Optimal Design Report

Team 5 – Go-Kart
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Go-Kart for Joey Toce
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1.1 Introduction

The purpose of the project is to design and build a go-kart for a child with Mixed type Quadriplegic Cerebral Palsy (CP) with a second diagnosis of Global Apraxia. The client is a six year boy, who enjoys having fun, the outdoors and all typical boy activities. His CP inhibits him from doing most activities including operating a typical go-kart. He has poor trunk strength, and limited motor control. He cannot sit up unassisted and does not have the strength or motor control to operate a steering wheel.

Due to his poor trunk strength, the client will need a seat with supports that will allow him to sit up. He also kicks his legs when he gets excited, which causes him to fall out of typical seats. The seat will be equipped with a harness system for his trunk as well as straps to prevent kicking. Strapping his legs will prevent him from falling out of the seat as well prevent injury to him or damage to the go-kart.

His limited motor control also prevents him from being able to operate a typical go-kart steering wheel. As of now, his motor control is so limited that he can only press buttons, but his strength is also restricted. This means that the buttons need to be very sensitive to touch.

The go-kart chassis will be purchased from Northern Tool and Equipment. The frame is made of steel and will have a roll bar to optimize safety. The chassis purchased will have steering and braking systems in place. The steering system will be replaced with electronic controls, and the braking system will be modified so that it can be controlled electronically.

The chassis also comes with a seat already in place. This seat will be replaced by two individual seats. The seat for the passenger will be a regular bucket seat with harness. The seat for the client will be tailored to his specific needs. Since he cannot sit up due to his limited trunk strength, the seat will have side supports to prevent him from sliding to one side. There will also be leg straps to prevent the client from kicking his legs when he gets excited. This is not only to prevent damage to the go-kart, but also to help prevent injury.

The power will be supplied by three deep cycle marine batteries. These batteries will provide power for the drive system and all of the other electric motors, and the electronic components. Since all of the systems in the go-kart are electrically powered, the batteries need to be durable and there needs to be a way to recharge the batteries.

There will be two different modes of control possible. The first mode of control will be a remote control. The remote control, donated by Miratron, Inc, will be custom built to meet our specific needs. The remote will control steering, speed and braking. There will also be an emergency stop button on the remote
which will shut down the go-kart. The second method of control will be jelly bean style push buttons. Jelly bean buttons are very sensitive to touch and require little force to be activated. Since the client is unable to push regular buttons, these buttons will be used. These push buttons will control steering, one for left, right and forward. All buttons will provide power to the go-kart. The buttons will need to be continually depressed in order for the buttons to continue function. To switch between the two methods of control, a switch button will be on the remote control. This will be able to indicate to the receiver what input should be used.

The signals from the radio remote control and the buttons will be fed into a receiver, also donated by Miratron, Inc. The receiver will also be designed around our specific needs. This receiver will be able to take input from not only the remote and the buttons, but also from other sensors on the go-kart such as the position transducer. The receiver will then process the signal and output the appropriate signal. The receiver is capable of directly driving servo motors, as well as several other types of output specified by the user.

1.2 Subunits

The go kart described is a compilation of smaller subunits. Each of these systems has been individually designed to accomplish a specific task, as well as integrate into the overall system. The following section describes each subunit and the significance of each of them.

**Mechanical Systems**

*Chassis*

The chassis option selected for the optimal design is the prefabricated Stingray complete go-kart chassis kit from Northern Tool. This option, though at first seemingly expensive, will ultimately save money on labor and potential raw material cost. This option was chosen mostly to save time on welding and machining a chassis, allowing for more time to design higher quality subunits. The secondary benefit as stated is in the event of mistakes welding or machining, money will not be lost re-purchasing damaged, unusable materials. This complete chassis kit comes with tires, wheels, brakes, cables, and 60-tooth sprocket. Fig. 1 shows the assembled Stingray Chassis as depicted on the product website.
This chassis has dimensions of $72 \times 43.5 \times 47.25$ in ($l \times w \times h$) and is meant for two people. This double seat model was chosen because it allows for the client’s parents to ride along. The remote control will allow for the parent to operate the kart from a distance as well as from within the kart itself, spending time closer to their son. Not only this, the client will not be able to operate the dashboard controls immediately and will require instruction and practice. By selecting a two seat model the client’s parents can sit in the kart with the client coaching him to learn the dashboard buttons. This will again increase time spent bonding as well as providing constant positive feedback to increase his pattern movements eventually leading to complete individual control.

**Wheel Assembly**

The wheels provided with the complete chassis kit have a 6 in diameter. The tires have a 16 in diameter with semi-deep treads to provide traction on variable surfaces. Fig. 2 shows the tires provided with associated components.
**Seats**

The chassis chosen is a two-person model, equipped with a seat and seatbelts. These do not meet the required specifications for the kart and will therefore not be used in the project. As shown in Fig. 1 the seat provided is a single bench seat with separate safety harnesses for both passengers. Instead of a single bench seat this project will implement two separate seats; one specialized for the client, the other for the passenger. It is important to make clear that the client’s specialized seat will be mounted in the driver’s position to symbolize him as the “owner” of the kart. The passenger seat will be a standard bucket seat depicted in Fig 3. This seat will be equipped with a standard harness providing enough safety for the passenger.

![Bucket Seat (Northern Tool – 13153)](image)

**Figure 3: Bucket Seat (Northern Tool – 13153)**

The specialized seat for the client will be based on his existing wheelchair seat, providing all the similar adjustable supports such as head and neck, trunk, waist and groin. An image of the client’s current wheelchair is shown in Fig. 4. The specialized seat will also have foot rests and leg straps to safely keep the client seated and protected.

![Client’s Current Wheelchair](image)

**Figure 4: Client’s Current Wheelchair**
This seat will only be based on the wheelchair, not exactly like it. The seat in the kart will be slightly tilted back keeping the client safely positioned while in motion, as well as keeping his knees bent without raising the center of gravity. Furthermore, it will be permanently fixed to the go kart on adjustable sliding tracks easing entry into the kart as well as accounting for future growth.

**Harness**

The harness show below in Fig. 5 is what will be used for the client’s specialized seat. This 5 point harness will provide maximum safety for the client while the kart is in motion. This harness coupled with the support features on the seat will undoubtedly keep the client in his required position for optimal safety as well as comfort. The harness will confine the client to a safe position without restricting his ability to use the dashboard controls.

![5 point safety harness](image)

**Figure 5: 5 point safety harness**

**Steering Mechanism**

The steering mechanism proposed for the go-kart need to be designed to be quick and responsive to handle optimum maneuverability while also being able to withstand the forces exerted on the system while it executes turns while in motion. Since the client lacks the motor control to be able to steer the go-kart manually, the steering system will be powered and controlled by a gear motor which will be used to power a rack and pinion. The rack and pinion will be connected to the wheel brackets via tie rods. The linear displacement of the rack due to the rotation of the pinion will result in a translational movement of the wheels which will steer the car left and right.
Figure 6: Dayton 1L469 Gear Motor

The Dayton DC gear motor (Part #: 1L469) shown in Fig. 6 will be used in the design to drive the rotation of the rack and pinion. The gear motor is capable of producing 50 lb-in of torque at 90 RPM. It has a source voltage of 12V and a current rating of 9 amps. The gear motor will be mounted on the frame of the go kart. It will give rotational power to the rack and pinion through a gearing reduction that will connect the drive shaft of the gear motor to the 36 spline input shaft which is also connected to the rack and pinion. The gears that will be used are 14.5° 20 pitch pressure angle spur gears from McMaster-Carr. The gears that will be used are a 48-tooth gear (Part #: 6325K86) attached to the gear motor and a 24 tooth gear (Part#: 6325K84) attached to the spline input shaft. This gear reduction gives an overall gear ratio of 2:1. This will allow the gear motor to efficiently rotate the rack and pinion at a maximum of 180 RPM which is double the torque rating for the gear motor alone. This output to the rack and pinion is more than enough to provide quick and responsive handling for the steering system of the go kart.

