8888 University Drive, Burnaby BC Canada
jac-ensc440@sfu.ca

March 9, 2011

Dr. Andrew Rawicz
School Of Engineering Science
Simon Fraser University
Burnaby, British Columbia
V5A 1S6

Re: ENSC 440 Design Specifications: Auto Secure Binding - An Automated Snowboard Binding System by JAC Innovations Ltd.

Dear Dr. Rawicz,

Please find enclosed the design specifications for the Auto-Secure Bindings (ASB) from JAC Innovations. We are advancing snowboarding binding technology by designing a prototype model of a completely automated snowboard binding system. The ASB brings an elevated level of convenience and style to snowboarding.

The design specifications present the set of low-level specifications required for the ASB's functionality throughout its various phases of development. This document shows the design requirements for the prototype version of the ASB. The engineering team at JAC Innovations will utilize to this document to ensure all the specified designs of ASB are implemented.

JAC Innovations consists of five motivated and knowledgeable fifth-year engineering students: Clara Luo, Andrew Ng, Jackie Ng, Jeffrey Sun, and Jacky Wong. These five individuals bring their experience in software engineering, hardware fabrication, and telecommunications to the team.

If you have any inquiries or comments regarding our project, please feel free to contact our team via e-mail at jac-ensc440@sfu.ca. Alternatively, you may contact me directly by e-mail at chiw@sfu.ca or by telephone at 604-751-5556.

Sincerely,

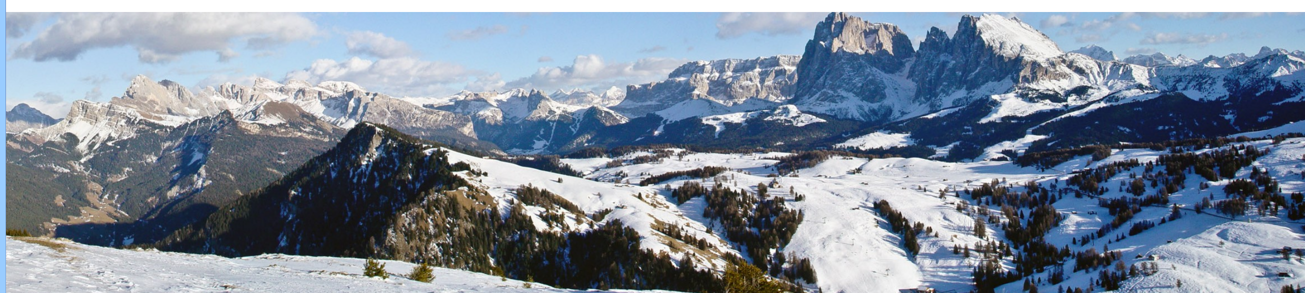
Jacky Wong
Chief Executive Officer
JAC Innovations Ltd.

Enclosed: *Design Specs for Auto-Secure Bindings - An Automated Snowboard Binding System*

JAC INNOVATIONS

Design Specifications

for an automated snowboard binding securing system



Project Team: Clara Luo
Andrew Ng
Jackie Ng
Jeffrey Sun
Jacky Wong

Team Contact: jac-ensc440@sfu.ca

Document Created: March 4th, 2011
Document Revised: March 12th, 2011

Submitted to: Dr. Andrew Rawicz
Michael Sjoerdsma
School of Engineering Science
Simon Fraser University

Executive Summary

Snowboarding is an incredible winter sport, it’s fast, exhilarating, and thrilling but it’s also physically demanding. Time and energy should not be wasted on fumbling with snowboarding bindings. The Auto-Secure Bindings (ASB) provides an elegant solution and makes the most out of the snowboarding experience. The ASB is an automated, easy-to-use, and efficient snowboard binding system.

This document gives detailed specifications for the designing and implementation of the prototype model of the ASB. User operation flowcharts, component breakdown, testing parameters, and software analysis are all described in detail. These specifications connect the gap between a creative idea to a physical model, thus realizing the ASB.

Note that the ASB is not an add-on upgrade product for existing snowboard bindings, it is a standalone system. Hence, the ASB is comprised of two units: a pair of automated snowboard bindings and a wireless remote controller. The pair of automated snowboard bindings is an improved hybrid design from all current types of bindings. Motors and specialized locking ratchet joints facilitate in tightening and holding the user’s snowboarding boot in place while riding down the mountain. The bindings will receive signals from the remote controller to perform its various automated functions. The wireless remote controller is a small handheld device with tactile buttons. The remote control will transmit commands to the snowboard bindings and the user can store the controller within their pockets when not in use.

The design specifications which are covered in this document will be designed and implemented for the primary prototype version of the ASB. Further prototype iterations will strive to reduce size, weight, aesthetics, and energy consumption. As well, additional advanced remote control functionality will be considered such as chronograph capabilities, speed and altitude statistics, map features, and GPS tracking.

Contents

List of Figures

List of Tables

Glossary

A	Amperes
ASB	Auto-Secure Bindings
AWG	American Wire Gauge
DC	Direct Current
H	Height
I/O	Input/Output
L	Length
LED	Light Emitting Diode
mcd	Milli-Candela
MCU	Microcontroller
PWM	Pulse-Width Modulation
RF	Radio Frequency
UI	User Interface
V	Voltage
VAC	Volts Alternating Voltage
W	Width

Introduction

The Auto-Secure Binding (ASB) is an electro-mechanical snowboard binding system which will greatly enhance the snowboarder's riding experience. This product is a dual unit system which contains a user-friendly wireless controller and a pair of motorized bindings. The wireless controller is responsible for transmitting signals to the binding unit via RF communication. The function of the binding unit is to secure and release the user's boot when the proper commands are received. The ASB is an innovative product which utilizes mechanical and electrical components to provide a fully automated snowboard binding system.

Our goal is to create a comfortable and convenient way for users to release and lock their bindings. The ASB will enable users to allocate more time for snowboarding rather than wasting time on manually adjusting and tightening the bindings. The detailed technical requirements and designs for the ASB are described in this document.

Scope

The objective of this document is to outline the technical design standards required. These documented specifications fully describe the design specifications of the prototype and to some extent describe the retail version of the system.

Along with the ASB's functional specification, this document will outline the implementation methods required to achieve the level of specification.

Intended Audience

The document is intended to be a reference for the members of JAC Innovations and affiliates. The design specification will provide a reference to the engineers to ensure that all requirements will be fully met.

All members of JAC Innovations can easily refer to this document to organize the development and milestones during the design and implementation phases of the ASB. Quality assurance technicians shall refer to this document for test plan criteria and make sure all the requirements are satisfied.

System Overview

The ASB is composed of two units: a pair of mechanized snowboard bindings and one wireless controller. The binding unit is the main component of the ASB. The wireless controller sends commands inputted by the user to control the binding unit in a variety of actions.

Overall System Design

The ASB integrates software and hardware components. The software controls the communication between the two units. Sending serial RF signals from the transmitter to the receiver, the MCU must process these messages to execute the proper motor commands. The hardware consists of the mechanical system, wireless transceivers, MCUs, and MCU controllers. The mechanical system includes the motors, gears, and physical binding frames.

Hardware Design Overview

The hardware must satisfy the requirements of securely locking and releasing the user's snowboarding boots. Housings for the MCU, transceiver, and respective peripherals for the binding and controller units are designed to occupy minimal space while preserving maximum functionality. The hardware on the main binding unit governs the binding functionality while the controller hardware provides a button UI.

Software Design Overview

The ASB uses the Arduino Duemilanove microcontroller board. The Duemilanove utilizes an open-source Processing language. This object-oriented language is closely related to C and Java languages. The Duemilanove contains an ATMega 328 MCU.

The code must handle the serial RF communication between the two units and execute the correct behaviour. In addition, the code translates the physical controller UI buttons into digital signals and processes them to send wireless messages. The inputs and outputs of the Duemilanove MCU board acts as the variables in which the code reacts to.

Binding Unit

The binding unit consists of a MCU which interprets the signals received from the wireless controller and it controls the corresponding mechanical system to actuate the binding(s). The bindings are initially in the open position so that the user can easily step into the apparatus. To secure the boot, a sturdy metal frame closes and applies pressure to the boot. There will be a total of two motors driving each binding, the front bracket and the back-plate. The motor is placed precisely beside the hinge. The front bracket will be mounted on two locking hinges and the front motor is responsible for actuating them. Similarly, the back-plate will be mounted onto two locking hinges at the rear of the binding. The actuation of this component is controlled by the rear motor. To unlock and rotate the hinges a center button must be pressed. This action is completed by another set of motors linked to a cable release mechanism. Figure 1 below should clarify the moving mechanism and the dimensions of the binding unit.

