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Designing and Controlling of Electric Go-Kart

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Abstract: -

Electric go-kart frontmost in sustainability transport and fun engineering. The document constructs design considerations and control tactics crucial for boost performance and safety of electric go-karts with a BLDC engine (5KW, 48V, 3000rpm) and lithium-ion battery (48V, 35Ah). This go-kart it's been designed under the regulations of Global Karting Championship - 2023 Season 9. By a detailed examination of writings and experimental study, we investigate crucial aspects like framework blueprint, engine picking, battery technological advancements, and control structure organization. The searching uncovers revelations about the complicated equilibrium among potency effectiveness, quickening, and manage qualities in electrical go-kart blueprint. Further, we tackle imperative safeness reflections, enveloping high-voltage electric arrangements and exigency shut-down system. The repercussions of this exploration stretch beyond the sphere of electrical go-karts, adding to the wider region of electronic automobile engineering and eco-friendly mobility. Design principle and control method clarification in this here paper establish the groundwork for forthcoming electric go-kart technology advancement, possible use in recreational or business environments.

Key Words: - Electric Go-karts, Design Considerations, Controlling Strategies, Enhanced Performance, and Safety system.

Introduction: -

Electric go-karts are swift becoming centrepiece in domain of environmentally friend transportation and recreational engineer. As push for environmentally conscious options intensify, electrical vehicles (EVs) have captured considerable attention, with electric go-karts stand out for combination of performance and eco-friendly.

However, amongst this undeveloped interest, there exists a perceivable gap in research regarding the complex engineering and control details vital for optimizing electric go-kart performance and safety. This paper aims to address this gap by exploring deeply into the technical complexities of electric go-kart design and control, with a specific emphasis on vehicles outfitted with a BLDC (Brush-less DC) motor (5KW, 48V, 3000rpm) and a lithium-ion battery system (48V, 35Ah).

Our main objectives are two-part: firstly, we aim to clarify the fundamental engineering principles regulating electric go-kart performance, particularly focusing on the complexities of the BLDC motor and lithium-ion battery system; and second, to devise advanced control strategies customized to optimize the efficiency, responsiveness, and overall performance envelope of such electric go-karts, especially in competitive races.

By utilizing a combination of theoretical analysis, computer-based modelling, and practical validation, this research seeks to provide actionable insights and practical suggestions for enhancing the design and operation of electric go-karts equipped with BLDC motors and lithium-ion batteries. Beyond the boundaries of electric go-karts, this research is positioned to contribute to the wider perspective of electric vehicle engineering and motorsport technology.

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Literature Review:

1) Design, Modelling and development of a Go-Kart Vehicle by Joe Johnson, Dinesh Kumar K, Sai Praneeth, Yathiraj and Ravi Shankar [2]: - In this research paper a Go-kart designed modelled and tested in track. The design requirements are as per guidelines of 2017 International Conference on Advances in Mechanical, Industrial, Automation and Management System (AMIAMS).

2) Design and fabrication of a Hybrid Go-Kart by Mohamed Haseb and Kizhakkelan Sudhakaran Siddharth [3]: - This paper practically designed a hybrid version of go-kart. Currently it operates by fixing an electric motor which acts as a secondary engine for this race car. The kart doesn't automatically change its primary power source to secondary source which is motor. It has to be switched manually.

3) Comparison of three different electric powertrains for the use in high performance Electric Go-Kart by Docter Harald Neudorfer [4]: - The comparison of the propulsion systems shows that the Electric Go-Kart powered by the Permanent Synchronous motor has the best results in efficiency and milage as compared to Switched reluctance motor and induction motor. Due to technology the drag losses of that Electric Go-Kart are the highest.

4) E-Racer, a Joystick Controlled Go-Kart by Alex Kattamis, Alex Peslak, Steve Ricciardelli, William Pruehsner, John D. Enderle [5]: - This go-kart was originally designed for a boy with cerebral palsy. In this steering wheel and driving pedals of the kart were removed and were connected with a joystick and a PIC microcontroller. One actuator motor is connected with steering column and the other with braking system.