Rack and Pinion

The rack and pinion depicted in Fig. 7 is used to take the rotational energy produced by the gear motor and translate it into a linear displacement of the rack which ultimately results in the right and left turning of the wheels. The rack and pinion system used for this go kart is an 11” Rack and Pinion steering unit (ubuilditplans.com). This product is designed for go karts and small dune buggies and will provide not only the necessary performance for efficient turning, but also durability for a higher quality and more rugged steering system. The rack and pinion ratio is 12:1 which equates to 1.5 turn of the pinion to a 4 inch displacement of the rack. The rack is made of billet aluminum and is equipped with steel gears and a sealed bearing. The rack also comes with a 3/8” male tie rod ends which can be screwed into the sides of the rack to allow for the adjoining of the tie rods. The rack also comes with a 5/8” 36 spline input shaft. This spline can be connected to a couple which is sold separately. This coupler acts as the connection between the rack and pinion and the steering column, or in the case of this go kart, the gear motor.
The go kart chassis that will be bought comes with tie rods but will not be used for this design. The go kart contains a manual steering system which will have to be removed from the go kart in order to implement the motorized system of steering. The problem with the manual steering system is that it is left side mounted to simulate the driver’s side for the two passenger cart. The motorized steering system will be mounted in the center of the go kart in order to maximize leg room for both passengers. The tie rods that will be used in this go kart are 6061-T6 high strength aluminum tie roads from McMaster-Carr (Part #: 6516K23). The tie rods contain a 3/8” thread size which will be ideal for the female rod ends which will be used to attach the tie rods to the rack and pinion on one end and to the rod arm of the wheel spindle shown in Fig. 8.
**Linear Position Transducer**

In order for the microcontroller to be able to track the linear displacement of the rack and pinion, a linear position transducer must be installed to move with the rack and pinion. The linear position transducer that will be used in the steering system is a Celesco CLWG Linear Potentiometer shown below in Fig. 9. These transducers have been proven time and again in the automotive and robotics industry and provide precise accuracy of measurement in a durable long lasting design. This transducer acts like a variable resistor which changes the voltage output to the microcontroller due to the linear displacement of the actuating tie rod. The best aspect about this product is that the pivot heads in the transducer can be attached male and female rod ends of the rack and pinion and tie rods. The transducer will be calibrated upon installation to have a set potentiometric resistance at point zero. Any movement of the actuating shaft inside the housing will change the internal resistance of the transducer and ultimately change the output voltage to the microcontroller. The microcontroller will read the voltage difference as a change in the linear position of the rack and pinion. The implantation of the linear actuator is crucial because the rack and pinion has no electrical component to interface with the microcontroller to help give information of the linear displacement.

![Figure 9: Celesco CLWG Linear Position Potentiometer](image)

**Speed Controller**

A speed control must be used in order to control the gear motor which drives the steering system. The speed controller that will be used in this system is the 24V IFI Victor 883 shown in Fig. 10. This drive motor has been engineering to be implemented in many robotics applications especially within drive and steering systems. The Victor 883 comes with a PWM signal driver which helps ensure that it is compatible with the incoming RF signal from the receiver. This speed controller can operate at higher currents with a continuous current rating of 25A which makes it ideal for the steering system. Also, the low voltage drop and high switching speed helps feed maximum power to the motor. The switching speed will help in the constant forward to reverse rotation of the motor that will occur during normal steering and will make the steering system even more responsive.
The motor that will be used to power the go kart is the C40-300 MagMotor shown in Figure 11. Magmotors have been engineered specifically for use in robotics combat competitions and also for use in electrically driven scooters and go karts. The C40-300 MagMotor is an electric motor that can produce 3.8 horsepower and 3840 oz-in of torque while putting out 4000 RPM at a maximum voltage of 24V. This is an extremely powerful motor and will be ideal for the design of the go kart. The MagMotor has many benefits including a high efficiency at higher RPM and also an easy mounting system that gives it versatility in the placement of the motor in the go kart. It also comes with built-in capacitors between the brushes in order to reduce RF noise. This is a very crucial feature considering the amount of RF communication that is already implemented into the design. The motor has a 1.75" drive shaft that is 5/8" in diameter with a 3/16" keyway which allows the shaft to be integrated with a custom sprocket to initiate the proper gear reduction. The motor will draw a lot of current trying to move the go kart if it was attached to the sprocket on the axle directly which will drain the power source quickly. The proposed gear reduction will have a ratio of 14:1. This means that when the motor is running at 75% (3000 RPM), the motor will be able to reach a top speed of approximately 10 mph. By having a gear reduction in place, the motor accelerates at a faster rate with increased torque. The other advantage is that since this motor is very powerful, the gear reduction will allow it to perform at a safer speed and also run more efficiently at a lower RPM. This will save a lot of power which will ultimately lead to longer continuous operation times.
Just as the gear motor needed a speed controller to gauge the voltage input, the drive motor needs one as well. However, since the drive motor will be drawing a much higher current, the speed controller for the drive motor must be much more robust and durable to handle the high current load. The speed controller that will be used to drive the main motor is a 4QD-300 speed controller designed by SLT Technology, Inc and is shown in Figure 12. This motor controller is compatible with the 24V MagMotor described previously and is powerful enough to withstand current draws of up to 300 Amps. The 4QD-300 is a notoriously very durable speed controller and is equipped with many fail safes in order to ensure maximum reliability and prolonged use. This speed controller is optimally designed for joystick input which is ideal considering the main method of control for this motor is going to be two single axis joysticks. Also, an external potentiometer is mounted on the controller to give the owner manual top speed control. This is a good additional feature for the client since as he becomes older, his parents may think he could be ready for some more speed. The 4QD-300 also has the ability to execute direction switching for drive braking giving it the ability to change the direction switch and break while moving forward at full speed. This is a very convenient feature to have for the go-kart however, considering this speed controller is mainly used in smaller robotics applications, a rotary breaking system will still be installed as a safety precaution.
**Braking**

The same problem with the steering controls is also present in the implementation of the braking system for the go kart. On a standard go kart, a brake line attaches the brake pedal to the brake calipers. When the pedal is pushed down, the leverage pulls the brake cable which compresses the calipers on to the brake rotor which slows down the go cart. The client does not possess the capability to be able to push down a brake pedal which means that this process is going to have to be done mechanically. This system will implement a gear motor and motor driver that is controlled by a microcontroller in order to safely and effectively apply brakes to the moving go kart.

**Braking Mechanics**

Since safety is the number one concern when it comes to the design and construction of this go kart, the entire braking system will be designed with very acute detail. The prefabricated go kart chassis comes with a 10 inch rotary brake disk along with brake calipers and a brake line. Therefore, the brake line that would originally be attached to the brake pedal will be attached to a gear motor that is controlled by a motor driver. The motor driver will take signals from a microcontroller and send them to the gear motor via PWM which allows for a variable compression force to be exerted on the brakes. In the case of this gear motor, maximum RPM and voltage input are not as much as a factor as the maximum torque and current draw are. The gear motor will be controlled by a motor driver that will be responsible for driving voltage to the motor which will pull the calipers together. The motor driver also has to be able to reverse the polarity of the signal to allow the motor to release the caliper compression on the brake rotor. The braking system also needs an electro mechanical feedback system to help govern the rotation of the motor which is where the linear transducer comes into the design again.