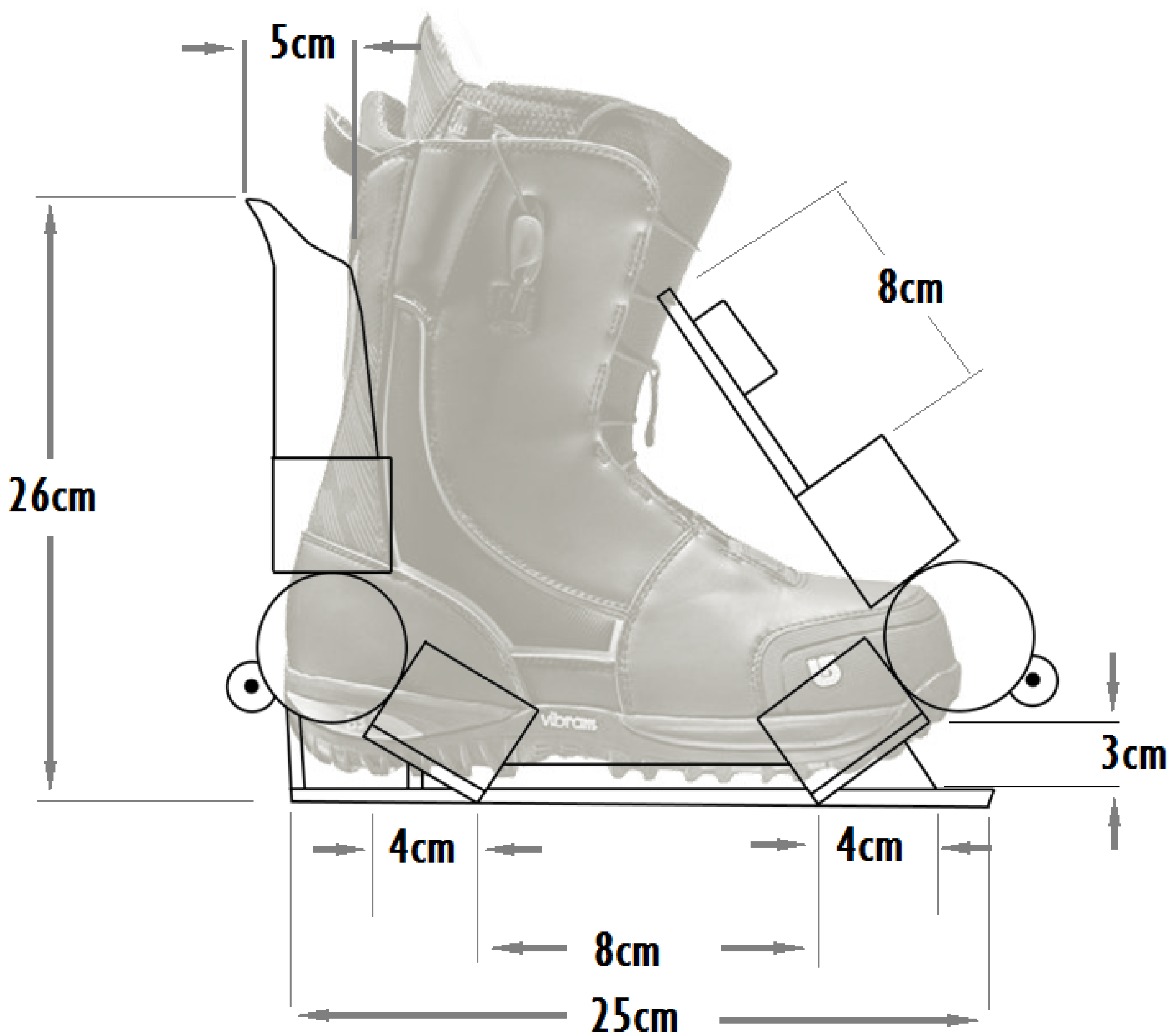


Figure 1 - An overview and dimensions of binding unit with hinges and securing bracket

Binding Frame

The binding frame is constructed from sheet-metal. The prototype will use a lesser grade steel sheet-metal. This sheet-metal is significantly heavier than the ideal aluminum sheet-metal which would be utilized in the retail version. The binding frame consists of three sections: base-plate, back-plate, and front-cover.

The base-plate is where the sole of the user's boot is placed. It provides a mounting surface for all the components that will be attached to the snowboard. The base-plate fits within a 25 cm (L) by 20 cm (W) rectangle and will allow enough space for the user's boot to step into.

The back-plate provides heel support of the user's boot. The inclined angle off the base-plate shall be 70 degrees. The back-plate will be fabricated from a 15 cm (L) by 16 cm (W) sheet. The sheet will be shaped to have a curvature depth of 5 cm.

The front-plate covers the user's boot in order to secure the front of the boot to the binding. The angle of the front-plate will start at 20 degrees then rise to an angle of 40^{o} covering the upper section of the boot. The dimensions of the front-plate will be conformed to the dimensions of snowboarding boots. This will be done by several iterations of trial and error to determine the optimal dimensions for strength and comfort. The front and rear view and dimensions of the binding is shown in Figure 2 below.

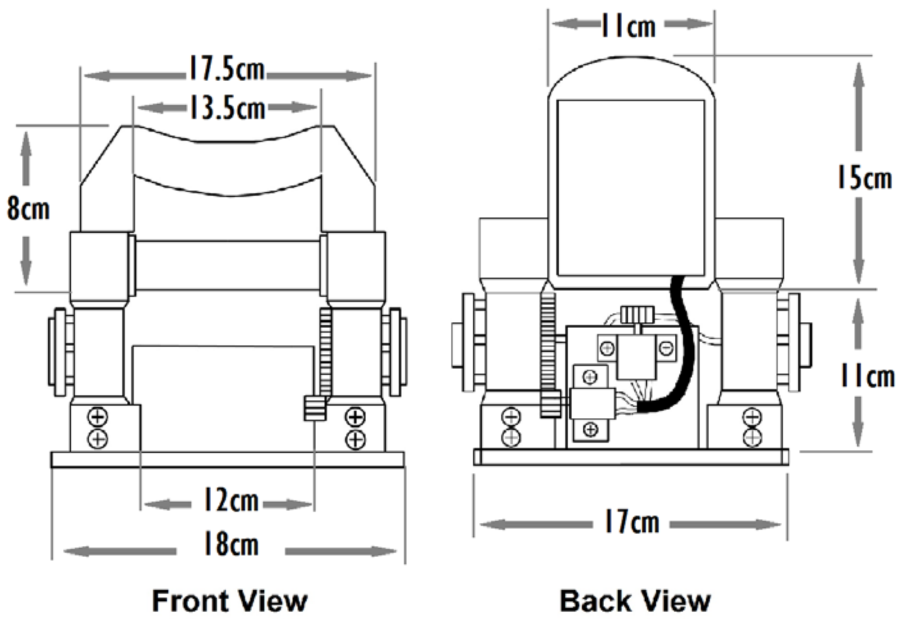


Figure 2 - Front and Back view and dimensions of the binding

Mechanical Design

The actuation of the bindings is comprised of two mechanical designs. One design is for the unlocking of the hinges to allow movement and second actuates the hinges to control the binding plates.

The design responsible for the unlocking of the hinges is achieved by a cable release mechanism attached to a motor. The motor spools the inner wire of a bicycle brake cable which would depress the unlocking button on a pair of hinges. Each binding will have two sets of these unlocking mechanisms, one for the front-plate and the other for the back-plate. Shown in figure 3 is an image of the cable-release mechanism.

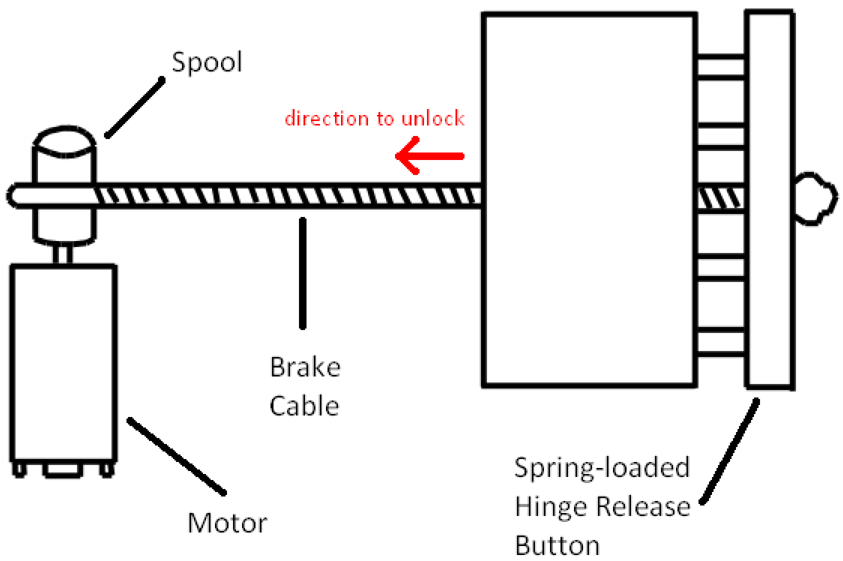


Figure 3 - Cable-Release Mechanism

The actuation of the hinges is performed by a motor driving a gear that is mated concentrically to the hinge's axis of rotation. There are currently two designs which can be applied to avoid size restrictions. The difference in the designs is the type of gears used. In one design, spur and pinion gears are used and the rotation of the gears are in the same plane so horizontal size will be utilized. The motor is tangential to the spur gear attached to the hinge. The other design using bevel gears will position the motor so that the motor is normal to the circumference of the bevel gear on the hinge. This design would occupy more space. However, there will be more freedom in choosing mounting locations.

