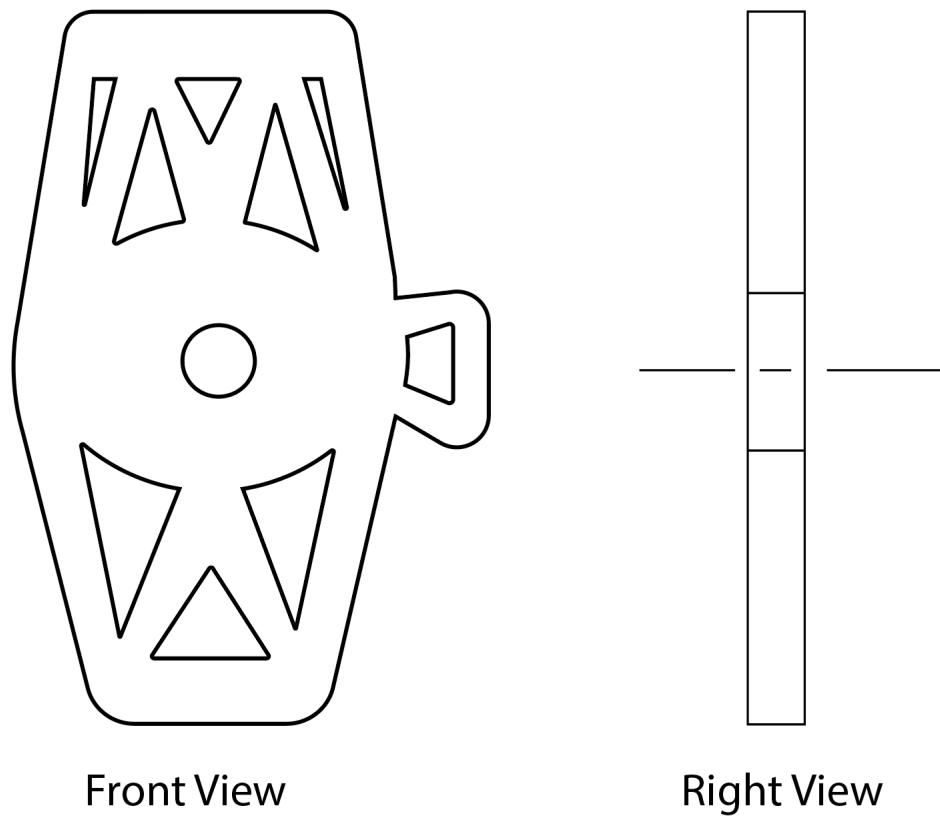


Figure 2.14: Steering Knuckle

2.2.4 Chassis

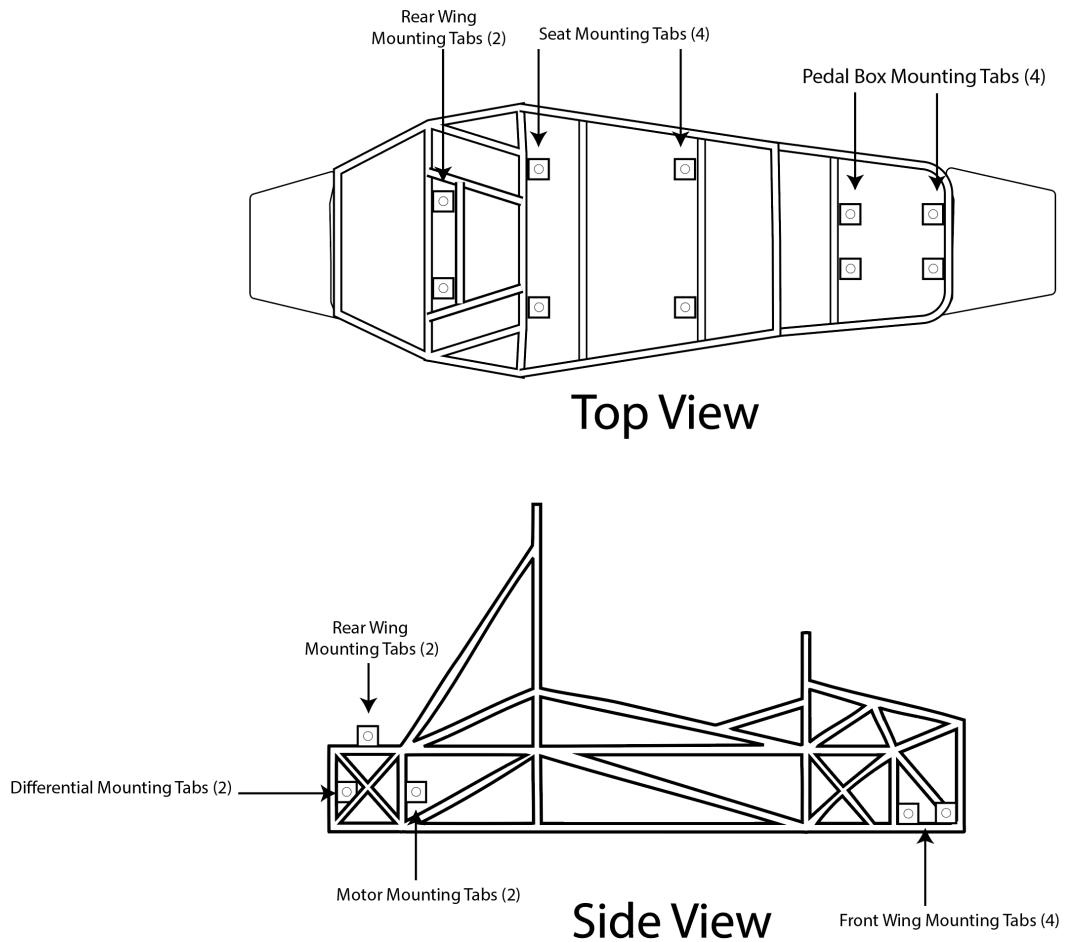


Figure 2.15: Chassis Mounting

2.2.5 Motor and Powertrain

2.2.5.1 Subsystems

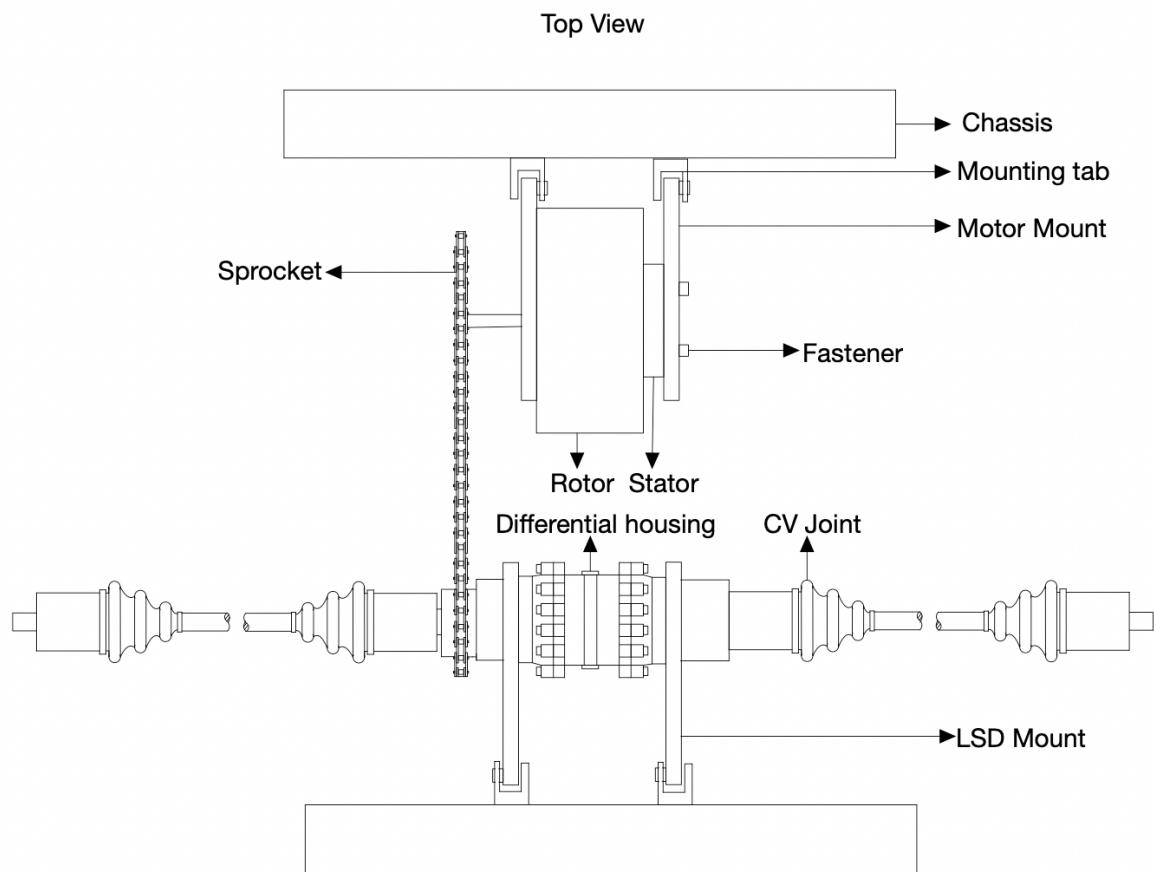


Figure 2.16: One Motor with Chain and Sprocket Configuration

2.2.5.2 Components

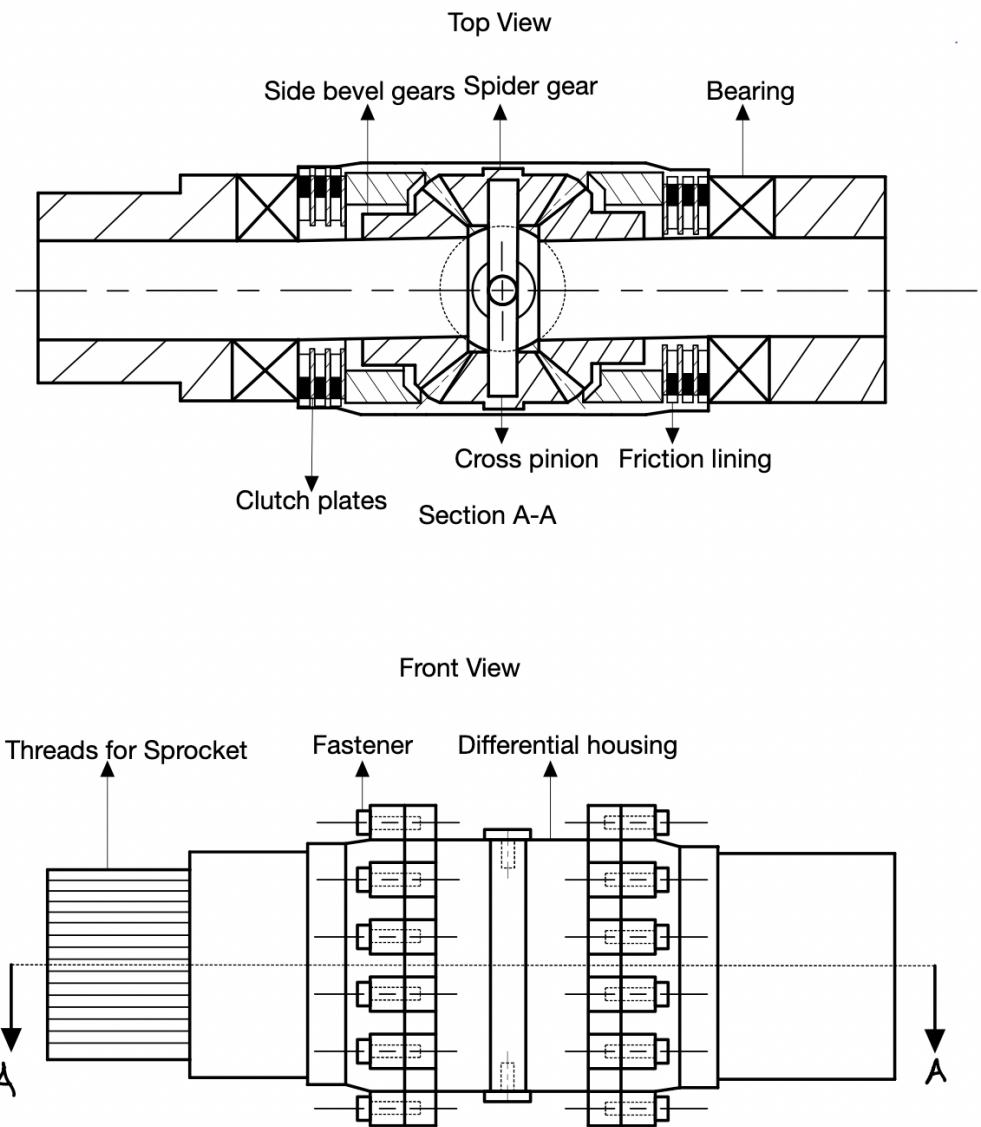


Figure 2.17: Front, Top, and Cross-Section Views of the Limited Slip (LSD) Differential