**Braking Motor**

The braking will be powered by a gear motor just like the steering system. The gear motor used in the braking mechanism from Midwest Motion Products (Part #: MMP S28 150E-48V) and is shown in Figure 13. This gear motor has a rated voltage of 48V and current rating of 8.1 Amps. The gear motor provides a continuous output torque of 72 in-lb at an RPM of 285. The brake line will be attached to the drive shaft of the motor and when the brakes are applied, the motor will rotate and pull on the brake line. This will close the brake pads on to the brake rotor and will slow down the go kart. Upon release of the brake, the motor driver will send a reverse polarity voltage to the motor causing the motor to rotate in the opposite direction to release the calipers from the rotor.
The IFI Victor 883 motor driver that is used in the steering system will also be used in the braking system. This motor driver not only excels in performance in steering systems but also has unmatched performance in braking systems. The efficiency of the IFI motor driver at high voltage and current capacities makes it ideal for the braking system because the motor is going to be resisting a lot of rotational force. This means that the gear motor will be drawing an ample amount of current in order for it to keep tension on the brake line to compress the calipers on the brake rotor. The motor driver is rated to be able withstand that current draw. That notion, along with its ability to control forward and reverse rotational movement, makes the IFI Victor 833 the ideal motor driver for the system.

**Braking Position Transducer**

A typical braking system on a go kart relies on a brake pedal to apply a mechanical advantage to the brake lines to close the calipers on to the brake disc. Due to the lack of motor control of the client, this process cannot be feasibly executed. Therefore, an electromechanical system will have to be used to gauge the position of the brake line with respect to the neutral position. This will be done with a linear position transducer just like in the steering system. The linear position transducer used in this system will be the Celesco MLP Miniature Potentiometer. This linear potentiometer will vary the feedback voltage to the braking microcontroller in order to give input as to the overall distance the brake line has moved which ultimately conveys the compression of the brake pads on the disc rotor. The stroke length for the brake line will not be nearly as large as it was for the steering system. This linear potentiometer has a stroke length of 6 inches which will be enough of a stroke length to close the brake pads on the rotor while providing it with a wide variance of voltage output for a feedback signal.
Electrical Systems

**Batteries**

The go-kart will use three Trojan SCS200 12V 115Ah Group 27 Superior deep cycle batteries. These batteries have an output voltage of 12V and amperage of 115Ah. Each battery is 12.75 in x 6.75 in x 9.75 in length, width and height respectively and weighs 60 pounds. The battery is a flooded lead acid which have the longest life and the least cost per amp hour. The terminals are configured with dual wing nut terminals. The battery can be seen in Fig. 15.

![Trojan Deep Cycle Battery](trojan-battery.jpg)

**Figure 15. Trojan Deep Cycle Battery**

**Control Box**

All of the electrical components need to be secured in a control box. This box will contain all of the major electrical components including the remote receiver, and the speed controller. This box will be made from plastic and will be secured to the chassis. Containing all of the electrical components will prevent them from being damaged in the case of collision. It will also insulate the components to protect the client and other users. All of the wiring will also be insulated, housed in a conduit and secured to the chassis, so that it does not harm the client. The wiring will be tightly secured to the chassis in such a way that they cannot be tripped over or pulled up.
Control Systems

The go-kart will consist of two different control systems. This first will be a remote control with dual axis joysticks to control steering, speed, and braking. The second control system will consist of three jelly bean style buttons which will control steering. The remote control will also have a switch that will change the mode of operation.

Having the two different methods of controls will allow for multiple operators. The jelly bean buttons will allow the client to control it, and the remote control will allow the guardian to operate the go-kart. This also provides the opportunity for continued learning. Should the client gain more motor control, the other controls will allow him to develop new skills.

Remote Control

The remote control will be custom built by Miratron Inc, Portland, Oregon. The transmitter used will be the T-1 model. The remote control will run off of 3 "D" batteries and will also be equipped with a tether cable. When connected momentarily, this tether cable allows the transmitter to “learn” the receiver address. This also allows for replacement of the transmitter without replacing the receiver. The remote will have a range of up to 1,500 feet and is enclosed in high impact polystyrene for durability. It will have two dual axis joystick controls. One joystick will control the acceleration and braking of the go-kart. The second will control the steering. There will also be a switch located on the remote that will change the mode of operation. This will allow the guardian the most amount of control over the go-kart, while still allowing the client to operate it. The remote will also have a small LED which will light up when the battery of the remote is at 40% power. The design of the remote submitted to Miratron is shown in Fig. 16. The data sheet for the T-1 transmitter can be found in Appendix B.
The receiver will also be provided by Miratron Inc, Portland, Oregon. The receiver will be the R-4 radio receiver model. The receiver will take inputs from the remote transmitter, and will also have inputs directly from the button controls. The receiver will be programmed to run the servo motors attached to the steering, and the braking of the system as well as the speed controller. The receiver will be able to act as the microcontroller eliminating the need for external microcontrollers and embedded code. This will help decrease possible problems in the go-kart controls and make the control system more compact. The receiver is encased in black nylon and is compact so that it can fit into small spaces and can be seen in Fig. 17. The data sheet for the R-4 receiver can be found in Appendix A.

![Figure 17. Remote Receiver from Miratron, Inc.](image)

**Remote Kill Switch**

The remote control will also be equipped with a kill switch. This kill switch will be a mushroom button located in the bottom center of the remote control. This kill switch will stop all output of the receiver and therefore stop any movement of the go-kart. The kill switch will also shut down all power to the go-kart. The kill switch will be red, and is marked “E-Stop” so that it is easy spotted, and the user is aware of its location.

**Jelly Bean Push Buttons**

The three jelly bean style buttons (model number 100-33400) will be purchased from AbleNet, Inc, Roseville, MN. The jelly bean button uses a micro switch inside. The switch is contained in a high impact disk which has a 2-½ inch activation surface which is highly sensitive to touch. The button requires less then two ounces of pressure for activation. The buttons also have a tactile and auditory feedback which indicates when the button is being pressed. The buttons come with a four different color changeable tops. A specific color will be chosen for each direction. The buttons will need to be continually pressed in
order for the go-kart to move. The buttons will be attached to the R-4 receiver which will act as the microcontroller. The receiver will take the push buttons signal and process it to send it to the servo motor and speed controller in the same way the remote control works. Figure 18 shows the jelly bean style button.

![Figure 18. Jelly Bean Button](image)

**Realistic Constraints**

**Economic**

This project, along with all other engineering projects, has a set budget that cannot be increased. The given budget will be enough to design and build a quality go-kart; however, as with any project, a larger budget would allow for an even better project. A larger budget would allow for the purchasing of higher quality components and higher grade materials. To stay within budget and still provide a quality product, donations and free parts will be taken advantage of. This will create the opportunity to build an excellent go-kart at a lower price. Without donations and free parts, the cost of this go-kart could possibly far exceed the given budget.

**Environmental**

The go-kart will be battery powered, meaning that there are little impacts on the environment. The batteries do contain corrosive and dangerous materials, and must be properly handled. Also all of the electrical components could potentially cause damage to the environment. Electrical components must be handled with care and disposed of properly.

Although the go-kart will have little impact on the environment, the environment will impact the go-kart. The go-kart will be stored inside; however, it needs to be designed so the environment does not hinder performance. It needs to be able to potentially operate in rain, snow and all other types of weather. It also has to be durable enough, so that if left outside, the go-kart will not be ruined. All components must be covered and waterproofed. The compartments also need to be easily cleaned, in case any dust or dirt gets into them.
**Sustainability**

This go-kart will be battery powered and therefore to maximize use the batteries will need to be kept charged. There will be a total of three batteries used on the go-kart. The batteries will be deep cycle batteries which can be charged with a battery charger. The client’s father owns a battery charger. The go-kart will be able to sustain itself for long amounts of time, assuming the batteries are fully charged.