Components

As mention in the mechanical design, mechanical movement of the device requires different set of mechanical component set – motor, gears and hinges. Detail description of each component is given in this section including its dimensions, specifications and descriptions.

Adjustable Locking Hinge

The hinges for the binding frame are made out of industrial-grade heavy duty thermoplastic. The top, inside, and outside views of hinge and their dimensions are illustrated in Figure 4.

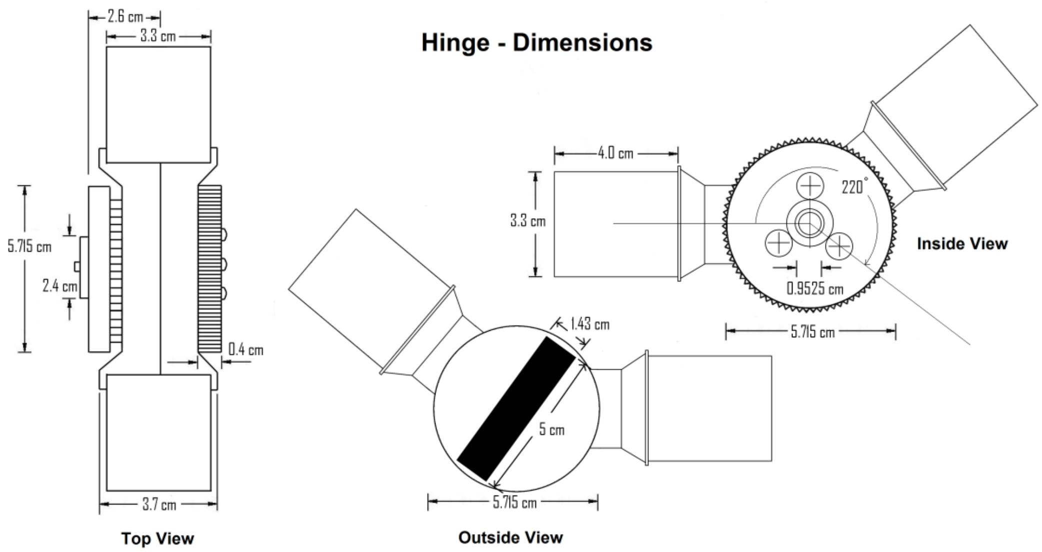


Figure 4 - Top, inside & outside view of the hinge and their dimensions

This adjustable locking hinge has a resolution of 10º. Once locked, the hinge becomes a rigid joint, able to withstand 51.8 Newton-Meters (N·m) of torque. The total range of movement is 220º. For the binding unit, a range of movement of < 100º is required.

There will be a total of four hinges on one binding – two hinges responsible for the front-plate and two for the back-plate. The placements of the hinges are shown in Figure 5 below.

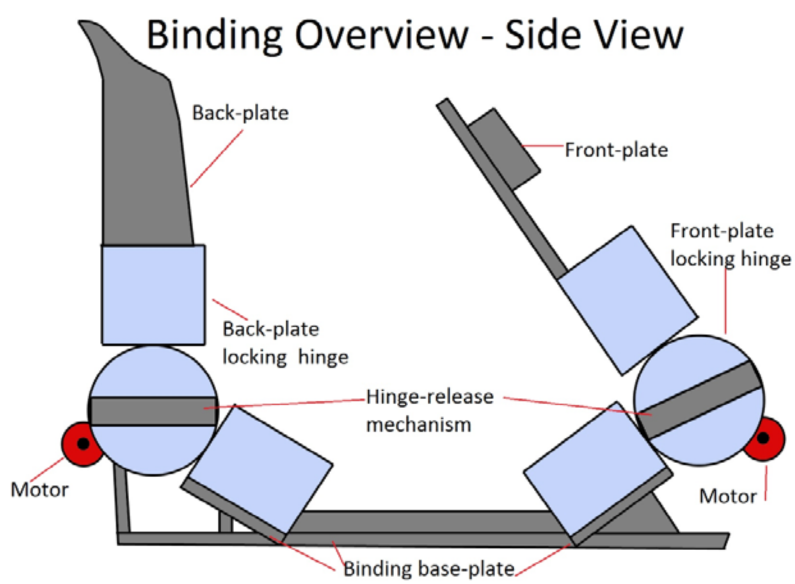


Figure 5 - Placement of Hinges (side view)

The locking mechanism within the hinge uses plastic caps and springs. The springs push the plastic caps into a slot thus locking the hinge. By pushing the release button, the springs are compressed and plastic caps retreat allowing for movement. The weight of each hinge is 164.4 grams. There will be a total of four hinges on one binding so the hinges will contribute 658 grams to the binding.

Gears

There are few types of gears used in the device. Spurs gear, bevel gears and pinion gears. The spur gears together with the pinion gears are responsible for the back hinge. The bevel gear set is responsible for driving the front-plate hinge. Table 1 contains detailed information about the gears.

Table 1- Table of Gears Specifications

Type	Module (Pitch)	Diameter	Number of teeth	Material	Pitch Diameter
Spur	32	5.2 cm	68	Plastic	0.80 cm
Pinion	32	0.9 cm	12	Steel	0.049 cm
Bevel Ring	N/A	3.4 cm	42	Steel	0.40 cm
Bevel pinion	N/A	1.3 cm	13	Steel	0.60 cm

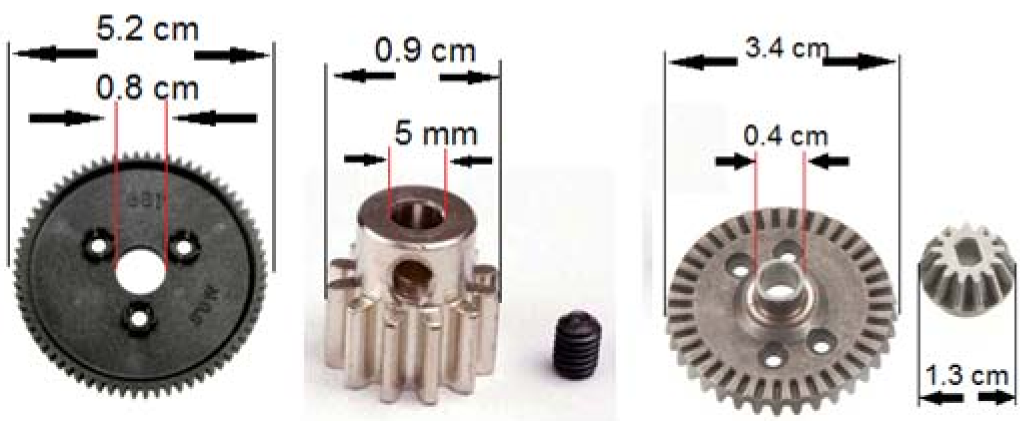


Figure 6 - Different types of gears used: Spur gear (left), Pinion gear with screw (middle) and Bevel gear set (right) [1,2]

Figure 6 shows the dimension of each gear used in the device. The pinion gear requires a screw to secure it on the drive shaft of the driving motor. The bevel pinion gear, on the other hand, was specially customized so that it would fit on a 0.049 cm motor drive shaft.

We have chosen the input gear with a smaller teeth number to drive the output gear with a greater teeth number in our device. The gear ratio of the rear hinge gear train is calculated as following:

$$Gear\ Ratio = \frac{\#\ of\ teeth\ on\ output\ gear}{\#\ of\ teeth\ on\ input\ gear} = \frac{68}{12} = 5.67$$

The higher the gear ratio, the higher the torque produced. Torque is desired over speed as the drive motors are required to be capable of lifting the frame plates and ensure a tighter angle of locking for the hinge. A gear ratio of 5.67 is respectably high. Therefore, this setup should provide enough torque to rotate the hinges.

It is important to identify that the front-plate needs to apply pressure against the user's boot. As a result, we have chosen metal gears instead of plastic ones because of their sturdiness.

Motor

The motor we have chosen for our device is a metal gear motor made by Pololu Robotics & Electronics. The Micro Metal Gear Motor has an internal gear-train which provides a gear ratio of 298:1. The small dimension of this particular motor fits the profile of our device but yet it is powerful enough to accomplish our goal. The dimension of the motor is shown in Figure 7.

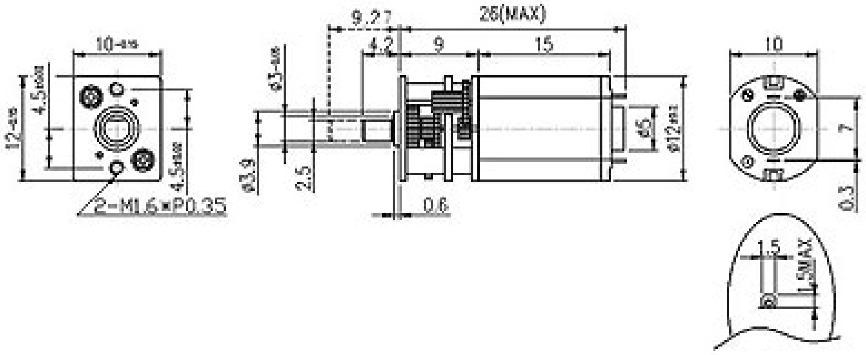


Figure 7 - Dimensions of Pololu 298:1 Micro Gear Motor [3]

This motor has a D-shaped metal output shaft which is 9.27 mm long. It is compatible with the profile of the pinion gear we described in previous section. The motor is intended for use at 6V. In general, it can run at voltages above and below this nominal voltage, so it should comfortably operate in the 3V – 9V range. Table 2 displays the specifications of this motor.

