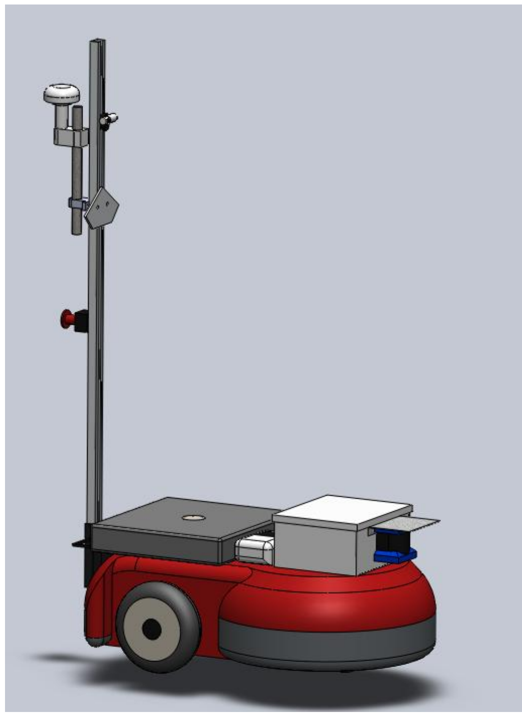
BEARCAT SHREDDER

UNIVERSITY OF CINCINNATI



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Executive Summary

The objective of the 8th Annual ION Robotic Lawnmower competition is to design and build an autonomous unmanned lawnmower, using the art and science of navigation, to rapidly and accurately mow a rectangle field of grass with static (non-moving) obstacles. The competition is held in Dayton, Ohio on June 2-4, 2011. This robotic lawnmower project has two intentions which consist of winning the ION Robotic Lawnmower Competition, and to also complete the senior design requirements of the Bachelor's Degree in Mechanical Engineering for the University of Cincinnati.

The University of Cincinnati Robotics Team has modified a RL850 robotic lawnmower built by the Friendly Robotics Company. Members have redesigned and rebuilt the previous year's lawnmower to work more efficiently. The lawnmower will need to mow a 10' by 15' field within a twenty (20) minute time period and must also be able to successfully maneuver around a single stationary object without touching it. Emergency stop systems (both manual and wireless) have been incorporated into the design. Many different microcontrollers and sensing sub systems were used to help drive the lawnmower and navigate around obstacles / barriers. These additional sensing sub systems added a different control element to the overall drive system of the robot.

This project will ideally demonstrate the ability of a robotic lawnmower to function autonomously with little to no human labor necessary. The success or failure of this project will be based on its performance at the ION Robotic Lawnmower Competition.

Objectives

The objectives of this project are as follows:

1. Enter into the ION Robotic Lawnmower Competition.

2. Rebuild / Redesign last year's entry to work more efficiently. This lawnmower should be able to mow a 10' x 15' field within a 20 minute time length.

3. Develop a simpler emergency stop system (both a manual and wireless system). This 'e-stop' system should be effective around the entire mowing field plus 10 meters in all directions.

4. Acquire / Research hardware that will allow the lawnmower to respond to commands from a laptop.

5. Qualify for the competition by creating a video of the mower running (for three minutes and either by radio control or autonomously), and submitting it to the Qualification Board of the Competition.

6. Use peripherals such as a Digital Camera, Compass, USB interface board, and a laser to send data to the robot about its positioning. This will allow the robot to navigate around obstacles / barriers.

7. Create an interface which will use a docking station to connect the laptop to the robot via a parallel port.

8. Develop code to run the robot autonomously using the hardware that is connected.

9. Submit a project report to the Board of the Competition prior to May 12, 2011

10. WIN the 8^{th} Annual Robotic Lawnmower Competition.

Overview

Team Organization

This year's team consists of Robert Armstrong, Kenneth Kramig, Brian Laiveling, and Eric Niehauser. All four individuals are expected to graduate from the University of Cincinnati in June of 2011 with Bachelor degrees in Mechanical Engineering. Mark Aull, a graduate assistant for the University of Cincinnati Robotics team, has been a very important contributor to the success of this project. Mark is very knowledgeable in electrical circuits and code simulations. He has been a valuable resource since the other members' area of expertise is in mechanical engineering.

Daniel Humpert, MSME and Associate Professor for Mechanical Engineering, is the UC Robotics Team advisor. He was responsible for finding different senior projects for students to work on. Professor Humpert lent support to our team through advice, encouragement, part donations, financial donations, workspace, and contacts for information.

Work was divided equally between all members of the group. The design, appearance, and electronics were all worked on by all group members. A major part of the code needed for the different peripherals to communicate with one another and the lawnmower was written mostly by Mark Aull. Other lines of code were found in previous year's projects and were manipulated to work within this new design. Mark has had a lot of previous experiences with both writing and interpreting code in Visual Studio.

Design Specifications

The competition has many different specification requirements that must be included in the overall design of each team's robotic lawnmower. Such specifications affect the size, speed, safety systems, power sources, and operating features of the lawnmower.