**Manufacturability**

Manufacturing this go-kart in a large quantity should be quite simple to do. Many of the parts are readily available for purchase, and there are several different types available. If a part used in the go-kart becomes unavailable, it would be easy to replace it with a similar part from a different company. With the correct materials list and design, most of the go-kart would be easy to replicate for manufacturing. The design would need to include all of the mechanical components, the electrical diagrams and all of the code for the microprocessor. The chassis was also purchased, but changes were made to the seat to account for the client’s disability. With the correct set of CAD drawings; however, these changes would be simple enough to manufacture at a large scale.

**Health and Safety**

The most important aspect of the go-kart is safety. The operator will be a child with CP, with limited motor control. Due to the limited motor control and motor planning, the go-kart must have more safety standards than other go-karts. The go-kart will be equipped with three different sets of controls. The first will be a remote control for his parents to operate the go-kart. This will include a remote kill switch that will safely shut the go-kart down if anything happens. By allowing the parents to operate and shut down the go-kart remotely, it will decrease the chances of potential harm to client. The second control will be a set of push buttons that the client will operate. By having two seats in the go-kart, the client will be able to use the push buttons, and the guardian will be able to help the client learn the movements needed. The chassis has been designed with a wide base to prevent tipping; however, in the case that tipping does occur, it is equipped with a roll bar that will protect the driver and possible passenger. The chassis has been built to withstand impact without ruining the go-kart. The client will also have a 5-point harness to keep him strapped into the seat. He will also have leg straps to keep his legs in place. Due to the fact that he kicks when he gets excited, having his legs strapped in will prevent any injury from occurring. It will also help prevent damage to the go-kart. The go-kart will also be equipped with a remote kill switch which will shut down the go-kart if anything happens. The speed of the go-kart will be at a maximum of 10 miles per hour, which is slow enough that if anything happens there will not be serious repercussions. All
of the components will be tested individually as well as part of the go-kart to help
prevent any malfunction of the go-kart.

**Social**

Aside from safety, allowing the client a new way to interact with the world
is the main objective of this project. The client’s father is heavily involved with
racing, and therefore the client has always wanted the chance to drive. He also
sees the other children in the neighborhood driving their go-karts and gets
jealous. Having a go-kart that he can operate will allow him the chance to play
with the other children as well as his father. By having two seats in the go-kart,
another person could ride along with the client. This would allow for a greater
feeling of normalcy. This go-kart will be built in such a way that it looks very
similar to traditional go-karts.

**Safety Issues**

Safety is the number one priority of the go-kart. The go-kart needs to be safe
for the operator, any passengers, and anyone near the go-kart. All of the
electrical and mechanical components of the go-kart need to be safe. All wires
will be housed in a conduit which will protect any users from current carrying
wires. This conduit will be secured in such a way that no one will get caught in it
or trip over it. Also there will be no bare wires, to further protect users. All other
electrical components will be protected from any potential interruptions such as
physical harm or harsh weather. All of the components used will also be rated at
a higher current than will be used as another measure to prevent overheating
and possibly fire.

The mechanical aspects need to also ensure safety for the driver, passenger,
and anyone else in the vicinity. All moving parts of the go-kart will have a shield
so that while in operation, the moving parts are difficult to get to. This will also
prevent injury in the case that something should fall off while moving. If it is
shielded then the part will not fly and injure people in the area. There should be
no parts that are not attached securely so the chance of something falling off
should be none. The chassis will also provide support for not only the
passengers, but also the parts. The steel frame will protect the parts from
damage should there be any crash. The chassis will also be equipped with a roll
bar, so that if the go-kart should flip the passengers will be protected. The seat
for the client will also be equipped with a five point harness and legs straps to
ensure that he is secured in the go-kart. The seat will also provide the client with
trunk support to keep him upright during operation of the go-kart. There will also
be a head support to prevent whiplash in case of a sudden stop. These
measures will further protect the client in case of a collision. The passenger seat
will also be equipped with a safety restraint to protect the passenger.
There are also possible chemical hazards associated with the go-kart. The go-kart will contain batteries which contain harmful chemicals. It is unlikely that the sealed batteries will leak any of the chemicals in the event of a collision. The go-kart batteries should be inspected to ensure that there are no chemical leaks. Also the go-kart should not be used around an open flame as this would increase the chance of not only overheating, but exposing a chemical leak in a deadly way.

There is a possibly of overheating as a thermal hazard. Overheating would be caused by warm electrical components. To prevent overheating, a cooling system will be put in place and all of the electrical components will be in an enclosed but ventilated box. By placing the electrical components in the box, it will prevent anyone from being able to touch the components while the go-kart is in use.

**Impact of Engineering Solutions**

The design of this go-kart could potentially have a large impact in a global, economic, environmental and societal context. While this go-kart is being designed and built for the specific needs of the client, there is a possibility of the go-kart or one similar, becoming mass produced.

If this go-kart were to be mass produced, it would open new doors for the handicapped. Handicapped people, especially children, would have the same recreationally opportunities as other people. They would be able to drive around the block on their go-kart, just as other kids are able to do. It would also allow them to get outside more and meet more people. They would not have to be ashamed of their disability because it would not hinder them as much. This would have large repercussions on society. Having a disability such as CP would not be seen in such a negative way. Because the children would be able to drive around in the go-karts in a similar way to the other children, other children would become more accepting. Eventually, everyone growing up would learn to accept people with disabilities as equals.

This would also impact the global society. People around the world would become more understanding and accepting of those with disabilities. Also if this product was manufactured in America, it would increase the global trade and possibly introduce trade with a new country or region. It would also improve the way other countries view America and Americans. We would not be viewed as selfish and careless; it would show the world that we are understanding and do care about the needs of others.

There is also the possibility that because everyone was more accepting, that more money would be spent on aiding those with disabilities. Other projects similar to this would allow for greater mobility of the handicapped and therefore, even greater social acceptance. Not only in finding new ways for them to be able
to things others can do, but also in the research that gets funded. Hopefully, more money would go into research foundations to cure and treat problems such as CP, multiple sclerosis and every other limiting disease. If diseases such as this are cured or treated effectively, this could possibly completely eliminate the need for handicapped devices.

This go-kart could also have an environmental impact. If this go-kart could be battery powered, and successful, then other go-karts could also become more environmentally friendly. Many of the go-karts have gas engines which output emissions. With the use of battery powered go-karts, the number of emissions would be decreased. In order to achieve the use of batteries, the go-kart needs to provide enough power; this is the problem with most battery powered vehicles.

**Life Long Learning**

Almost every part of this project required learning. The first part of the learning required learning about the client and the client’s needs. This led us to research CP and all the effects of it, mental and physical. Knowing the physical and mental limitations of the disease was pertinent to designing the go-kart. The seat needed to have special supports and straps, including leg straps. The leg straps are critical to maintaining proper safety while using the go-kart. It was also discovered that the strength is so limited that regular buttons are not suitable and therefore, a special type of buttons, a jelly bean button, needed to be used.

The design of the go-kart also required detailed learning. Due to the use of a remote control, research had to be done as to what was the best type of remote control. A radio frequency remote was chosen; however, a lot detail also had to be found about radio frequencies. The type of push button also required some research. It was discovered that the only button suitable for the client was a jelly bean style, and then we had to connect the buttons and interface them with the microcontroller. The go-kart also required the use of several other circuits and signaling techniques. The speed controller and the H-bridge both use pulse width modulation (PWM) signals as there input. This requires basic knowledge of the PWM and knowledge of the speed controller and H-bridge.