Table 2 - Specification of Pololu 298:1 Micro Gear Motor

Nominal Voltage (V)	Free RPM	Stall Torque (kg-cm)	Stall Current (mA)	Reduction	Size (mm)	Weight (g)
6	100	6.5	1600	298:1	3.61 x 0.99 x 1.19	10

There will be eight of the same motor installed on our device which will add an additional 80 grams to the overall weight of the device.

Placement of Mechanical Components

Figure 8 is the top view of the pair of binding with the locations of the different mechanical components. The front-plate and back-plate are both omitted from the figure to provide a clearer view of the mounting locations.

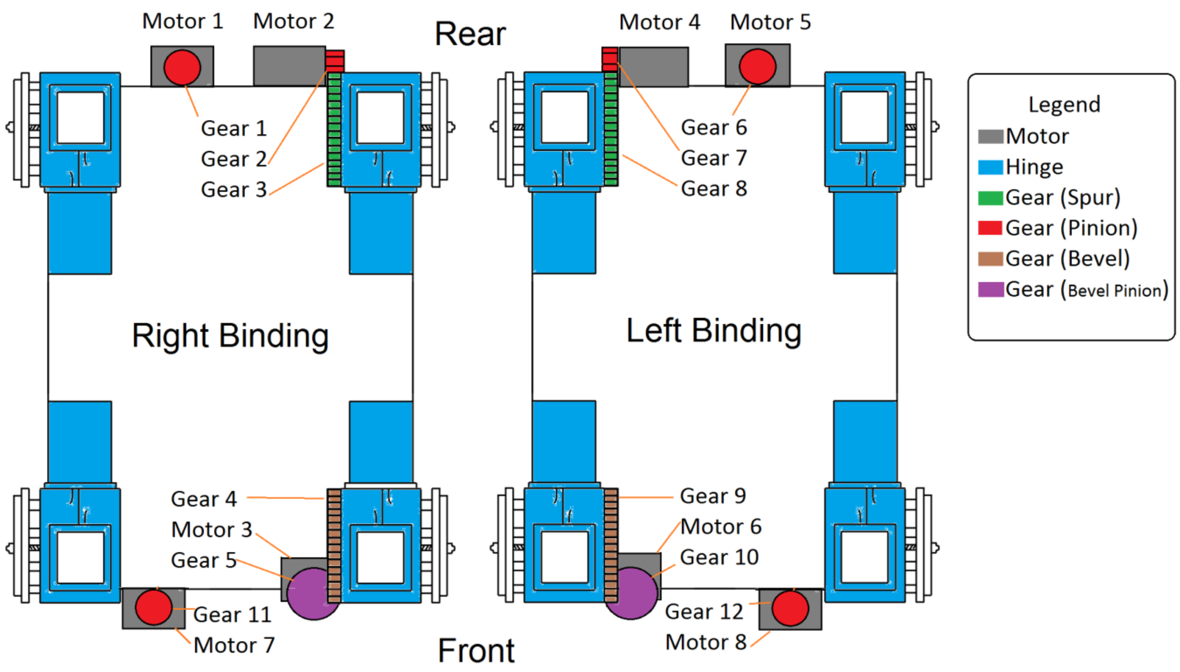


Figure 8- Top view of the device with location of different mechanical components

Each binding will have four hinges placed in the corner of the base of the binding. Each pair of hinges will be driven by one motor. In addition to the movement of the hinges, there are two motors responsible for releasing the hinge's locking mechanism on each binding. Therefore, there will be a total of 8 motors and 12 gears on both binding units as illustrated in figure 8.

Electrical/Software Design

The binding unit is controlled by two types of input, a switch on the base-plate that detects the user's boot and the wireless control unit. The inputs are processed by an MCU which will determine the appropriate output action. The switch on the base-plate closes the circuit wherein the MCU begins initialization. The setup function will actuate the mechanical portions of the binding, thus securing the user's boot. After the initialization, the XBee transceiver will be active and will be awaiting commands from the wireless controller unit. Upon receiving the commands from the controller, the XBee relays the message to the MCU. The MCU then deciphers the message and performs the respective action. When the user releases the bindings and removes their boot from the base-plate switch, the circuit is now open and the electronic components are deactivated. The flowchart is shown in figure 9.

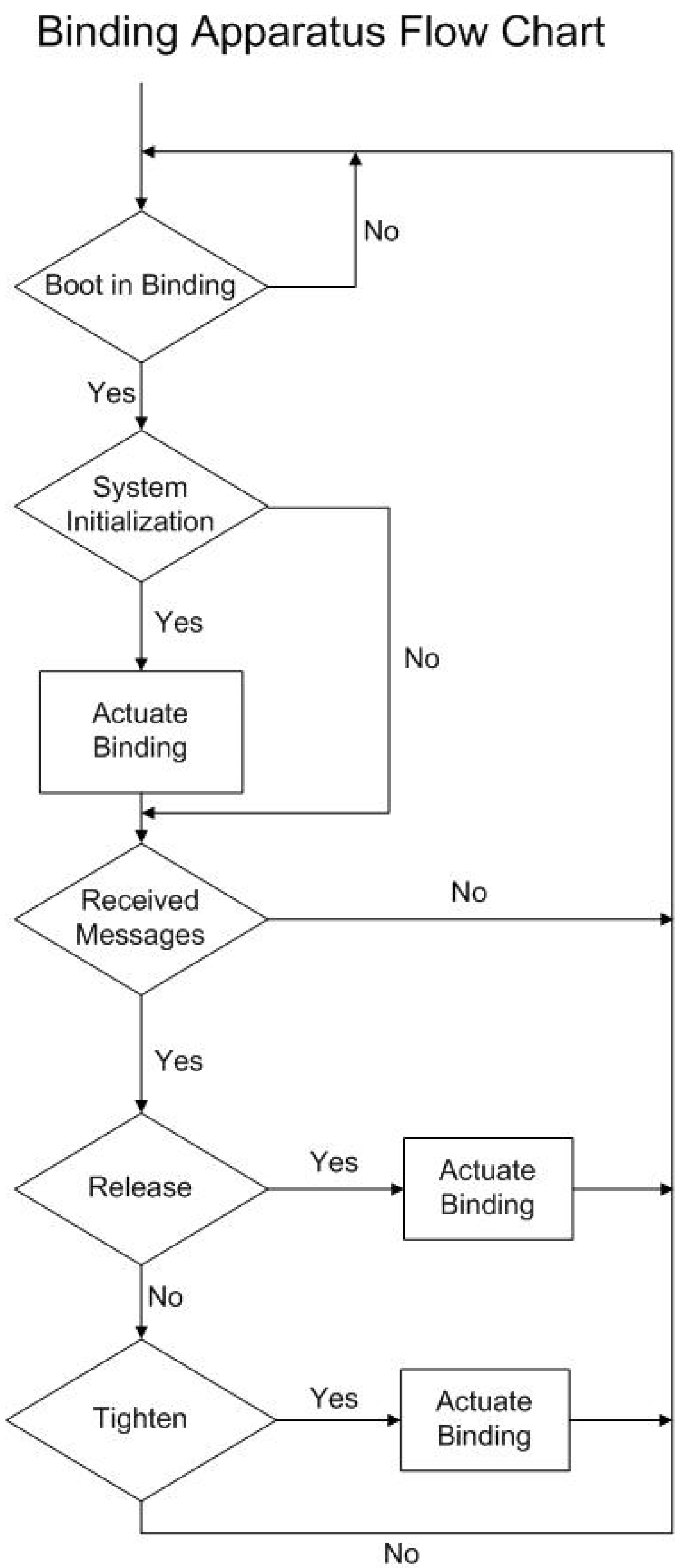


Figure 9 - Binding Apparatus Flowchart

Components

MCU & Controller

The MCU we are using in the device is ATMega328 8-Bit processor from Atmel Corporation. It is surface mounted onto the Arduino Duemilanove USB Microcontroller Board. The Duemilanove has 14 digital I/O pins, 6 analog inputs, a 16 MHz crystal oscillator, a USB connection, a power jack, and a reset button. The USB connection allows us to program the MCU on a computer and easily upload programs to the MCU. The Duemilanove is powered by a 9V battery pack. Table 3 and Table 4 shows the specifications of the Duemilanove and ATMega328 [4].

Table 3 - Specification of Arduino Duemilanove

Arduino Duemilanove Specifications						
MCU	Operating Voltage	Input Voltage	Digital I/O Pins	Analog Input Pins	DC Current per I/O Pin	DC Current for 3.3V Pin
ATmega 328	5V	7V–12V	14 (6 PWM)	6	40mA	50mA

Table 4 - Specification of ATMega328 MCU

ATMega 328 MCU Specification			
Flash Memory	SRAM	EEPROM	Clock speed
32 KB	2 KB	1 KB	16 MHz

Figure 10 below displays the labelled top view of the Duemilanove and its peripherals.