Dimensions

The lawnmower must not exceed two (2) meters in any direction. The overall dimensions of the Bearcat Shredder are approximately 1.00m long x 0.67m wide x 1.75 m tall. It has a mass of 57 kg or approximately 125 lb. The cutting width of the RL850 is approximately 53 cm / 21 in.

Mower Speed

There are requirements for the competition which involve the speed of the lawnmower. The maximum speed allowed by the competition is 10 km/hr. The Bearcat Shredder (RL850) chassis has two (2) speeds, a low speed and a high speed. The low speed operates at approximately 0.90 km/hr or 0.25 MPH. The high speed operates at 1.80 km/hr or 0.50 MPH. The Bearcat Shredder has the ability to operate at both speeds when cutting the grass, both of which do not exceed the competition's speed limit.

Safety Systems ("E-Stop")

According to the rules of the competition, all robotic lawnmowers must be equipped with two (2) different emergency stop systems. These systems include both a manual emergency stop system and wireless emergency stop system. These emergency stop systems should be effective for the entire field of operation, plus ten (10) meters in all directions. More information on the emergency stop systems can be found in the Safety and Reliability section of this report.

Power Supply / Energy Usage

This competition also requires the lawnmower to be powered by combustible fuel (gasoline), batteries, or both. The Bearcat Shredder was built with the consideration of efficient, green energy. It is powered by a fuel cell or 24-Volt DC battery rather than an internal combustion engine or other pollutant-producing energy sources. The laptop is being charged by the same 24-Volt battery, and is connected through a modified version of a cigarette lighting system that is used in cars. Last year's design required a power inverter to keep the laptop charged due to a very old and aged battery within the laptop. A new computer was purchased for this competition this year, which has a new battery capable of holding a charge for over three (3) hours. Therefore the lawnmower is now capable of mowing a much larger area of grass per charge than the previous year's mower could handle.

Other Specifications

The lawnmowers must have direct contact with the ground at all times. Our lawnmower is held up by three (3) wheels. The rear wheels not only drive the mower, but also steer the mower. The single front wheel swivels, and heads in whatever direction the rear wheels tell the mower to roll.

Methodology

The work has been broken down into different categories: mechanical design, software design, electrical design, cosmetic design, and administrative work.

Mechanical Design

Chassis

The team has chosen to use a commercially available, battery powered lawnmower. This substantially cut down on the required mechanical design for the chassis, in order to focus on other problems related to designing the robot. Most design work related to the chassis involved mounting various sensors and assorted equipment.

Housing Box

One major problem involved figuring out how to store the various electrical components, such as the step down transformer and the Velleman circuit board. These components needed to be protected from potential rain while still allowing for air flow to avoid overheating. We found a metal box with a lid to protect from rain, but it also has holes on two sides for air flow. The holes also allow for wire to access the components contained within. We mounted the box directly to the chassis with four screws, one in each corner of the box.

The box also serves as the mount for our laser. The laser's mounting screw sockets are located on the back of the unit, so the box provided the simplest mounting solution. The box's flat sides also made it easier to level the laser, verses the mower's curved chassis. To cut down on excess sunlight interfering with the laser's operation, we also mounted an aluminum visor above the laser. Like the laser, the visor is also mounted to the metal box, just below the lid.

Laptop Mounting

The laptop needed to be mounted securely, but in such a way as to avoid excess vibrations. Fortunately, the team from last year had designed a shock-absorbing tray that we reused. Mounted with the laptop are the GPS unit and remote emergency stop receiver.

Tower

Along with the various electrical components, we needed a place to mount sensors and emergency stop button. To solve this, we added a rectangular aluminum pole to the hitch located on the back of the mower. This tower provides an optimal mounting location for the video camera, as the additional height gives the camera a good viewing angle. It is also the best place for the GPS antenna to get a good signal from the satellite. We put the emergency stop button on the tower to make it easy to access.

Electrical Design

Robot Power Source

As stated previously, this mower runs on a 24 V battery pack. This battery pack is composed of two 12 V batteries connected in series. When the mower was purchased, it came with three battery packs which could be used interchangeably if the power in one was used up. The team wired two of the batteries up to match our modified system so that we could connect everything to either of the batteries in case one fails at the competition.

Charging Cable

Originally, the battery could only be charged while being attached to the mower. The team wanted to make it possible to charge the battery while not being hooked up to the mower so one could be charging at all times. To do this, the team cut the charging wire in half, and installed connectors on each side to make it re-attachable. The charging wire is simply connected to the battery that is not plugged into the robot, and if it is necessary to recharge the battery in the robot the charging wire is attached there instead. When the mower is out being run with one battery pack, the other battery pack can be inside charging for when it is needed.

Step Down Power Converter

Some of the electronics required only 12 V DC instead of the 24 V DC received from the battery pack to run correctly without risking overload. To properly wire these components to work on the lawnmower, the team decided that it was best to use a step down power converter to transform the 24 V down to 12 V. This configuration made it easier to get 12 V off the main battery. The figure displayed below shows the way that the step-down transformer is wired up.