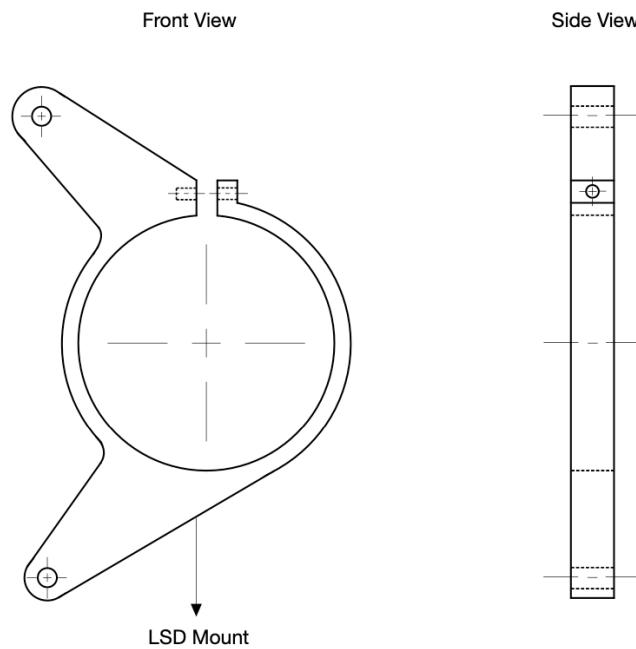


Figure 2.18: Front and Side Views of the Differential Mount

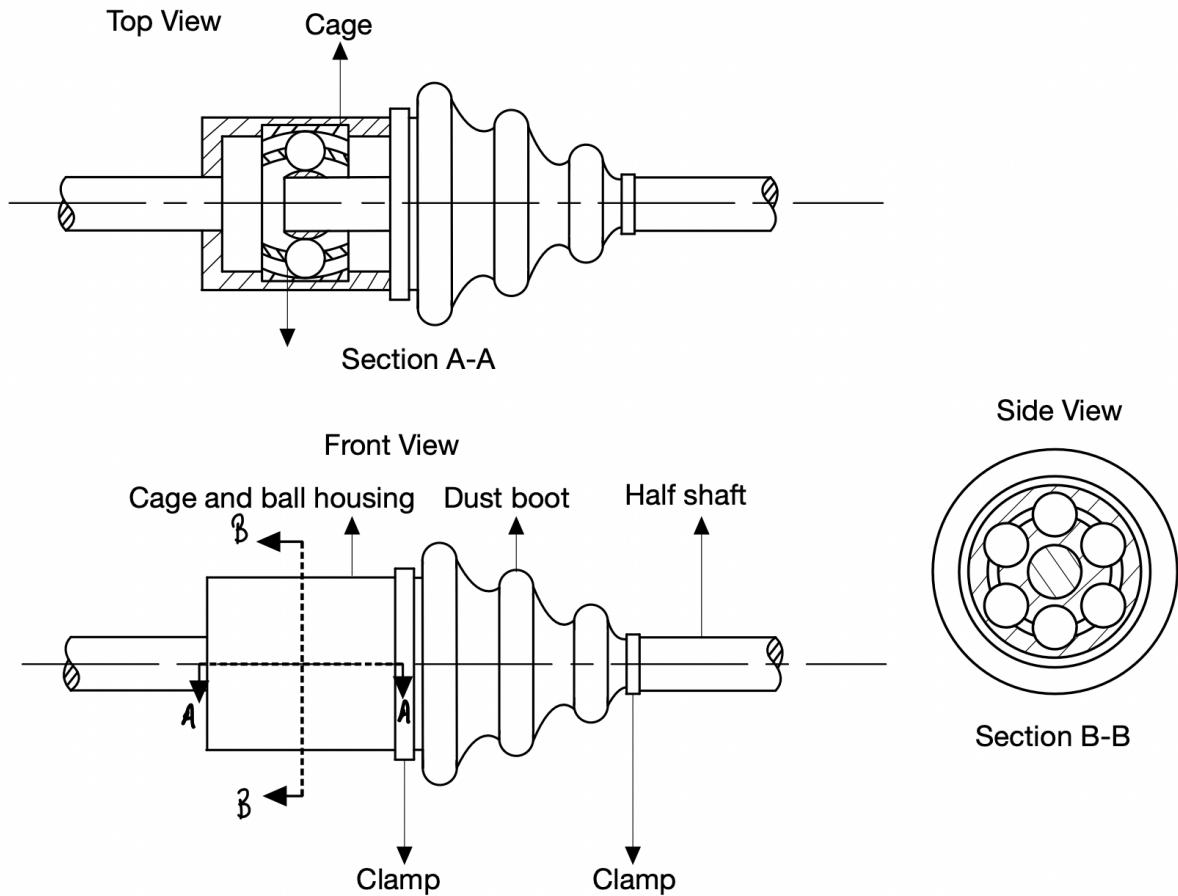


Figure 2.19: Front, Side, Top and Cross-Section Views of the CV Joint

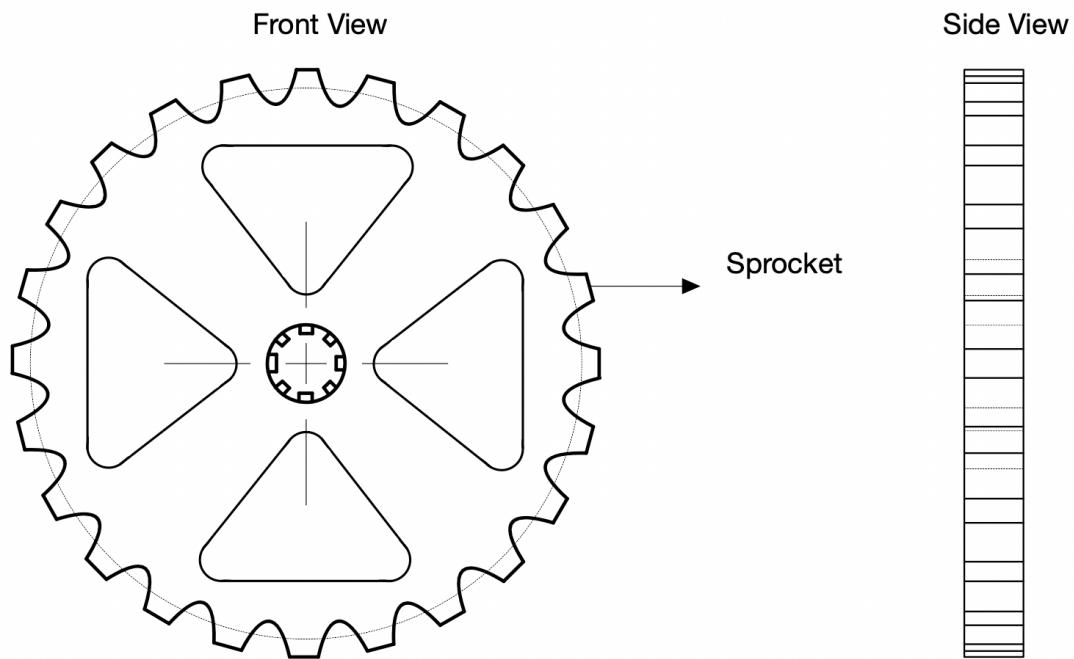


Figure 2.20: Front and Side Views of the Sprocket

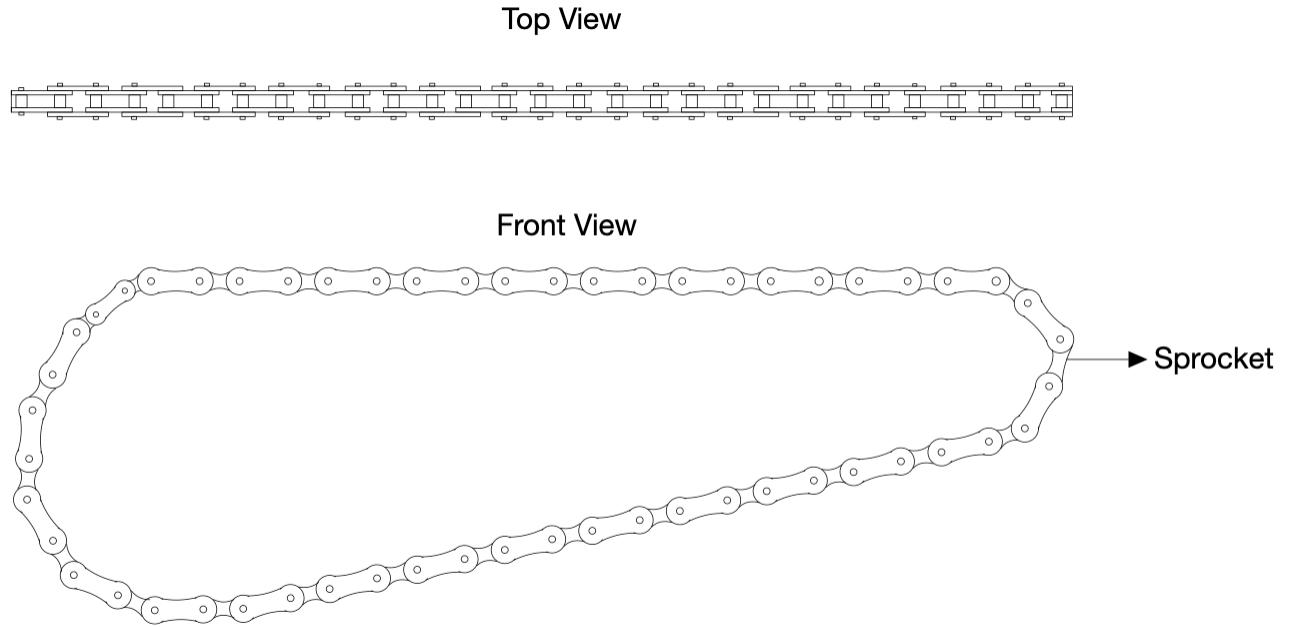


Figure 2.21: Front and Top Views of the Chain

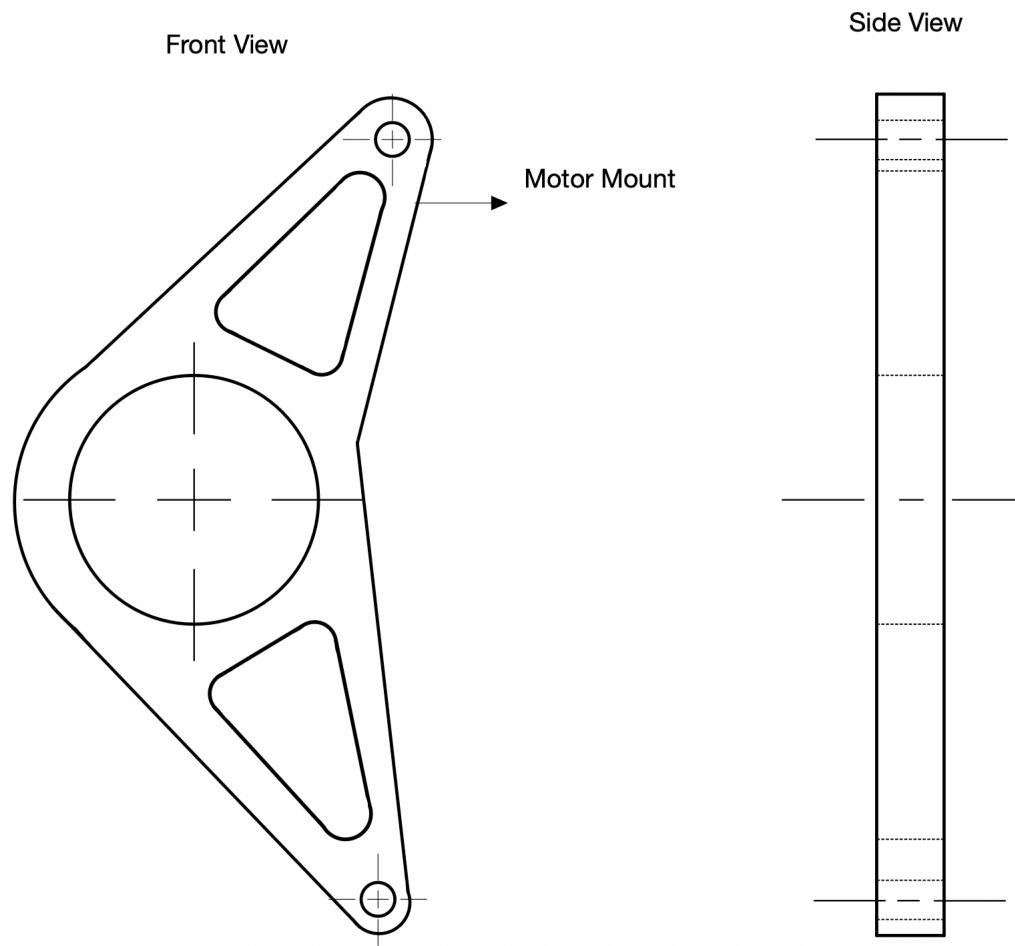


Figure 2.22: Front and Side View of the Motor Mount

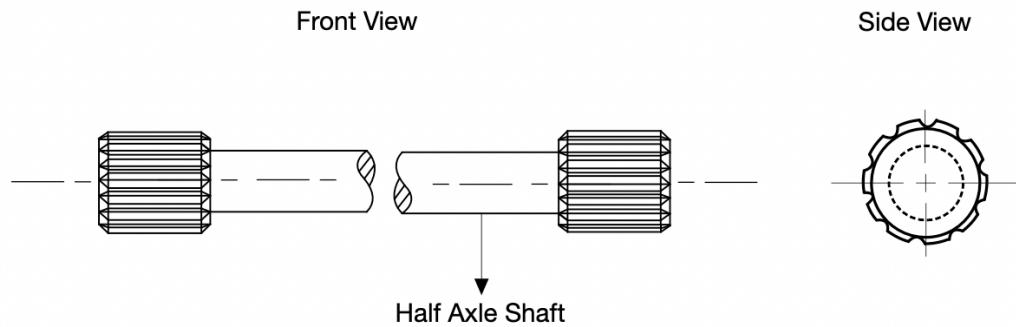


Figure 2.23: Front and Side Views of the Half Axle Shaft

2.2.6 Pedals

2.2.6.1 Subsystems

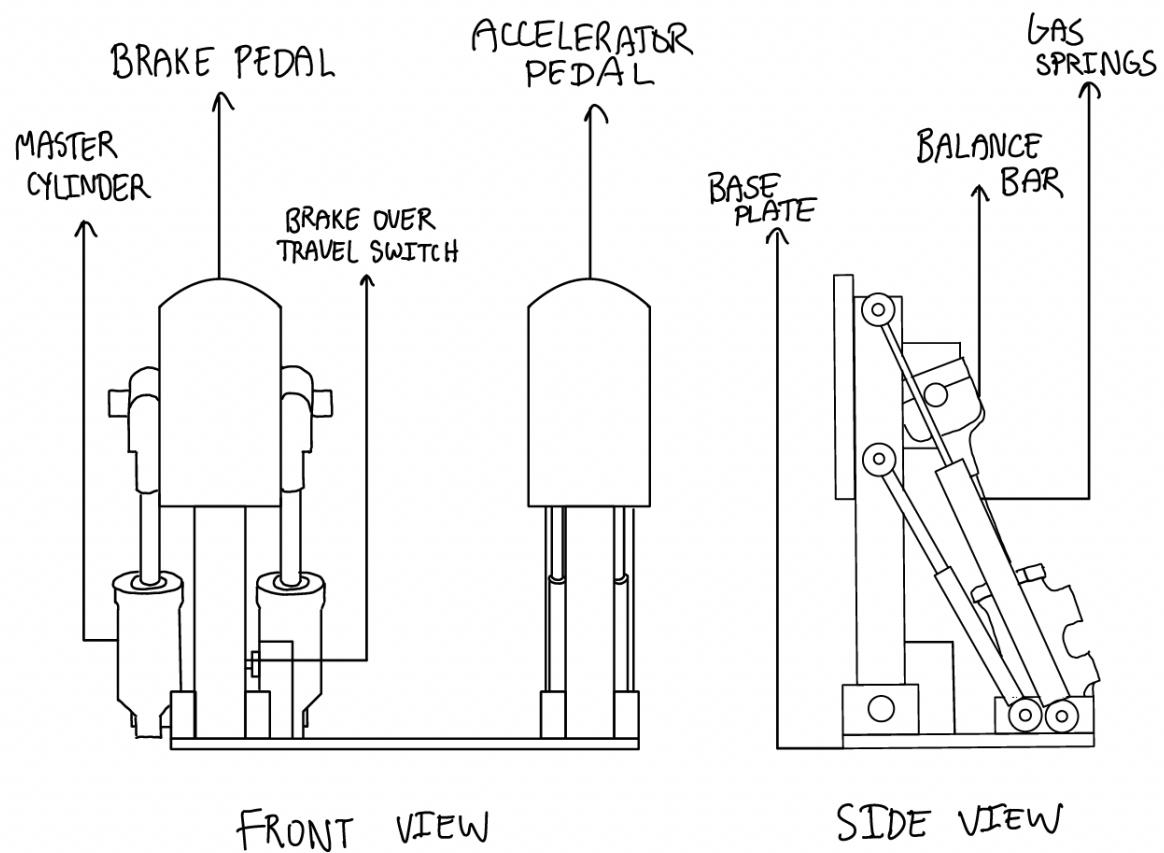


Figure 2.24: Front and side view of the pedal box assembly

2.2.7 Seat

2.2.7.1 Components

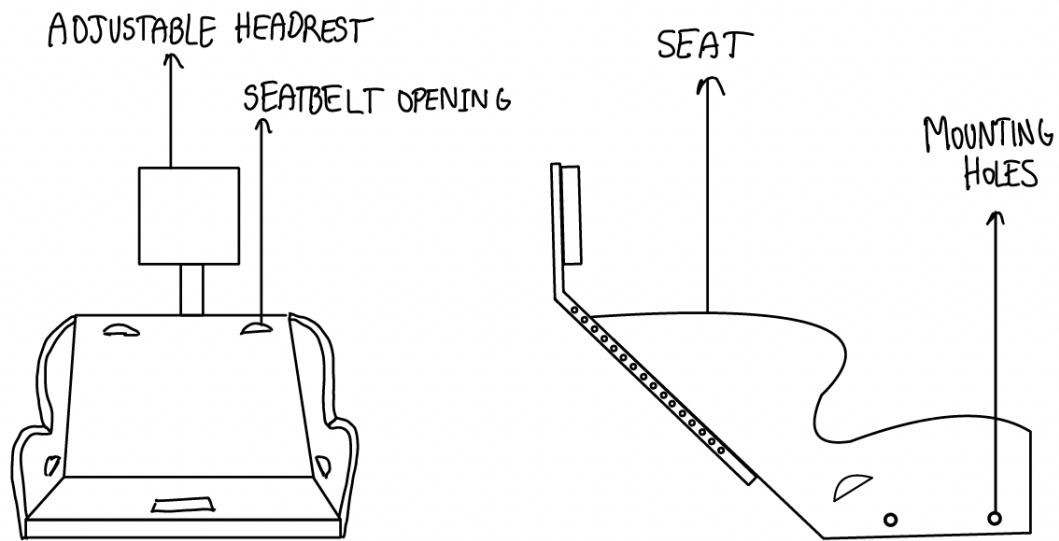


Figure 2.25: Front and side views of the driver seat

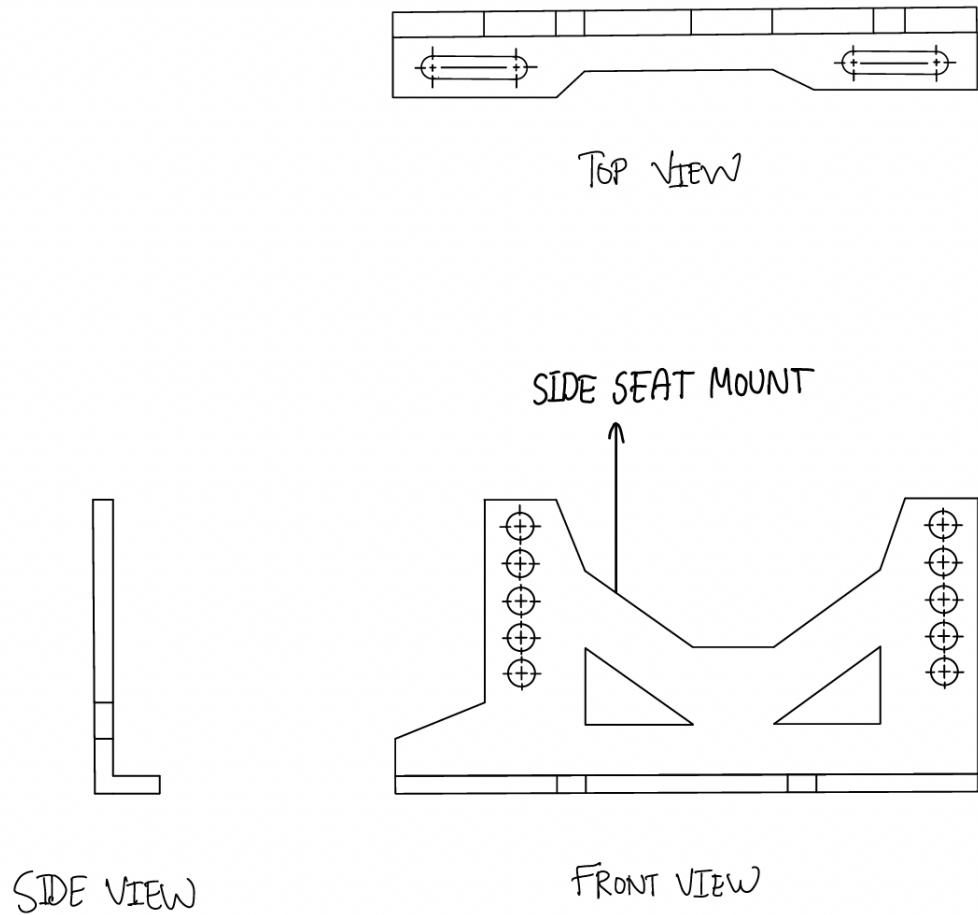


Figure 2.26: Front, side, and top views of the side seat mount

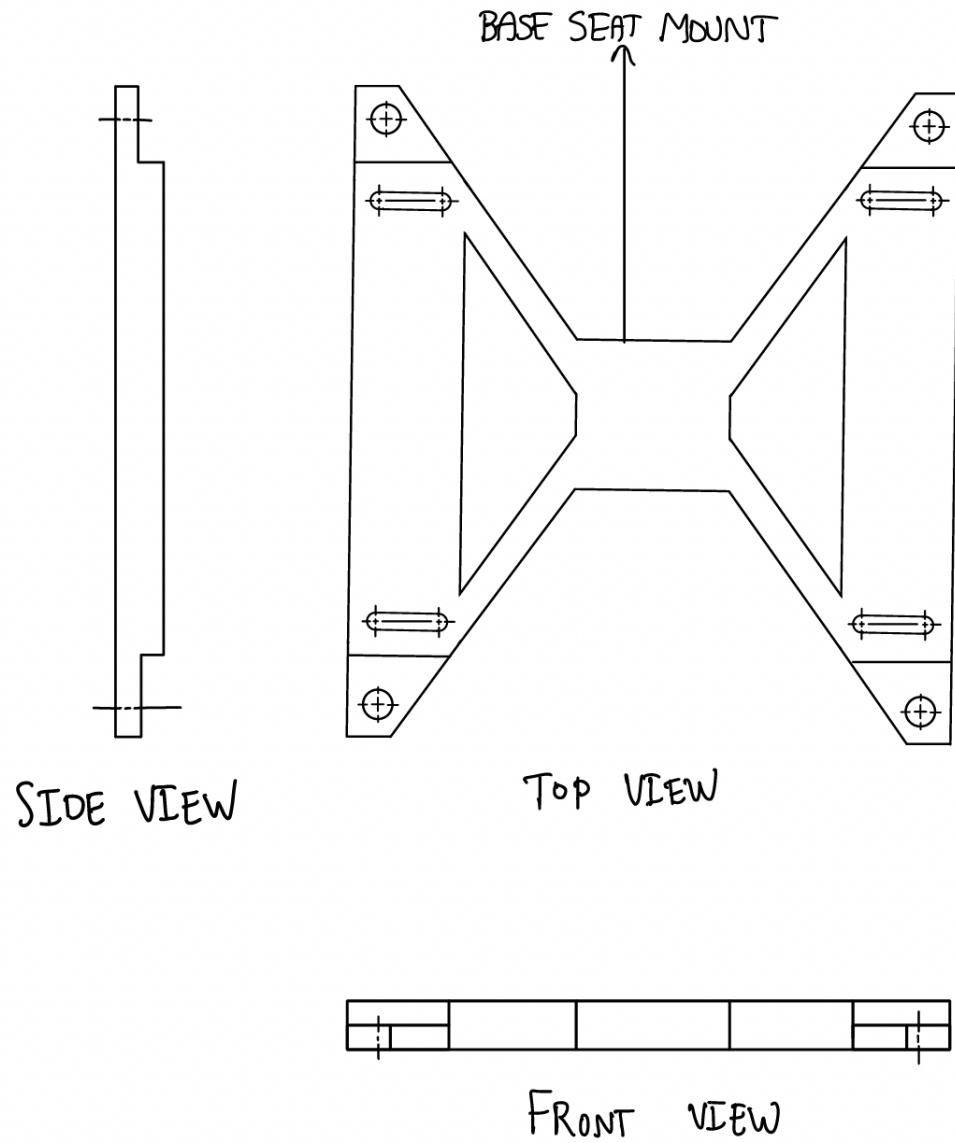


Figure 2.27: Front, side, and top views of the base seat mount

2.2.8 Steering

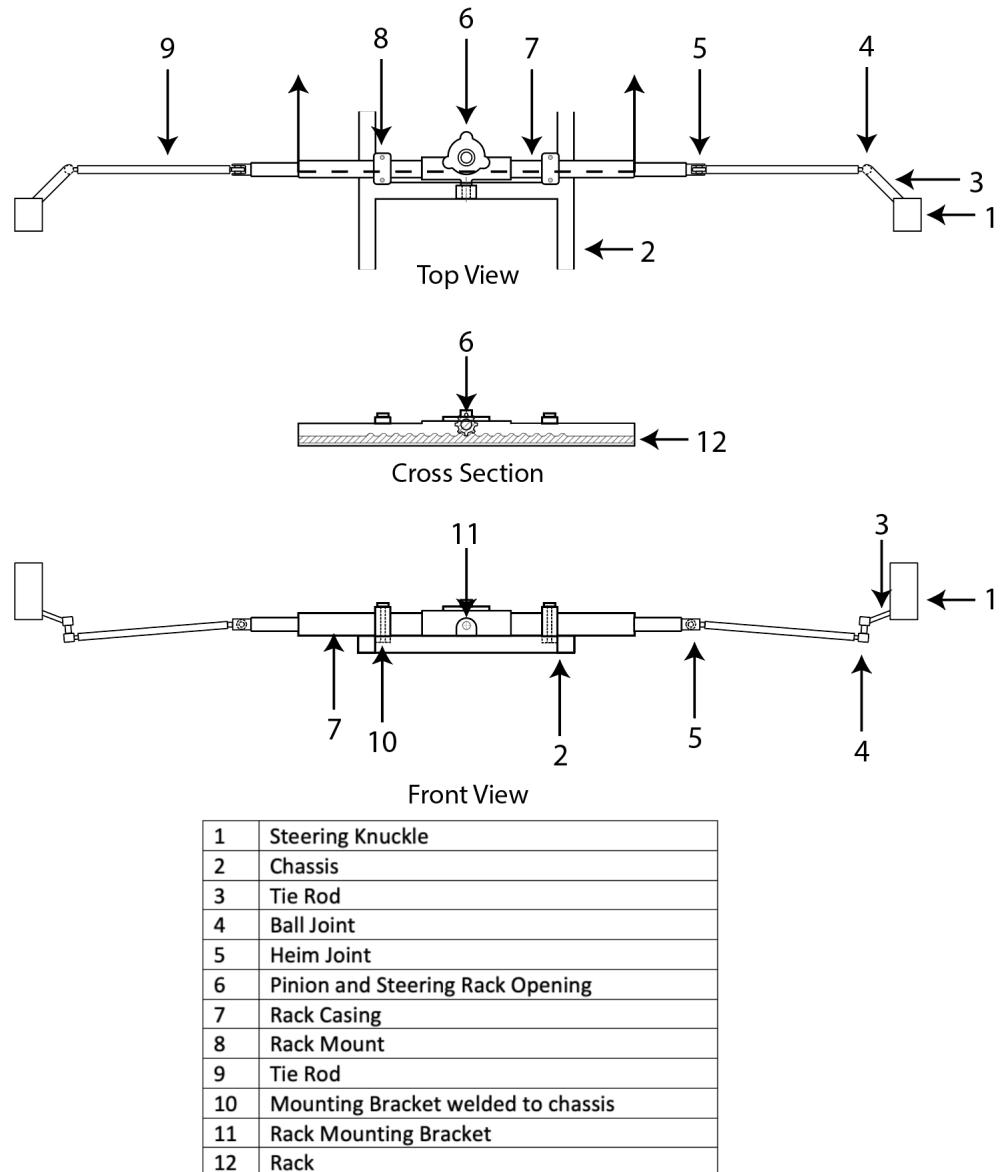


