GO BaBy Go – MROC

Successful Collaboration of Faculty, Students, and Licensed Professional Engineers

The Go Baby Go (GBG) project is to design, build, and implement an upgrade to commercially available ride-on vehicles for disabled children and is a joint project between University A - Electrical and Computer Engineering and Mechanical Engineering Departments and University B - College of Health and Physical Therapy Departments. The project provides an economical solution to combat the issues associated with limited mobility. This solution involves supplying 13-months to 3-years old children with Modified Ride-On Cars. (MROCs). An MROC is a customized electric ride-on car that is altered to accommodate the specific needs of an individual child. MROCs are an alternative to purchasing expensive motorized chairs that many families can not afford. The GBG project aims to provide additional opportunities for early skill development. Also, the vehicles allow the children to gain independence and the ability to socialize with others more readily.

Over 16 professionals, consisting of 8 PEs, 2 EIs, an attorney, and 5 health and physical therapy-related specialists along with 8 individuals from industry and university staff, mentored student teams or served as consultants and evaluators for the project. Students developed several videos to share with professionals describing their work. In January of 2021, students created a blog (https://gbgdatalogger.University_A.org/) with the assistance of an officer of the Memphis Section of IEEE to facilitate communications between students and professionals. In the blog, a faculty member and occupational therapist from University B wrote,

> "Participating in the Go Baby Go project allows us to learn in an inter-professional setting while helping to improve the quality of life of many young children. We support the mission of facilitating improved access to engagement in everyday activities as we work in collaboration with their families and individuals in other professions to remove barriers for children with disabilities in our community. Through this initiative, we provide opportunities for early, independent mobility, socialization, and overall skill development for children with challenges in these areas. We want to bring more awareness to this cause and encourage others to join and follow us on our project journey."

Participating in the Go Baby Go project allows students to learn in an inter-professional setting while helping to improve the quality of life of many young children. In collaboration with their families and individuals, students, engineers, and health professionals work to remove barriers for children with disabilities in the community.

Protection of Public Health, safety, and Welfare of the Public

Being able to move independently helps children develop their motor, language, cognitive, social, and play skills. Children with disabilities can experience delays in these areas when they are not able to move independently. This project focuses on affording young children with physical disabilities the same opportunities as their peers without disabilities. This work introduced a workable solution, the MROC. The electric cars customized for this project are the "Best Choice Products 12-V Kids Bentley EXP 12 Ride On Car w/ Remote Control" and the "Audi Costzon Audi R8 Spyder 12V Electric Kids Ride On Car Licensed MP3 RC Remote Control." The MROC is a children's ride-on car that has been modified to make it safe and possible to be used by a young child with disabilities. As the accelerator of these electric ride-on cars are on-off switches, a crucial modification is removing the "lurch" or sudden movement of the car when the accelerator is pressed or when the car is otherwise activated. The primary goals of this work are to (a) ensure the safety and welfare of the children, (b) reduce the acceleration rates, (c) reduce the maximum speed of the car, (d) add postural support, (e) add or modify the accelerator pedal using a joystick or push button, (f) install a data logger to measure and record the direction the MROC is driven (i.e., forward, backward, stop) and the exact time and duration each event occurs, (g) add fuses to prevent overheating of motors if the motors are stalled, and (h) to implement these modifications for $250 to $300.00, including the cost of the car. University B's Physical Therapist evaluates each child to determine their requirements for an MROC and instruct parents or guardians on the use and capabilities of the MROC. The cost of the modifications depends on the needs of a particular child.

Professional Participation in an Online Multidiscipline Environment

The Go Baby Go project has spanned two years. The project began in the spring of 2019 when faculty at University B approached the faculty of University A to assist in modifying small electric cars to fit the needs of children who are physically challenged. The following describes the progress of the project:

- During the spring and summer of 2019, University A's students modified seven cars that reduced the rate of acceleration and speed on nine cars. This work was performed by three students guided by faculty from University A and B. Two electrical engineering students modified the controls to reduce the maximum speed and acceleration rate. One mechanical engineering student modified the steering on some of the cars for children who were unable to steer.
- On September 14, 2019, a Go Baby Go Rodeo was held at University B, as shown in Figure 1. Students modified the cars on an as-need basis during the redo to accommodate the children at the direction of faculty, one a professional engineer.