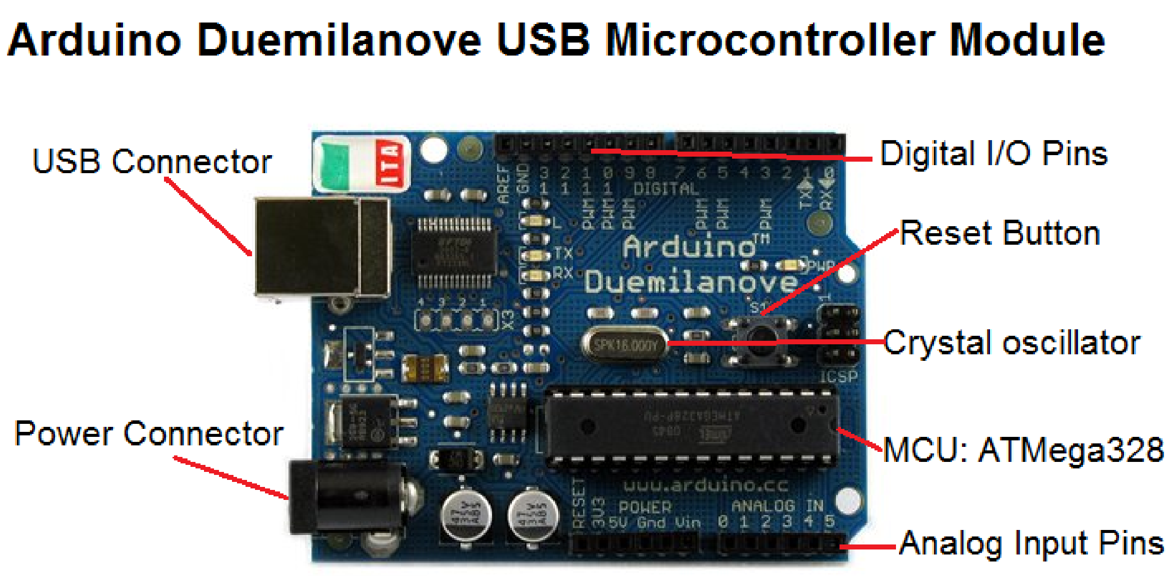


Figure 10 - Top view of Arduino Duemilanove USB Microcontroller Module

Motor & Motor Shield

The motor we are using in this device requires 6V of DC power. However, the motor needs an agent to regulate the voltage and the number of rotations. The motors require a motor controller so the MCU is able to communicate with the motors. Hence, we need a motor shield to facilitate this communication between the components. A motor shield kit for Arduino from Adafruit was assembled and implemented. This motor shield is specifically built to be compatible with the Arduino Duemilanove. The shield is powered by the Duemilanove's power pins. However, the motors will require an external 9V battery. The following is a list of some important features of the motor shield [5].

- Connection of up to 4 bi-directional DC motors with individual 8-bit speed selection
- 4 H-Bridges: L293D chipset provides 0.6A per bridge (1.2A peak) with thermal shutdown protection, 4.5V to 36V
- Pull down resistors keep motors disabled during power-up
- Big terminal block connectors to easily hook up wires (10 – 22 AWG) and power
- Arduino reset button brought up top
- Compatible with Arduino Duemilanove

Figure 11 below displays the labelled top view of the Motor Shield.

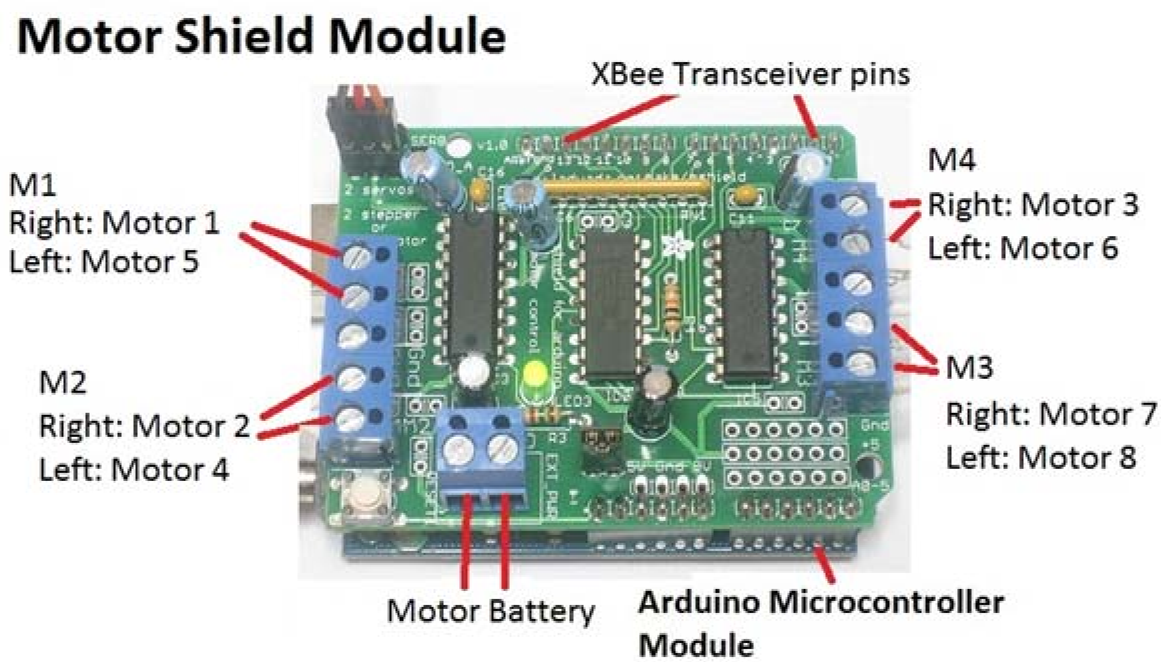


Figure 11: Top view of the Motor Shield Kit

Table 5 below explains the motors connections to the 4 DC motor output terminals on the motor shield.

Table 5 – Corresponding Motors for the Output Terminals on the Motor Shield

Output Terminal	Corresponding Motors		Description
	Left	Right	
M1	1	5	Back hinges release
M2	2	4	Back-plate rotation
M3	7	8	Front hinges release
M4	3	6	Front-plate rotation

Placement

Figure 12 below illustrates the wire connections between the four DC motors and RF transceiver to the motor shield.

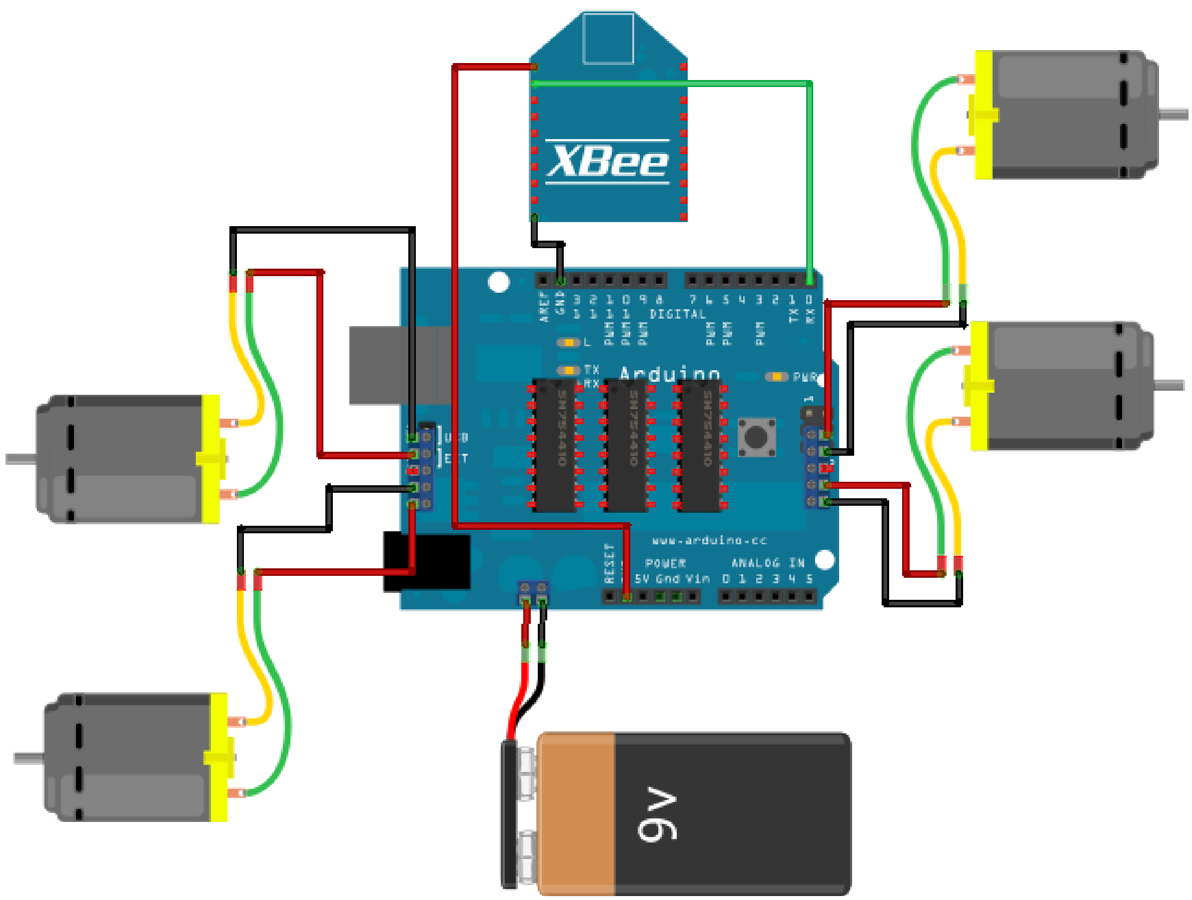


Figure 12: The placement of the various electrical components

Output pin 1 on the XBee transceiver is connected to 3.3V output pin on the motor shield and the output pin 2 on the XBee connects to the RX input pin 2 on the motor shield. This pin 2 is pulled up from the bottom Arduino controller layer. The RX input port is responsible for receiving external serial messages. All electrical components, except the motors, will all be enclosed in a waterproof housing. The dimension of the enclosure is 12 cm (L) x 7 cm (W) x 4 cm (H).