Figure 2.28: Pinion and Rack Assembly

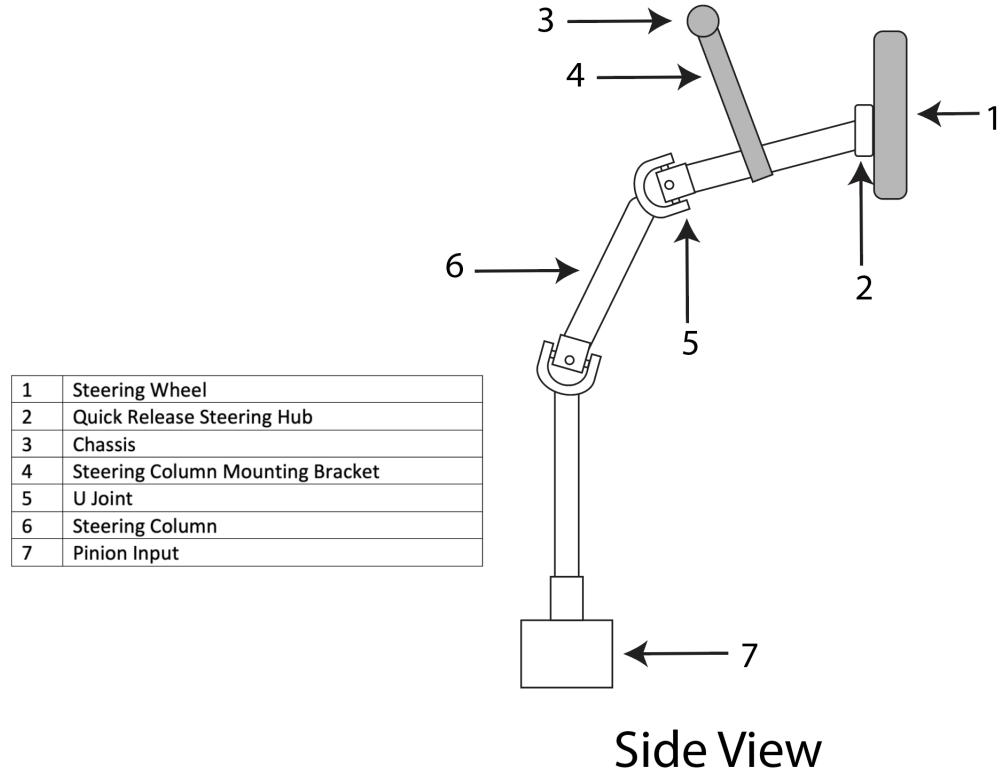


Figure 2.29: Steering Mounting Assembly

2.2.9 Suspension

2.2.9.1 Subsystems

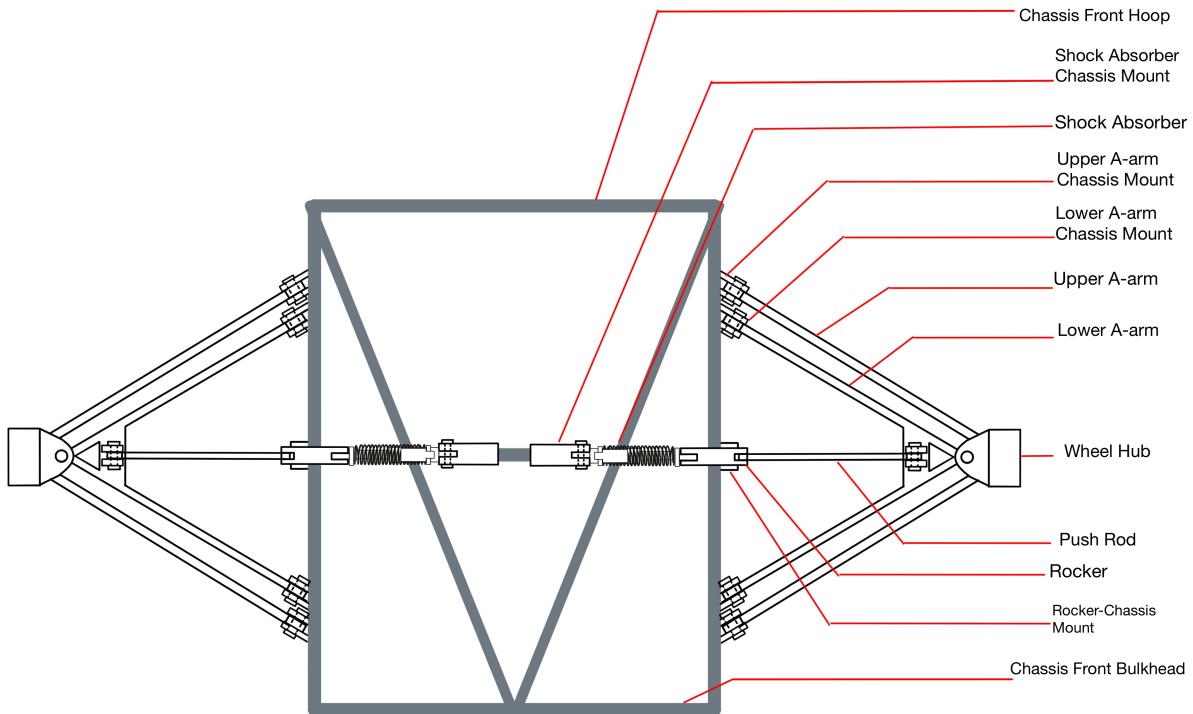


Figure 2.30: Front Suspension Top View

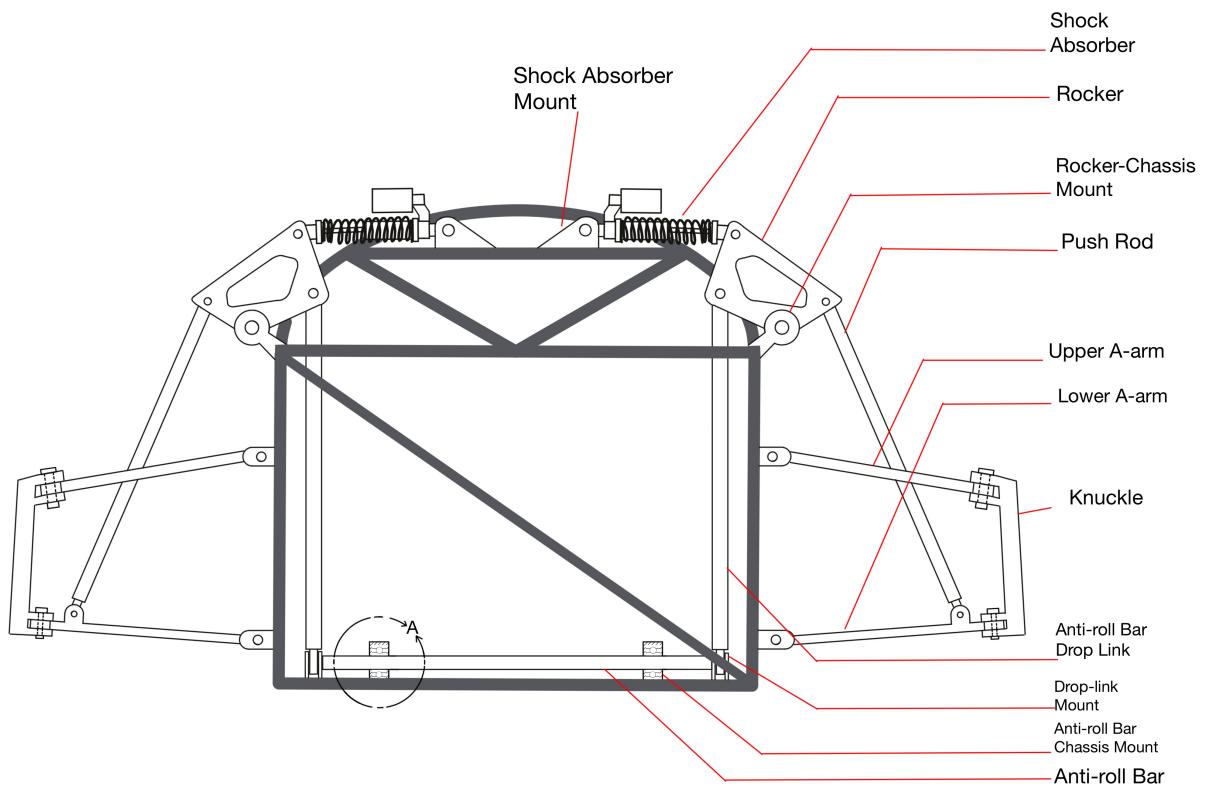


Figure 2.31: Front Suspension Front View

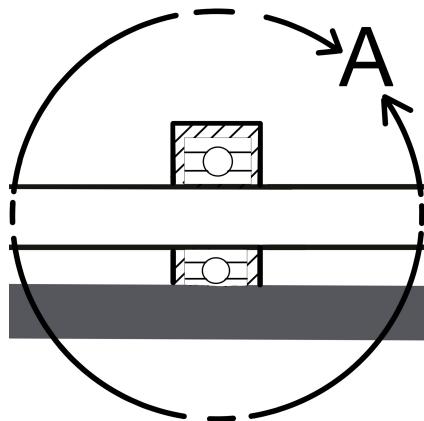


Figure 2.32: Anti-Roll Bar Bearing - Detail A

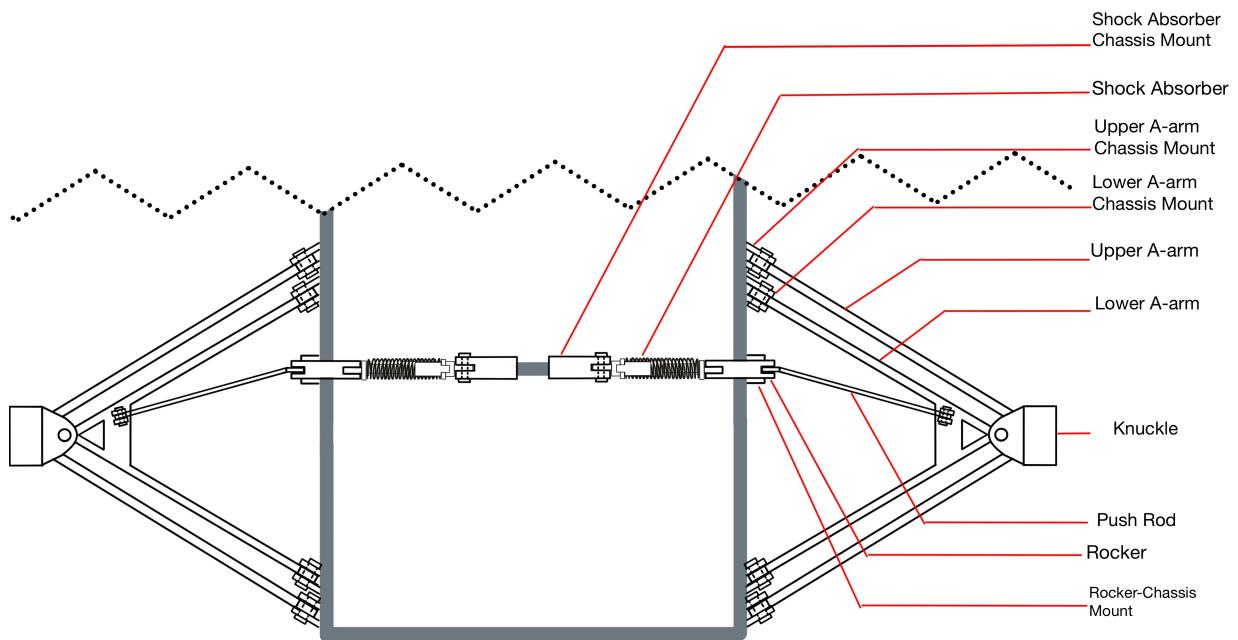


Figure 2.33: Rear Suspension Top View

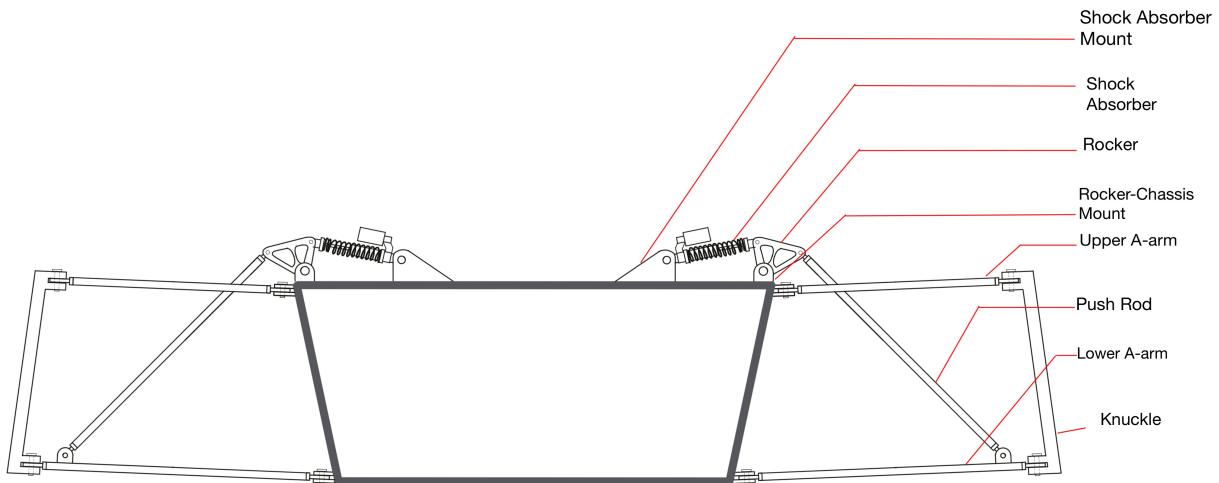


Figure 2.34: Rear Suspension Front View

2.2.9.2 Components

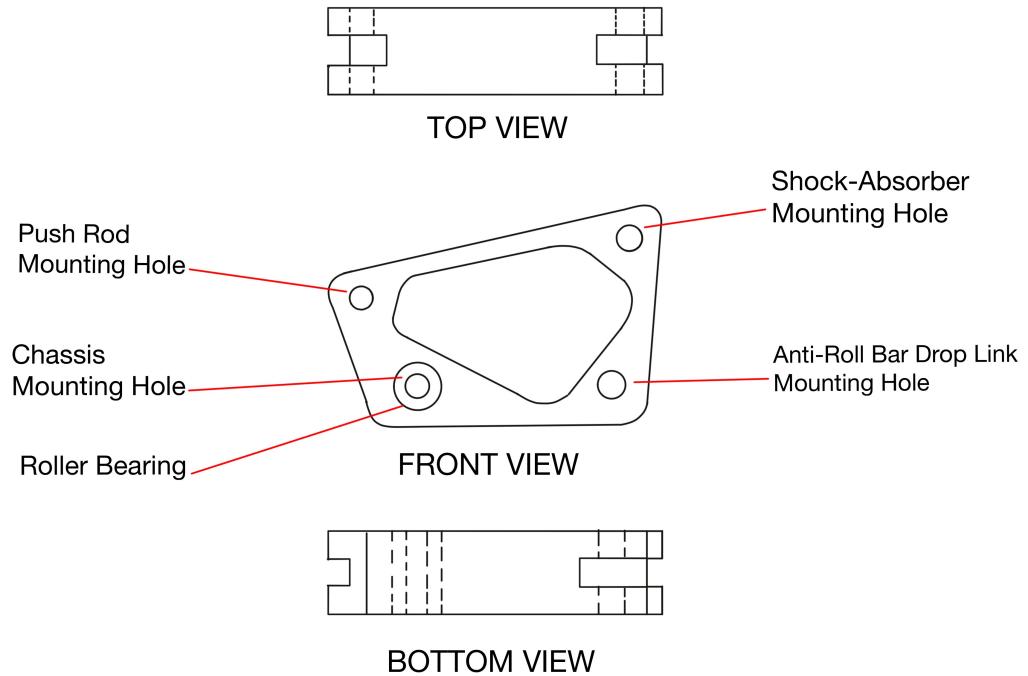


Figure 2.35: Rocker

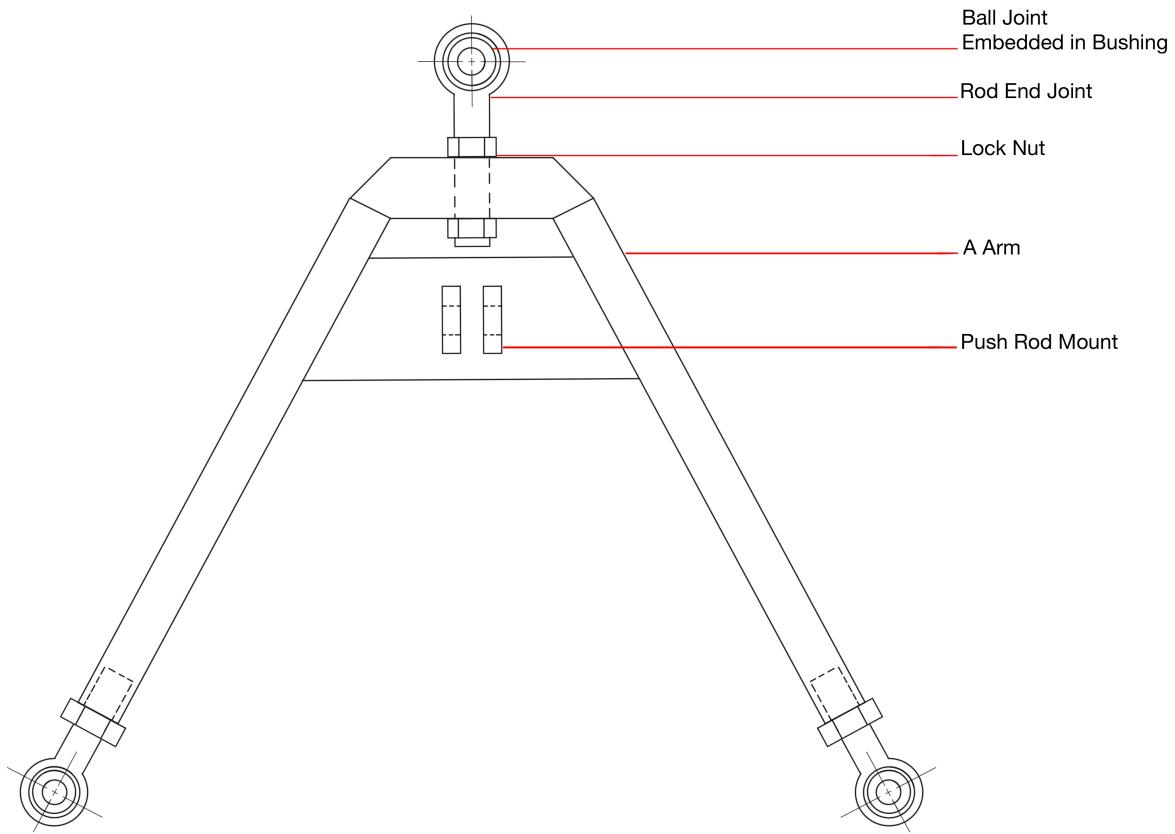


Figure 2.36: Front Suspension Lower A-Arm

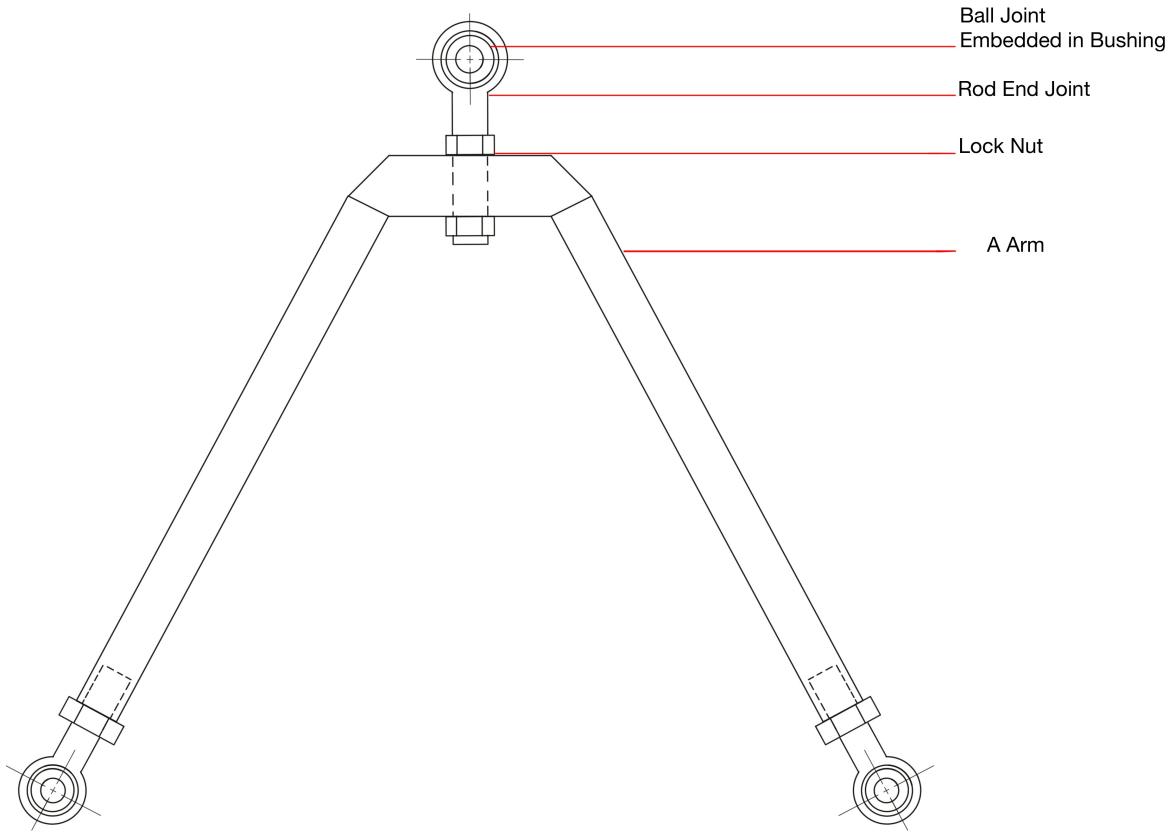


Figure 2.37: Upper A-Arms

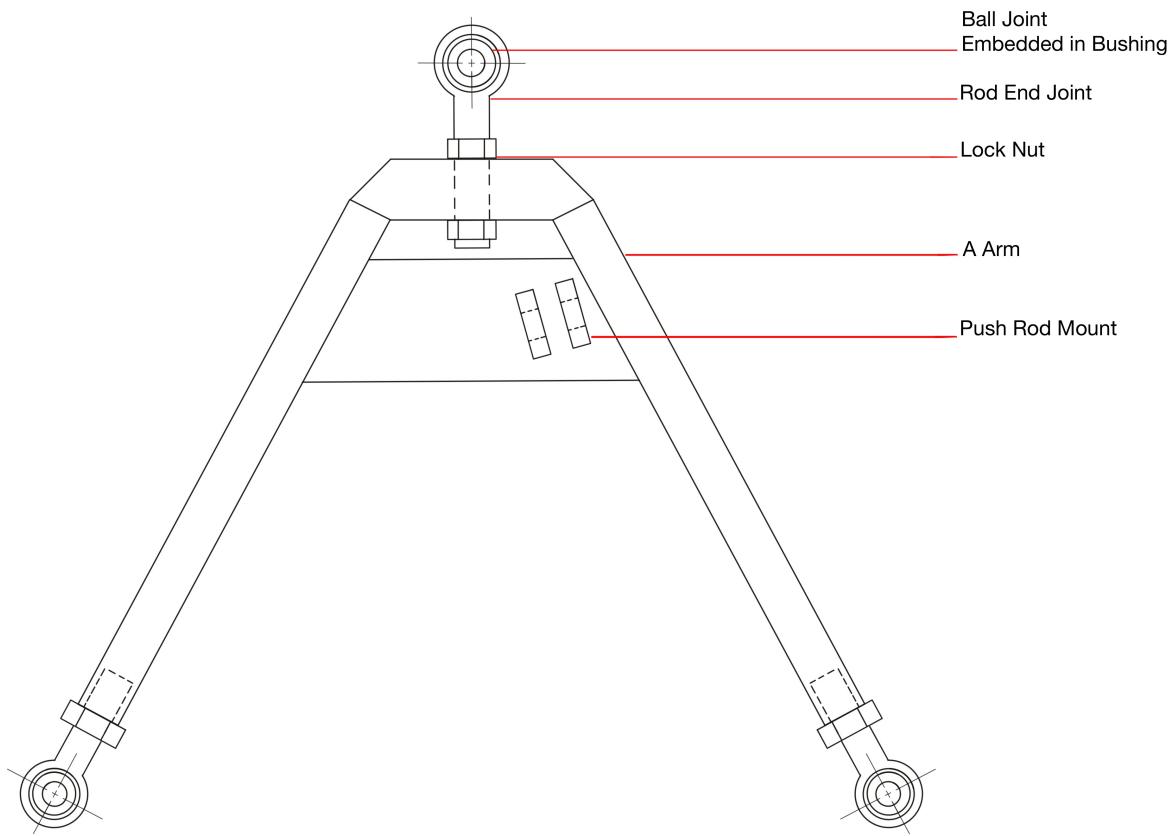


Figure 2.38: Rear Suspension Lower A-Arm

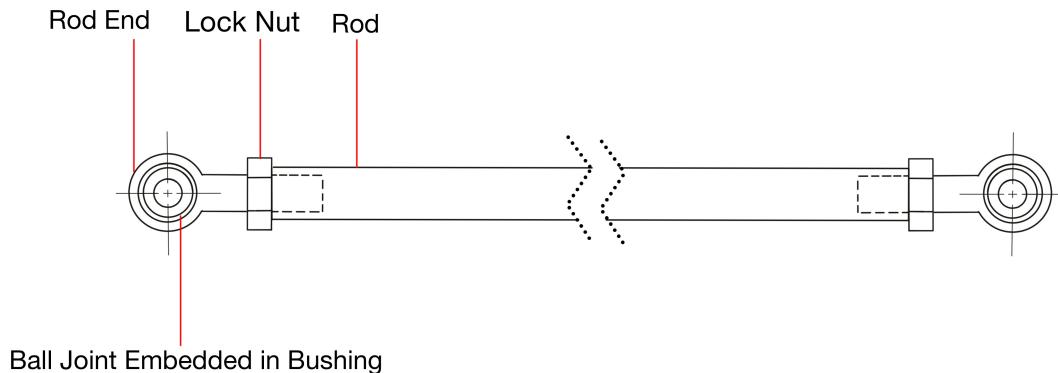


Figure 2.39: Push Rods/ Anti-roll Bar Drop Links

APPENDICES

Appendix A

Data Sheets

A.1 Sony VTC 6 Data Sheet summary

2. Cell Rating セル定格

Item 項目	Rating 定格	Note 備考
