­Electric Go Kart

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**Abstract**

Go karts are fun, fast, little vehicles that can ride on both dirt and asphalt. However, gas go karts are loud, produce a lot of toxic fumes that harm the environment, and get hot to the point of burning. Performance of gas go karts is also abhorrent since the torque reaches a maximum at a non-zero speed. Thus, a motor must wind up to produce peak torque and peak acceleration. This has led to more go karts being powered by electric motors instead since they develop peak torque at zero RPM. This paper will go through the modeling, design, construction, and testing of building a simple 12V electric go kart using mostly off the shelf parts with custom controller code as well as developing a kit for others to buy and convert their gas kart to electric power.

Keywords: *SIMULINK, MATLAB, SEPERATELY EXCITED DC MOTOR, ELECTRIC GO KART*

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Electric Go Kart

Electric vehicles are hot topic in 2020, more and more vehicles are being made as hybrids such as the Chevy Volt and others such as the Tesla Roadster, all electric. However, go karts are still mainly gas powered which have poor torque speed curves and produce a lot of dirty smoke that is bad for the environment. However, since cars have the capability of being made all electric, why cannot go kart be made similar. Therefore, I decided to design and build a 2kW electric go kart system using mostly off the shelf components but with custom controller software. One goal of this project is to develop a model of the kart with many low order effects such as air resistance, rolling resistance, etc. Another main goal of this project is to build a kit that anyone could order and adapt to a kart they already have.

# Modeling

## Model and performance parameters

Modeling is the second part of the design process behind making back of the hand calculations to see if the request is possible. Modeling provides insight to how the device will behave under different conditions without the possibility of safety issues or parts breaking. While it cannot produce real world tests, they are usually accurate enough to make a design that requires minimal changes during actual construction. Table 1 shows some of the design parameters that I have set for the kart.

|  |  |
| --- | --- |
| **Parameter** | **Value (unit)** |
| Mass | 200 (kg) |
| Driven Wheel Radius | 0.2286 (m) |
| Transmission Gear Ratio | 12.75:1 |
| Sprocket Ratio | 1:1 |
| Number of Motors | 6 |

Table . Rough design parameters

Table 2 shows some of the performance requirements that have been set.

|  |  |
| --- | --- |
| **Parameter** | **Value (unit)** |
| Top Speed | < 25 (MPH) |
| 0 to Top Speed Acceleration | <5 (s) |
| Current Draw at Full Speed | < 15 (A/motor) |
| Total Cost | < $2000 |

Table . Desired performance metrics

At this point, it is necessary to note that these are just desired performance and design parameters. They can change at any point of they cannot be obtained or if they conflict. An example of conflicting parameters would be having six motors, but it causes the cost to go above $2000. This would require a decision to be made as to which parameter is more important. If the cost of having six motors goes above the maximum cost but having only 4 motors decreases the run time by 50% due to increased current draw, it is not worth downgrading to only four motors.

## Separately excited DC motor

This kart will use separately excited DC motors of the 12V variety. While 48 and 72V motors would be better since the current draw is not as high. The component cost to use them would go up as well as the number of batteries required which makes the kart heavier. First, we develop the model of the motor as itself and then we can add the other parts of the system in. Separately excited motors can be modeled using the simple circuit shown in figure 1.

**Diagram, schematic

Description automatically generated**

Figure . Simple model of DC motor

Now we can develop a set of equations to make the model. Using KVL we get equation 1.

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ea is the input voltage to the system and is how we control the motor. eb is the back-EMF produced by the rotor spinning in the static magnetic field produced by the permanent magnets attached to the inside of the stator. Next, we develop the equation for the rotational system through torque equations.

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Here, τm is the torque that the motor can deliver, J is the moment of inertia, τL is any load torque that is applied to the motor, and B is the motor drag coefficient. τL will be used later to apply air drag, rolling resistance, etc.

These two equations have 4 unknown variables and so we must come up with two more equations to solve it. The two equations relate the armature current in the motor to the torque it can produce and the other is the amount of back-EMF generated by the motor.

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(4)

Using equations 3 and 4 in equations 1 and 2, we get the following result.

(5)

(6)

Since equations 5 and 6 are now just in terms of two variables ia and ω. We can create a block diagram of the model. Figure 2 shows the block diagram of the motor without any loading affects from outside sources.

Diagram

Description automatically generated

Figure . Block diagram of separately excited DC motor

In our case, TL would be zero since there are no outside forces acting on the motor shaft. We also will not be using the block since we care about motor speed.

The issue now is that we have some unknown constants for our system. However, these can be found by doing some calculations on the motor torque-speed curve. This requires us to pick a motor and for this cart, the 2.5” CIM motor from AndyMark was chosen. Looking at the motor curve provided on the site, the stall current is 131A. Combined with the nominal 12VDC input and the internal resistance comes to 91.6mΩ. KT can be found by using the stall torque and the stall current since it is a linear relationship. The stall torque is 2.41Nm and by equation 3 makes KT = 18.39695E-3 . In a perfect motor, KT and KI would have the same value. However, since this motor is not perfect, this value can be found by using equation 5 at steady state meaning the current in the motor is not changing. Thus equation 5 will reduce to

(7)

From which KI can be calculated. Using the parameters derived so far, and an angular speed of 5330 RPM (558.15629 rad/s), KI equals 21.06215E-3 .

B is found by using equation 6 at steady state conditions. Using the free-running speed and torque since friction is the only contributing factor during free-run, B equals 88.99257E-6 .

The last two constants J and L are found by using the step response of the system or direct measurement. However, using the values found from systemvision.com [1] those values are 7.75E-5 and 5.90E-5 H for J and L respectively. Table 3 lists all parameters that will be used for the motor.

|  |  |
| --- | --- |
| **Parameter** | **Value (Units)** |
| Ra | 91.6m (Ω) |
| La | 5.90E-5 H |
| B | 88.99257E-6 |
| J | 7.75E-5 |
| KT | 18.39695E-3 |
| KI | 21.06215E-3 |

Table . Calculated DC motor model parameters

# Noise Generation and Visualization

# Message Generation and Visualization

# Message Modulation using FM

# Channel

# Message Demodulation using Differentiation and Envelope Detection

# SNR

# Conclusion

References

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