Figure 13 below shows the rear view of the binding. The water-proof enclosure is going to be mounted at the back of the back-plate. The figure also shows the circuitry inside the enclosure box.

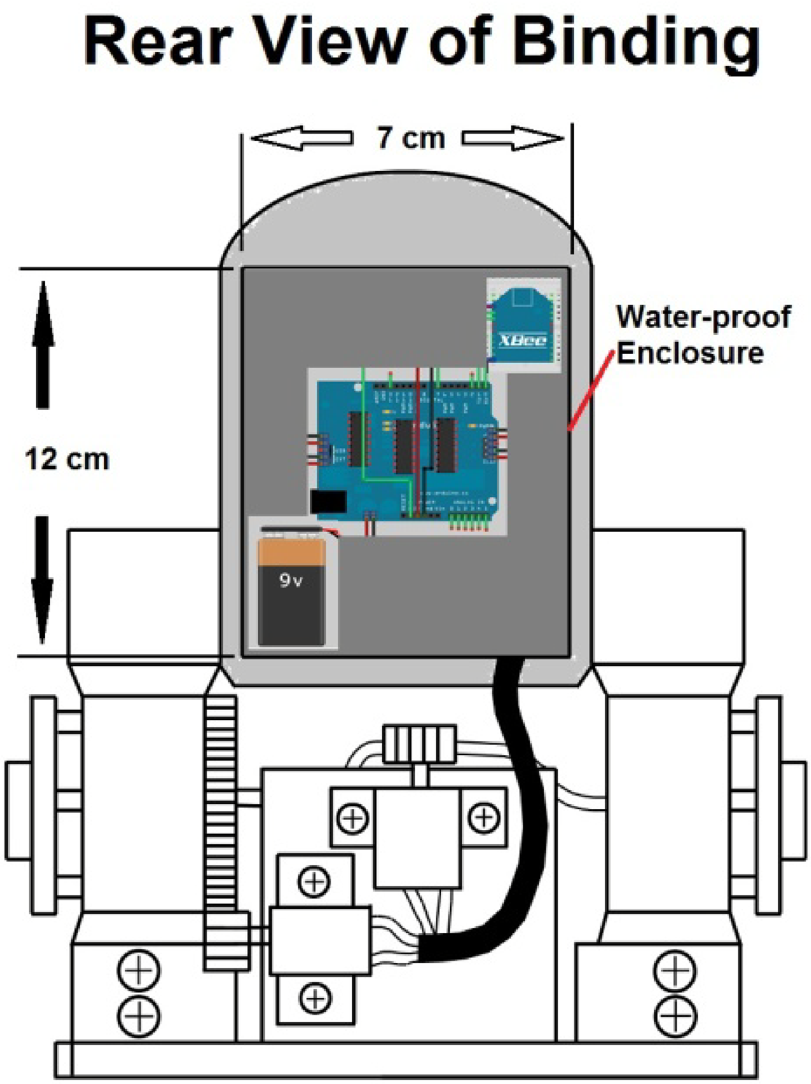


Figure 13 - Rear view of the binding with placement of the circuitry

Other Considerations

In case of electrical failure, manual control of the binding unit is available. The user would need to press a pair of unlock buttons on the side of the hinges, either the front pair or the back pair.

Wireless Controller Unit

The wireless controller unit is essentially a box with push-button inputs. It houses all the required electronic components for this to be a standalone unit that will communicate with the binding unit described above. Figures 14 and 15 show the basic layout design of the remote control.

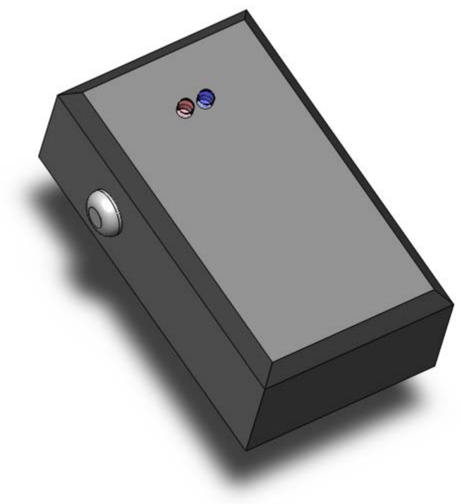


Figure 14 -Left Side Isometric View of the Wireless Controller

On the left side of the wireless controller box shown in figure 14, there is a single momentary switch. This is the safety switch which needs to be held down to turn on the unit and allow users to input commands.

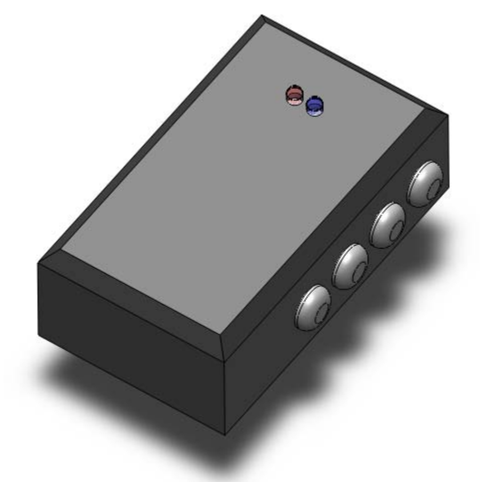


Figure 15 –Right Side Isometric View of the Wireless Controller

On the right side of the remote shown in figure 15, there are four momentary push-buttons. These act as the inputs, depending on which button is pressed its designated command will be sent.

Shown in figure 16 is the flowchart used for the software component of the wireless controller.

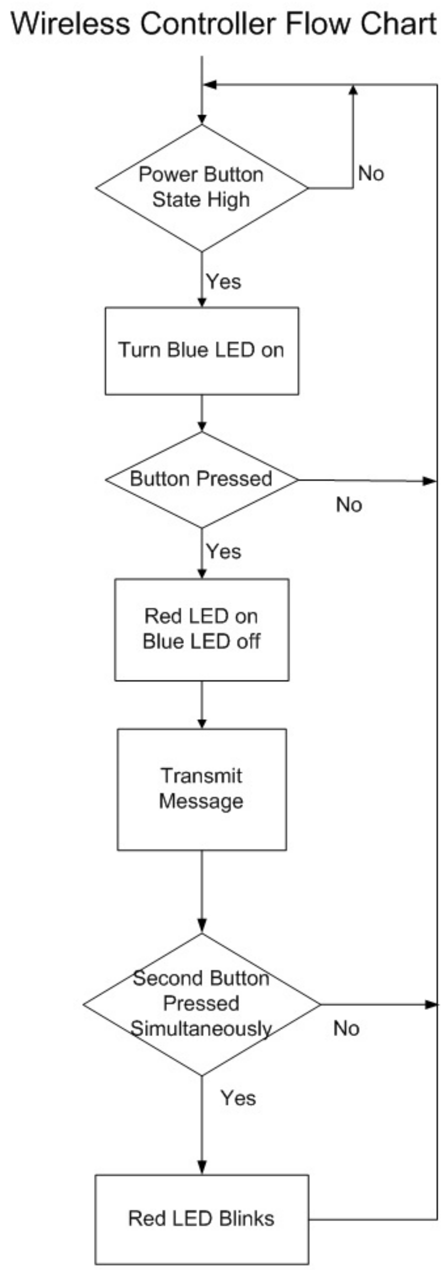


Figure 16 - Wireless Controller Flowchart

Mechanical Design

The wireless controller is enclosed within a plastic case. This box must be at least 12 cm (L) by 7 cm (W) by 4 cm (H) so that all the components can fit within it. There are five momentary switches, four for input commands and one for closing the circuit. The switch responsible for closing the circuit needs to be held down during the time of operation in order for the components to have power. This is a safety feature so that the user does not accidently release the bindings. To reiterate, for the user to enter a command, via wireless controller, they must simultaneously hold down the power switch then press the button corresponding to the desired command.

Components

Momentary Switches

The switches are simple push-button which when pressed closes a circuit. This single pull single throw is rated at 3A/125VAC. The rating provides more than enough headroom for the wireless unit's circuitry. Figure 17 shows a picture of what the switch looks like [6].