2.1 Rated Capacity 定格容量	3000mAh	Discharge at 0.2ItA, 2.0Vcutoff after Standard Charge 0.2ItA, 2.0V 終止放電での容量規格値、充電は標準充電
2.2 Maximum Charge Voltage 最大充電電圧	4.25V	
2.3 Cut Off Voltage 放電終止下限電圧	2.0V	
2.4 Continuous Maximum Charge Current 連続最大充電電流	5.0A	Continuous 連続
	6.0A	Pulse パルス
2.5 Continuous Maximum Discharge Current 連続最大放電電流	30A	(With 80 deg temperature cut) (温度カット 80°Cあり)
	15A	(Without 80 deg temperature cut) (温度カット 80°Cなし)
2.6 Allowable Environment Temperature 使用雰囲気温度	Charge 充電	0～+60°C
	Discharge 放電	-20～+60°C
2.7 Weight 質量	46.6+-1.5 g	

※ Cell condition at the shipment About 75% discharged. セル 出荷状態 約 75%放電

Figure A.1: Data Sheet for Sony VTC6 Battery Cell (1)

2.8 Cell Temperature Spec セル温度規格									
2.8.1 Charge Conditions 充電条件									
Temperature Range / Cell Surface Temperature Range 温度範囲 / セル表面温度			Upper Limited Charging Voltage 上限充電電圧	Maximum Charging Current 最大充電電流	Charging Current Recommendation 推奨充電電流				
1	Low Charging Temperature Range 低温度域	$0^{\circ}\text{C} \leq T < 10^{\circ}\text{C}$	A	4.25V	2.00A				
			B	4.15V	4.00A				
2	Standard Charging Temperature Range 標準温度域	$10^{\circ}\text{C} \leq T \leq 45^{\circ}\text{C}$		4.25V	5.00A				
