Spring 4-2008

VolTron - 2008 IEEE Hardware Design Competition

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VolTron – 2008 IEEE Hardware Design Competition
Senior Honors Project

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April 28, 2008
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1.0 Abstract

Each year, the IEEE holds a hardware design competition at their Southeastern Conference. Many universities design and construct robots to compete in a specific task which is predetermined by the event organizers. The task for 2008 was to acquire wooden blocks from a playing field and return to its home base. The University of Tennessee's entry utilizes a IR range finder and beacon detection solution to complete the task. The design process is discussed, focusing on areas of the robot that the author was specifically involved. These areas include team integration, fundraising, team logistics and RFID exploration. The robot, known as VolTron, was designed, constructed within a three month time period.

2.0 Task Definition

The 2008 hardware design competition involved a single robot attempting to retrieve a maximum of four blocks from a playing field and then to return with them to its respective starting point. The playing surface was constructed from two 3' x 6'x ½" plywood. The board was divided into two sides and the robot has the option to start at either base. The field consists of three different surfaces including flat, a paint-sand mixture and pea gravel.

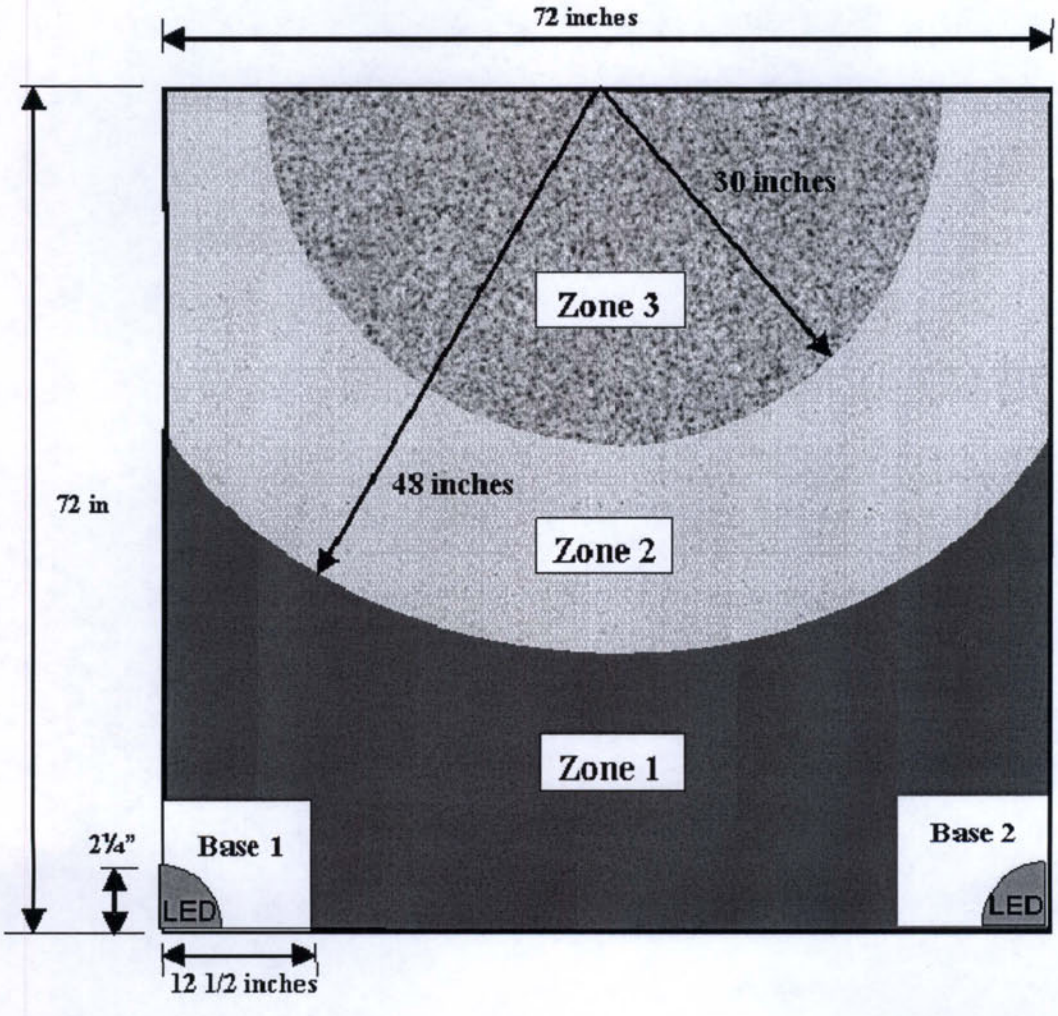


Figure 1: Competition Playing Surface

A scale diagram of the playing surface is given in Figure 1. Each robot begins the round in a 12 ½ inch by 12 ½ inch white starting square. The robot is signaled to begin the round by a switch which is required to be located on its top surface. Once a round starts, each robot must navigate anywhere around the field with the objective to retrieve four wooden blocks. Red, white, and blue blocks will be placed in the center of 10" squares arranged in a grid pattern.. The placement grid will begin approximately 6 "from the walls and 3 ½ "from the inner base boundaries.

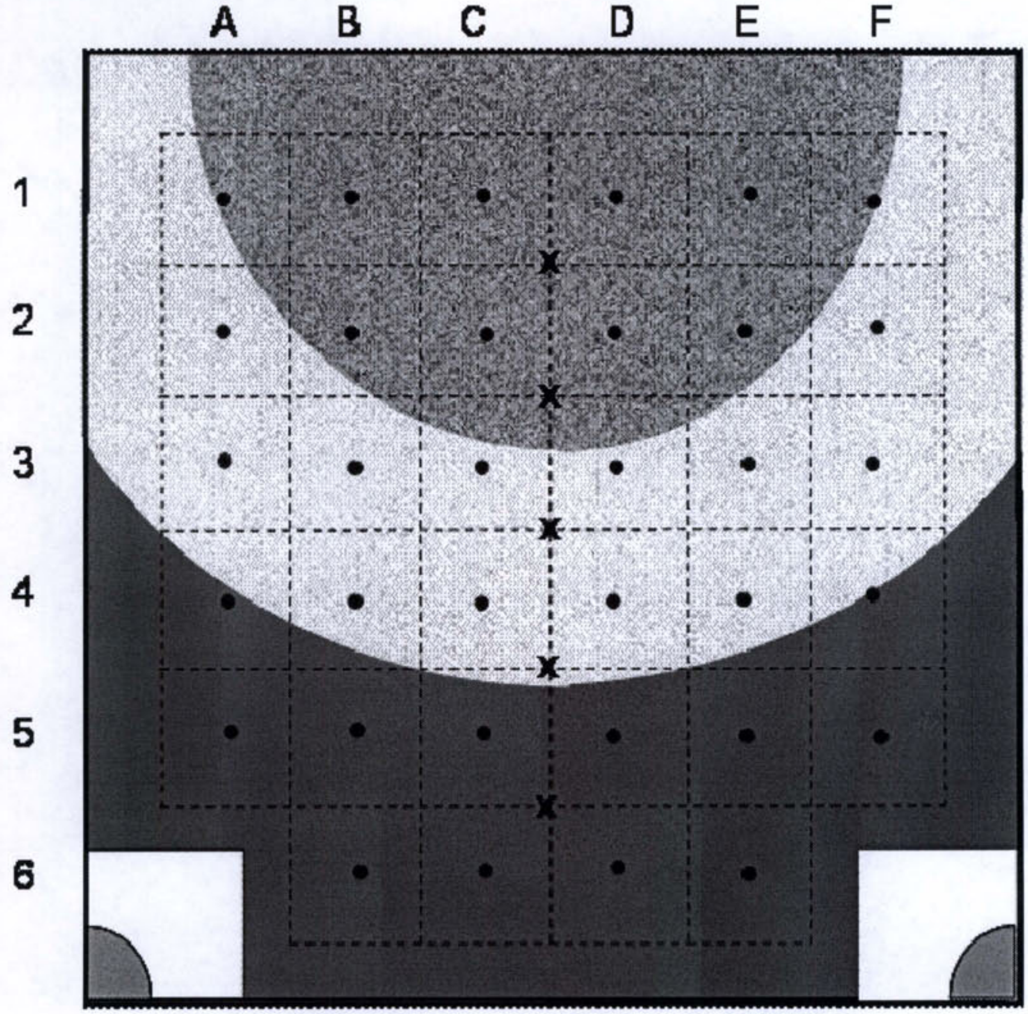


Figure 2: Allowable regions for block placement.

There will be a total of seven blocks placed on the field during each round. One red, one white, and one blue block will be placed on one side of the center vertical line and another of each color placed on one side of the center vertical line and another of each color placed symmetrically on the other side of the central vertical line. The black block will be placed on the intersection of the center line and one of the horizontal lines, but not along the edge. For scoring purpose, the red, white, blue, and black blocks are worth 15, 20, 25, and 30 points respectively. A RFID tag with a unique number encoded will be attached to the each block for identification purpose.

Another notable aspect of the playing field is the addition of the IR navigation beacons. One navigation aid will be placed in each of the playing field home base corners. One beacon will flash its LEDs at 4.0 kilohertz, while the navigation aid on the left will flash its LEDs at 2.5 kilohertz. Both navigation beacons will use a square waveform.

Each round of the competition has a time limit of six minutes. Each robot has to fit a 10" x 10" x 11" square and has no weight restrictions. One restriction is that the robot has a bumper that covers a minimum of 80% of its perimeter in a continuous stretch. Links to a more detailed list of rules and playing surface construction details are located in Appendix A.

3.0 Robot Systems

3.1 Introduction

After reviewing the competition guidelines, an overall strategy of the robot was devised. Since the block with the most point value is always located along the center line, the goal is to always head towards the center line to obtain that block. It is important for the robot to have a locomotion system that will be able to tolerate the three surfaces. Below is a diagram of the initial design chosen by the team. The robot developed by the design team is made up of several subsystems, which will each be briefly introduced here.

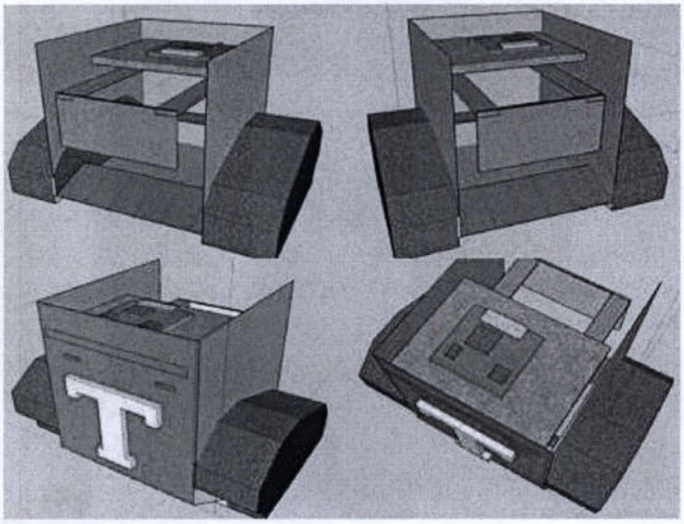


Figure 3: Initial Design

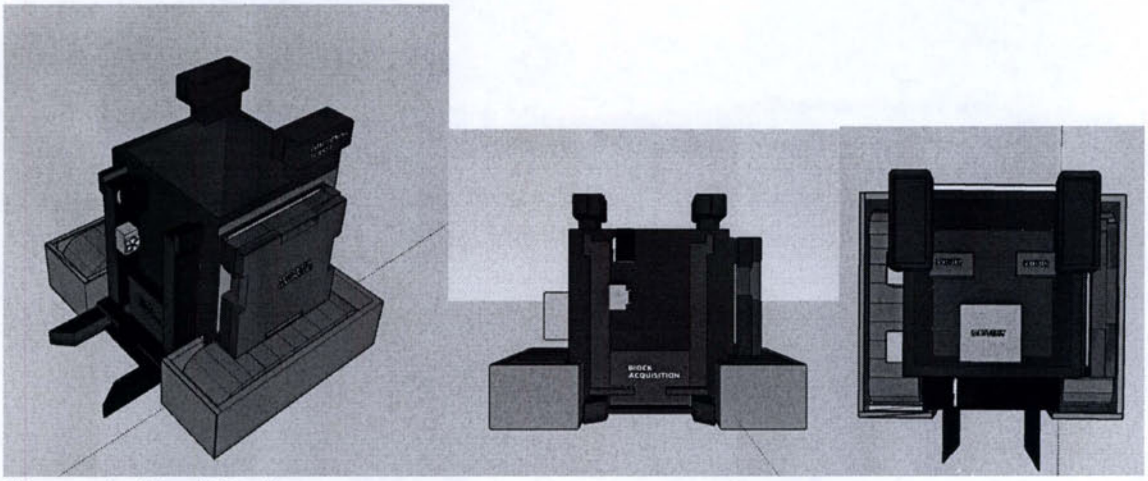


Figure 4: Final Design

3.2 Chassis

PVC panels, which are pictured below, were chosen for use in the final chassis design because of its success with the past robot teams. The PVC proved to be inexpensive, durable, easy to work with, and was aesthetically pleasing.