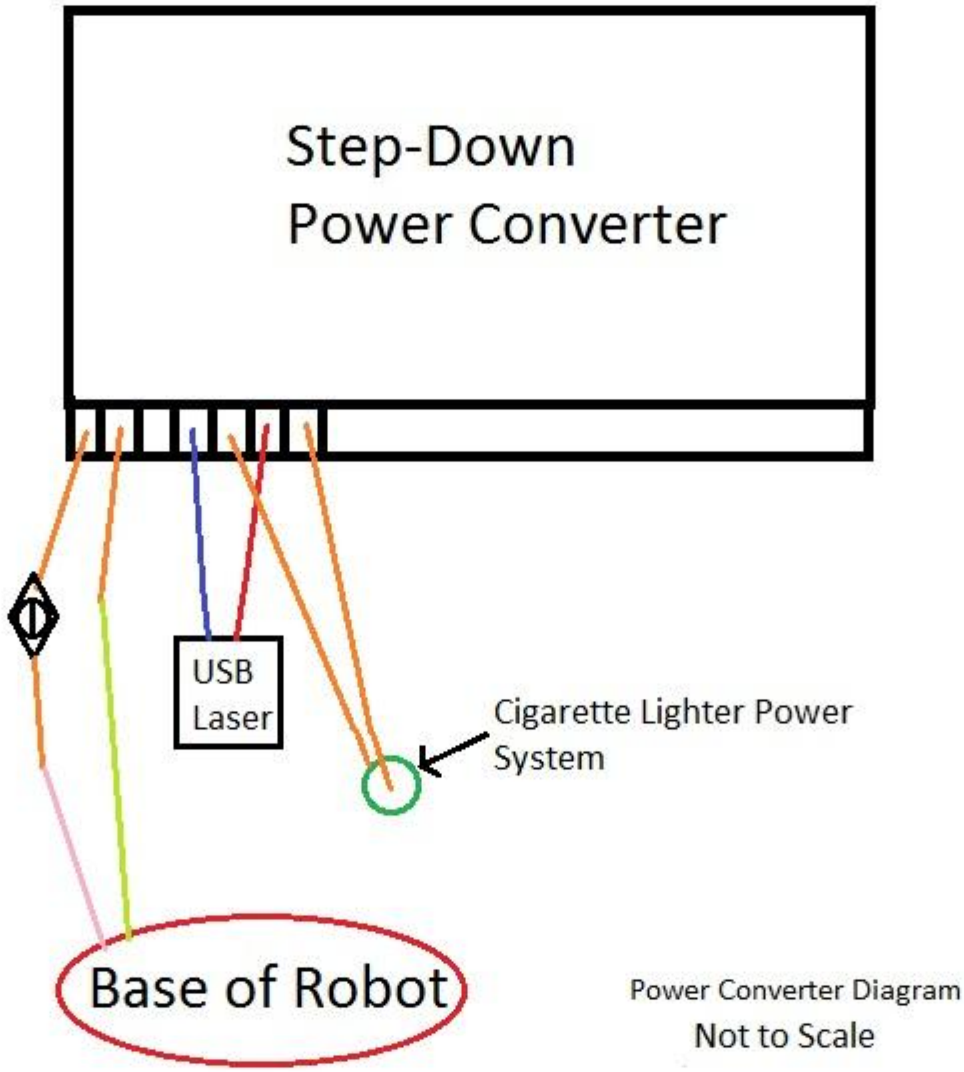


Figure 1 - Power Converter Wiring Diagram

Laptop Power Source

The previous ION Team used a power inverter to keep the laptop charging while it was on the mower. The power inverter was heavy, and zapped a good amount of current from the battery while powered on. To prevent the possibility of overload, we removed the power inverter and installed a device that transfers power from the laptop's power cable to the battery of the mower. The device resembles a car's cigarette lighter system. The laptop power cable is plugged into a Black & Decker power converter, which plugs into the female end of the cigarette lighter system. As shown in Figure 1, two wires connect the female end to the step down power converter. The step down power converter is then connected to the main power wires in the front of the robot that run into the robot's battery. This system will allow the laptop to charge from the battery of the mower while it is in operation.

Software Design

From a computer operating system standpoint, the team has downgraded the laptop to Windows XP. Multiple attempts to get the robot to work on the manufacturers pre-set Windows Vista system ended up being a failure due to the sensors not being compatible with the operating system. The laptop was initially upgraded to Windows 7, but the unsigned device drivers would not work with that operating system either. Since Windows XP is a relatively stable operating system that allows all of the sensors to work with the robot, it was an excellent choice to be used to run the robot.

The team has using Microsoft Visual Studio to write code for the Bearcat Shredder. The code from the previous year's Bearcat Shredder was modified to work with the new peripherals. The basic premise is that the robot will check to see how far it can travel on each path, and goes straight until an obstacle is detected. When the robot comes across an obstacle, it will either go a different way, or turn in place to avoid the item.

Cosmetic Design

The ION team has modified the appearance of the robot system to match the University's colors of black and red. Also in further amplifying its appearance, the team has added university decals to the body. The mounting box on the front of the robot was painted white to reflect all light and keep the peripherals in the box from getting overheated from being out in the sun too long.