Figure 1. Go Baby Go Rodeo

- In August of 2019, two electrical engineering students choose Go Baby Go as their capstone project. The students refined previous work and worked under the direction of the faculty from University A and B, one being a professional engineer.
- On February 1, 2020. The electrical engineering students presented their work to parents, professionals, and faculty of University A and B. A rubric was developed to assess the students' work.
- Worked halted on the project from March of 2020 to August of 2020 due to the COVID-19 pandemic. In August of 2020, two other electrical engineering students and three other mechanical engineering students chose the Go Baby Go Project as their Capstone projects to work under the direction of faculty at University A and B. A free software license was acquired.

- In January of 2021, two electrical engineering students created a blog to facilitate communications between students, faculty, professions, and the public during the COVID-19 pandemic. The number of electrical engineering students working on the project increased to nine. Although the blog centered on developing a data logger for the project, it provided a platform for a multi-disciplinary approach for planning and designing the MROC. Students were assisted in developing the blog by members of the executive board of the local section of IEEE.
- On February 20, 2021, students presented their work to University A's faculty, which included two professional engineers in an online meeting. The students had improved and standardized the design of the controller with the assistance of professionals. A rubric was developed to assess the work.
- On March 5, 2021, electrical engineering students presented their work to University A's faculty and professional engineers from local engineering firms in an online meeting.
- In online meetings on March 10 and 11, 2021, two professional engineers from the Memphis Chapter of Tennessee Society of Professional Engineers and one professional engineer from industry reviewed the work of the electrical and mechanical engineering students.
- On May 15, 2021, mechanical engineering students from University A presented their work to University A's mechanical engineering faculty. The work included adding postural supports, a push-button for the accelerator, and an emergency cutoff switch with faculty assistance from both universities and professionals.

These presentations, meetings, and events allowed the student to interact with professional engineers and defend their work.

Knowledge Gained

An important task was to modify the existing circuit to reduce the acceleration and deceleration rates with minimal changes to the existing systems. Figure 2 is a block diagram of the car's pre-modified controller/motor configuration. The pre-modified circuit (PMC) consists of two 6-VDC (Volt Direct Current) batteries, a controller, motors, and the driver-related instruments used to drive the ride-on car. The controller acts as the hub receiving inputs and controls components for a specific action. The batteries are wired in series so that 12-VDC supplies power to all systems. When the accelerator pedal is depressed, a switch is closed, sending a signal to the controller. Once the controller detects this signal, it applies voltage to the motors. The voltage output of the controller will depend on the voltage of the battery. Table 1 depicts the direction of motor rotation based on the motor controller output.

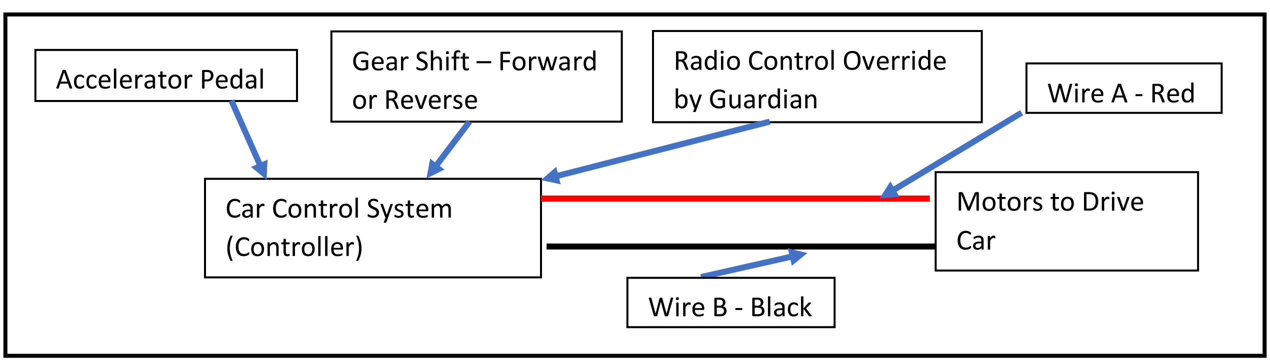


Figure 2: Pre-modified Circuit (PCM)

Table 1: Existing Controller Output

Motor Rotation	Existing controller output to motor- Red	Existing controller output to motor- Black
No movement	12.6-VDC	12.6-VDC
Forward	12.5-VDC	~0-VDC
Reverse	~0-VDC	12.5-VDC

The PMC was modified by disconnecting the leads from the motors and placing an "Additional Control System" between the PCM controller and the motors, as shown in Figure 3.