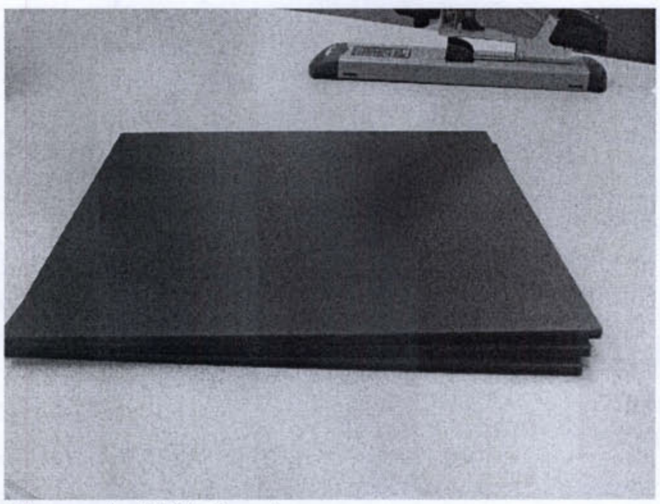


Figure 5: PVC Panels

3.2.1 Initial Design Concept

Based on the team's decision to transport all four blocks at one time, a holding system was to be developed. From Figure 3, a three-tiered chassis was determined to be the best solution. The first level would contain the acquired blocks and the batteries/power regulating system. The second level would house the block acquisition mechanism. The third level would house all computer hardware. One con of this design is limited space for containing four blocks.

3.2.2 Final Design

The final chassis design was a simple box. This could be accommodated due to the change in the design of the block acquisition system which will be explained in a later section. Figure 6 details the specifics of the box design. The box designed so that all components can be mounted to the exterior side surface and still remains within competition guidelines. The placement of the additional components will create a sturdy design which will be stable in the x, y, and z planes.

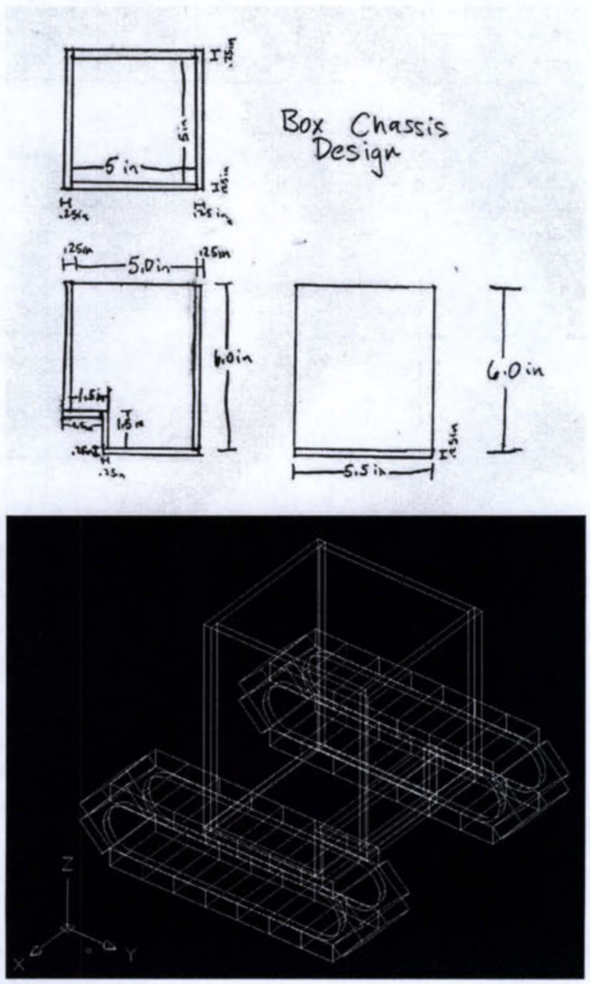


Figure 6: Box Chassis Design

3.3 Block Acquisition

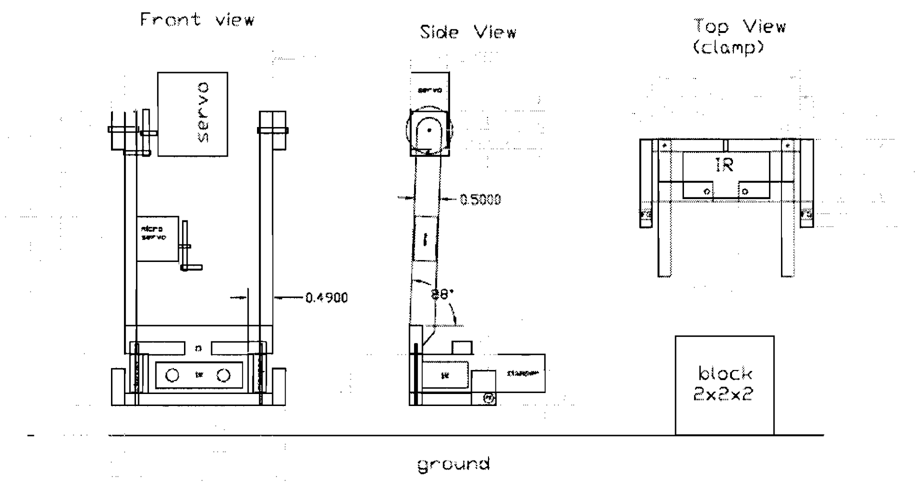
The purpose of the block acquisition system is to retrieve and store the wooden blocks as the robot moves across the course. The block acquisition systems must be able to pick up a block that is 2" x 2" in measurement.

3.3.1 Initial Design Concept

The initial block acquisition design consisted of a simple rake. From Figure 3, one can see that the mechanical arm will be placed on the second tier where it extend a certain distance and push the blocks into the holding area. One con of this design is the face that the blocks have to be pushed for a small distance. Also, the implementation of the extension system can be complicated. F

3.3.2 Final Design

After analyzing cons of the initial design and its limited holding space, the team decided to look into other options. The new design entailed a mechanical arm that will lift each block into a box holding area. Figure 7 represents the new design. This system is composed of servos, PVC material and fish wire which will act together to grip and lift the blocks.



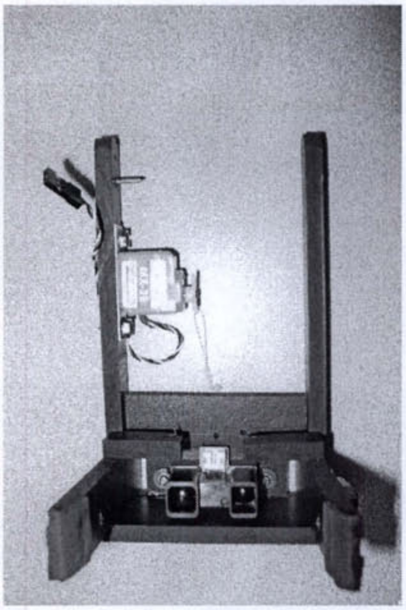


Figure 7: Block Acquisition Design

3.4 Drive Train

The drive train was made up of the drive motors, track wheels and associated hardware, as well as the control circuitry for the motors. This system was responsible for moving the robot around the playing field. It is discussed in more detail in a later section.

3.4.1 Locomotion

When decided on a locomotion system, a track system was unanimously decided as the choice because of its ability to easily navigate all three playing field surfaces. The actual idea for the construction of the locomotion came from a pre-fabricated robot. A robotics kit from Lynxmotion was ordered and included a track system and motors. The team decided to go along with the same concept but tailor it to our application. Figure 8 displays the design for the drive system. It consists of two gears, fifteen track pieces and rollers to help reduce any friction

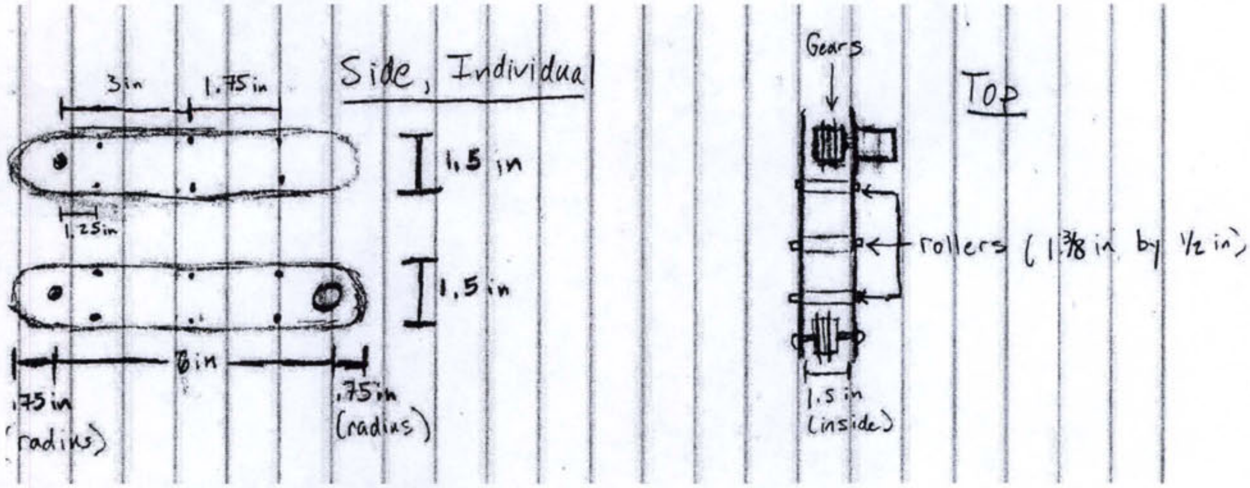


Figure 8: Block Acquisition Design

3.4.2 Motors

The motors used for the drive train were the same from the robot kit. Theses motors are desirable because they are fast and strong enough to survive any rigorous circumstances the robot may encounter. The parameters are the following:

Operating Range: 6-12 Vdc
50:1 Ratio
Rated Load at 12Vdc: 120RPM
Withstand Voltage: 300 Vdc for 1 sec
Speed at Rated Load: 95 RPM
No Load Current at 12 Vdc: <108mA
Current at Rated Load: <269 mA

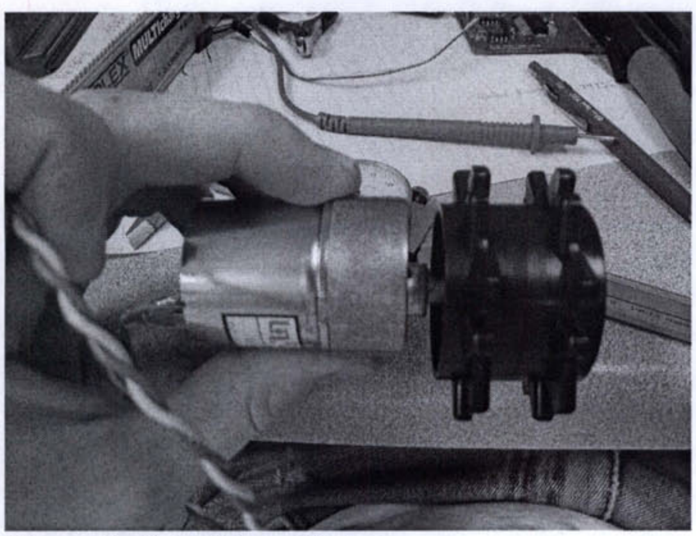


Figure 9: Drive Train Motor

3.5 CPU

This system was made up of a computer and several microcontrollers. It was responsible for the overall control of the robot. This system takes all data gathered by the various sensors, interprets it, makes a decision, and issues commands to the various motors and actuators on the robot.

3.5.1 Overview of Controller Board

The main controller board is very similar to the motherboard located in personal computers and laptops, except on a much smaller scale. Packaged in the PC-104 form factor, this compact size motherboard is only 3.6" x 3.8". Its small size was a major factor in its selection. Manufactured by Kontron Inc., the MOPSlcdVE offered computing power that rivaled desktop machines. This board allowed the team to connect a laptop hard drive for storage, run a Windows or Linux operating system, and program in the C and C++ coding languages. We also used PIC microcontrollers which were programmed in assembly language to generate a PWM square wave which controlled 2 servos.