5) Electric Go-Kart with Battery-Ultracapacitor Hybrid Energy Storage System by W. O. Avelino, F. S. Garcia, A. A. Ferreira, and J. A. Pomilio [6]: - The combination of ultra capacitors and batteries along with the suggested control strategy, offers substantial benefits by effectively leveraging the unique strength of each power source. A multiple-input DC-DC converter was employed to merge the two energy storage devices, facilitating a control strategy that allocates power between them effectively.

6) Design of an autonomous electric single-seat vehicle based on environment recognition algorithms by Jason Valera, Luigi Huaman, Lui Pasapera, Eduardo Prad, Luis Soto, and Luis Agapito [7]: - The simulations accurately mimic real-world conditions, allowing neutral networks and computer vision to tackle genuine road driving challenges. Furthermore, mechanical, and electrical designs cater to full size vehicle requirements.

7) Design and Development of a Go Kart by Tyrone Machado and Prof. Vijay Kulkarni [8]: - The go-kart design prioritizes safety while maintaining a simple yet robust structure. This approach ensures that the go-kart can be manufactured easily, benefiting from its straightforward design without sacrificing safety or performance. It consists of 4 innovations: GPS, seat belt ignition interlock, side bumper protection, and remote kill switch.

8) Structural optimisation of go kart chassis with basic electronic driver assistance systems by Kulbeer Rawat, Deepak Kumar, Roushan Kumar, Deepak Bharadwaj, Vedaant Soti, Gopal Rathore, Debdyuti Biswas, and Poornima Singh [9]: - The chassis was redesigned according to standards set by the federation of motor sports clubs of India, enhancing the existing structure used by team dirt marshals in the auto India racing championship season 4. Some additional systems for added for instance, obstacle detection system and anti-lock braking system.

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FRAME DESIGN

- **Objective**

  The principal objective of the chassis was to sum up all the components required for the kart, including the driver, optimally and safely. The most important factors of the chassis focused on during the designing and applying included safety of the driver, integration of the drive train, weight of the structure, and ergonomic for operator. The top priority in the chassis designing was safety for the driver. The design assured:

  1. Protection of the driver.
  2. Low centre of gravity was maintained.
  3. Chassis with good strength and low weight
  4. Every component was fitted on the chassis perfectly.

- **Design**

  The chassis of a go-kart be a skeleton frame constructed of pipes and materials of varied cross sections. The chassis of a go-kart need to have stability, torsional rigidity, and somewhat of flexibility being without any suspension. Besides, it should give adequate strength in sustaining the load of an operator and other accessories.

  The chassis design with consideration for the convenience and safety of the operator. The chassis were planned for a safe ride and to carry loads without jeopardizing their structural integrity.

Fig.1 – Chassis Design

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a) Material Specification

In our endeavour to engineer an electric go-kart that excels in both performance and safety, we've opted to employ AISI 1020 steel tubes for the chassis construction. Praised for their robustness and weldability, these tubes form a solid foundation for our vehicle, ensuring durability and structural integrity on the track.

AISI 1020 steel, which an inferior carbon steel mix, commonly uses in different industry jobs thanks its great weld ableness, machine ableness, and formability.

The chemical composition of AISI 1020 is as

Carbon C	=	0.202%
Iron Fe	=	99.225%
Manganese Mn	=	0.525%
Phosphorus P	=	0.014%
Sulphur S	=	0.004%

Properties: -

Density	7.87 g/cc
Hardness, Brinell	121
Hardness, Knoop	140
Hardness, Rockwell B	68
Hardness, Vickers	126
Tensile Strength, Ultimate	518 MPa
Tensile Strength, Yield	403 MPa
Elongation at Break	15 %
Reduction of Area	40 %
Modulus of Elasticity	186 GPa
Bulk Modulus	148 GPa
Poisson’s Ratio	0.29
Machinability	65 %
Shear Modulus	72.0 GPa

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BHARTIYA MANUFACTURING INDUSTRIES
PLOT NO. 427 INDUSRTIAL AREA, PHASE-2 CHANDIGARH
WORK TEST CERIFICATE

CUSTOMER : TEAM EGTA
SIZE : 25.4 ODX1.6mm, 31.75 ODX1.6mm
INVOICE NO : 12558
DATE : 29.11.2023
SPECIFICATION : AISI 1020
BATCH CODE : BMI/2023-24/2433