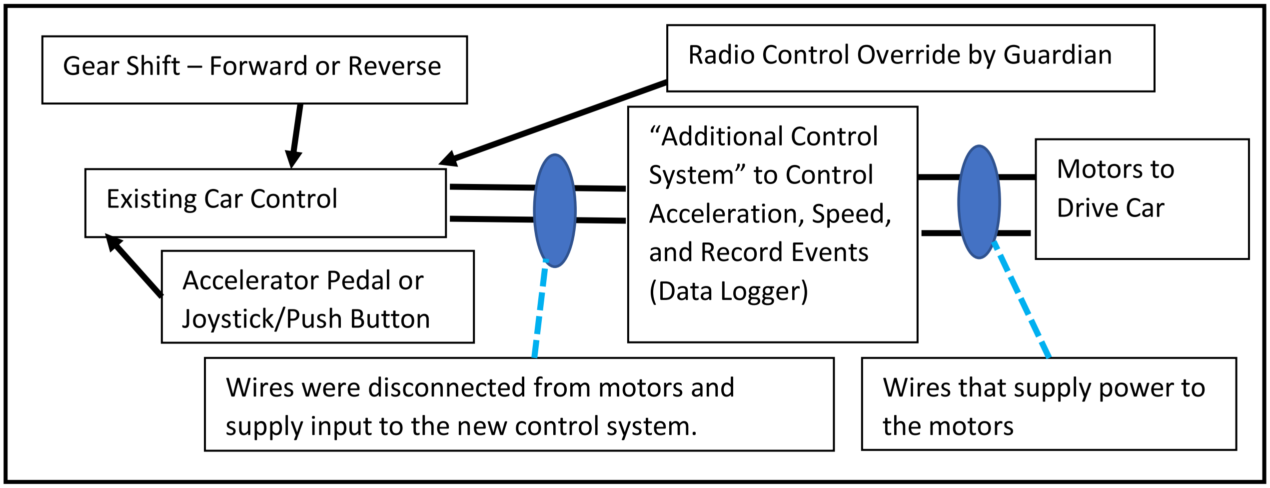


Figure 3. Modified Ride-On Car Block Diagram

The modified circuit has all the components of the PMC but also has an added motor-controller, Arduino Nano, 5-VDC relay, potentiometers, additional fuses, and resistors, as shown in Figure 4. The Arduino Nano will receive signal changes from the existing controller, wires A and B of Figure 2, and provide control signals to the Cytron MDD10A motor controller.