3	High Charging Temperature Range 高温度域	$45^{\circ}\text{C} < T \leq 60^{\circ}\text{C}$		4.20V	5.00A				
At Low Charging Temperature range, condition A and B are both available. Recommended condition is B. 低温度域は条件 A または条件 B のどちらかを選択できる。推奨は条件 B。									
2.8.2 Discharge Conditions 放電条件									
Discharge at cell surface temperature below 80°C . セル表面温度が 80°C 以下で放電をおこなうこと。									
3. Cell Nominal Value セル公称値									
Item 項目	Nominal 公称	Note 備考							
3.1 Nominal Capacity 公称容量	3120mAh	Discharge at 0.2lA, 2.0Vcutoff after Standard Charge 0.2lA, 2.0V終止放電での容量規格値、充電は標準充電							
3.2 Nominal Voltage 公称電圧	3.6V								
3.3 Charge Voltage 充電電圧	4.20V								
3.4 Energy Density エネルギー密度	631Wh/l								
4. Shape/Dimension and Appearance 形状 / 寸法と外観									
4.1 Shape/Dimension (Ref. P11 7. Outline) 形状 / 寸法 (参照:P11 7. 外形)									
Diameter of crimp クリップ部外形	18.35 +0.15 / -0.20mm								
Diameter of trunk 創部外形	18.35 +0.15 / -0.20mm (excluding wrinkle on the tube)								
Total Height 総高	65.00 +/- 0.2mm								
4.2 Appearance 外観									
It shall be free from any defects such as remarkable scratches, breaks, cracks, discoloration, leakage, or deformation. It shall be clean, and have equality and product value. 著しい傷、破損、ひび、変色、液漏れ、変形のないものとし、清潔、均一で製品価値を持つものとする。									