T.C. NO. 2861
DATE: 29.11.2023

S. NO	DIMENSION		PHYSICAL PARAMETRS				CHEMICAL PARAMETERS						
	O.D [mm]	Thickness [mm]	AREA	TS Mpa	YS Mpa	% El	C%	Mn%	S%	P%	Si	Cr.	Mo.
1.	25.40 MM	1.6 MM	-	518	403	15	0.202	0.525	0.004	0.014	-	-	-
2.	31.75 MM	1.6 MM	-	530	411	17	0.208	0.560	0.006	0.020	-	-	-

LENGTH - MTR/KGS

This is to certify that the material supplied confirm to all requirements as specified by the customer

BHARATIYA MFG. INDUSTRIES
427, Indl. Area, Phase-II,
Chandigarh - 160 002
(Q.C.)

BHARATIYA MFG. INDUSTRIES
427, Indl. Area, Phase-II.
Chandigarh - 160 002
AUTHORIZED SIGNATORY

Fig. - Material Test Certificate (MTC)

b) Safety

Roll cage feature was first implemented by keeping in mind safety requirements. The primary safety standard first focused on during design was maintain a correct clearance of driver's body rest to rigid parts like engine compartment, firewall structure. After essential requirements were fulfilled, other safety designs were implemented. The chassis was designed to provide occupant with extra space for controlling the vehicle easily. The location of the fire extinguisher is designed at an easily accessible point and, earthen foam padding is provided over the pipes adjacent to driver.

ELECTRICAL SYSTEM

- **Motor: -**

The motor we are using for our go kart is the Brushless DC motor (BLDC) which is 5KW 48V 3000 RPM.

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Initially, the force output of 5KW guarantees plentiful torque and acceleration possibilities, enabling the go-kart to achieve high speeds rapidly. This high-power output is vital for competitive racing scenarios where swift acceleration can create a remarkable difference.

Also, the voltage rating of 48V provides an equilibrium between performance and safety. A 48V system offers enough power while still being practical and secure for the driver, particularly in terms of electrical safety and jolt risks.

Furthermore, the brushless design of the motor provides numerous advantages over conventional brushed motors, including superior efficiency, lesser maintenance conditions, and a lengthier lifespan. These parameters are fundamental for decreasing downtime and guaranteeing uniform performance on the racetrack.

Finally, the motor's rated speed of 3000rpm allows for versatile performance. It provides suitable top speed for racing while also supplying good low-end torque for receptive acceleration, facilitating the go-kart to operate diversely in various driving environments.

In conclusion, the BLDC motor with a rating of 5KW, 48V, and 3000rpm delivers the ideal balance of power, safety, efficiency, and performance attributes required for our electric go-kart project, making it the best choice for our application.

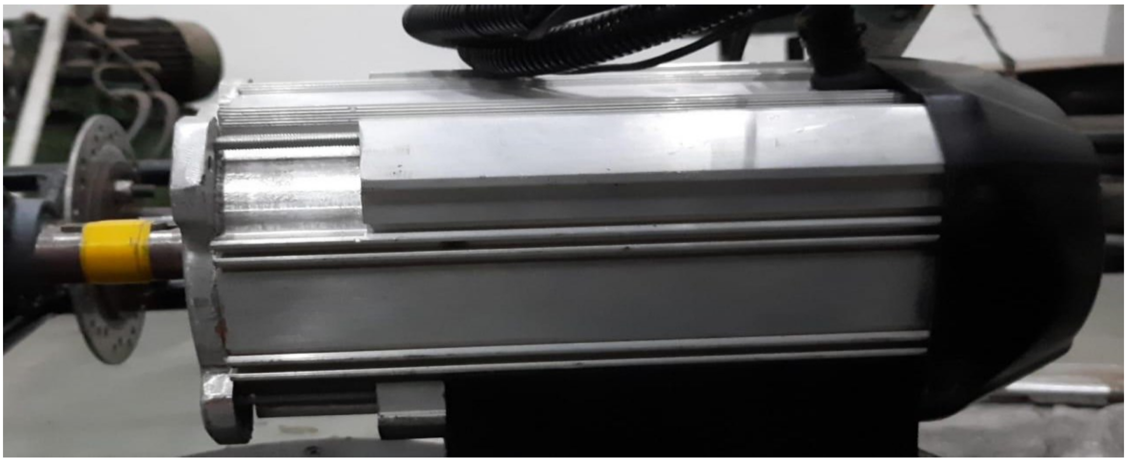

Fig. – BLDC Motor

- **Controller: -**

Based on our motor we must choose our controller according. For that reason, we have used KELLY Programmable Controller.