Safety and Reliability

Safety is a major concern when it comes to building anything, especially a lawnmower. There are many factors that allow this machine to be dangerous, which can include anything from the cutting blades to it running out of control and hitting someone / something. In order to ensure the safety of everyone / everything around, two (2) emergency stop systems have been incorporated into the Bearcat Shredder. In the rules of the competition, it is clearly stated that the wireless emergency stop system should be effective around the entire mowing field, plus 10 meters in all directions. The rules also state that the manual emergency stop system should be easily accessible by the standing operator behind the lawnmower, must be red in color, and have a diameter of at least 40 mm. For both of the emergency stop systems, it is understood that the lawnmower must cease / shut off within three (3) seconds and come to a stop within a distance of two (2) meters. After testing both emergency stop systems of the Bearcat Shredder, it was found that our emergency stop systems more than meet the requirements listed above.

One (1) of these emergency stop systems includes a manual E-Stop button that immediately cuts all power to the lawnmower when pushed. The manual button has been wired in series directly to the main power source of the lawnmower, the battery. When the button is pushed in, the mower shuts off because it cancels all power traveling from the battery to lawnmower. If the operator wishes to re-enable power, they must pull out the same button they pressed in and must also press the button on the wireless remote. The button is located on the rear side of the lawnmower, approximately one (1) meter off the ground. The location of this device is ideal because the operator does not have to worry about backing up when attempting to emergency stop the lawnmower. The operator can just run to the robot and safely press the button while following it. It is also a safe height off the ground. The operator does not have to bend down to press the button and run the risk of getting their hand caught under the mower. They also do not have to jump to reach the button and run the risk of jumping, landing wrong, falling, and getting run over.

The second emergency stop system includes a remote “E-Stop” which is run off a wireless system. The remote is part of a garage door opening assembly. This consists of a two different parts, one of which is a hand-held clicker that resembles the lock / un-lock button on your keychain for your car. The other involves an electrical box / circuit board which is wired in series to the battery of the lawnmower. When a first button of the clicker / controller is pressed, either all power is instantly cut from the lawnmower, or is enabled. Once the button is pressed, a wireless emergency stop signal or ground signal is sent into the circuit connected to the battery of the lawnmower. It instantly causes the signal relay to drop into the stopped state, cutting off all power to the lawnmower. If the operator wishes to re-enable the system, all they have to do is click the button again to remove the ground signal and power will once again run through the lawnmower.

Reliability is essential when it comes to safety. This is a major reason why there are two (2) different emergency stop systems incorporated into the overall design of the robotic lawnmower. If for some reason one (1) of the systems should fail, it is vital that there is an additional / back-up system available to stop the lawnmower.

Another safety feature of the Bearcat Shredder is that if the front wheel comes off the ground, the mower blades will stop. This is helpful because if the mower somehow rolls over, anything coming within contact of the blades will not be cut into pieces. An alarm will sound when the front wheel is not touching the ground, and the wheel must be put back into place before the blades can be restarted.

Reliability plays more than one (1) role in the specifications of the robot. In this competition, teams are given twenty (20) minutes to cut a 10’ x 15’ section of grass. Therefore the robotic lawnmowers should be reliable enough to run for at least twenty (20) minutes, so all of the time allotted by the competition is strategically used to cut as much of the field as possible. The Bearcat Shredder has been designed in such a way that cutting grass for twenty (20) minutes has never been an issue. As long as our batteries are fully charged, the lawnmower can run for approximately three (3) hours before all energy in the battery will be exhausted.

Economics / Budget

The University of Cincinnati Robotics Club allotted a $7,000.00 budget for the ION Robotic Lawnmower Project. The ION team has purchased multiple pieces of equipment and supplies, which have been used to put the Bearcat Shredder in the best position to WIN the ION Competition. The table below shows the ION Project's budget and a complete list of all equipment / materials purchased, along with the price for each item.

DATE	DESCRIPTION	AMOUNT
01/04/11	University of Cincinnati Project Budget	$7,000.00
02/12/11	USB to Parallel/Serial Cable	-$12.95
02/14/11	Velleman USB Interface Board	-$89.41
04/08/11	Spray Paint and Primer	-$7.50
04/11/11	Spray Paint and Clear Coat	-$12.72
04/15/11	Laser	-$2,950.00
05/03/11	Stanley Auto Cigarette Lighter	-$8.85
05/03/11	Step Down Power Converter	-$72.47
05/04/11	Velcro	-$1.29
	AMOUNT REMAINING:	**$3,844.81**

Table 1 - Project Expenses

Conclusion / Summary

This project initially began slowly, as the team wasn't quite sure of where to begin. However, through hard work and unselfish help from other members of the robotics club, the team picked up steam and made tremendous progress. We have been successful in not only getting the robot to work under computer control (using the computer as a remote control), but we have also had success in getting it to work autonomously through code. We have also been successful in integrating both on-vehicle and remote control emergency stops. Both have proved useful, particularly when testing the vehicle in autonomous mode.