This project also required an in-depth knowledge of microcontrollers and embedded code. The code had to be able to control the functions of the microcontroller. The code also had to upload to the microcontroller. The microcontroller had to take inputs from the various controls and be able to output the proper mechanical response.

This project also required use of a CAD program; the program used was Solidworks. This CAD program allow for the initial designs of the go-kart as well as design of components such as the seat.
Several motors and batteries also had to be researched to find what would be
the most effective for the go-kart. The motors need to be able to output enough
power to drive each system. Also the battery needs to be able to provide enough
power to the motors. The number of batteries also had to be determined in order
to maximize efficiency without increasing the total weight of the go-kart too much.

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115ah-group-27-superior-deep-cycle-battery/language/en?currency=USD>
**Website Links**

C40-300 MagMotor


4QD Speed Controller


IFI Victor 883 Motor Driver


Jelly Bean Switches


Rack and Pinion

[http://www.desertkarts.com/item80857.ctlg](http://www.desertkarts.com/item80857.ctlg)
Appendix A: Radio Receiver Datasheet

R-4 1-16 Channel Factory Configurable Receiver
With Connector, Cable and Internal or External Antenna

FEATURES
- Simple to Set Up and Use
  Pre-wired cable harness with Deutsch DTM series connector. Factory programmed for your application. Wiring diagram included.
- Compact, Rugged Enclosure
  Compact size is ideal for mounting in tight spaces. Environmentally sealed for harsh off-highway applications. IP66 rated enclosure and connector.
- Affordable
  Fully integrated receiver. No external modules required. Outputs factory configured for your application. Pay only for the outputs and features you need.
- License free
  Pre-certified FCC - no license required.
- External Antenna (Option)
  Flexible antenna can be installed away from obstructions to improve range.

OPERATION
Radio Operation
Up to 16 factory installed outputs can be any combination of digital (bang/bang), proportional current, ratiometric, or unamplified. Can directly drive a wide range of coils and other DC loads.
Up to 7 of the available output channels may be configured as inputs with popular voltage ranges suitable for reading sensors or switches.
Programmable Logic
Receiver can be factory programmed to perform a wide range of logical functions and sequences.
Pushbutton/Tether Learn
Transmitters and receivers are “married” to permit operation of multiple radios in the same area without cross-control. Transmitters and receivers can be married in the field by pushing a button in the receiver or momentarily connecting the optional tether cable.
Safety Features
Receiver automatically detects when transmitter is out of range, and returns outputs to a safe condition. Normally-closed E-stop output also available. Monitored receiver electronics disables outputs on fault condition.

APPLICATIONS
- Crane control
- Wood chippers and grinders
- Blower trucks
- Sawmill machines
- Conveyors
- Earth compactors
- Rock crushers
- Robotics
- Remote process control
- Winch systems
- Specialty off-highway equipment

ORDERING INFORMATION

<table>
<thead>
<tr>
<th>PART #</th>
<th>DESCRIPTION</th>
</tr>
</thead>
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<tr>
<td>RX4</td>
<td>Standard range 16 channel receiver</td>
</tr>
<tr>
<td>RE4</td>
<td>Extended range 16 channel receiver</td>
</tr>
<tr>
<td>RZ4</td>
<td>International 16 channel receiver</td>
</tr>
</tbody>
</table>
Appendix B: Transmitter Data Sheet

**T-1 Multi-Function Belly Pack Transmitter**

**Fully Customizable Controls**

**FEATURES**

- **Long-Range Reliability**
  Up to 1,500 feet range (line of sight). Monitored radio link keeps equipment under control.

- **Customizable**
  Transmitter is available with toggle switches, joysticks, potentiometers, paddles, displays, or combinations. Choose the ideal combination of controls for your application.

- **Rugged Construction**
  Environmentally sealed for harsh off-highway applications. Ex rated intrinsically-safe models available.

- **Tether**
  Tether cable allows transmitter to operate without batteries. Also allows transmitter to "learn" receiver address.

- **License free**
  Pre-certified FCC - no license required.

- **Standard Batteries**
  Operates from standard "D" cell alkaline or rechargeable batteries. No downtime waiting for specialty battery packs to charge. Internal charger option available.

**OPERATION**

**Radio Operation**

Models available with outdoor range of 1500 feet or more. Frequency hopping spread spectrum (FHSS) transceiver uses two-way communication for maximum reliability and safety. Operates on 902-928MHz (USA) or 2.4-2.4835GHz (International) unlicensed ISM band. No end-user license required.

**Controls**

Many combinations of toggle switches, joysticks, potentiometers, paddles, and LCD are possible to customize transmitter functions. Use the product configurator to specify functions and labeling. Every transmitter ships with custom engraved front panel and user specified controls.

**Transmitter Matching**

Momentarily connecting transmitter to receiver using tether cable allows transmitter to "learn" receiver address. Matching the transmitter to the receiver prevents cross communication in applications where multiple radios are in use. This feature also allows the transmitter to be replaced without changing the receiver.

**Batteries**

Operates from 3 "D" cell batteries. Rechargeable types can also be used. Internal battery charger available. Batteries are easily accessible.

**ORDERING INFORMATION**

<table>
<thead>
<tr>
<th>PART #</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>TX1</td>
<td>Standard range belly pack transmitter</td>
</tr>
<tr>
<td>TE1</td>
<td>Extended range belly pack transmitter</td>
</tr>
<tr>
<td>TZ1</td>
<td>International belly pack transmitter</td>
</tr>
</tbody>
</table>

Add "-XL" suffix for jumbo belly pack option.
Add "-EX" suffix for explosion proof version. Consult factory.
4QD Controllers for Electric Scooters and Electric Cars

(Distributed by SLT Technology, Inc.)

4QD-150D, 4QD-200D and 4QD-300D ranges of motor speed controllers for 24v, 36v and 48v motors. They are designed to give currents in the range 100 to 300 amps making them probably the most powerful controllers in their price range. Although small they are fully electronic and need no external relays whatsoever. They have many fail-safes built in for reliable long time use and misuse.

The controllers are wide supply voltage range, 36v and 48v both working also down to below 24v, so there is no separate 24v version, the 36v version should be used.

Models

3 basic models are available in several voltage options:
4QD-150-24/36 or -48: 160 amps cold
4QD-200-24/36 or -48: 210 amps cold
4QD-300-24/36 or -48: 320 amps cold

The 4QD-150, 4QD-200 and 4QD-300 are full Four-Quadrant chopper drivers suitable for speed control of battery operated motors up to 300A and voltages between 24 and 60. They give full control of forward and reverse acceleration and braking. They have been developed in conjunction with a top motor manufacturer and golf buggy manufacturers. There is, as far as we know, no other design of controller of comparable specification at a similar price.

Input is suitable for a joystick (center zero) or for a single ended speed pot plus separate reversing switch (mode is selected on board by a moveable link). There is an on-board adjustment to alter input sensitivity. Alternatively an external pot or switch can be added to give a user top-speed control.

Also on board is an adjustable torque limit, which limits the continuous motor current, to avoid overloading smaller motors.

Direction switching and drive/brake switching is entirely electronic so in a vehicle equipped with a 4QD it is quite permissible to change the direction switch whilst traveling at full forward speed. The 4QD will brake, stop and reverse under full control. There are on board ramp controls to separately adjust acceleration and deceleration rates. With maximum rates the controller is very lively!

Output devices are kept in their safe operating area so failures are rare. However 4QD have considered the possible failure mechanisms. Worst would be an output device failing short-circuit so the drive would go to full speed. Such failures normally cause the MOSFET gate to go short-circuit. This condition is normally detected by internal circuitry and shuts the controller off completely and safely. Control circuit failures could be overridden by the ignition switch.