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Fig. – Kelly Controller

- **Battery: -**

We have chosen 48v, 35Ah Lithium-ion battery. Voltage rating of 48 volts supplies a harmonious balance between power output and safety. It provides adequate voltage for high-performance functions while still being controllable and safe for driver, particularly concerning electrical safety and shock hazards.

Not to mention, the high capacity of 35Ah ensures sufficient energy storage for extended driving durations, allowing for prolonged driving sessions without recurrent recharging, essential for endurance racing or long track sessions. On top of that, lithium-ion chemistry offers multiple advantages over traditional lead-acid batteries: higher energy density, lighter weight, and longer lifespan, crucial for reducing overall weight, enhancing performance, lowering maintenance requirements, and increasing battery pack longevity.

Furthermore, lithium-ion batteries' capability to provide high currents constantly makes them ideal for applications requiring rapid acceleration and high-power output in competitive racing scenarios! Ultimately, the 48-volt, 35Ah lithium-ion battery provides the optimal synchronization of voltage, capacity, energy density, and performance attributes necessary for our electric go-kart project! Its reliability, safety, and efficiency make it the best choice for powering our vehicle and ensuring a competitive edge on the racetrack.

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Fig. – Lithium-ion Battery

STREERING SYSTEM DESIGN

The mechanical system selected to be implemented in this kind of steering system was utilized because of its straightforward design, mechanism, and a steering ratio of 1:1. The steering system implemented in this electric go kart is Ackerman Steering System.

Reason: Ackerman offer 60-degree lock-to-lock twists of helm wheel that be so suite for track as it gives quick twists with tiny information and be extra precise at same time

BRAKING SYSTEM DESIGN

For our project on electric go kart we have used the Hydraulic Braking System. The mechanism of the brakes must give adequate force to fully lock the wheels at the end of given acceleration run, and along with that it should be cost efficient too.

In go-karts, hydraulic braking systems function similarly to those found in larger vehicles. Albeit in a more compact and simplificated form due to the smaller scale of go-karts. When the driver applying presses to the brake pedal, the system initiates a sequence of hydraulic actions. This mechanical force is transnoted to the master cylinder, a key component of the hydraulic system, which converts it into hydraulic pressures.

The hydraulic pressures generated are then transnoted through brake lines or hoses to the brake callipers, typically located on the rear axle of the go-kart. In modern go-karts, hydraulic disk brakes are commonly used. The hydraulic fluids enter the brake callipers, where pistons push brake pads against brake disks (rotors) attached to the rear axle. This contraction creating frictions, slowing down the rotation of the rear wheels and consequently, the go-kart. While the brakes pads are pressing against an disk, frictions was generated, convert the kinetic energies of a moving go-kart into hot energy, effectually slowing down the vehicle, and brought it to a stop.

When drivers release a brake pedal, hydraulic pressures in a brake line are relieved, that allows a brake pads to retract from a disks, and wheels for rotating freely once more. This hydraulic braking system offers responsive, precisely, and consistencies braking performances, crucial for navigating tight cornering and achieving optimal laps times on the tracks. While also requiring minimal maintenances and providing excellently modulation for the driver's controls.

Complete Vehicle Specification:

S.No.	Parameters	Specifications
1.	Overall Length	69”
2.	Overall Width	45”
3.	Overall Height	48”
4.	Wheelbase	40”
5.	Front Track Width	30”
6.	Rear Track Width	32”
7.	Ground Clearance	1.5”
8.	Max Speed	90km/hr
9.	Max Acceleration	4.5m/s^2
10	Stopping Distance	2.6m
11.	Overall Weight	165kg
12.	Steering Ratio	1:1
13.	Motor	BLDC motor 5KW 48V 3000rpm
14.	Battery	48V 35Ah Lithium-ion