3.5.2 Selection of I/O Board

The software group used the MC68HC812A4 microcontroller as its control system during the first semester. Shifting from a microcontroller to an actual computer made it necessary for the team to seek out a new input/output solution. While a microcontroller has many pins available for I/O, a computer's ports are generally more specialized, and not well suited to connecting logic level devices. Several PC-104 I/O boards were available from different manufacturers. The one decided upon was the Onyx-MM manufactured by Diamond Systems Incorporated. This board stacked on top of the Kontron board and offered 48 lines of digital I/O. It also had 3 16 bit counter/timer ports with hardware interrupt capability. These ports allowed the team to be able to read devices that would update periodically, like the shaft encoders, without having to poll the status of the devices constantly. Since the design called for the use of analog sensors, a stackable analog I/O board was also obtained.

3.6 Power

The competition rules state that each robot must operate under its own power. The robot required voltage levels of 5V and 12V. Sanyo 4/3A batteries were ultimately selected to power the robot. These batteries were advantageous for several reasons. These batteries fit the AA form factor and could be arranged in a variety of configurations to gain the voltage and/or current required. They also were rated at 4000 mAh, meaning that each cell was capable of sourcing a large amount of current. This was important as current draw for the total design was estimated to be 5.0 amps. One downfall is that these batteries take over an hour to charge. The design team had battery packs custom made, each containing sixteen NiMH rechargeable batteries in series in order to obtain a suitable voltage level. One of these packs is shown below in Figure 10. Also in the figure is the power regulation board, which is responsible for stepping the battery voltage down to the level required by the computer.

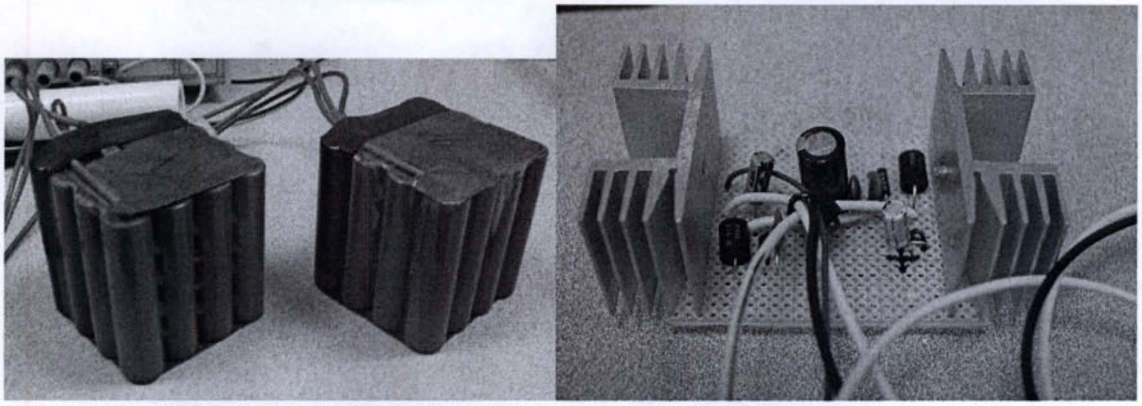


Figure 10: Batteries and Power Regulator

3.7 Sensor Systems

This system is responsible for providing all non-visual input to the control system. Sensors are very important for keeping track of the robot's orientation and position. The robot is heavily dependent on sensors for detecting obstacles or blocks in its path.

3.7.1 Block Acquisition

The strategy of this sensor system is to search for blocks on the middle line and during the return trip. In order to accomplish this goal, Infrared sensors are placed at six locations around the circumference of the robot. These analog, non-linear sensors have an effective range of 4 – 30 inches. From testing, it is found that the blocks are highly directional and have no significant color dependence. The middle line is a main target because the black block (most point value) is always located on this line. While on this center line, the front IR sensors will search for blocks within an 8 inch range. Upon returning to the home base, the front IR sensors are polled to detect blocks in the path. Sweeps of the front IR sensors are performed to detect any nearby blocks. Lastly, the side IR sensors are polled detect any blocks in passing. A diagram of this scheme can be seen in Figure 11.

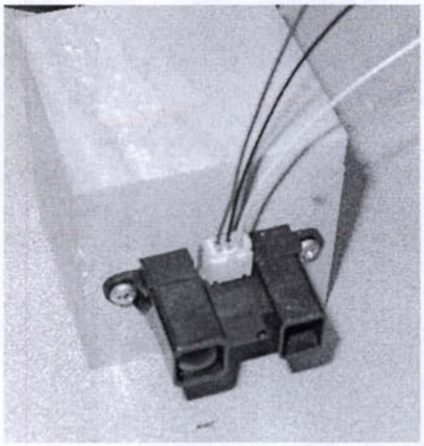


Figure 11: IR Sensor

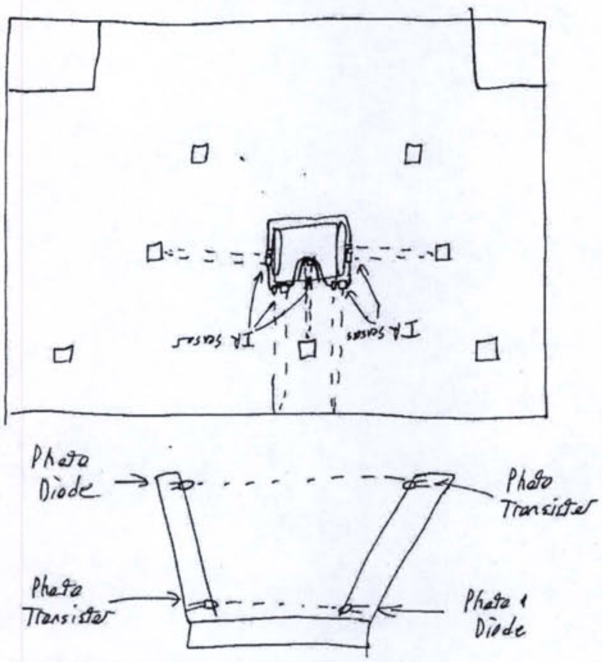


Figure 12: Block Acquisition Strategy

3.7.2 Positioning

The positioning sensor system is important for the robot to be able to detect its distance from key points of the field. In this design, the infrared beacons located at home base are used to determine the direction of home base. Once that is determined, the robot aligns itself to face that direction and moves towards home. Possible solutions for this system considered were ultrasonic range finders, infrared range finders, measuring distance arc on field and beacon tracking.

3.7.2.1 Beacon Recognition Circuit

A circuit was designed to detect the IR signal sent from the beacons. Figure 12 displays the final circuit design.

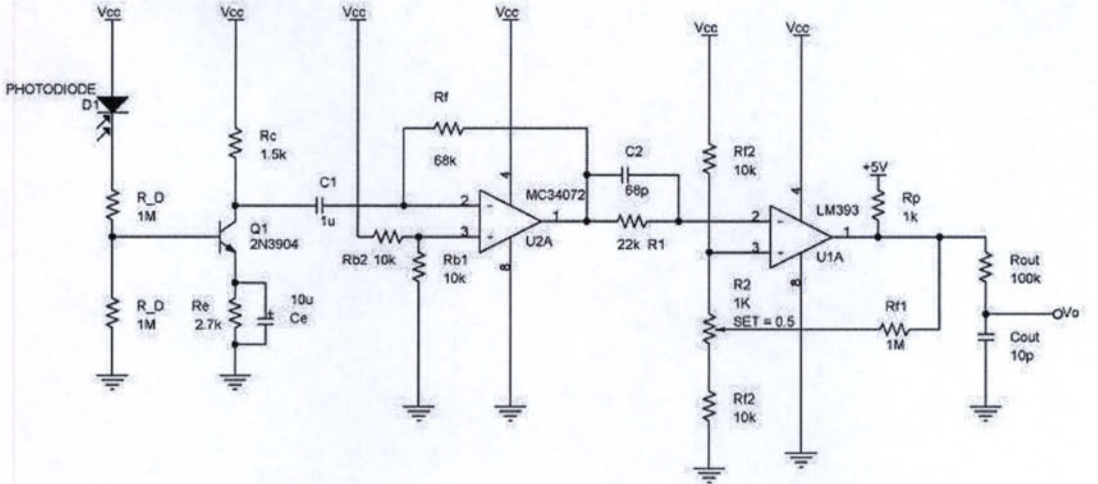


Figure 13: Final Circuit Design

3.7.2.2 Turret System

In order for the device to detect the location of the beacons, some type of rotational base is needed. The idea of the positioning sensor turret came into place. The device described in the previous section was mounted on a servo that rotates 180 degrees. By looking at the angle between the beacons, it would be possible to approximate position on the field and always find home.

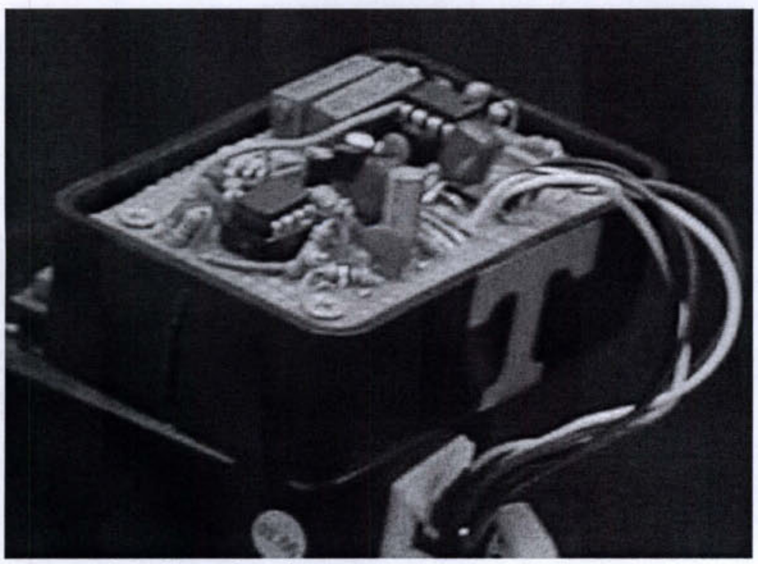


Figure 14: Completed Positioning Turret System

3.8 Software

3.8.1 Positioning Sensor Software Design

The programming team used 6 infrared sensors to locate blocks and the wall on the playing-field. These sensors output a voltage between 0V-2.5V based on the distance between the robot and an object directly in front of the sensor. The analog I/O board reads this voltage using a C++ function. This value is stored into a file that contains voltages coupled with the respective distances. This data is used to determine the distance between the robot and another object. After calibrating each sensor, an algorithm using C++ functions was developed to control which sensors were being probed. The main function for the IR sensor reads the voltage from the sensor, and based on the values in the sensor data file, the function will return a distance. A photo gate is used to detect whether a block is the robot's pinchers. In this case, the photo gate will return a voltage of zero or five volts depending on the sensor data. . This voltage is useful for main subroutine to determine whether the robot was in the position to pick up a block.

3.8.2 Software: Mechanical Control

The digital I/O board is used to control the various mechanical components on the robot. The tracks were controlled using an h-bridge to interface with the digital I/O board. C++ functions are utilized to output 5V signals from the I/O board to the enable pins on the h-bridge. Once the proper control sequence is determined, several C++ functions are developed to command the robot to drive forward, reverse, turn right, turn left, and even drive forward slowly.

To control the servos, PIC microcontrollers are programmed in assembly language to generate the pulse width modulation. The I/O board sends five volts to the PIC chips to generate the square wave needed to control the mechanisms in the block acquisition system

3.8. Main Subroutine

The main subroutine contained various functions and subroutines that were called to read from specific sensors and control mechanical components on the robot. Since the black block is worth the most points, the goal is to always go to the center line for that block. For the initial three seconds, no sensors are polled and the robot is set to a Go Forward() function. Once the robot reached the center line, it will pole the front three IR sensors to look for that block. After acquiring the black block, the robot will continue to drive forward until it sees a block or a wall. If it sees a block, then it faces the block and picks it up. If it sees a wall, then it will rotate and face the home base using the torrents to locate the base. It will then drive home using all of the infrared sensors to poll for blocks on the way home.

4.0 Research / Design

4.1 Introduction/Goal

My goal is to integrate all sub-groups into the design, deal with project logistics including fundraising, and make sure that we are on schedule. Also, I will assume a technical role by investigating the addition of RFID system into the current design.