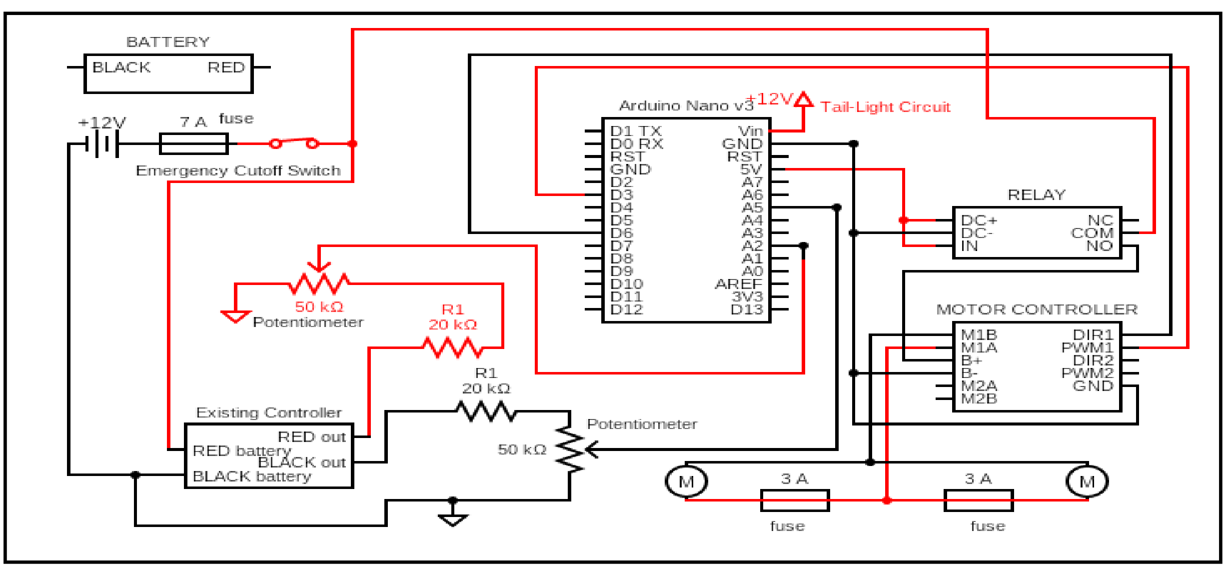


Figure 4: Modified Circuit

The relay acts as a switch, turning the Cytron MDD10A "On" when the Arduino Nano is switched "On." This keeps the Arduino Nano and Cytron MDD10A from drawing current from the batteries when the car is not turned "On." Three-amp fuses were added to ensure the motors would not overheat if the wheels were blocked from turning or placed under a heavy load.

Three data loggers were constructed and tested to record MROC motion for interaction analysis. The data loggers include the Adafruit Data Logger Shield, the DS3231 Real-Time Clock (RTC) Module SD Card Module, and the Kaptery Nano Data Logger Shield. The Kaptery Nano Data Logger Shield was the most cost-effective and recorded the forward, backward, and stop motions as in Figure 5. The data is saved to a file on an SD card. Upon retrieval, the file on the SD card can be downloaded and saved as an EXEL file to be analyzed.

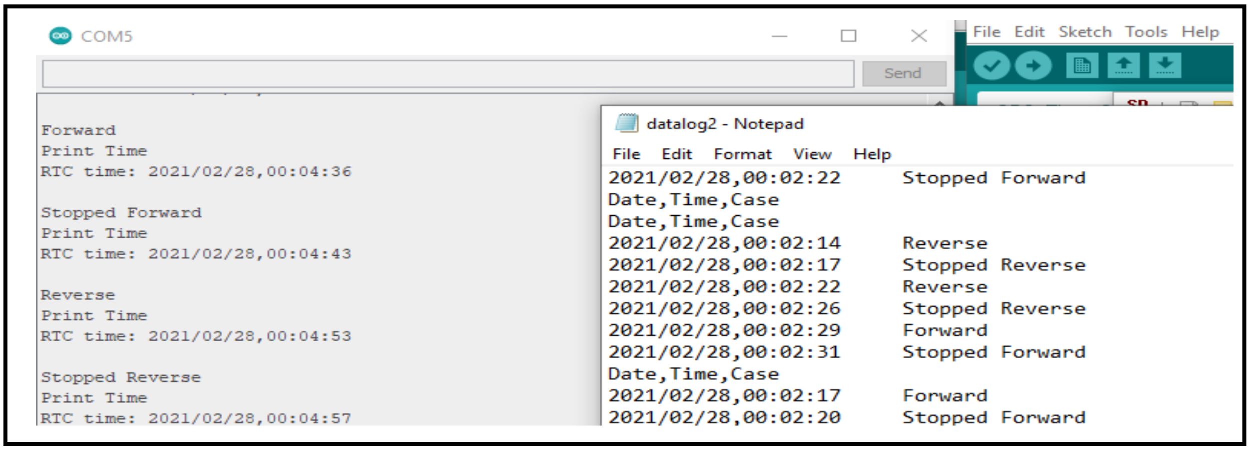


Figure 5: Data Logger Results

Students added postural supports, a push-button for the accelerator, and an emergency cutoff switch, as shown in Figure 6. The emergency cutoff switch allows a parent or guardian to stop the car in an urgent situation. A PVC frame with Styrofoam pool noodles covering the sides and back was installed onto the car for postural support. Since the young child will grow rapidly, the car needs to be future-proof for about four years. The PVC frame needs to comfortably support the child's back and sides with the knowledge that the child will grow.