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CHASSIS DESIGN

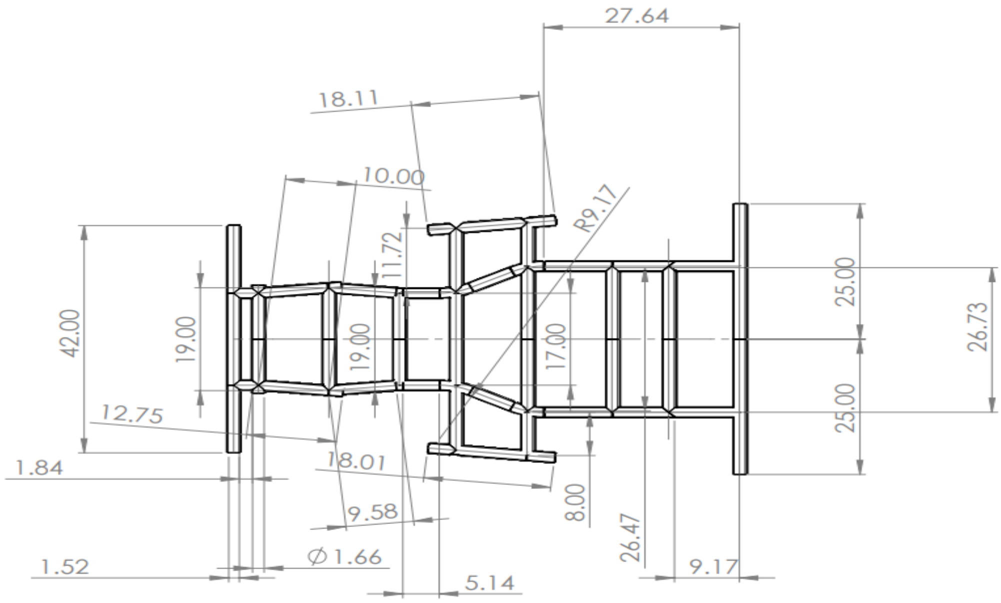

Fig. – 2D Model of Chassis

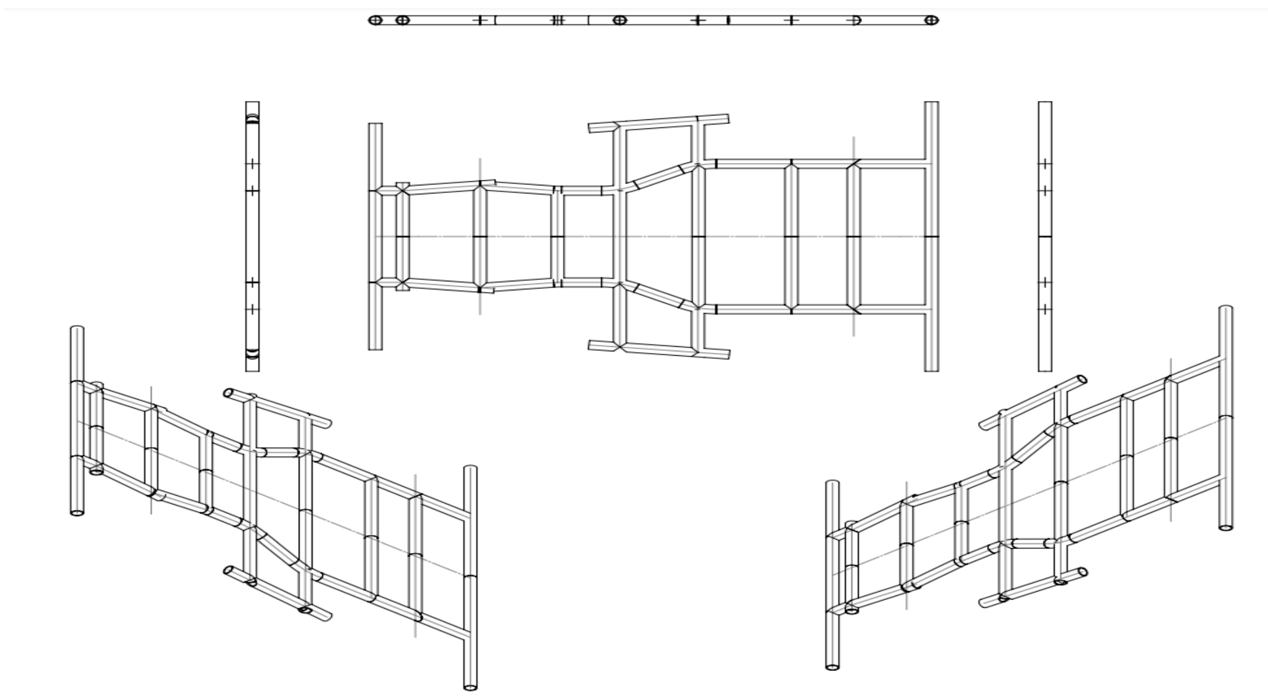

Fig. – Chassis made from AISI 1020

ANALYSIS

- Battery

Calculation of Battery charging time:

