The Holden Elementary School Autonomous Vehicle (HESAV)

By

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Abstract

One challenge that must be met for a successful capstone design course is to select a project that excites a student team while solving a real world problem. This paper will discuss the results of a senior design project that met both of those criteria. The project objective was to design and build a fully autonomous vehicle for use by physically challenged children at the Holden Elementary School. This paper will discuss the project scope; vehicle specifications, operational constraints and required safety features needed to complete the project.

Project Objective

The primary objective of the project was to build a fully autonomous vehicle that could be used by the physically challenged children at the Holden Elementary School. The school has a physical and occupational therapy department that works with children that have moderate to severe physical challenges. One of the goals of their therapy is to encourage the students to optimize their limited capabilities to affect their local environment. One approach is to provide a reward structure. If a student makes contact with an input device, music may play or lights may turn on. The HESAV would be used to promote any kind of body movement by rewarding children with a short ride along a designated path.

Project Design

In September of 2003, Dr. Lynn Gitlow of Husson College contacted Dr. Dunning of the University of Maine College of Engineering to request design assistance. Dr. Gitlow's area of expertise is occupational therapy. She works closely with area K-12 schools supervising therapy for children. At Holden Elementary School, she was working with faculty treating several severely disabled children. These children have minimal limb control. As part of their therapy, the children are encouraged to make use of their abilities to interact with their environment. Thus, they are led to contact large sensors and receive an award based upon their input.

On a daily basis, the children are secured to a small cart that is used to wheel them around the room. This is a practical and fun activity. Dr. Gitlow wanted to know if a student design team could develop a motorized version of the cart that could respond to a single input from the child by providing a "free" ride around the room. The design solution for this problem was called the HESAV. It is pictured in Figure 1.

During the preliminary design process, the student team met the end users, the faculty at Holden Elementary School and Dr. Gitlow. As the design developed, subsequent meetings were held with school officials. The vehicle was presented and delivered in May 2002.

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The HESAV uses two IR sensors to follow a track consisting of reflective tape placed on the floor. When the car is started on the track, it will follow the tape for a fixed period of time in response to input from the rider. The tape track allows the teacher to easily change the track layout to maintain student interest. For safety purposes, a sonar sensor is located on the front of the cart. If the cart approaches an object, it will shut down before colliding with the object.

The cart is equipped with three on/off switches and a momentary switch. Each switch controls a different layer of code. When the Master switch is turned on or 'high' both motors turn on and stay on until the Master switch is turned off or 'low'. The Master switch does not activate the two IR sensors or the sonar, because this switch should only be used when the teachers want to move the HESAV down halls or across rooms.

Switch one is similar to the Master switch only it activates the two IR sensors and the sonar. Switch one is used when the teachers want the HESAV to follow the track continuously. Switch two activates the momentary switch so the HESAV will start to move when the child strapped into the HESAV pushes the big red momentary switch. When switch two is on and the momentary switch is pressed the code is activated, which activates the motors and the HESAV moves for about fifteen seconds and then stop, where it will stay until the child pushes the momentary switch again.

Figure 1 – External View of HESAV

The IR sensors are mounted on the underside of the HESAV about sixteen inches apart. The IR sensors will continuously send output signals to the OOPIC microprocessor for processing. The OOPic microprocessor will then use the input signals to determine which DC motor to operate to keep the cart on the track. When the HESAV starts to move off the track, the IR sensor that moves over the reflective tape sends a signal to the OOPIC microprocessor. This causes the processor to turn off the corresponding DC motor, which forces the HESAV to turn back on the track. If the IR sensors malfunction, the sonar sensor shuts the cart down prior to a collision with an object within two feet of the front of the HESAV. Figure 2 shows the circuit cabinet on the back of the HESAV.

Figure 2 – Close-up of Control Compartment

Circuit Schematics

One of the first challenges for the team was to address the low current and voltage limits related to the OOPIC microprocessor. This required the application of motor relays to close the path from the two six-volt DC batteries hooked up in series to the DC motors. The motor relay circuit is pictured in Figure 3.

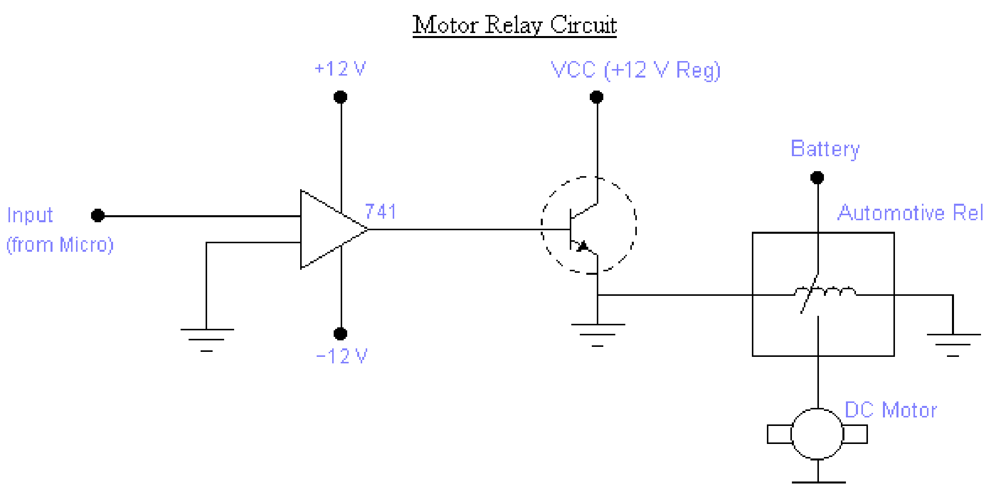

Figure 3 – Motor Relay Circuit

Given the high current flow from the batteries to the motors, the OOPIC microprocessor board was isolated from the main battery circuit and powered from a separate power supply.