Mechanical construction is such that the controller can be mounted in thermal contact with the vehicle chassis, so this acts as additional heat-sinking, although this is not normally required.

You can buy with confidence as the controllers come with a detailed instruction manual and we give full technical service and advice, covered by the 12 month guarantee.
<table>
<thead>
<tr>
<th>Specifications</th>
<th>18v to 45v</th>
<th>18v to 66v</th>
<th>24/36v version</th>
<th>47v</th>
<th>24/36v version</th>
<th>48v version</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply voltage</td>
<td>18v to 45v</td>
<td>18v to 66v</td>
<td>24/36v version</td>
<td>68v</td>
<td>24/36v version</td>
<td>48v version</td>
</tr>
<tr>
<td>Over-voltage operation</td>
<td>47v</td>
<td>68v</td>
<td>24/36v version</td>
<td>-150 and -200</td>
<td>-150</td>
<td>-200</td>
</tr>
<tr>
<td>Supply current</td>
<td>70mA</td>
<td>100mA</td>
<td>-300</td>
<td>-150</td>
<td>-150</td>
<td>-200</td>
</tr>
<tr>
<td>Voltage drop at 100 amps (typical, full speed)</td>
<td>800mV</td>
<td>600mV</td>
<td>-200</td>
<td>47v</td>
<td>600mV</td>
<td>48v version</td>
</tr>
<tr>
<td>Output voltage</td>
<td>on 24v</td>
<td>0v to +24v</td>
<td>48v version</td>
<td>on 36v</td>
<td>0v to +36v</td>
<td>48v version</td>
</tr>
<tr>
<td>Output voltage</td>
<td>on 48v</td>
<td>0v to +48v</td>
<td>48v version</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Output current</td>
<td>max, cold</td>
<td>160A, 210A and 320A</td>
<td>4QD-150-24 without additional heatsink.</td>
<td>4 minute rating</td>
<td>120 amps</td>
<td>4QD-200-24 without additional heatsink.</td>
</tr>
<tr>
<td>Output current</td>
<td>4 minute rating</td>
<td>120 amps</td>
<td>typical</td>
<td></td>
<td>150 amps</td>
<td></td>
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<tr>
<td>Current limit adjustment</td>
<td>20% to 100% full current</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reverse current limit</td>
<td>70% of forward current</td>
<td></td>
<td></td>
<td></td>
<td>85% of forward current</td>
<td></td>
</tr>
<tr>
<td>Overheat cut-out</td>
<td>95°C internal temperature</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Acceleration</td>
<td>0.3s to 12 sec, linear</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Deceleration</td>
<td>0.3s to 12 sec, linear</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>'Ignition On' threshold</td>
<td>&gt; 3v</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>'Reverse' threshold</td>
<td>&gt; 3v</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Switching frequency</td>
<td>20kHz approximately</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Size (mm)</td>
<td>250 x 103 x 60</td>
<td></td>
<td></td>
<td></td>
<td>280 x 103 x 60</td>
<td></td>
</tr>
<tr>
<td>Weight</td>
<td>150 and 200</td>
<td>1300g</td>
<td></td>
<td></td>
<td>300</td>
<td>1685g</td>
</tr>
<tr>
<td>Weight</td>
<td></td>
<td></td>
<td></td>
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<td>Weight</td>
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</tr>
<tr>
<td>Weight</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Input</td>
<td>from Pot or Joystick (5K to 25K) or voltage following</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Input</td>
<td>Single-ended mode</td>
<td>0-3v (adjustable)</td>
<td>separate forward reverse signal</td>
<td>Joystick mode</td>
<td>5.5v +/-1.5v</td>
<td>speed and direction</td>
</tr>
<tr>
<td>Mode switch</td>
<td>Single ended or Joystick</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Brake output</td>
<td>1A</td>
<td></td>
<td>over-current operates at about 1.2 amp</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**Key Performance Features:**
- Smooth 4-Pole Performance
- Dynamically Balanced Armatures
- IP 65 Sealing
- Round or Optional NEMA 42 Mounting
- 12-120 VDC Typical

---

**Motor Characteristics**

<table>
<thead>
<tr>
<th>FRAME SIZE</th>
<th>STACK LENGTH</th>
<th>PEAK STALL TORQUE (T_p) OZ-IN</th>
<th>CONT. STALL TORQUE (T_c) OZ-IN</th>
<th>ROTOR INERTIA (J_t) OZ-IN-SEC^2</th>
<th>FRICTION TORQUE (T_f) OZ-IN</th>
<th>THERMAL RESISTANCE (Rm) °C/WATT</th>
<th>MAX RECOMMEND SPEED RPM</th>
<th>MAX WINDING TEMP. °C</th>
<th>POWER RANGE W</th>
<th>WEIGHT LB</th>
</tr>
</thead>
<tbody>
<tr>
<td>C40 -- 200</td>
<td></td>
<td>1200</td>
<td>248</td>
<td>0.16</td>
<td>12</td>
<td>2.0</td>
<td>3000</td>
<td>155</td>
<td>275</td>
<td>10</td>
</tr>
<tr>
<td>C40 -- 300</td>
<td></td>
<td>1984</td>
<td>416</td>
<td>0.24</td>
<td>14</td>
<td>1.3</td>
<td>3000</td>
<td>155</td>
<td>430</td>
<td>13</td>
</tr>
<tr>
<td>C40 -- 400</td>
<td></td>
<td>2480</td>
<td>512</td>
<td>0.30</td>
<td>16</td>
<td>0.98</td>
<td>3000</td>
<td>155</td>
<td>570</td>
<td>15</td>
</tr>
<tr>
<td>C40 -- 500</td>
<td></td>
<td>3040</td>
<td>640</td>
<td>0.37</td>
<td>18</td>
<td>0.79</td>
<td>3000</td>
<td>155</td>
<td>720</td>
<td>17</td>
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</tbody>
</table>

---

**Sample Windings**

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<thead>
<tr>
<th>Torque Constant (Kt) oz-in/amp</th>
<th>A</th>
<th>C</th>
<th>E</th>
<th>G</th>
<th>A</th>
<th>C</th>
<th>E</th>
<th>G</th>
<th>A</th>
<th>C</th>
<th>E</th>
<th>G</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>18.0</td>
<td>26.4</td>
<td>43.2</td>
<td>64.4</td>
<td>23.0</td>
<td>37.7</td>
<td>59.6</td>
<td>94.5</td>
<td>31.8</td>
<td>48.3</td>
<td>76.8</td>
<td>122.4</td>
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<table>
<thead>
<tr>
<th>Voltage Constant (Ke) Volts/Krpm</th>
<th>A</th>
<th>C</th>
<th>E</th>
<th>G</th>
<th>A</th>
<th>C</th>
<th>E</th>
<th>G</th>
<th>A</th>
<th>C</th>
<th>E</th>
<th>G</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>13.3</td>
<td>19.5</td>
<td>32.0</td>
<td>47.6</td>
<td>17.0</td>
<td>27.8</td>
<td>44.1</td>
<td>69.9</td>
<td>23.5</td>
<td>35.7</td>
<td>56.8</td>
<td>90.5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Term. Resistance (Rt) Ohms (cold)</th>
<th>A</th>
<th>C</th>
<th>E</th>
<th>G</th>
<th>A</th>
<th>C</th>
<th>E</th>
<th>G</th>
<th>A</th>
<th>C</th>
<th>E</th>
<th>G</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.31</td>
<td>0.76</td>
<td>1.5</td>
<td>2.7</td>
<td>0.4</td>
<td>0.6</td>
<td>1.25</td>
<td>3.4</td>
<td>0.57</td>
<td>0.75</td>
<td>1.8</td>
<td>5.2</td>
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</table>

<table>
<thead>
<tr>
<th>Peak Current (A) Amps</th>
<th>A</th>
<th>C</th>
<th>E</th>
<th>G</th>
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<tbody>
<tr>
<td></td>
<td>80</td>
<td>50</td>
<td>32</td>
<td>20</td>
</tr>
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<table>
<thead>
<tr>
<th>Cont. Current (A) Amps</th>
<th>A</th>
<th>C</th>
<th>E</th>
<th>G</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>17</td>
<td>10</td>
<td>7</td>
<td>4</td>
</tr>
</tbody>
</table>

VALUES AS LISTED ARE TEST CONDITIONS, ACTUAL RESULTS MAY VARY
**C40 Series Options**
- Optical Encoders
- Tachometers, Brakes and Gearbox
- Application Specific Windings and Mechanical designs
- NEMA 42 Flange Mounting
- IP 65 Sealing
- For more options, see magmotor.com custom solutions, or call us.