During this past five (5) month process, there were many setbacks. Most of these were software and compatibility issues in getting the computers to interface with the lawnmower. To solve these issues, the team found it best to downgrade the computer from Microsoft's Vista operating system back to the XP operating system. Our first attempt at connecting a laptop to the lawnmower also proved unsuccessful, due to compatibility issues. These were solved with the addition of the port replicator. Once these issues were solved, progress was quick and steady.

A new cosmetic design was put into effect over the month of April. All sensing sub systems were mounted differently on the robot. Their new locations give the Bearcat Shredder a look that shouts both organized and stylish. The design enables all sensors to be located on the robot in a position where they will function most effectively.

Currently, our biggest issues have been getting the lawnmower to run autonomously with the use of multiple sensing sub systems, which all provide a different control element to the overall drive of the lawnmower. The lawnmower can function using these multiple sensors, however it is not functioning quite as we would like it to. These sensors include a Laser, GPS, Webcam, Velleman, etc…

At this point in time, there haven't been any catastrophic setbacks. This is due to the fact that the team has been very dedicated to each step of this project. We began very early, making sure we could get as much done as possible to prevent having to cram everything into the last few weeks prior to the competition. As previously stated, the team still has many weeks until the competition begins. With time still available, the team plans on making some adjustments to the code / software, so the Bearcat Shredder's autonomous capabilities function ideally during the day of the competition.

The University of Cincinnati Robotics Club is dedicated to the ION project and expects to have great success at the 8th Annual Robotic Lawnmower Competition in Dayton, Ohio. All team members have been very committed to this project, dedicating much of their free time to work on the robot. Equal participation was made between each team member on this project. Our team would like to take this time to thank all individuals who have made any kind of contribution to the well-being of this year's robotic lawnmower. A special thanks goes to Mark Aull, a graduate assistant of the U.C. Robotics' Club, who has been a key reason for the progress made on the University of Cincinnati's robotic lawnmower.

References

1. Control.com. Emergency Stop Circuit and Controls. February 15, 2000. January 29, 2011 <http://www.control.com/thread/950636217>.

2. K8055. Velleman Inc. February 2, 2011 <http://www.vellemanusa.com/us/enu/product/view/?id=500349>.

3. McMaster Carr. January 17, 2011 <http://www.mcmaster.com/#screws/=c9ddp4>.

4. MSC Industrial Supply Co. Step Down Transformer - 24 V to 12 V. April 3, 2011 <http://www1.mscdirect.com/ecommerce/navigationservlet/lighting-electrical/electrical-power-generation-distribution/power-inverters-converters-transformers/transformers/buck-boost-transformers/_/n-77gvr?refinement=4292459488&searchandizedok=y>.

5. Open Source Computer Vision. April 29, 2011 <http://opencv.willow-garage.com/wiki/>.

6. Slip Stream Service Pack 3. March 1, 2011 <http://lifehacker.com/386526/slipstream-service-pack-3-into-your-windows-xp-installation-cd>.

7. The ION Robotic Lawnmower Competition. May 11, 2011 <http://www.ion.org/satdiv/alc/>.

8. University of Cincinnati Robotics Club Members. January 15, 2011 – June 2-4, 2011.

9. Visual Studio Help and Support. February16, 2011 <http://msdn.microsoft.com/en-us/vstudio/cc136615>.

10. VNC Viewer. February 22, 2011 <http://www.realvnc.com/products/free/4.1/winvncviewer.html>.

Appendix A: Diagrams

The following figure shows how the peripherals are connected to the laptop computer:

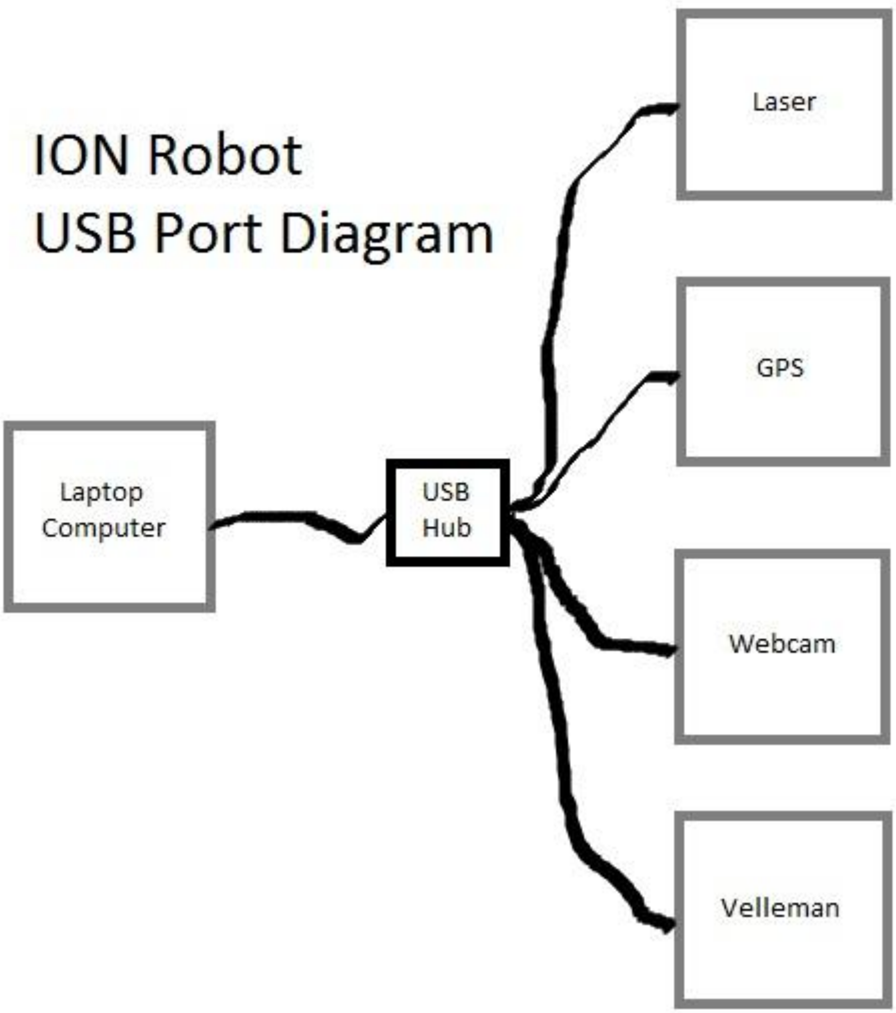
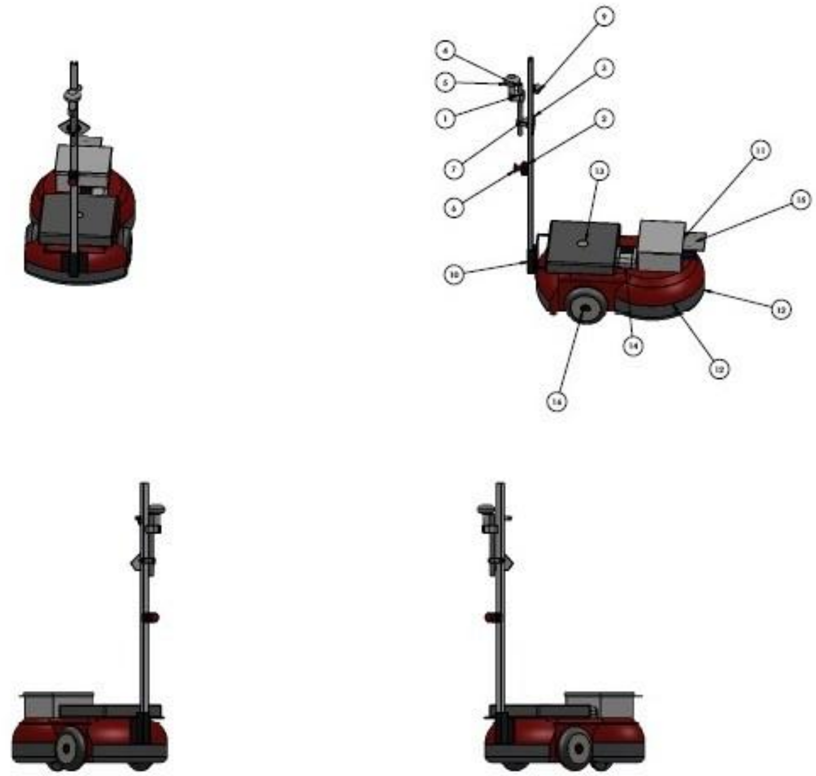


Figure 2 - USB Port Diagram

The diagram on the next page shows a 3D model of how the Bearcat Shredder looks. A bill of materials is included on the diagram.



ITEM NO.	PART NUMBER	QTY.
1	GPS_Holder	1
2	Tower	1
3	Plate_Bracket	1
4	Mounting_Tube	1
5	GPS	1
6	E_Stop	1
7	Mount Holder	1
8	Wheel	2
9	Camera	1
10	Brace	1
11	Box	1
12	Body	1
13	Computer	1
14	GPS_Screen	1
15	Laser	1
16	Axle	1

D Assembly_1

Appendix B: Schedule

A project log has been kept track ever since the first meeting our group had for the ION project, or lawnmower competition. This project log consisted of the days we met, what work was done during the day we met, if we were successful or unsuccessful with the work we were doing, and homework assignments that involved finding out more information on what would be covered at the following meeting. A project log consisting of the above consideration can be seen below.

<u>1/14/2011</u>

- Met with Dan Humpert and the Robotics Team.
- Introduced to the Lawn-O-mower, ION project for our Sr. Design class.
- Observed the lawnmower, along with other equipment that would be used for the project.
- <u>Homework Assignment:</u> Learn the rules to the competition and understand the project's object.

<u>1/21/2011</u>

- Cleaned up the back room of the Robotics Lab, making a sufficient work environment for the ION project.

- Took parts of the lawnmower apart to get a better understanding for everything that would be used during the project.
- Obtained model numbers and serial numbers for all products involved with the lawnmower
- Homework Assignment: Search on the internet for the use of each product on the lawnmower.