Figure A.2: Data Sheet for Sony VTC6 Battery Cell (2)

A.2 Emrax 228 Data Sheet Summary



User's Manual for Advanced Axial Flux Synchronous Motors and Generators

EMRAX 228 Technical Data Table (dynamometer test data)

Technical data	Type	EMRAX 228 High Voltage			EMRAX 228 Medium Voltage			EMRAX 228 Low Voltage										
		AC	LC	CC	AC	LC	CC	AC	LC	CC								
Air cooled = AC																		
Liquid cooled = LC																		
Combined cooled = Air + Liquid cooled = CC																		
Ingress protection	IP21	IP65	IP21	IP21	IP65	IP21	IP21	IP65	IP21	IP21								
Cooling medium specification (Air Flow = AF; Inlet Water/glycol Flow = WF; Ambient Air = AA) If inlet WF temperature and/or AA temperature are lower, then continuous power is higher.	AF=20m/s ; AA=25°C	WF=8l/min at 50°C; AA=25°C	WF=8l/min at 50°C; AA=25°C	AF=20m/s ; AA=25°C	WF=8l/min at 50°C; AA=25°C	WF=8l/min at 50°C; AA=25°C	AF=20m/s ; AA=25°C	WF=8l/min at 50°C; AA=25°C	WF=8l/min at 50°C; AA=25°C	WF=8l/min at 50°C; AA=25°C								
Weight [kg]	12,0	12,3	12,3	12,0	12,3	12,3	12,0	12,3	12,3	12,3								