Figure 17 -Momentary Push-Button Input Switch

Physical Enclosure

The housing of the wireless controller is made from plastic. Gasket seals will be used to make sure that water does not seep into the interior and damage the electronic components. Some sort of grip on the faces with buttons shall be employed so that the user has a secure hold of the remote. An optional wrist strap or lanyard attachment hook can be implemented to further convenience.

Electrical/Software Design

Enclosed within the wireless controller are an MCU controller, an XBee transceiver, LEDs, and momentary switches. Each momentary switch is wired with a 10kΩ pull-down resistor. When the switch closes, this will send a 5V signal to the digital pins on the Arduino Duemilanove. These pins are active high and the software will determine which button have been flagged as high and send the respective message via the XBee transceiver. There are two LEDs, a blue one for power indication and a red one which indicates when a button is pressed. If the user presses two command buttons at the same time, the red LED will blink, indicating that too many buttons have been pressed simultaneously. Each LED is wired in series with a 220Ω current-limiting resistor to protect the LEDs from current overloading. Figure 18 shows the schematic of the wireless controller.

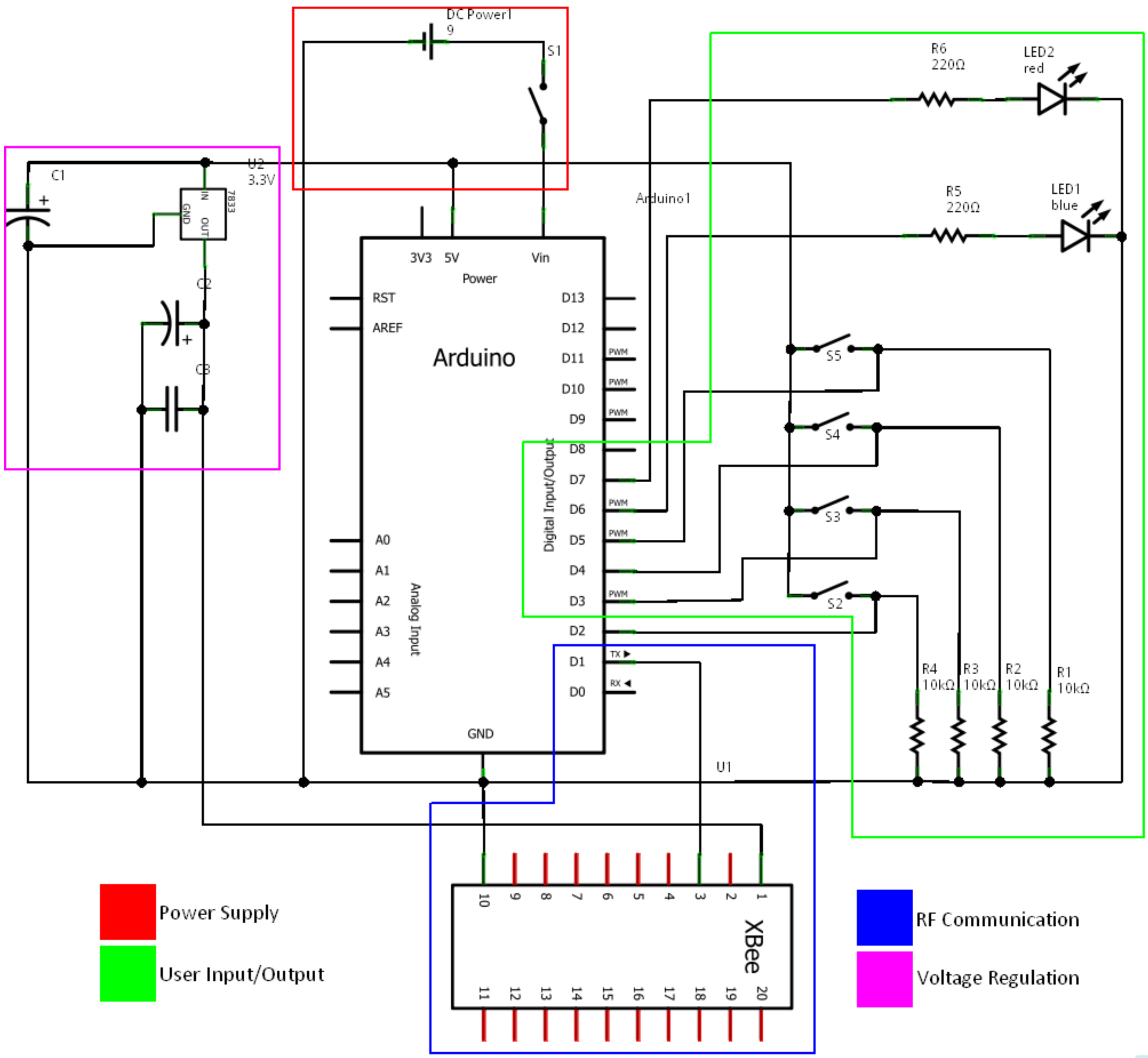


Figure 18 - Circuit Schematic of the Wireless Controller

To ensure that one unit will not communicate to another unit we have implemented a string header acting as a identifier. This header will contain a code specific to each unit as well as a pass code for our products. Following the header will be the command generated depending on the user's input. These commands will be tighten all, release all, release left, release right.

Components

MCU & Controller

The same MCU and MCU controller is used for the wireless controller unit as the binding unit. These are the Atmel ATMega328 8-Bit processor and the Arduino Duemilanove. The Arduino Duemilanove is the core component of the remote where all the peripherals are connected to it. A 9V battery will be the power supply for the Arduino Duemilanove. The Arduino Duemilanove will then distribute the power accordingly at a stepped-down voltage of 5V or 3.3V.

XBee Regulator Shield

The shield steps down the input voltage to the XBee from 5V to 3.3V. This shield is used mainly so the XBee will have a mounting platform, as the XBee has non-standard pin spacing. With the shield, the XBee can be easily mounted to a PCB where the rest of our circuit is placed.

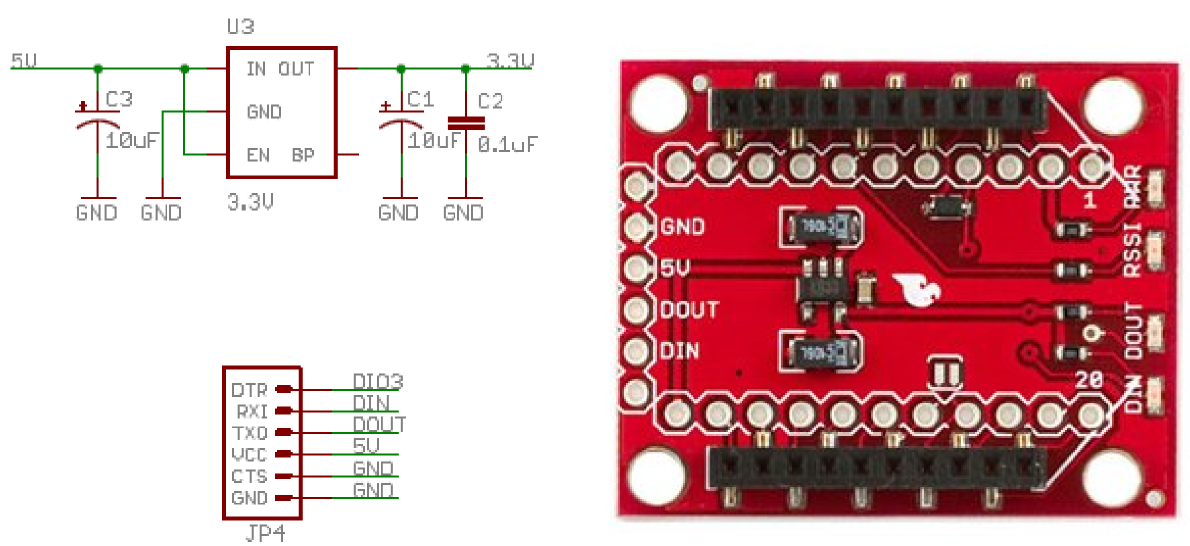


Figure 19 - XBee Regulator Shield

Figure 19 shows the regulator shield [7] and its schematic [8]. At the centre of the shield lies the voltage transformer circuit. The two long black pin headers will accept the pins of the XBee. On the left side of the shield, there are 4 pins: GND, 5V, DOUT, DIN. These are connected to the Arduino controller. 5V is the input power supply to be stepped-down. GND is the common ground which forms the complete circuit. DOUT is the data output from the XBee antenna which will not be used as the wireless controller unit acts only as a transmitter and not a receiver. DIN is the data input to the XBee antenna which will facilitate in sending the messages controlled by the Arduino output.

XBee Transceiver

Figure 20 - XBee Transceiver

The XBee is a 2.4GHz 1mW transceiver made from MaxStream. We will be using it to communicate with the binding via serial RF signals. The chip antenna was selected over the whip antenna model due to size constraints. Shown in Figure 20 is an image of the transceiver [9]. Figure 21 shows the transceiver's pin labels [10].