1/27/2011

- Met with Mark McCrate and learned more about what this project involved.
- Got a better understanding for each part and why it was used.
- Were able to ask Mark many questions that we were unsure of.
- An I.T. student, Tim, sat in on the meeting and said he would like to help with project.
- Homework Assignment: Make a list of all necessary materials. Determine what materials on this list need to be purchased.

2/4/2011

- Received a new computer from the Robotics team for the ION project.
- Loaded MATLAB and other necessary software on the computer.
- Purchased a parallel port adapter online so the new computer could be adequately connected to the hardware of the lawnmower.

- Tried to get a hold of Tim, IT student, but were unsuccessful.

2/7/2011

- The Parallel Port Adapter was received in the mail and brought to class.
- Acquired information on what numbers of the parallel port require a signal so the lawnmower will move and operate. This was determined by using a paper-clip.
- Purchased a Velleman k8055 circuit board since the old Velleman k8055 was broken (fried) from last year.
- Began a 2-day download of Visual Basic onto the new Dell laptop. Tim, IT student, claimed to be quite proficient in Visual Basic.
- <u>Homework Assignment</u>: Learn about Visual Basic commands so the computer can be programmed to send the lawnmower signals and operate autonomously. Need to learn this because all software and programming help from IT volunteers have been unsuccessful.

2/8/2011

- Completed Visual Basic download.

2/10/2011

- Purchased a Port Replicator

- Jacked up the lawnmower with mini-jacks and made attempts to get the lawnmower operating through the computer using MATLAB. The group is still unsure about Visual basic, but are continuing to try to learn more about it.
- Trials were unsuccessful.

2/15/2011

- The new Dell laptop was docked onto the Port Replicator. The Port Replicator was found to be more useful than the Parallel Port Adapter.
- Additional trials were made to get the lawnmower functional with the computer (using MATLAB), connected through the male parallel port of the Port Replicator and the female parallel port of the remote control. The lawnmower would run briefly and then shut off. Errors in the command were unknown.
- Homework Assignment: Find why the code / commands were not working. Also, look into relays and both stationary and remote emergency stop buttons.

2/17/2011

- Group met with Mark Aull. He was very helpful with Visual Basic.
- Errors were discovered as to why the lawnmower would only run for a brief period of time and stop.
- The lawnmower is now capable of running autonomously. It accepts commands from the computer and will drive in all directions with or without the blades running.

- Progress was made on the remote emergency stop button.
    - The E-stop must be in series if it is put on the wire between the batteries.
    - Maybe wire one of the terminals on the outside of the battery pack (better location for E-stop).
- Suggestions were made to remove Windows Vista from the computer and install / upgrade to Windows 7. Windows 7 would be more compatible with everything that is trying to be run.

<u>2/22/2011</u>

- A copy of Windows 7 was acquired. The computer will be reloaded in the next couple of days pending someone in the group knows how to reload / upgrade a computer's operating system.
- MATLAB, Visual Basic, and all other necessary programs will have to be re-installed onto the computer after the upgrade.

<u>2/24/2011</u>

- Attempted to get a computer with Windows 7 to run the lawnmower. Due to administration issues, these attempts were unsuccessful.
- The original computer with Windows Vista was used to gain further knowledge on what was needed to send signals to the lawnmower for it to run. Visual Basic is the software used to make this possible.

- The manual and remote E-Stop systems were played around with. Since the main battery of the lawnmower consists of two smaller batteries, they are wired in series. Therefore, wires were split and the circuit board for the remote E-Stop was wired in series with the lawnmower batteries in attempt to get the safety system working. No success up to this point. More research will be done at home to get this functional.

2/25/2011

- Both the manual E-Stop and the remote E-Stop systems were worked on. Both of these systems now work properly and are fully functional when the lawnmower is on and running. Additional tests were made on both systems to ensure they worked properly on each and every attempt to E-Stop the lawnmower and shut it off.
- After speaking with Mark Aull, he said there isn't any real reason why the ION project needs to be run with a newer operating system, Windows 7. Therefore, Windows Vista will continue to be used. "If it works, don't try to fix it."
- Once the main battery for the lawnmower was wired correctly to suit both E-Stop systems, an additional battery was wired the same exact way so testing would not be limited to a short period of time if outside running the lawnmower.
- The main power charging cord was cut in half in attempt to get the batteries to charge without being in the lawnmower. The wires were connected to the external power charging source on the battery pack. This now allows additional batteries to charge

while testing is made on the lawnmower so no time is wasted during the actual testing. A charged battery will no longer have to be waited on.

3/4/2011

- This day was meant to run code from the computer to the robot to attempt to get other applications function. However, the day was a nightmare and our group ended up spending most of the time fixing problems or errors rather than making more progress (this day was bound to come).
- Wiring was re-done on terminals of the battery and the new external power charging adapter (due to a "check battery" error).
- Fuses were replaced, which ended up solving all of the electrical problems.
- Windows XP was now suggested to be the operating system of our computer and a older version of Visual Basic (Visual Basic 8) was recommended instead of the newer versions due to compatibility errors.
- A video of the lawnmower outside running and cutting grass is scheduled for Monday, March 7th, 2011.