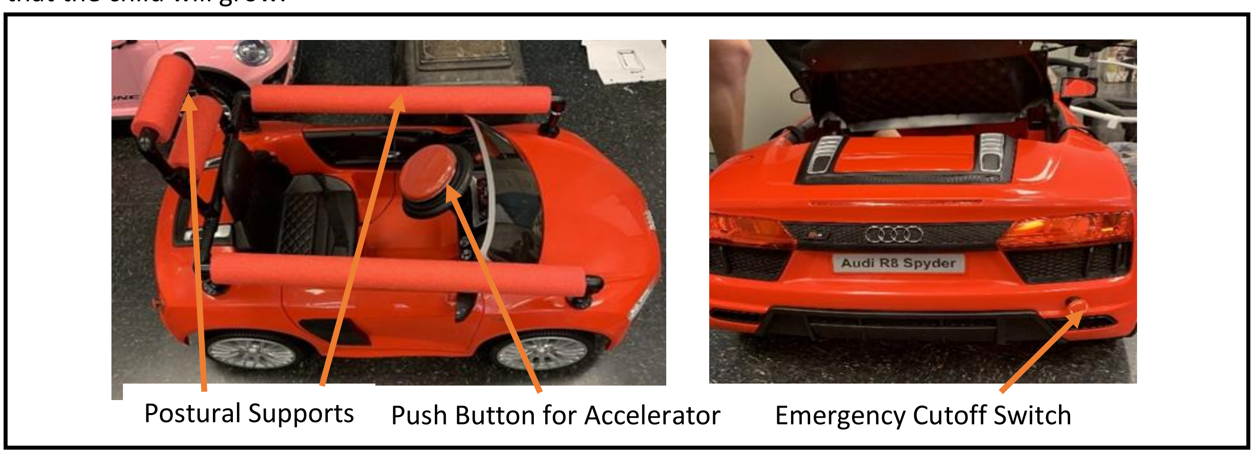
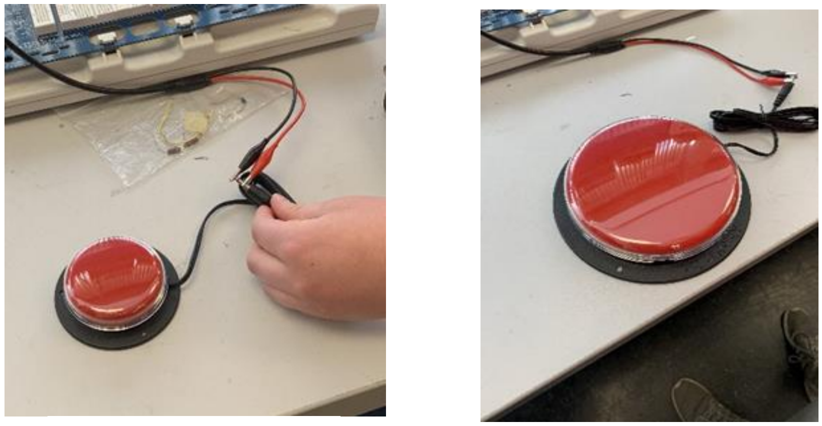


Figure 6. Postural Supports, Push Button for Accelerator, and Emergency Cutoff Switch

Exchanging the acceleration pedal for a wheel/dashboard-mounted momentary push-button switch is a common modification for Go Baby Go vehicles. This mechanical alteration allows children to utilize their stronger and more coordinated arms when ankles/legs are weak. Several different switches can be used based on needs, such as push-button switches with a large touch surface, positive feedback rewards, and button sensitivity. The buttons compared included handicap-specific buttons such as the AbleNet Jelly Bean and AbleNet Big Red, as shown in Figure 7.



AbleNet Jelly Bean AbleNet Big Red

Figure 7. Wheel/Dashboard Mounted Momentary Push Button Switches

The pressure needed to activate the switches is shown in Table 2. Sensitivity was an average of the experimental values for the center and outer edge sensitivities of the buttons. The stated website sensitivity for AbleNet Jelly Bean and AbleNet Big Red is 0.16 lbs. and 0.34 lbs, respectively, matching the test results when pressed at the center. No "best" or "right" push button switch covers all children.

Table 2. Test Results on Wheel/Dashboard Mounted Momentary Push Button Switches

Test	AbleNet Jelly Bean		AbleNet Big Red	
	Center [lbs.]	Outer Edge [lbs.]	Center [lbs.]	Outer Edge [lbs.]
T1	0.25	0.06	0.35	0.26
T2	0.20	0.06	0.36	0.25
T3	0.15	0.09	0.37	0.20
T4	0.15	0.06	0.37	0.27
T5	0.15	0.05	0.35	0.19
T6	0.15	0.05	0.36	0.21
Average	0.175	0.0617	0.36	0.23

Software

The Arduino Nano receives two inputs from the car's controller. Based on this information, the Arduino Nano is programmed to determine whether the car is to go forward , reverse, or stop. The Arduino Nano continuously receives data from the car's controller to determine whether the car should continue, accelerate, decelerate, or stop. The code for this work can be downloaded at a GitHub site (https://github.com/University_A_faculty/GoBabyGo.git). Figure 8 is a flow chart of the program.