4.2 What is RFID?

RFID stands for Radio-Frequency Identification. The main purpose of RFID is for identification using radio waves. There are two types of RFID tags: active and passive. Active tags have their own power source and its signal is much stronger. Pass RFID tags do not require batters and can be much smaller and have an unlimited life span. An RFID system consists of three parts: a scanning antenna, a transceiver with a decoder to interpret the data, a transponder (RFID tag) which has been programmed with information. It works by sending out radio-frequency signals in a relatively short range that provides a means of communication with the RFID tag and in some cases, provide the RFID tag with the energy to communicate. When an RFID tag passes through the field of the scanning antenna, it detects the activation signal from the antennae. This enable the RFID chip to power up and transmit the information on its microchip to be picked up by the scanning antenna.

RFID systems are detected by their frequency ranges. Low frequency (30 kHz to 500 kHz) systems have short reading ranges and lower system costs. High frequency (850 Mhz to 950 MHz and 2.4 GHz to 2.5 GHz) systems, offer long read ranges at high reading speeds.

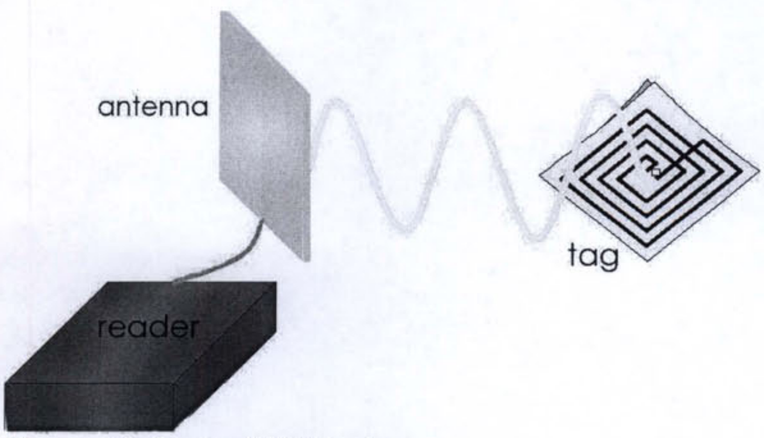


Figure 15: Typical RFID setup

4.2.1 Applications of RFID

RFID technology is very versatile in the fact that the antenna can be embedded into any time of surface. They can be manufactured in a wide variety of shapes and sizes that can be useful in several applications. Current applications include passports, transportation payments, product tracking, lap scoring, animal identification, inventory systems, human implants and more.

4.2.2 Benefit

One major benefit of RFID is its non-contact, non line-of-sight nature. Information can be read through a variety of substances such as fog, ice, paint and other environmentally challenging conditions. On top of its performance in challenging circumstances, it able to do so at very fast speeds (~ 100 ms). RFID has become indispensable for a wide range of automated data collection and identification applications.

4.3 RFID Technology in SoutheastCon

4.3.1 RFID Reader Specs

The competition provided a low range RFID reader (ID-20 Reader).

Data Sheet at:
www.id-innovations.com/ID%20EM%20moudule%20SERIES%202005-12-9_%20v21.pdf

A typical circuit using the ID-20 is attached.

As the ID-20 reader approaches a tag, it will read the tag one time when in-range. It will not re-read the tag unless it is brought out-of-range for at least one second and then brought in-range again. It is suggested that experiments with individual and multiple tags, and in the presence of metallic robot parts be performed.

4.3.2 RFID Tag Specs

The following specifications were made by the competition:

1. There are seven tags with individual numbers encoded.
2. The tags are write protected.
3. The encoded numbers are ten hex digits long. Some readers or terminal programs may also add a two-digit check sum, carriage return, or other special characters before or after the encoded hex number.
4. The enclosed tags have their encoded digit displayed with a stick-on label
5. The enclosed tags are identical with those that will be used in the Hardware Competition, except that the competition tags do NOT have stick-on labels.
6. The tags and their associated blocks are as follows:

TAG NUMBER (Hex)	BLOCK	VALUE

1111111111	RED	15
2222222222	RED	15
3333333333	WHITE	20
4444444444	WHITE	20
5555555555	BLUE	25
6666666666	BLUE	25
7777777777	BLACK	30

4.3.3 Block Attachment

For the competition, RFID tags are place on each of the individual blocks. In total seven blocks are used during the competition. The tags are physically attached to the blacks via a metal screw. Each team has the option to use this technology in their robot design.

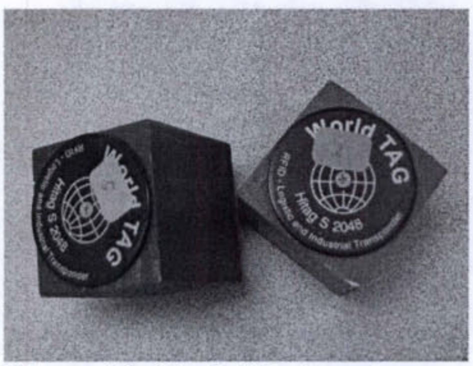


Figure 16: Block Attachment

4.4 Strategy and Testing

In the previous sections, the overall design and strategy of the robot does not require the use of RFID technology. The goal of the team is to grab any of the four blocks and return to home. An obvious strategy for using the tags is to identify which block you were acquiring. Methods for integrating the RFID system into the robot design included using them as another method for block detection or wall detection. For example, the RFID reader is able to communicate with a tag that is a certain distance away. Instead of viewing what data is being transmitted, the act of the reader "waking up" the chip in the tag can serve as a sensor.

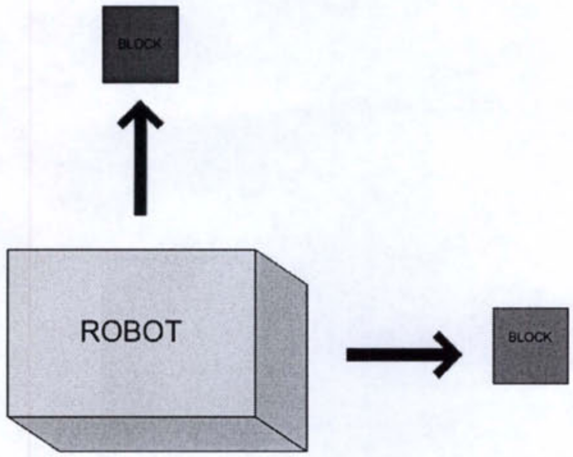


Figure 17: RFID Sensor Strategy

From viewing the datasheet, the ID-20 is a passive low frequency circuit. The range can be anything over 16 centimeters. A few simple tests are performed to determine the range of the reader. The circuit represented in Figure 17 outlines the setup for taking data from the ID-20 Reader.

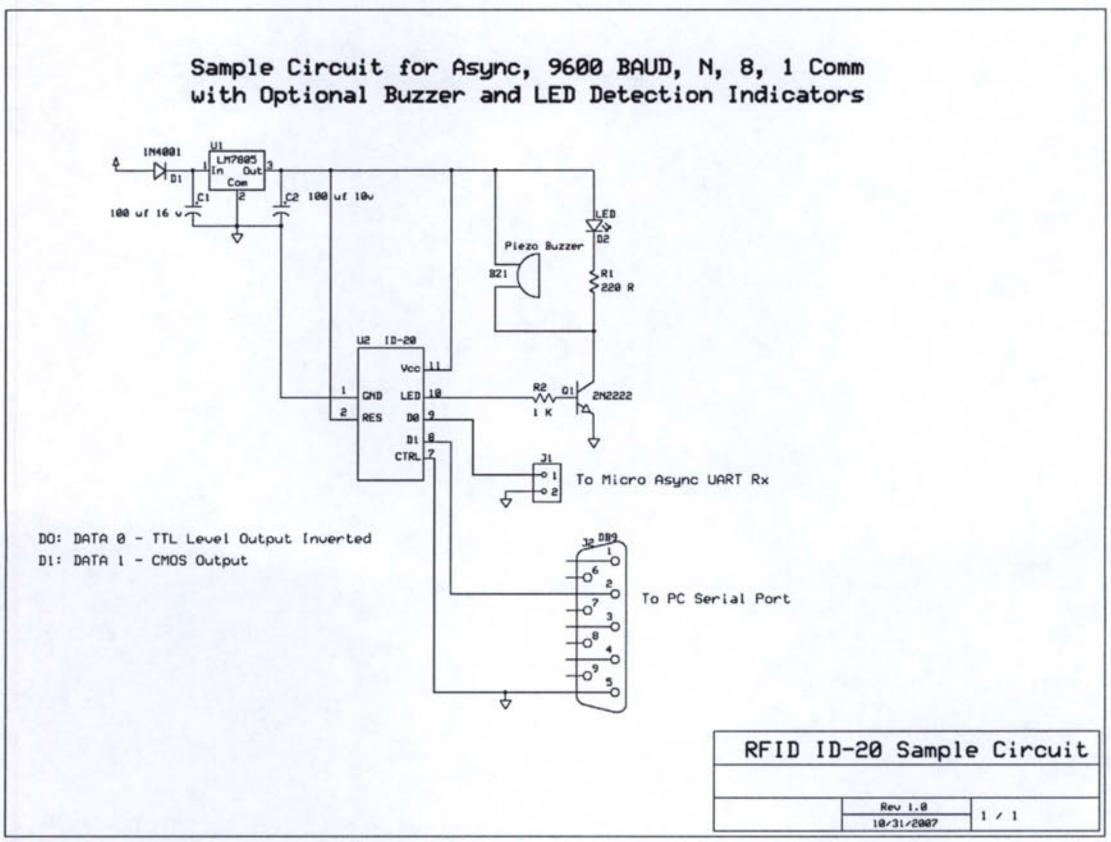
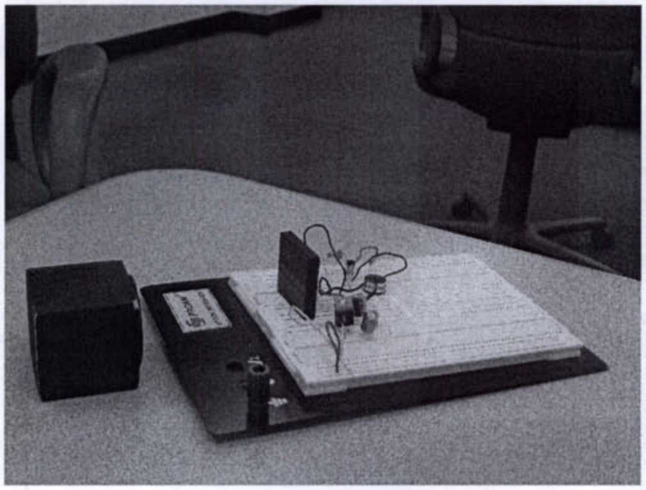


Figure 18: ID-20 Circuit Schematic



PARTS LIST		
Component	**Type**	**QTY**
Diode	1N4001	1
Capacitor	100µF	2
RFID Reader	ID-20	1
RFID Tag		7
Resistor	1000 Ω	2
Piezo Buzzer		1
NPN Transistor	2N2222	1
LED		1
Micro UART	TI.com	1
Cable	RS232	1

Figure 19: RFID System Testing Setup

4.4.1 Block Sensing

From testing, the maximum range of the RFID system is 3.7 inches when reader is directly facing the tags. This may not be ideal for adding to the system when infrared sensors with a range of ~20 inches are already being used in the system. During testing, there were some blind spots where the IR sensors are not as effective. Integration of this RFID system into those blind areas can be considered. During initial testing, the maximum range was found by placing the block and reader in sync. Would this be true is there was a 30 degree offset? This problem is investigated by performing a few additional tests. The first test was to find the peripheral range where the sensor would still be effective at its maximum range. The angle between the block and reader was incremented by 5 degrees and readings were taken at this instance. If the tags were still in range, this was documented. The following data was collected.

Angle(°)	Reading	Angle(°)	Reading
0	Y	40	Y
5	Y	45	N
10	Y	50	N
15	Y	55	N
20	Y	60	N
25	Y	65	N
30	Y	70	N
35	Y	75	N

From this data, it is found that the maximum angle between the two is 40 degrees. Other tests were conducted by identifying different types of interference. There may be interference from the infrared beacons at the home base or the aluminum piece used for the bumpers.

4.4.2 Wall Detection

A problem that has been occurring with the robot integration is being able to distinguish a wall from a block. When the algorithm goes into search mode, it attempts to find all of the blocks within its region. Sometimes, the sensors mistake the wall as a block and the robot will attempt to pick up the wall until the function is timed out. An RFID system can be helpful in determining that is a block that will be acquired. The reader is small enough that it can be mounted to an area on the front of the robot. In the situation where the robot will attempt to pick up a wall, after some time the main algorithm can check the RFID reader to see if there is any data being transmitted. If there is no data being transferred, then there is no block.