3/7/2011

- A video was scheduled on this day to show to test the lawnmower and equipment currently attached to it.
- An older version of Visual Basic (Visual Basic 8) was downloaded.

- A version of Windows XP was acquired and attempts were made to reload the computer with this operating system. Errors occurred with the formatting and this attempt was unsuccessful.
- The robot was unable to be controlled with the Robotic Team provided laptop, therefore a Remote Desktop was set-up between that laptop and another, which was used to control the lawnmower.
- The lawnmower was taken outside and run for approximately 30 minutes cutting grass and maneuvering around the campus lawns. A video was taken, however, the grass was not quite long enough so another video will be taken for the competitions application requirements once the grass grows.

3/9/2011

- Windows XP was loaded onto the ION Project computer.

3/10/2011

- The ION Hardware and Parallel Joystick code was loaded onto the ION Project computer as well as MS Office 2007 – trial version.

3/11/2011

- Visual Studio 2008 was installed onto the laptop because new versions of Visual Studio were not compatible with Windows XP.
- Code was written in attempt to have the lawnmower run off of autonomous commands.

A 3-WEEK BREAK FROM PROJECT WAS TAKEN DUE TO FINAL EXAM WEEK & SPRING BREAK

3/31/2011

- A peer to peer connection was attempted between the Ion Robotic Lawn-O-mower computer and one of the group member's personal computers. This was attempted so a wireless network would not be needed to communicate with the robot.
- Attempts to enable this connection were unsuccessful.

4/1/2011

- A peer to peer connection was again attempted. This attempt alone took over four (4) hours and was again unsuccessful.
- A wireless connection was made between the computers.
- An additional trial-run of the Bearcat Shredder was made. A three (3) minute film was taken for the application/registration requirements for the ION competition. Grass was

clearly cut, however the response time between the remote desktop and the robot was delayed (sometime by 10 seconds).

- A peer to peer connection needs to be made.

4/7/2011

- Trials were made on the encoders to not only ensure they were functioning, but to make changes to code so commands would be more
- Ideas and thoughts on a storage structure for electrical components / devices were developed.
- A power-box was torn apart and fitted to store all electrical devices and wires the ION Robotic Lawn-O-mower would need. This was used to help give the robot a clean, sleek look.
- Information was found on how to paint the robot, which was based off of the material that the robot cover was made of.
- The Robot was taken apart and then taken back to a member's house to prepare for the painting process

4/11/2011

- Painting of the robot's lid and electrical storage box took place.
- The lid and storage box were cleaned, primed, and painted. Many coats of red “Rust-ol-em” spray paint were applied.

- Components were left to dry over night.

4/12/2011

- A clear coat was sprayed on the components to help protect the new red layer or paint and give the robot an overall shinny appearance.

4/13/2011

- Attempts were made to get the cover / lid back on the robot. This was unsuccessful.

4/14/2011

- Attempts were again made to get the cover / lid back on the robot. These attempts were successful. Slits were made in the robots cover/lid in order to get the motherboard to line up with the fitted grooves of the lid.
- Drilling took place on the power box, which is used to store electrical devices. Holes in the box were made according to the holes in the lid cover of the robot and were securely fastened down.

4/15/2011

- Application forms for the 8th Annual Robotic Lawnmower Competition were filled out and submitted. A video of the Bearcat Shredder cutting grass was edited and uploaded to youtube.com.
- The application forms and a copy of the lawnmower cutting grass were mailed out to the competition in Dayton, Ohio.
- A thinner, lighter beam was attached to the back of the lawnmower where the manual E-Stop and camera were mounted. This lighter beam will prevent the lawnmower from tipping backwards (driving only on rear wheels) since the weight is more evenly distributed.
- The webcam was torn apart to determine the best way to mount it to the vertical beam, and was then put back together.

4/22/2011

- A cigarette lighter input was purchased. This will be used to power the miniature power converter, which will supply power to the laptop and port replicator.

4/29/2011

- The laser was mounted to the robot. Shims were used to help get the electrical component pole sturdy. Autonomous code was written involving the new laser.

5/5/2011

- Group members worked on getting the electrical box as level to the earth's x-axis while attaching it to the body of the Bearcat lawnmower. The compass was mounted to the body of the lawnmower with Velcro. The laser was mounted to the front face of the electrical box, which allows it to scan a full 180 degrees ahead without anything interfering with it. The group also attached a piece of aluminum above the laser to prevent direct sunlight from entering the laser's view and affecting whatever the laser is intended to be detecting at any particular time.

5/6/2011

- Group members worked on connecting the cigarette lighter adapter to the lawnmowers power source. As previously stated, this will supply power to the laptop and port replicator.

5/11/2011

- Group members finished creating the 3D schematic for the report.
- Report was finalized, and reviewed by all members.

5/12/2011

- The final report was submitted to the competition as this time. Group members strenuously worked on this report from the middle of April, 2011 until the day prior to it being due. As one might anticipate, many changes occurred on the robot during this period of time, therefore many changes also occurred within the report.

Current / Future Work Tasks:

- WIN the 8th Annual Robotic Lawnmower Competition on June 2-4, 2011.