**Typical Applications**
- Coil Winders
- Textile Machines
- Machine Tools
- Electric Vehicles
- Packaging Machines
- Image Acquisition and Printing Equipment

---

[Diagram of C40 Series Options]

- #4-40 x .25 deep 2 places on a Ø1.812 B.C.
- #14 AWG red & black leads, 13" long standard
- .107 deep x .167 wide x 1.30 long keyway
- C40-300 6.85"
- C40-400 7.85"
- C40-500 8.85"

- 5/16-18 .46 deep 4 places on a 4.950 Ø B.C.
- Ø.33 thru flange 4 places on a 4.950 Ø B.C.

- Standard round face mount
- NEMA 42 flange mount

---

[Diagram of C40 Series Options]
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 24V 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 24v 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:**

1. Always install jumper to prevent loss. 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 + 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

<table>
<thead>
<tr>
<th>Date Code</th>
<th>Changes</th>
</tr>
</thead>
<tbody>
<tr>
<td>9-25-06</td>
<td>Revised Brake/Coast Section</td>
</tr>
</tbody>
</table>
Linear Potentiometer

Precision Potentiometric Output
Ranges: 0-3 to 0-30 inches [0-75 to 0-750 mm]
5K – 10K ohms • IP65

Specification Summary:

GENERAL
Full Stroke Ranges ................................. 0-3 to 0-30 in. (0-75 to 0-750 mm)
Output Signal ...................................... voltage divider (potentiometer)
Linearity ................................................. ± 0.04 to 0.1% full stroke, see ordercode
Repeatability ............................................. < 0.01 mm
Resolution ................................................ essentially infinite
Life Expectancy ........................................... 50 million cycles
Enclosure Material ...................................... aluminum
Sensor ..................................................... conductive plastic linear potentiometer
Operating Speed ....................................... 200 inches (5 M) per second, max.

ELECTRICAL
Input Resistance ...................................... 5K to 10K ohms (±20%), see ordercode
Recommended Maximum Input Voltage .......... 25-30 V(AC or DC)
Recommended Operating Wiper Current .............. ≤ 1 µA

ENVIRONMENTAL
Enclosure Design ..................................... IP65
Operating Temperature .............................. -22º to 212ºF
Vibration .................................................. up to 10 G’s to 2000 Hz maximum

Developed specifically for a wide range of demanding applications, Celesco’s CL series position transducers offer unrivalled performance in terms of accuracy, repeatability, life expectancy and ease of mounting. Such applications include industrial automation, automotive and robotics.

The CLWG uses a twin-bearing actuating rod, backlash-free pivot heads and a superior wiper system to provide outstanding linearity and performance.

Outline Drawing

All DIMENSIONS ARE IN INCHES [MM]
CLWG • Linear Conductive-Plastic Potentiometer

Ordering Information:

Model Number:

**CLWG**

*order code: R A*

Sample Model Number:

**CLWG - 75 - NC4**

- range: 3 inches [75 mm]
- electrical connection: 4-pin, 90° M12 cordset

Full Stroke Range:

<table>
<thead>
<tr>
<th>measurement range, in. [mm]:</th>
<th>75</th>
<th>100</th>
<th>150</th>
<th>225</th>
<th>300</th>
<th>360</th>
<th>450</th>
<th>500</th>
<th>600</th>
<th>750</th>
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</thead>
<tbody>
<tr>
<td>resistance, (±20%):</td>
<td>3K</td>
<td>3K</td>
<td>5K</td>
<td>5K</td>
<td>5K</td>
<td>5K</td>
<td>5K</td>
<td>5K</td>
<td>5K</td>
<td>10K</td>
</tr>
<tr>
<td>linearity, %:</td>
<td>0.1%</td>
<td>0.1%</td>
<td>0.08%</td>
<td>0.07%</td>
<td>0.06%</td>
<td>0.05%</td>
<td>0.05%</td>
<td>0.05%</td>
<td>0.05%</td>
<td>0.04%</td>
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Electrical Connection:

<table>
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<tr>
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<th>MC4</th>
<th>SC4</th>
<th>NC4</th>
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<tbody>
<tr>
<td></td>
<td>4-pin M12 connector (no mating plug supplied)</td>
<td>4-pin M12 connector w/ mating plug</td>
<td>4-pin M12 connector and 4 meter length cordset w/straight mating plug</td>
<td>4-pin M12 connector and 4 meter length cordset w/90° mating plug</td>
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</table>

Cordset Wire Color

<table>
<thead>
<tr>
<th>Pin#</th>
<th>Cordset Wire Color</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>BROWN</td>
</tr>
<tr>
<td>2</td>
<td>WHITE</td>
</tr>
<tr>
<td>3</td>
<td>BLUE</td>
</tr>
<tr>
<td>4</td>
<td>BLACK</td>
</tr>
</tbody>
</table>

version: 3.1 last updated: April 9, 2009
Linear Potentiometer

Miniature • Extended Temperature Range
Ranges: 0-.5 to 0-6 inches [0-12.5 to 0-150 mm]
1.25K – 10K ohms • IP67

Specification Summary:

**GENERAL**
Full Stroke Ranges: 0-0.5 to 0-6 in. (0-12.5 to 0-150 mm)
Output Signal: voltage divider (potentiometer)
Resolution: ±0.01 mm
Linearity: ±0.5% full stroke
Repeatability: essentially infinite
Life Expectancy: > 25 million cycles
Operating Speed: 400 inches (10 M) per second max.
Enclosure Material: aluminum
Sensor: conductive plastic linear potentiometer
Weight: 1.6 oz. (46 g) max., see ordering information

**ELECTRICAL**
Input Resistance: 1.25K to 10K ohms (±20%), see ordering information
Recommended Maximum Input Voltage: 42 VDC
Recommended Operating Wiper Current: <10µA
Electrical Cable: 24 AWG Raychem SSM wire with VITON sleeve
Electrical Cable Length: 19 inches (500mm)

**ENVIRONMENTAL**
Enclosure Design: IP67
Operating Temperature, Continuous: -22º to 300ºF (-30º to 150ºC)
Operating Temperature, Short Term: 350ºF (175ºC)
Vibration: up to 10 G's to 2000 Hz maximum

**ORDERING INFORMATION:**

<table>
<thead>
<tr>
<th>Item Number:</th>
<th>MLP-12</th>
<th>MLP-25</th>
<th>MLP-50</th>
<th>MLP-75</th>
<th>MLP-100</th>
<th>MLP-125</th>
<th>MLP-150</th>
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<tbody>
<tr>
<td>measurement range, in. [mm]:</td>
<td>0.5 [12.5]</td>
<td>1 [25]</td>
<td>2 [50]</td>
<td>3 [75]</td>
<td>4 [100]</td>
<td>5 [125]</td>
<td>6 [150]</td>
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<tr>
<td>resistance, ohms (±20%):</td>
<td>1.25K</td>
<td>2.5K</td>
<td>5.0K</td>
<td>7.5K</td>
<td>6.5K</td>
<td>8.0K</td>
<td>10.0K</td>
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<tr>
<td>linearity, %:</td>
<td>±0.5%</td>
<td>±0.5%</td>
<td>±0.5%</td>
<td>±0.5%</td>
<td>±0.5%</td>
<td>±0.5%</td>
<td>±0.5%</td>
</tr>
</tbody>
</table>

Celesco’s miniature MLP series linear potentiometers offer unrivaled performance in an amazingly small size. Though small, the MLP is environmentally robust (IP67), operates over a broad temperature range (-22º to 300ºF) and is long lasting (>25 million cycles).