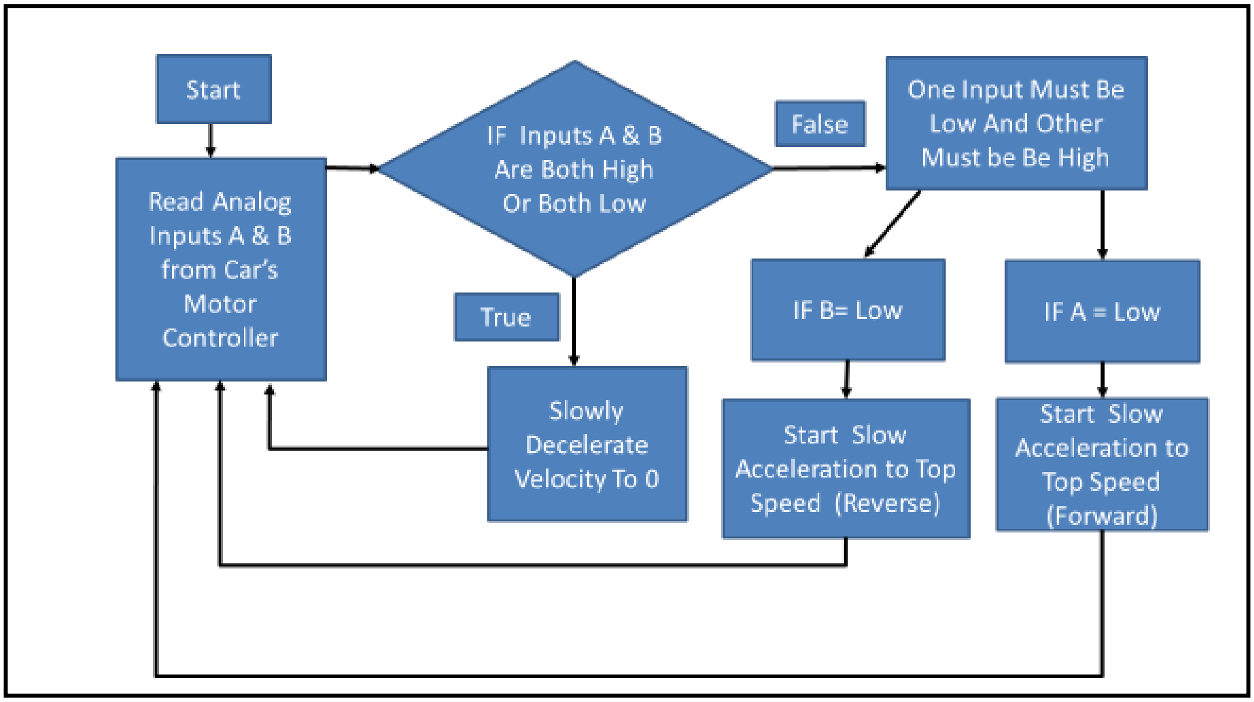


Figure 8: Flow Chart

The project used two different cars, each having unique control systems. No plans for electrical or mechanical systems were furnished with the cars, and students were required to examine the cars construction and electrical systems to determine the appropriate modifications to meet the needs of the children. Students defined the following software variable to meet the requirements of a variety of cars: Maximum Speed Forward, Maximum Speed Reverse, Acceleration Rate Forward, Acceleration Rate Reverse, and Time Delays to ensure steady-state conditions. The 20-kΩ resistor and 50-kΩ potentiometer, shown in Figure 4, are the voltage divider networks to reduce the 0 to 12-V signal (output of the car's motor controller) to 0 to 5-V to meet the requirements of the Arduino Nano.

Conclusion

Projects are undertaken for many reasons, but few are as fulfilling as helping a disabled child and their family. The design was based on inputs to the motors; this concept enables designers to readily adapt the software and hardware to a wide range of cars from different manufacturers and allows parents to use the radio control capabilities of the car. Projects are undertaken for many reasons, but few are as fulfilling as helping a disabled child and their family. This project has truly been a wonderful experience. Families acquire the MROC free of charge, and companies, organizations, and individuals contribute funds to cover the cost of cars and modifications. This is essential considering the cost of the car and parts is between $250 and $300. This highly fulfilling project has had its share of challenges. The technical side took longer than anticipated, failing to reach milestones frequently due to design challenges. However, after overcoming the design challenges, the MROC reliably works as designed.