Diameter ø / width [mm]						228/86												
Maximal battery voltage [Vdc] and full load/no load RPM	670 Vdc (5300/6500 RPM)			470 Vdc (5170/6500 RPM)			130 Vdc (4400/5200 RPM)											
Peak motor power at max RPM (few min at cold start / few seconds at hot start) [kW]	100																	
Continuous motor power (at 3000-5000 RPM) depends on the motor RPM [kW]	28 - 42	28 - 42	35 - 55	28 - 42	28 - 42	35 - 55	28 - 42	28 - 42	35 - 55									
Maximal rotation speed [RPM]	5500 (6500 RPM peak for a few seconds)																	
Maximal motor current (for 2 min if cooled as described in the manual) [Amps]	240		340		900													
Continuous motor current [Amps]	115		160		450													
Maximal motor torque (for a few seconds) [Nm]	240																	
Continuous motor torque [Nm]	125																	
Torque / motor current [Nm/1Aph rms]	1,1			0,75			0,27											
Maximal temperature of the copper windings in the stator and max. temperature of the magnets [°C]	120																	
Motor efficiency [%]	92 – 98																	
Internal phase resistance at 25 °C [mΩ]	18			8,0			1,12											
Input phase wire cross-section [mm²]	10,2			15,2			38											
Wire connection	star																	
Induction in Ld/Lq [μH]	177/183			76/79			10,3/10,6											
Controller / motor signal	sine wave																	
AC voltage between two phases [Vrms/1RPM]	0,0730			0,0478			0,0176											
Specific idle speed (no load RPM) [RPM/1Vdc]	9,8			14			40											
Specific load speed (depends on the controller settings) [RPM/1Vdc]	8 – 9,8			11 – 14			34 – 40											
Magnetic field weakening (for higher RPM at the same power and lower torque) [%]	up to 100																	
Magnetic flux – axial [Vs]	0,0542			0,0355			0,0131											
Temperature sensor in the motor	kty 81/210																	
Number of pole pairs	10																	
Rotor inertia (mass dia=175mm, m=5,5kg) [kg*cm²]	421																	
Bearings (front:back) - SKF/FAG	6206:6206 (for radial forces) or 6206:7206 (for axial-radial forces; for pull mode, e.g. for air propeller) or 6206:3206 (for axial-radial forces; for pull-push mode; $\alpha=0^\circ$ orientation, $\alpha=25^\circ$); other bearings are possible (exceptionally)																	

Figure A.3: Data Sheet for Emrax 228 Motor