These features make our miniature MLP linear potentiometer the perfect solution for many applications including industrial, medical, automotive and motion control.
Planetary Gearmotor

**Model Number:** MMP S28-150E-24V GP81-014

**INTEGRAL BRAKES AND OPTICAL ENCODER OPTIONS AVAILABLE – SEE PAGES 2 AND 3 FOR DETAILS**

<table>
<thead>
<tr>
<th>Dimensions</th>
<th>Note: The Center of the Output Shaft contains an M6 Threaded Hole, 25mm Deep</th>
</tr>
</thead>
<tbody>
<tr>
<td>MD = 2.75” (70mm)</td>
<td>SL= 49mm (Usable Shaft Length = 40mm or 1.575”)</td>
</tr>
<tr>
<td>L (2) = 8.44” (214mm)</td>
<td>GD= 3.2” (81mm)</td>
</tr>
<tr>
<td>KW = 6x6x28 mm</td>
<td>BD= 1.97” (50mm) Pilot is 5mm long</td>
</tr>
<tr>
<td>SD = 0.748” (19mm + 0, -21μm)</td>
<td>BHC (dia.) = M6 x 12mm deep (4ea) on a 65mm BCD</td>
</tr>
</tbody>
</table>

**DC MOTOR PERFORMANCE PARAMETERS:**

<table>
<thead>
<tr>
<th>Value</th>
<th>Units</th>
<th>Tolerance</th>
</tr>
</thead>
<tbody>
<tr>
<td>24.0</td>
<td>VOLTS</td>
<td>- - -</td>
</tr>
<tr>
<td>8.1</td>
<td>AMPERE</td>
<td>- - -</td>
</tr>
<tr>
<td>110</td>
<td>OZ - IN</td>
<td>- - -</td>
</tr>
<tr>
<td>2100</td>
<td>RPM</td>
<td>+/- 15%</td>
</tr>
<tr>
<td>170</td>
<td>WATTS</td>
<td>+/- 15%</td>
</tr>
<tr>
<td>2400</td>
<td>RPM</td>
<td>MAX</td>
</tr>
<tr>
<td>0.48</td>
<td>AMPS</td>
<td>MAX</td>
</tr>
<tr>
<td>10.0</td>
<td>V/KRPM</td>
<td>+/- 10%</td>
</tr>
<tr>
<td>13.5</td>
<td>OZ –IN / A</td>
<td>+/- 10%</td>
</tr>
<tr>
<td>14.2</td>
<td>OHMS</td>
<td>+/- 15%</td>
</tr>
<tr>
<td>155</td>
<td>DEGR. C</td>
<td>MAX</td>
</tr>
<tr>
<td>1100</td>
<td>OZ - IN</td>
<td>- - -</td>
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</tbody>
</table>

**PLANETARY GEARMOTOR OUTPUT PARAMETERS:**

<table>
<thead>
<tr>
<th>Value</th>
<th>Units</th>
<th>Tolerance</th>
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<tbody>
<tr>
<td>14 : 1</td>
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<td></td>
</tr>
<tr>
<td>72</td>
<td>LB-IN.</td>
<td>MAX</td>
</tr>
<tr>
<td>1062++</td>
<td>LB-IN.</td>
<td>MAX</td>
</tr>
<tr>
<td>150</td>
<td>RPM</td>
<td>- - -</td>
</tr>
<tr>
<td>33</td>
<td>Arc Minutes</td>
<td>MAX</td>
</tr>
<tr>
<td>75%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>LBS</td>
<td>MAX</td>
</tr>
</tbody>
</table>

**NOTE:** TENV DESIGN; MEETS IP-54 STANDARD ~ TRUE PLANETARY GEARING ~ BALL BEARINGS  
++ All Peak Torque Values are dependent upon duty. Kindly consult our Sales Offices for further details
OPTION 1: OPTICAL “KIT” ENCODER  
Consult our Sales Office for Pricing

**Encoder Resolutions available: 32 PPR, 100 PPR, 250 PPR, 500 PPR, 1024 PPR**
(Use Suffix “EU-xxx” after model # to designate the Encoder and its resolution)

The Standard “Kit” Encoder Option, mounted integrally to the back of the Motor, includes an Index Pulse, and 12” Long Flying Leads with Connector – Mounted and tested before shipping.

Option 2: “IP-65” Optical Encoder, 1000 PPR STD  
Consult our Sales Office for Pricing

Features Index Pulse, Complementary Output Signals, IP-65 Rated protection for harsh environments, 6 FT Long Cable.

**Encoder Resolution 1000 PPR available from stock, but many other resolutions available.**
(Use Suffix “Ei-xxx” after model # to designate the Encoder and its resolution)
OPTION 3: INTEGRAL BRAKE OPTION

Consult our Sales Office for Pricing

- For “Mid Sized” Gearmotors and Motors, including the MMP C21 Series, MMP S23 Series and MMP B23 (Brushless) Series, most are sufficiently served by a 5 In-Lb to 10 In-Lb Brake. The Standard “Small” Brake / Cover Dimensions are as follows:

Typical dimensions 2.15” Diameter by 1.55” Long, with 24” Leadwires
Typical Brake Current = 250 mA

- For “Large Sized” Gearmotors and Motors, including the MMP S28 Series, MMP C40 Series, MMP MT36 Series, MMP PT28 Series and the MMP MT33 Series, most are sufficiently served by a 15 In-Lb to 50 In-Lb Brake.

The Standard “Large” Brake / Cover Dimensions are as follows:

Typical dimensions 3.05” Diameter by 2.1” Long, with 24” Leadwires
Typical Brake Current = .400 mA (50 In Lb Brakes are typically 4” Dia by 3” L)

(Use Suffix “BR-xxx” after model # to designate the Brake and its’ Torque)

Please specify “BR-xxx” for Standard “Holding” Brake (not to be used for Dynamic Braking)…
This Part Number Suffix also identifies a “Failsafe” type brake – the brake engages in the ABSENCE of input power to the coil.
Please also notify if the brake operating voltage is to be DIFFERENT THAN the Motor’s specified Operating Voltage. If not otherwise noted, the Brake’s Coil Voltage will match the motors’ operating voltage.

For a “Power ON” brake, or a brake that is engaged with POWER APPLIED, please specify the Part Number Suffix “BR-xxxN”.

Both of the above mentioned brakes are integrally mounted to the back of the motor, and are enclosed in an aluminum cover.
The Standard Cover doubles as an Encoder Mounting Surface. Most MMP Brake Motors and Gearmotors are designed to include Encoder Compatibility.

For additional details and assistance with configuring the model number for Brake and Encoder Options, please feel free to contact our Sales Offices.