4.4.3 Conclusion

The option of incorporating RFID into the overall design did not fit into the overall timeline. Since the team only had four months to design and build the project, there was not much time into learning about new technology. No one was familiar with RFID technology and I took on the responsibility of looking into our options. In the end, the technology was not used on the final product due to time and size restrictions. Although the dimensions of the reader are relatively small, space was not available due to several wiring configurations. Since the hardware for the robot was not completely integrated until a week before the competition, there was no time to integrate code for something that was not needed.

5.0 Team Logistics

When the idea of forming an robotics team was offered by the University of Tennessee student chapter, several students jumped at the opportunity. Since time as limited, nine people were selected to participate on the 2008 team. A variety of backgrounds were considered when forming the team including power, controls, mechanical design, and programming.

5.1 Member Breakdown

Integration – Brittnee Robinson
Chassis – John Sliger
Motors – Kevin Omoumi
Power – Shupeng "Chris" Zhang
Block Acquisition – Andrew White
Sensors: Block Acquisition – Nathan Rowe
Sensors: Positioning – Daniel King
Software: Positioning Control – Justin Kopp
Software: Mechanical Control– Akaninyene Udoeyop

5.1.2 Bill of Material

A challenge of this year's team is to fully fund their robotics endeavors. My drafting a proposal, the team was able to receive $3000 in engineering fee money for robotics parts. One stipulation was that the team had two weeks to spend the money before it becomes unavailable. The team ordered necessary parts such as computer hardware. A detailed Bill of Material can be found in the Appendix. Approximately $2600 worth of items were ordered leaving roughly $400 for shipping.

5.1.3 Cost Analysis

Cost to remake this robot is $1556.60. The cost breakdown by subgroups can be found in the appendix.

5.1.4 Fundraising

In an attempt to fund additional expenses such as travel, a series of fundraising events were held. During these fundraisers, we sold Chick-fil-A biscuits and software. The purchase price for one Chick-fil-a biscuit is $1.50 and we sold each one for $2.50. Combinations of biscuits and juice were also sold for $3.25. The software was purchase for a fourth of what we listed them. Overall, $1,275 was raised. See Appendix for more detailed breakdown.

6.0 Conclusion

Although VolTron did not make it to the tournament round in the IEEE competition, the team feels that the project is an overall success. The robot has successfully completed several mock runs, each with a run time of less than three minute. The project was a very challenging capstone to the college careers of each member. Each member of the team gained a great deal of experience in robotics, project management, and teamwork. The team was able to develop a robot that can serve as a research platform for future students and hopefully be useful to the department for many years to come.

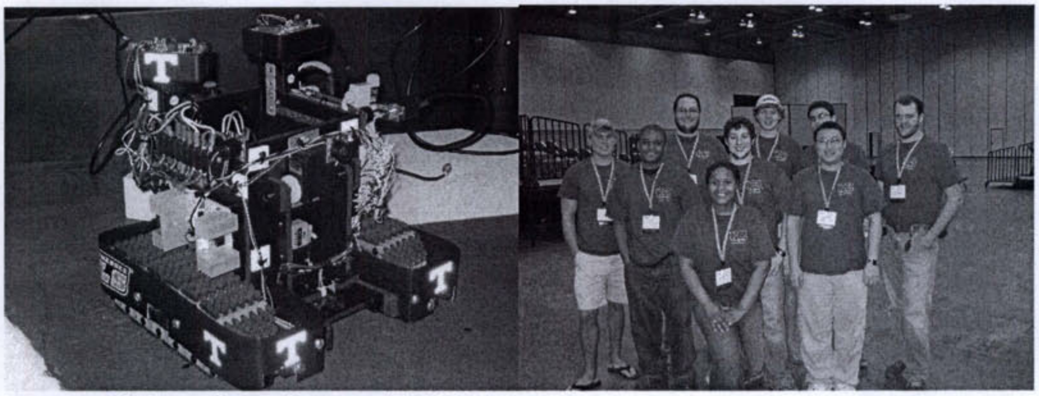


Figure 20: Final Product and 2008 UT Team

Appendix

I. Competition Rules

Below are the 2008 SoutheastCon Hardware Competition Rules. While a lot of attention has been given to developing these rules, we realize that they may need further clarification. We invite your questions, comments, and suggestions. Please see the Robot Competition FAQ for rule interpretations and ancillary information. We will make every attempt to provide prompt responses to your questions and concerns (our goal is four business days).

Modification History

November 17, 2007

1. Attachment B, Playing Field Blocks. RFID Tag alternate sourcing.

August 7, 2007

1. VII. Judging & Scoring. Remove points awarded for returning to home square.

July 31, 2007

1. Re-modify Zone 2 sand and paint mixture ratio (1 quart of sand to 1 quart of WHITE paint).
2. Eliminate painting pea pebbles RED.
3. Hoarding Penalty clarification.
4. Modify Blocking Penalty and Bumper Violation rules (Section VII, numbers 6 and 8).
5. Added points for robot mobility – leaving and returning to base.
6. Modify Attachment F – Playoff Round Ladder
7. Modify Playoff Round procedures.

July 23, 2007

1. Blocks must be picked up, not pushed across the surface, to score.
2. Specify Zone 2 paint and sand mixture ratio (1 ½ parts sand to one part WHITE paint).
3. Paint pea pebbles RED.

June 13, 2007

1. Increase competition time from four to six minutes
2. Change orientation of RFID tags from facing up to facing front of playing field.
3. Give each block a unique RFID number.
4. Increase number of IR LED's per beacon from three to six.

5. Change Zone 2 and 3 of playing field from White Marble Chips and Lava Rock to sand mixed with paint, and pea pebbles. The marble chips are no longer carried by Home Depot and the Lava Rock is difficult to maneuver over.
6. Sections *VI. Rules of Play, VII. Judging & Scoring, and VIII. Tournament Format* – Major Revisions. Single robot on playing field during early rounds; two robots on playing field during playoff rounds. Other scoring rule modifications.
7. Attachment F – Playoff Round Ladder
8. Various clarification wording throughout.

October 11, 2007

1. Corrected playoff seeding order (Attachment F).

2008 SoutheastCon Hardware Competition Rules "Return to the Moon"

I. Objective

To find, retrieve and return to home base, 2-inch cube, wooden blocks with attached RFID tags within the competition time limit of six (13 June) minutes. The block point values are determined by their color and numbers encoded on attached RFID tags.

II. Introduction

In the not-too-distant future, mankind has returned to the moon, whereupon valuable mineral deposits have been discovered. Exploration and development of this resource has been licensed to private enterprises. Many organizations, perhaps yours, have decided to enter into a competition to harvest the mineral deposits and return them to Earth. The process is arduous and expensive, and international regulations only permit unmanned, autonomous prospecting robots on the moon. The color and magnetic properties of the mineral deposits are correlated with their worth. Good luck in your venture!

III. Playing Field

1. The playing field (see Attachment A) will be based on a 6-foot by 6-foot plywood deck surrounded by walls that extend 8-inches above the playing field surface. The walls will be attached to the outside edge of the plywood deck.
2. The playing field will be divided into three zones plus robot home bases. Zone 1 will be painted BLUE, except for the home bases, which will be painted WHITE; Zone 2 will be covered with sandy WHITE paint; Zone 3 will be covered with pea pebbles. The rocky surface will be bonded to the plywood base with tile adhesive. The playing field walls will be painted flat BLACK.

3. One navigation aid will be placed in each of the playing field home base corners. Each navigation aid will consist of one quarter section of an 8-inch-tall, 4.5-inch-diameter, schedule 40 PVC cylinder into which six (13 June) LEDs have been placed (see Attachment C). The navigation aid on the right (as viewed from the robot home base side of the playing field) will flash its LEDs at 4.0 kilohertz, while the navigation aid on the left will flash its LEDs at 2.5 kilohertz. Both navigation beacons will use a square waveform.
4. The 12 1/2-inch-square robot home bases will be located in separate corners on the same side of the playing field. The bases will be painted WHITE (see Attachment A).
5. The playing field will contain seven wooden blocks 2" on each side. The layout pattern will have bilateral symmetry with respect to a line dividing the playing field in half between the robot bases (see Attachment D for the block specification; Attachment E gives the block layout pattern). Each block will have a round, passive RFID tag attached to one (13 June) surface and the block will be painted according to its point value. The RFID tag will be positioned to face the front (home base side) of the playing field (13 June). See Section V for more information on the blocks.
6. The playing field environment lighting is not specified except that it will be well lit. Flash photography and infrared range finders on cameras and camcorders are permitted. Intentional interference with the operation of the robots is not allowed, and may result in sanctions.

IV. Robot

1. The robot must operate completely autonomously once started and be entirely self contained, including any power source. Robots that do not meet this requirement will not qualify.
2. The maximum size is 10 inches by 10 inches by 11 inches tall. This maximum size applies when the robot is in the starting square at the start of a match or is in motion on any part of the playing field. When not in motion, the robot may extend a maximum of six inches by six inches in any one direction at a time. The extension must be physically connected to the main robot at all times.
3. There is no weight limit or construction material restriction except that anything that is deemed by contest officials to be dangerous or injurious to the participants, audience, staff, playing field or surroundings will result in disqualification. If in doubt, ask in advance. Pyrotechnics, compressed gas, toxic or corrosive materials are not allowed.
4. A robot may not operate in a manner that excessively damages the landscape. The rocky surface may become littered with loose rocks during the course of play (such is the nature of the lunar surface). This is expected and considered normal wear and tear, and operating conditions.
5. Each robot must have a bumper that surrounds a minimum of 80% of its perimeter in a continuous stretch. This bumper must be the outermost structure at all times when the robot is moving. The bumper must present a vertical surface at least 1" high and cover, at a minimum, the space from 1 ½ to 2 ½ inches above the

playing field. The bumper may be of any shape around the robot and need not be outwardly convex on all surfaces but must not have any radius of curvature less than ½ inch. The bumper must be included in the maximum 10 by 10 inch by 11 inch tall overall size.

6. A robot must have a button or switch somewhere on its top surface to start the robot in play.
7. In addition to meeting safe operation requirements, a robot must fit inside a 10¼ inch by 10¼ inch by 11¼ inch box to qualify for the competition. The qualification inspection will be available prior to the first round of play.
8. Robots may be modified physically, reprogrammed, and/or recharged between each match. However, any physical modification will require a re-inspection for safety and overall size compliance

V. Playing Field Objects

1. Wooden blocks will be used to represent mineral-bearing rocks on the moon. The blocks will be cubes measuring 2 inches on each side (see Attachment D).
2. There will be a total of seven blocks. Two of the blocks will be colored RED, two will be colored WHITE, two will be colored BLUE, and one will be colored BLACK.
3. One passive RFID tag will be attached to each block. The tags will have numbers encoded in them. Each block will have a unique number (13 June).
4. Seven RFID tags with the same numbers as those to be used in the competition will be mailed to each registered team. The tags are 50 mm in diameter.
5. RED blocks have a 15-point value, WHITE blocks have a 20-point value, BLUE blocks have a 25-point value, and the BLACK block has a 30-point value.
6. The color of a block and the color of the playing field on which it resides are not necessarily the same.

VI. Rules of Play

1. During the first three rounds, there will be only one robot on the playing field (13 June).
2. During the playoff rounds (see Appendix F), two robots will compete on a single playing field at the same time (13 June).
3. Prior to the beginning of play, the next team(s) to play will be announced. They must present their robots and place them on a robot home base within one minute of the announcement. Missing this deadline will result in disqualification for the missing team(s) for that match. For the playoff rounds, home base assignments will be decided by the flip of a coin by one of the contest officials (13 June).
4. A hands-off period will follow the placement of a robot on the playing field. During this time, seven wooden blocks with RFID tags will be placed on the playing field in a symmetrical pattern with respect to each robot home base. This pattern will be randomly drawn from a set of unique patterns established prior to

play. The blocks will be placed with the RFID tags facing toward the front (home base side) of the playing field (13 June).

5. After the blocks have been placed on the playing field, a contest official will give a verbal start command. A team member may then manually start the robot by pressing a button or flipping a switch on the top of the robot. The start button or switch must be indicated to a contest official prior to the start command. No further interaction between the robot and a person may then take place until the six-minute match ends or a team decides to terminate its participation. Any points scored until early play termination for a team will count towards the final point tally for that match.
6. The end of a match will be indicated by a buzzer.
7. The blocks must be picked up off of the field and transported to the home square to score. Blocks that are pushed across the surface will not score (23 July). A robot may transport any number of blocks at a time.
8. Destructive Interference: A team may not take any action that purposely interferes with the course of play or causes damage to the playing field or competing robot. The penalty for destructive interference is disqualification for that match.
9. A match is six minutes (13 June) from the point that the verbal start command is given. A buzzer will sound the end of a match and no further points will be scored.