Next, the team had to specify the IR and sonar sensors and determine their operating parameters. The team had an extremely limited budget and that was the key factor in sensor selection. After a significant search, IR and sonar sensors were located that fit within the budget parameters of the project.

To utilize the inexpensive sensors, separate power supplies had to be designed to power them. Additionally, power supplies were necessary to supply the operational amplifier used in the motor relay circuit. Figures 4-6 demonstrate the circuit schematics for the three different power supplies developed by the team. Figure 4 illustrates the supply that was built to provide the op-amps with positive twelve-volts DC.

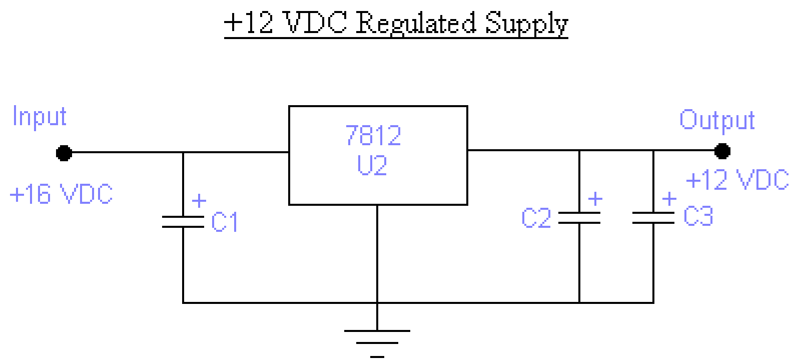

Figure 4 - +12 Volt Supply

Figure 5 provides the schematic diagram for the power supply that was designed to provide the op-amps with negative twelve-volts DC.

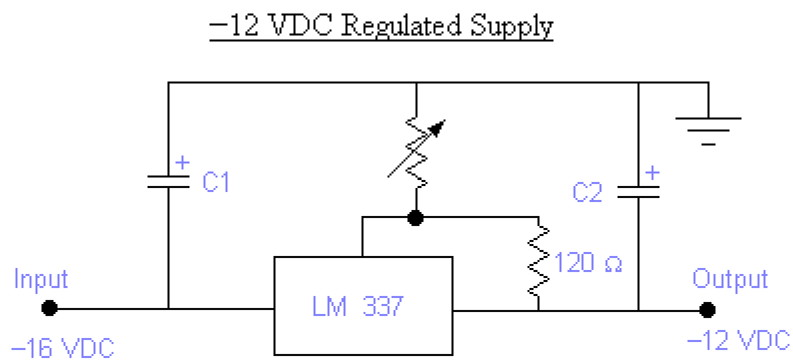

Figure 5 - -12 Volt Supply

The third and final power supply provides a positive five-volts. This was required by the IR and sonar sources. The schematic diagram is shown in Figure 6.

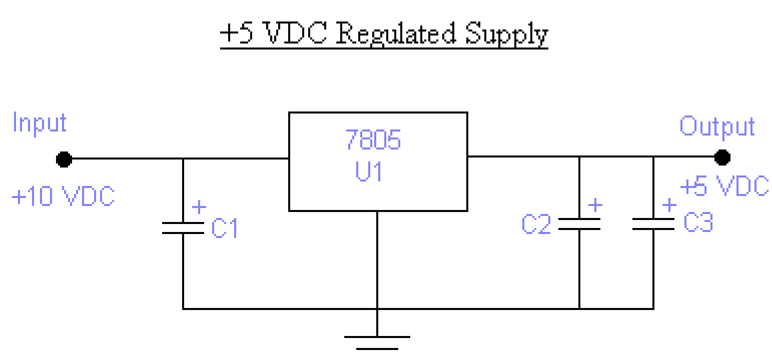

Figure 6 - +5 Volt Supply

Once the circuit design was completed the team focused on software programming. This proved to be fairly straightforward. The OOPIC is easy to program and comes with excellent support materials. The necessary programming required just a few subroutines that were easily developed.

Construction Issues

After the circuit design, the team ran into some minor challenges during construction. Initially, a wheel similar to those used by shopping carts was mounted on the front of the cart. This was not adequate since it would lock in one direction and cause jerky movement. Next, a one half-inch roller ball was tried. While it provided smooth response, it was prone to lock-up due to surface dust on the floor. Finally, a 1.5-inch roller ball was attached and it worked satisfactorily.

The physical body of the cart was constructed out of wood. The front on the cart holds the foam seat while the back of the cart consists of an enclosed motor control compartment. Arranging the motors, batteries and control circuitry in a limited space required significant redesigns. The switches are located on the back of the cart where the occupant cannot reach them.

Project Conclusion

The project met the objectives defined by the University of Maine. The student team gained confidence in their ability to apply electrical engineering principles to solve complex problems. Additionally, the students were pleased to be able to assist the students at the school. The use of the HESAV by the Holden Elementary School has the possibility of improving the quality of life provided to their students. The project is also important to the teachers because now they have another tool to use in their students' physical and mental development. This project is important for the department since it may lead to a grant from the Lemelson Foundation through the Assisted Technology Development Center at Hampshire College.[1] The grant would allow us to pursue other adaptive technology projects in the future.

Bibliography

[1] www.lemelson.org

Biography

SCOTT C. DUNNING is an Associate Professor and Department Coordinator for the Electrical Engineering Technology program at the University of Maine. He received his Ph.D. in Electrical Engineering from the University of Maine. He is a licensed professional engineer in the state of Maine. He is a Senior Member of IEEE and a Member of ASEE.

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