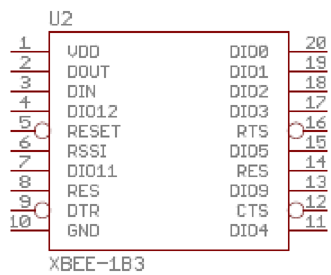


Figure 21 - XBee Pin Labels

Pins 1, 3, and 10 are used for the wireless controller unit. Pin 1 is the VDD where it requires a clean 3.3V DC input voltage. Pin 10 is the common ground. Pin 3 is the data input pin for the XBee. Serial messages received at this pin will be transmitted through the XBee’s antenna for other XBee modules to receive.

LED

Figure 22 - 5mm LED

There are two colours of LEDs used on the controller, red and blue. The blue LED is rated at 3.2V at 20mA. The red LED is rated at 1.8V at 20mA. They are used as status indicators for the unit. The blue one is the power indicator and red for button presses. They possess a respective 15 and 30 degree viewing angle so the ideal mounting orientation will be directly pointing at the line of sight. The blue LED has a mcd 3500 while the red LED has a mcd of 2500. Therefore, the blue LED will appear to be brighter than the red one. An example of the LED is shown in Figure 22 [11].

System Test Plan

Component Testing

- MCU – Power
  - Condition: Ability to function powered by a battery for extended amount of time.
  - Procedure: Attach the MCU to a battery and see if the power LED is turned on.

- MCU – Connectivity
  - Condition: Ability to output signals to peripherals.
  - Procedure: Attach a peripheral to GPIO ports and use MCU to actuate.

- MCU – Functionality
  - Condition: Ability to contain and run programs.
  - Procedure: Construct and run a program which tests the data paths.

- Buttons – Functionality
  - Condition: Ability to open and close circuits
  - Procedure: Input power to button. Use voltmeter on the output.

- LED – Functionality
  - Condition: Ability to light without burning out.
  - Procedure: Test different resistances for maximum brightness without burning out.

- Motor-Functionality
  - Condition: Ability to rotate on command.
  - Procedure: Attach the motor to a power supply.

- Hinge – Functionality
  - Condition: Ability to turn when external forces are applied.
  - Procedure: Unlock hinge and turn the joint.

- Motor Shield – Connectivity
  - Condition: Ability to power the unit once connected to a power source.
  - Procedure: Connect the Motor Shield to the MCU and connect to a power source through the MCU's USB port.

- XBee Transceiver – Connectivity
  - Condition: Ability to send and receive signals at the correct frequency.
  - Procedure: Create a message for one chip to send and the other to receive.

Module Testing

- Binding Unit: Auto-Secure
    - Condition: Ability to automatically bind user's boot to the snowboard.
    - Procedure: Place a boot into the binding and verify bindings are in correct position.

- Binding Unit: Boot Release
    - Condition: Ability to release boot upon command.
    - Procedure: Run test code for releasing boot. Verify bindings perform the correct action.

- Binding Unit: Manual Control
    - Condition: Ability to manually operate the bindings.
    - Procedure: Attempt to manually move the joints of the bindings.

- Binding Unit: Receiving Signals from Wireless Controller
    - Condition: Ability to receive and distinguish commands sent by the wireless controller.
    - Procedure: Send a message from the wireless controller. Verify correct message is received.

- Binding Unit: Withstand the extreme conditions
    - Condition: Ability for the unit to function properly in cold, moist, and unstable conditions.
    - Procedure: Have a team member submerge the encased system into water, put into a freezer, and in a test box that will replicate normal wear and tear conditions on a snow mountain for one month.

- Wireless Controller Unit: Sending Signals
    - Condition: Ability to send commands to the binding unit.
    - Procedure: Send a message from the wireless controller. Verify correct message.

- Wireless Controller Unit: User Interface
    - Condition: Ability to provide signals of power on, in use, or error to user.
    - Procedure: Check the LED status during power up, running test code, or having errors.

- Wireless Controller Unit: Simultaneous control
    - Condition: Ability to simultaneously control the left and right binding.
    - Procedure: Run a test code and verify that both the left and right binding are both responding accordingly.

- Wireless Controller Unit: Individual control
    - Condition: Ability to control the left or right binding individually.
    - Procedure: Run a test code that sends a signal specific to only one binding

Functional Testing

JAC Innovations will ensure that all hardware and software testing will be applied. In doing so, all modules will be confirmed to be in a working order. The amount and criteria of tests to be completed will be based on the requirements listed in the Functional Specification document. For all our products, we will run a set of tests to ensure that they are in prime conditions. The tests will include one typical usage scenario and two extreme cases scenario to ensure the product's safety and reliability expectations are met.

Typical Usage Scenario:

1. User adjusts their preferred tightness on first usage.
2. User steps into the binding unit and triggers the initial tightening process.
3. User can tighten or loosen the binding with the wireless controller.
4. User can use the wireless controller unit to release the binding for a specific boot or both.

Boundary Case

1. Hinge Obstructed by Foreign Object
    - Testing: Observe ASB response to obstructions in movement.
    - Remedy: Reduce openings on the physical frame which prevents objects from jamming.
2. Electronic Failure/Depleted Battery
    - Testing: Operate bindings without a power source.
    - Remedy: Physical manipulation of the hinges and front and back plates.

Failure Testing

In order to avoid errors and failures due to improper usage of the ASB, JAC Innovations have implemented programming code as well as physical safety measures to significantly reduce the chances of failure. Additionally, our system will provide feedback to let the user know if an invalid action has been performed. The notification will be in done in the form of LED indicators. Table 6 lists the techniques that we have incorporated into our ASB system.

Table 6 - Failure Testing Scenarios

Situation:	Solution:
Multiple buttons pressed simultaneously	Red LED will blink repeatedly and ignore the inputted commands.
Accidental button pressing	A second button must be pressed and held in order for the commands to be sent
Electronic Failure	Bindings can be manually operated

Environmental Considerations

The ASB utilizes a variety of materials types: metals, silicon-based, and polymers. The MCU board and peripheral boards contains all of the above material which would make recycling a more difficult process. However, there exists recycling facilities which handle the recycling of discarded electronic components.

Wires can be easily reused or the copper can be melted down and recycled as copper ingot. The miscellaneous metal and polymer components can be also melted down and recycled.

However, the electronic components used on the ASB are soldered so that the components are modular and can be removed without sustaining any damage. Therefore, the parts used can be reused and the environmental impact is reduced.

Conclusion

The design specification document gives a detailed description and specification of the components implemented in the proof-of-concept prototype design of the ASB. It also discusses the design choices JAC Innovations has made in order to meet the functional requirements. The components selected were decided to withhold reliability, energy consumption, usability, and financial constraints. A prototype with the specifications described in this document will be completed by the target date of April 16th, 2011.

Reference

[1] TRA 3960 Traxxas Spur Gear 0.8P 68T E-Maxx E-Revo –Summit. (2011). Retrieved March 10, 2011 from R/C Planet Online Hobby Superstore: http://www.rcplanet.com/Traxxas_Spur_Gear_E_Maxx_p/tra3960.htm

[2] TRA 3951 Traxxas Pinion Gear 32P 15T E-Maxx. (2011). Retrieved March 10, 2011 from R/C Planet Online Hobby Superstore: http://www.rcplanet.com/Traxxas_Pinion_Gear_32P_21T_p/tra3951.htm

[3] Pololu 250:1 Micro Metal Gearmotor. (2011). Retrieved March 09, 2011 from RobotShop Distribution Inc.: http://www.robotshop.com/content/images/design/pololu-micro-dimensions.jpg

[4] Arduino Duemilanove USB Microcontroller Module. (2011). Retrieved March 10, 2011 from RobotShop Distribution Inc.: http://www.robotshop.com/ca/arduino-usb-microcontroller-board-3.html

[5] Motor Shield Kit for Arduino. (2011). Retrieved March 10, 2011 from RobotShop Distribution Inc.: http://www.robotshop.com/ca/adafruit-motor-shield-kit-rduino-2.html

[6] SPST 3A ON-OFF, Black round cap. (2011). Retrieved March 10, 2011 from RP Electronic Components Ltd: http://www.rpelectronics.com/456-601-spst-3a-on-off-black-round-cap.html

[7] XBee Explorer Regulated. (2011). Retrieved March 10, 2011 from RobotShop Distribution Inc.: http://www.robotshop.com/ca/sfe-xbee-explorer-regulated-3.html

[8] XBee Explorer Regulated Schematic. (2011). Retrieved March 10, 2011 from RobotShop Distribution Inc.: http://www.robotshop.com/ca/content/PDF/schematic-wrl-09132.pdf

[9] Maxstream 1mW XBee Transceiver Module (chip antennae). (2011). Retrieved March 10, 2011 from RobotShop Distribution Inc.: http://www.robotshop.com/ca/maxstream-xbee-transceiver-module-chip-antenna-4.html

[10] Xbee Transceiver Pin Label. (2011). Retrieved March 10, 2011 from RobotShop Distribution Inc.: http://www.robotshop.com/ca/content/PDF/schematic-wrl-09132.pdf

[11]5mm Blue LED. (2011). Retrieved March 10, 2011 from RP Electronic Components Ltd: http://www.rpelectronics.com/55-558sb-1-5mm-blue-2000mcd.html

[12] Recycle. (2011). Retrieved March 10, 2011 from Crave Cupcakes: http://www.cravecupcakes.ca/media/images/blogs/recycle-symbol.jpg