VII. Judging & Scoring

1. Points are scored by placing blocks in a robot's home base. "In a robot's home base" will be interpreted as meaning that any portion of a block is within the boundary of the home base square. If a block is placed wholly or partially on another block in the home base square, it will count as being in the home base square.
2. Ten points are awarded to a robot that completely leaves the starting square.
3. If a robot carrying blocks is in any part of the home square at the end of play, all the blocks it carries, up to the maximum number allowed, will score.
4. During the first three rounds, a block will only score if placed in the robot's home square (13 June). If a block is placed in an opponent's home square (during the playoff rounds), its value will score points for the owner of that square (13 June).
5. The contest's judge decision is final regarding whether a block is in scoring position or not.
6. Hoarding Penalty: Due to limitations in transporting mass back to earth, a robot may only score (31 July) a maximum of four blocks. If more than four blocks are placed in home base, points will only be scored for the four lowest value blocks. During the playoff rounds (13 June), any blocks in excess of the four lowest scoring (31 July) will be scored for the opponent team.
7. Blocking Penalty: A robot may not persistently position itself near a competitor's home base so as to block it from reaching its home base. If this situation occurs, the blocked robot will score all the blocks it possesses or deposits in the vicinity of its home base. A stalled (doesn't move for one minute), blocking robot will be removed from the playing field.

8. Poaching Penalty: Disturbing or removing blocks from an opponent's square, whether intentional or not, will not decrease the score of the "poachee" nor increase the score of the poacher and MAY be considered grounds for disqualification. If disqualified, the offending robot will be removed from the playing field and play will continue.
9. Extending a portion of the robot beyond the bumper while the robot is in motion will result in a penalty of one point per second of violation.

VIII. Tournament Format

1. There will be three preliminary rounds of play for all robots, and playoff rounds for the eight highest scoring robots (13 June).
2. Each team will play three preliminary rounds in which only one robot will be on the playing field (13 June)
3. The final score for a team will be the sum of points accumulated in the three preliminary rounds. A team's pre-playoff rank will be determined by its final score. The highest scores will determine the top eight teams. In case of ties, i.e. more than eight teams qualify for the playoffs, the time taken for the last block scored, will be used as a tie breaker (31 July). If more than eight teams still qualify, additional, single robot matches will be held for the tied teams.
4. The top eight teams will play each other in head-to-head competition, with two robots competing for blocks on the same playing field, during the playoff rounds. The two winners of the semi-final playoff will play each other for first and second place honors (13 June). The two other semi-final teams will play each other for third place honors (31 July). The play-off elimination ladder is shown in Attachment F.
5. IEEE student membership is required of all team members participating in the competition. Only one entry is allowed per school and the school must be in Region 3 (southeast) and have registered by March 7, 2008 (31 July). Team registration form is located elsewhere on the web site (31 July).
6. All judges' decisions are final

IX. Tolerances

All materials, sizes, and construction techniques and tolerances are given in the appropriate attachments.

X. Contact Information

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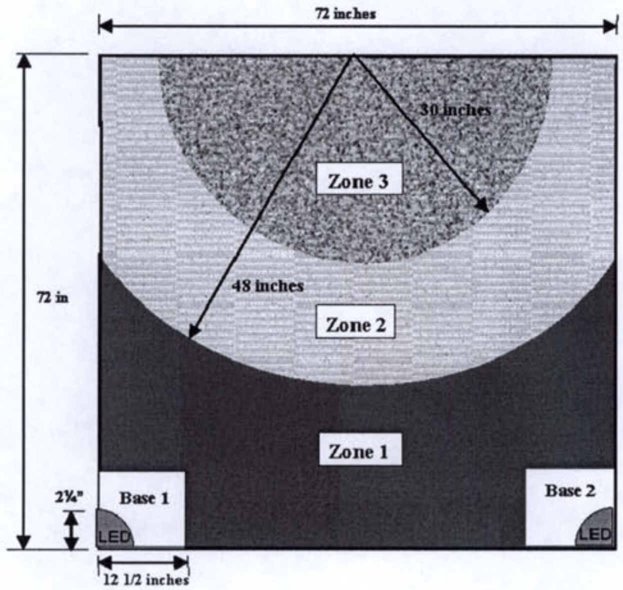
ATTACHMENT A
Playing Field



Note: This sketch is not drawn to exact scale!!!

Playing Field Materials

1. **Plywood Base**
   The base is constructed from two pieces of 3' x 6' 1/2" thick plywood. The competition playing field will use A grade plywood, although B/C plywood is useable, since 2/3 of the surface area is covered by coarse material.
2. **Wall Material**
   An eight-inch-high wall of 1/2-inch thick plywood painted flat black will completely surround the plywood playing field base. The top of the wall will be 8 inches from the top of the playing field and is attached to the outside edge of the plywood base so that the interior of the base measures six feet by six feet.
3. **LED Beacons**
   There are two LED navigation beacons, one in each of the home base corners. Each is constructed from a PVC housing, six (13 June) IR LEDs, and current

limiting resistors. A square wave-driving circuit powers the beacons. The housing is cut from 4.5-inch diameter, schedule 40 PVC. The PVC is cut into an eight-inch high section and then cut into quarters lengthwise. One piece is used for each beacon, details in Attachment C.

4. **Paint Specifications**
   Four paint colors are used: flat black, flat white, gloss red (23 July), and blue enamel. Paint product specification is given in Attachment B.
5. **Rock Specifications**
   Two types of coarse materials are used to cover portions of the base: sand mixed with paint and pea pebbles (13 June). Material product specifications are given in Attachment B, construction details below.
6. **Adhesive Specifications**
   The sand will be mixed with white paint for Zone 2 and an adhesive is used to bond the pea pebbles to the plywood base. Adhesive product specification is given in Attachment B.

Construction Details and Suggestions

1. Cut Base. Cut each 4 x 8 sheet of ½-inch plywood into a 3- by 6-foot piece. These two pieces will form the entire playing field base.
2. Establish Zones. Temporarily put the two plywood pieces together to form a 6' by 6' base. From the middle of the long edge of one piece draw two circular arcs, one 30 inches in radius and one 48 inches in radius on the plywood surface, as illustrated in the Figure above. The area enclosed by the 30-inch arc is Zone 3; the area between the 30 and 48 inch arcs is Zone 2. Outline a 12 1/2"-by-12 1/2" square in each corner opposite Zones 2 and 3. The area outside the arcs and bases is Zone 1.
3. Prepare Coarse Material. Mix one quart of sand with one quart of white paint (31 July) to paint Zone 2. First wash the pebbles in water to remove all the fine, gritty material (23 July). Remove the rocks from the gritty material by passing a cat litter scooper through the washed pea pebbles. Keep all the rocks and dispose of the grit. Process enough of the pea pebbles to cover Zone 3. You will need a little less than one bag (23 July) of sorted pea pebbles to cover Zone 3.
4. Prepare Zone 3. Spread the entire bucket of gray adhesive evenly over Zone 3. You may use a wide-bladed putty knife or a tiling trowel to smooth the adhesive. Spread the pea pebbles fairly evenly over the area and press **firmly** into the adhesive. Let set for at least 48 hours at room temperature. When the adhesive is set, tip the upper half of the playing field to remove all the loose rock that did not bind to the adhesive. A few <u>good</u> taps to the bottom of the plywood will help shake off the loose material.
5. Prepare Zone 2. Paint Zone 2 with the sand and paint mixture.
6. Prepare Zone 1. Before painting Zone 1 blue, paint the white home base squares. Use two coats of paint and when dry mask off with painters masking tape. Then apply a coat of blue paint to Zone 1.
7. Prepare Walls. Cut the 1/2-inch plywood into 8 ½ " strips and paint flat black. When dry, affix the walls to the plywood base on all sides in any manner that is

sturdy. The official playing fields will have the walls nailed and glued to the edge of the base and have 2" L-shaped, steel brackets on the outside connecting the walls to the base. Brackets will also be used on the outside of the corners.

8. Assemble Playing Field. In order to get the two halves of the base to meet, you may need to use a putty knife to remove excess material from the inner edges of the plywood halves. The official playing field will use metal brackets on the outside of the walls to join together the two playing field halves. Affix the IR Beacon PVC housing by gluing or screwing to the walls (attaching with #4 wood screws will allow easy removal for modification or repair. Pre-drill screw holes with a 1/8" twist bit).

Dimensional Tolerances

The overall playing field size will have a size tolerance of +/- one-half inch. We will strive for quarter-inch tolerance, but wood is not a precise medium and the size is also subject to humidity changes. The texture of the rocky surface can not be specified accurately, as is appropriate to the nature of a lunar surface model. Some areas will have more material than others, and although we will attempt to make the surface level, irregularities will exist.

ATTACHMENT B
Shopping List

Playing Field

1. Base. Two, 4' x 8' by ½" thick plywood panels. The main property required is flatness. You may also use OSB panels or plywood sheathing used for roofing. The choice depends on how much you want to spend. The official playing field will use 1/2 " thick, grade A plywood.
2. Walls. One 4'x8' panel, 1/2" thick.

Paint

1. WHITE. Rust-Oleum, Painter's Touch, Flat White, 1 quart. Home Depot SKU 359-339
2. BLACK. Rust-Oleum, Painter's Touch, Flat Black, 1 quart. Home Depot SKU 217-927
3. BLUE. Rust-Oleum, Protective Enamel, Gloss Royal Blue, 1 quart. Home Depot SKU 527-117
4. RED. Rust-Oleum, Painter's Touch, Gloss Apple Red, 1 quart. Home Depot SKU 217-868

Rocks

1. Sand. Pool Filter Sand, Home Depot SKU 747-181.

2. Pea pebbles. Vigoro Decorative Stone, 0.5 cubic foot, Home Depot SKU 440-773

Adhesive

1. GRAY. Tile Perfect, Gray Premixed Thinset, 1 gallon. Home Depot SKU 699-006

Infrared Beacon

1. IR LED. High Output, 5 mm, twelve (13 June). Radio Shack 276-143.
2. PVC Pipe. 4.5 inch diameter, schedule 40. Home Depot SKU 295-112 (This commonly comes in 5 and 10 foot lengths.)

Playing Field Blocks

1. Wood cubes, 2" on a side. Woodworks, Ltd., SQ-2000, www.craftparts.com/mall/Blocks.asp
2. RFID Tags, World Tag 50 mm, S2048. We supply seven tags to registered teams. These tags will be identical to those used during the competition.

Parts and Tools (suggested, not required)

1. Adhesive Spreader. 3" wide blade putty knife or a notched tiling trowel, about 4 ½ " by 9 ½" (notched edge not used) makes the job a lot easier. A rubber float (used for grouting tile) is handy for pressing the rocks into the adhesive.
2. Buzzer. Radio Shack, TBD.
3. Kitty Pan Scooper.