Time taken for charging = Battery AH / Charging Current (A)

Calculation of Charging current = current of charging should be 25% of Ah rating of battery

=35(25/100) =8.75A

Due to losses, we take it as (8.75A + 1A) loss = 9.75A

T= 35/9.75 = 3.589 ~3.6 hour (ideal case)

Practical Case = 40% loss occur = 35(40/100) = 14A

Charging time of battery = (35+14)/9.75 = 5.02 hour

Discharging time = (battery Ah * battery volt)/ applied volt

= (49 x 48)/ 2500 = 56min27sec

- **Complete Vehicle Specification:**

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RESULTS




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OTHER COMPONENTS USED

Fig. – Taillight

Fig. – Wheel

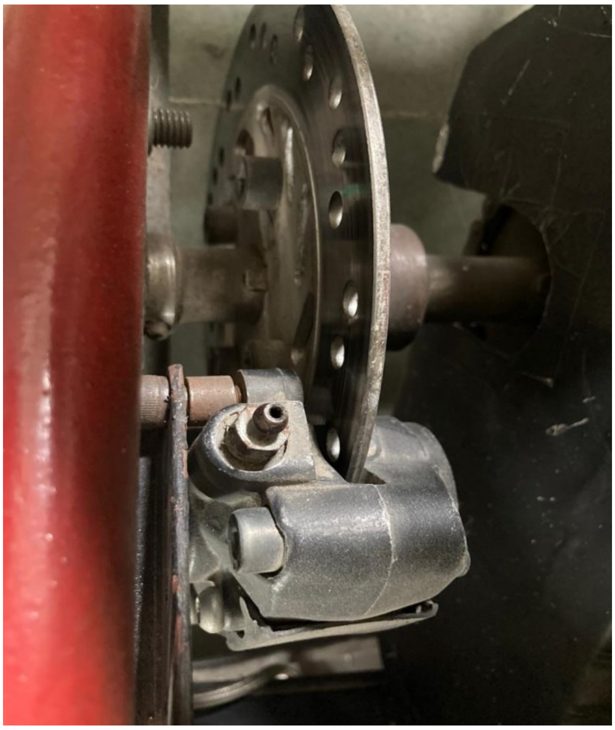

Fig. – Wheel Cylinder

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CONCLUSION

In this project, we have carefully engineered an electric go-kart that exemplifies advanced technology and innovative design principles. By incorporating a high-performance BLDC motor (5KW, 48V, 3000rpm) with a robust 48-volt, 35Ah lithium-ion battery, we have attained exceptional levels of power output and energy efficiency, producing superior on-track performance.

Our design includes advanced features such as the Ackermann steering mechanism and hydraulic braking system, engineered to provide precise handling and dynamic responsiveness. The utilization of a complex programmable controller facilitates seamless integration and synchronization of propulsion and braking systems, enhancing overall vehicle dynamics and control.

Fabricated from AISI 1020 steel tubes, the chassis provides a lightweight yet structurally rigid platform that ensures ideal weight distribution and torsional stiffness. Safety considerations are of utmost importance, with the inclusion of a kill switch and strategically placed bumpers (front, rear, and side) to minimize collision risks and safeguard the driver.

Through meticulous testing and verification, we have demonstrated the reliability and effectiveness of our electric go-kart design in real-world racing conditions. Our project highlights the revolutionary potential of electric propulsion in motorsports, leading the way for sustainable and high-performance racing platforms.

As we draw this project to a close, we remain devoted to continual enhancement and improvement of our design through recurring development cycles and data-driven analysis. With a focus on pushing the limits of electric vehicle technology, we are prepared to lead the charge towards a greener, faster, and more thrilling future in motorsport engineering.

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8. Design and Development of a Go Kart by Tyrone Machado and Prof. Vijay Kulkarni
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