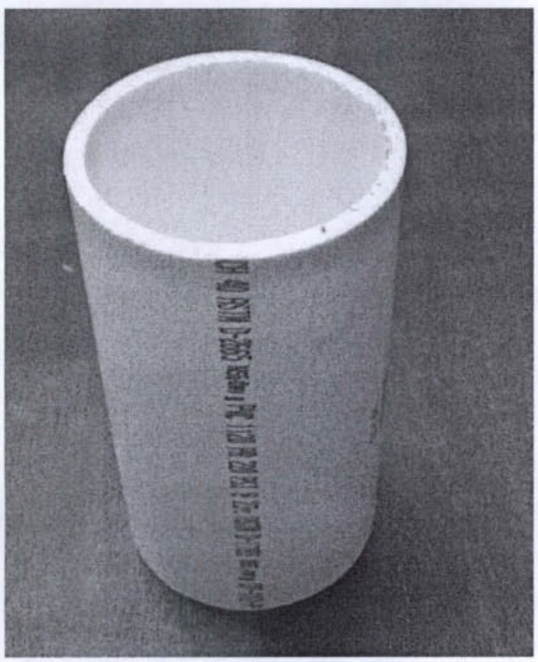
ATTACHMENT C
Navigation Beacons

Navigation Beacon Materials

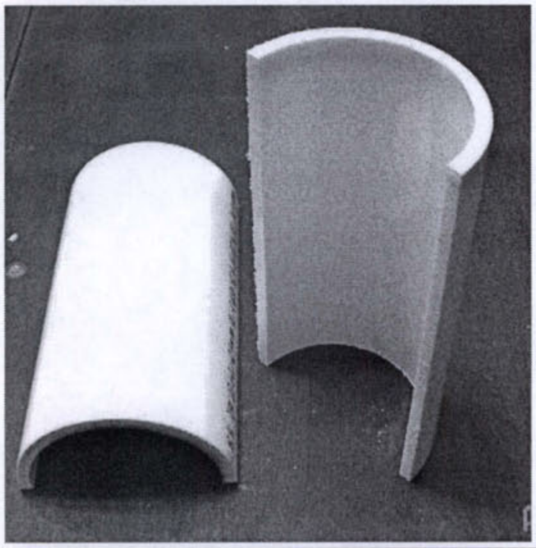
1. **PVC Pipe.**
   Four-and-a-half-inch diameter, schedule 40 PVC pipe will be used.
2. **IR LEDs.**
   Six (13 June) IR LEDs per beacon will be connected in series with an appropriate current limiting resistor to operate the LEDs at approximately 100 ma.
3. **Timer Circuit.**
   The timing circuit will flash the left beacon LEDs with a 2.5 kHz (plus or minus 5%), 50% duty cycle square wave, and will flash the right beacon with a 4.0 kHz (plus or minus 5%), 50% duty cycle square wave.

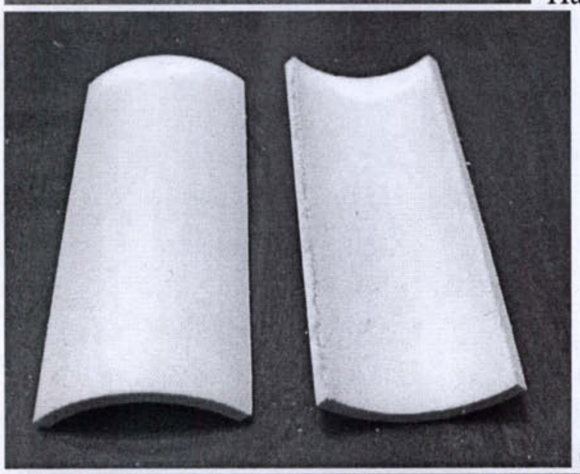
Construction

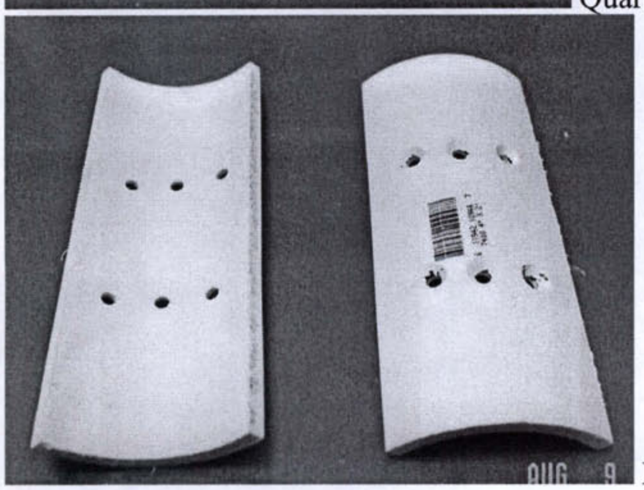
1. Beacon Housing. Cut off a eight-inch long section of the PVC pipe. Slice this section lengthwise in quarters. Drill six (13 June) one-quarter-inch diameter holes equally spaced along two horizontal, parallel lines located one third and two thirds of the way between the ends of the pipe (13 June). Countersink the holes on the convex side to provide the LEDs
with a wider angle of illumination (31 July). Do this for both beacon housings. Paint the convex side flat black, the same as the playing field walls.
2. LED Assembly. Fit the LEDs into the beacon housing holes and fix in place (we used hot glue over the back of the LEDs). Solder the LED leads in series, anode to cathode. Choose a current-limiting resistor, of appropriate wattage, according to the power supply voltage you choose and solder to one end of the LED string. It is suggested that you wire a polarized, locking connector to the LED assembly and wire a visible LED in parallel with the IR LEDs to visually verify when power is applied.

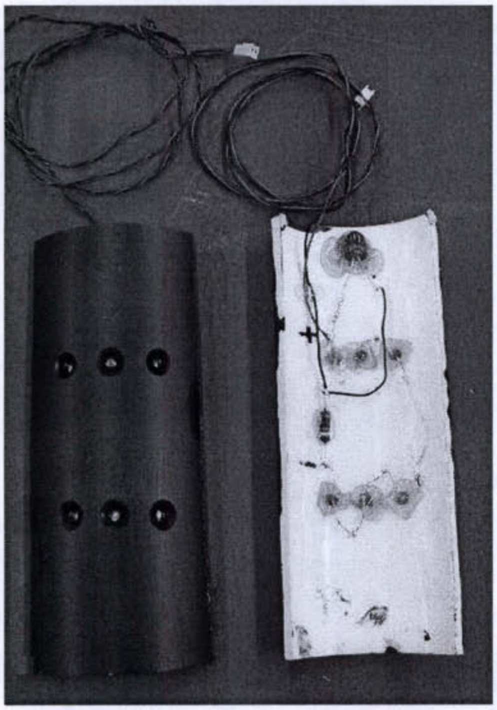


Full Cylinder Section


Half Cylinder


Quarter Cylinder


Drilled Quarter Cylinder



IR Beacon: Wire six IR LEDs in series with a current limiting resistor and hot glue in place. Wire the large red LED (which contains a current limiting resistor) in parallel with the IR LEDs to give a visual indication of power on.

ATTACHMENT D
Playing Field Blocks

Playing Field Blocks Construction

1. Seven Wooden Cubes. Make or purchase seven, wooden cubes two inches on a side. Two blocks are painted RED, two WHITE, two BLUE and one BLACK.
2. Affix the RFID Tags. RFID tags will be sent to each school team that registers for the hardware competition. The RFID tags will be affixed to one face of each block. Each block will have a unique number (13 June). These ID numbers will be furnished along with the tags.

RFID Tags

The committee will supply RFID tags to registered teams.

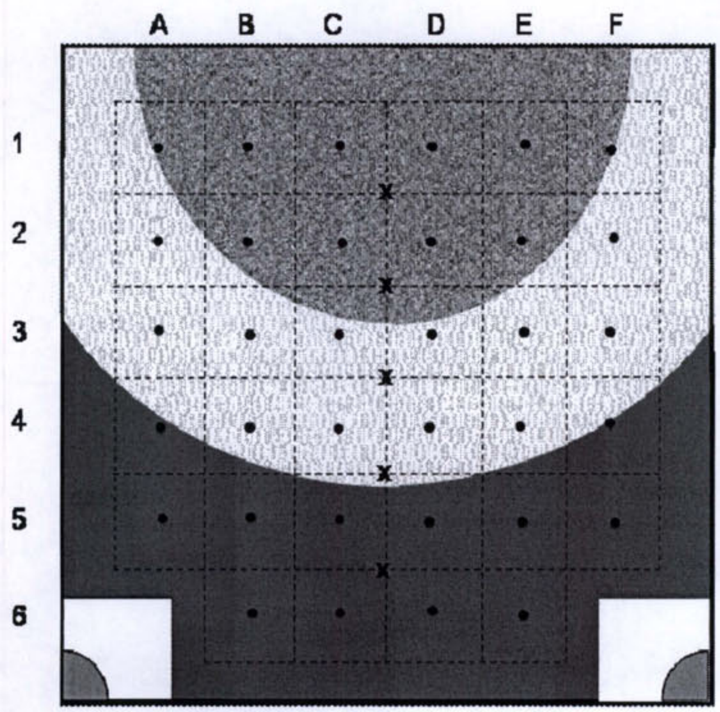
Dimensional Tolerances

The blocks will have a size tolerance of 1/8-inch on each side.

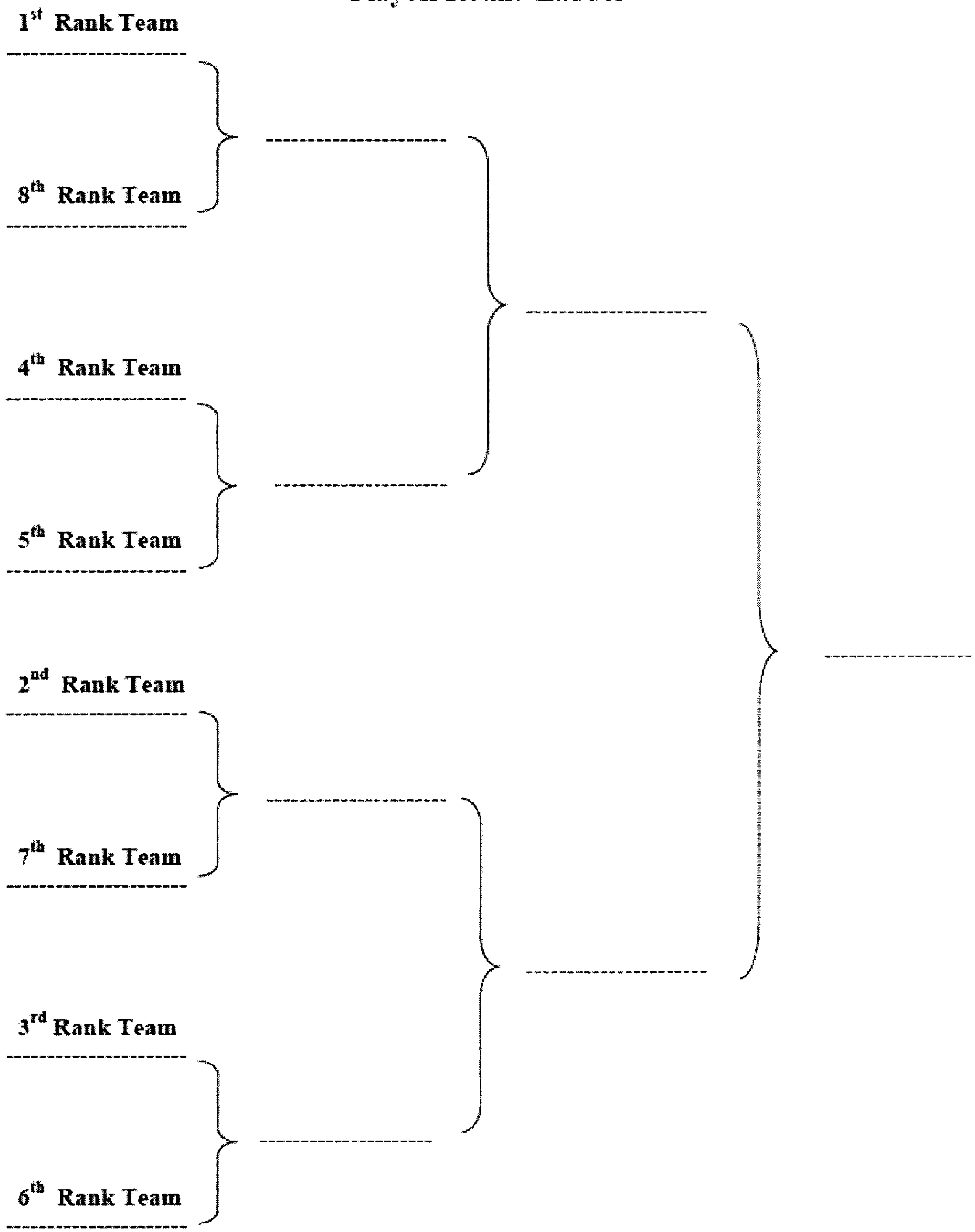
ATTACHMENT E
Playing Field Block Layout Pattern

In the grid pattern below, RED, WHITE, and BLUE blocks will be placed in the center of 10-inch squares (position of dots in diagram), and the BLACK block will be placed on the center vertical line (x in the diagram). Neither grid nor dots nor 'x' marks will appear on the playing field. Each block of the same color will be placed symmetrically about the vertical center line in the figure below. Areas around the home bases and adjacent walls will be excluded, as shown below, 6-inches from the walls and 3 1/2-inches from the inner base boundaries.

1. RED, WHITE, and BLUE blocks will be placed in the center of 10-inch squares (position of dots in diagram), arranged in the grid pattern below (neither grid nor dots nor x's will appear on the playing field.
2. Blocks may be placed in adjacent squares, except no block will be placed within one square of the BLACK block.



Playoff Round Ladder



II. Bill of Material

Vendor	Part Desc	Model #	Price	number	Total
Lynxmotion	Track Assembly	TTRK-KT	220.95	1	220.95
Lynxmotion	Extra Track	TRK-01	24.95	4	99.8
Lynxmotion	UltraSonic Range Sensor	USR-01	35.95	3	107.85
VexLabs	Metal Kit	Alum-Metal-Kit	99.99	1	99.99
Think Geek	RFID Experimentation Kit		99.99	1	99.99
Jameco Robot Stor	PING)) Ultrasonic Sensor	Parallax Inc. 28015	24.95	2	49.9
Budget Robotics	360 Degree Pan Turret	Turret-200	24.95	1	24.95
Spark Fun Electron	Infrared Proximity Sensor	GP2Y0A21YK	12.95	5	$64.75
Spark Fun Electron	RFID reader	SEN-08419	29.95	1	$29.95
Spark Fun Electron	Ultrasonic Range Finder	SEN-08502	24.95	5	$124.75
Spark Fun Electron	H-bridge 1A	COM-00315	2.35	4	$9.40
Spark Fun Electron	Photo Interrupter	SEN-00247	1.95	2	$3.90
Acroname Robotics	SensComp 6500 Sonar Range Finder	R11-6500	42.5	2	$85.00
Acroname Robotics	IR Range Sensor(Triangulation)	R144-GP2Y0A02YK	12.5	2	$25.00
Acroname Robotics	Ultrasonic Range Finder	R271-SRF05	29.5	2	$59.00
Acroname Robotics	Sub-Micro Servo	R281-MX-35	25.5	3	$76.50
Elenco	Resistor Kit	RK365	13.25	1	$13.25
Elenco	Black 22gauge wire	884410	1.3	1	$1.30
Elenco	Red 22 gauge wire	884420	1.3	1	$1.30
Lynxmotion	IR Proximity Detector Sensor	IRPD-01	29.95	4	$119.80
	DC to Pulse Width Modulator Kit	120539	22.95	2	45.9
		386388	130.45	1	130.45
	Tank Track & Wheel Set	3-985	14.95	1	14.95
http://www.robotma	Powersonic PS-612 F1 6V 1.4ah	PS-612	15.95	2	31.9
	Multiplex MULTIcharger LN-5014 Charger		79.99	1	79.99
	antiweight flat battery packs		30	2	60
	B-Series Beetle Gearmotors	B62 model	31.99	2	63.98
	Simple-H - H-Bridge circuit		79.99	2	159.98
	Dual 6A Ant/Beetle Speed Controller with	Scorpion HX	139	1	139
http://www.budgetr	Expanded PVC Plastic Sheet		5.75	10	57.5
http://www.allelectr	SET OF 5 GEARS AND BUSHINGS	GR-5	2.75	10	27.5
http://www.wdlsyst	Board	1jcdlxp	340	1	340
HobbyTron.com	Organizer Tool Kit	E-TK-1000	49.95	1	49.95
/www.robotmarketp	3-Speed Crank Axle Gearbox	Tamiya 70093 Single	6.29	2	12.58
/www.robotmarketp	6-Speed Gearbox H.E.	Tamiya 72005	14.99	2	29.98
/www.robotmarketp	GWS Mini STD Servo		10.49	2	20.98

TOTAL	2581.97

III. Cost Analysis

Drew - Mechanical Design

Category	Part Name/Number	QTY Ordered	QTY used	Cost per	TOTAL Cost	Final Design
Block Acq	MX-35 Sub Micro Servo	3	1	$ 25.00	$ 75.00	$ 25.00
	Expanded PVX Plastic	10	1	$ 5.75	$ 57.50	$ 5.75
	Super Glue	1	1	$ 1.00	$ 1.00	$ 1.00
	Fishing Line	1	1	$ -	$ -	$ -
	Thin Steel Plate	1	1	$ -	$ -	$ -
	Fishing Nails	3	3	$ -	$ -	$ -
					Total	$ 31.75

Nathan Block Acquisition Sensors						
Category	**Part Name/Number**	**QTY Ordered**	**QTY used**	**Cost per**	**TOTAL Cost**	**Final Design**
Sensors	Sharp GP2Y0A02YK IR Sensor	7	5	$ 12.50	$ 87.50	$ 62.50
	Ultrasonic Range Finder	5	3	$ 24.95	$ 124.75	$ 74.85
	Emitter and Detector	2	2	$ -	$ -	$ -
					Total	$ 137.35

Chris Zhang - Power						
Category	**Part Name/Number**	**QTY Ordered**	**QTY used**	**Cost per**	**TOTAL Cost**	**Final Design**
Batteries	4/3A NiMH 3600maH flat top batte	16	32	$ 6.99	$ 111.84	$ 223.68
Regulator	IC ADJ LDO Linear Regulator	6	2	$ -	$ -	$ -
	Multiplex MULTIcharger LN-5014 Charge	1	1	$ 79.00	$ 79.00	$ 79.00
	Heat Sink		2	$ -	$ -	$ -
					Total	$ 302.68

AK and Justin - Software						
Category	**Part Name/Number**	**QTY Ordered**	**QTY used**	**Cost per**	**TOTAL Cost**	**Final Design**
Hardware	Kontron PC/104 Board 1jcdlxp	1	1	$ 340.00	$ 340.00	$ 340.00
Hardware	Diamond-MM Analog I/O Board	1	1	$ 295.00	$ 295.00	$ 295.00
	Visual Studio	0	0	$ -	$ -	$ 8.00
	Hitachi Travelstart 40GB Hard Driv	0	1	$ 129.00	$ -	$ 129.00
					Total	$ 764.00

Kevin - Servos and Motors						
Category	**Part Name/Number**	**QTY Ordered**	**QTY used**	**Cost per unit**	**TOTAL Cost**	**Final Design Cost**
Motors	Gear Head Motor	4	2	$ 21.96	$ 87.84	$ 43.92
	Futaba S3017 Micro Servo	2	1	$ 18.99	$ 37.98	$ 18.99
	Dual H-Bridge Circuit v2.0	N/A	1	$ 15.00	$ -	$ 15.00
					Total	$ 77.91

Dan - Positioning Sensor (In House Design)						
Category	**Part Name/Number**	**QTY Ordered**	**QTY used**	**Cost per unit**	**TOTAL Cost**	**Final Design Cost**
Sensors	Positioning Sensors	N/A	2	$25.00	$50.00	$50.00
					Total	$50.00

Miscellaneous	$ 200.00

TOTAL $ 1,556.69

IV. Fundraising Efforts

Chick-Fil-A Chicken Biscuit Sale

Purchase Price	$1.50
Selling Price (single)	$2.50
Selling Price (multiple)	$2.00

	QTY Ordered	QTY Sold	Profit
12-Feb-08	100	76	$60.25
15-Feb-08	100	82	$97.35
22-Feb-08	50	45	$45.25
29-Feb-08	50	46	$48.75
4-Mar-08	50	48	$53.00
7-Mar-08	50	47	$48.20
11-Mar-08	40	37	$40.50
28-Mar-08	30	28	$27.25
1-Apr-08	50	46	$48.75

TOTAL PROFIT	**$469.30**

Software Fundraiser

Sold Software during the following dates

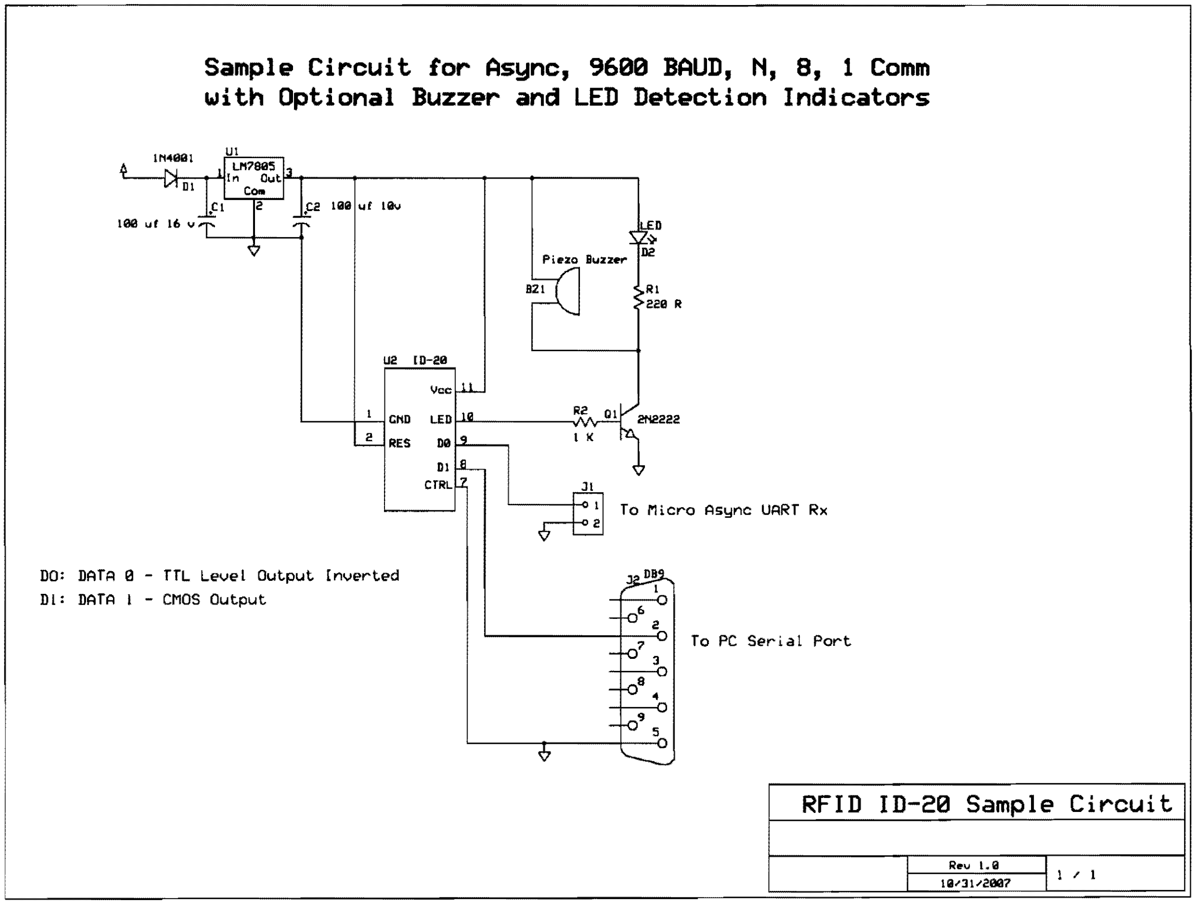
	XP	Vista	Visual Studio	Visio
Purchase Price	$4.50	$4.50	$16.50	$4.50
Selling Price (member)	$10.00	$20.00	$25.00	$10.00
Selling Price (non-mem)	$20.00	$40.00	$50.00	$20.00

Summary of Progress made during Software Sale

	XP		Vista		Visual Studio		Visio	
	Mem	Non-Mem	Mem	Non-Mem	Mem3	Non-Mem	Mem4	Non-Mem4
29-Feb-08	24	2	9	1	2	0	7	1
4-Mar-08	6	7	7	0	1	1	4	0
7-Mar-08	1	1	1	0	0	0	1	0
11-Mar-08	3	0	0	0	1	0	0	0
28-Mar-08	1	0	1	0	0	0	0	0
1-Apr-08	2	0	0	0	0	0	1	0
Total Sold	34	10	18	1	4	1	12	1
Profit	$187.00	$155.00	$279.00	$35.50	$34.00	$33.50	$66.00	$15.5
OVERALL PROFIT		**$805.50**						

Profit by Sales Date	
29-Feb-08	$409.00
4-Mar-08	$314.00
7-Mar-08	$42.00
11-Mar-08	$25.00
28-Mar-08	$21.00
1-Apr-08	$16.50

Circuit Configuration


Sample Circuit for Async, 9600 BAUD, N, 8, 1 Comm
with Optional Buzzer and LED Detection Indicators
1N4001
D1
U1
LM7805
In
Out
Com
C1
100 uf 16 v
C2 100 uf 10v
LED
D2
Piezo Buzzer
BZ1
R1
220 R
U2 ID-20
Vcc
GND
LED
RES
D0
D1
CTRL
R2
1 K
Q1
2N2222
J1
To Micro Async UART Rx
D0: DATA 0 - TTL Level Output Inverted
D1: DATA 1 - CMOS Output
J2 DB9
To PC Serial Port
RFID ID-20 Sample Circuit
Rev 1.0
10/31/2007
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