Elementium

Cost Effective Braille Embosser

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Corporate Team

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Overview

- Introduction/Motivation
- System Overview
- High Level Design
- Financial Outlook
- Project Organization
- What we learned
- Conclusion

Introduction

- ~594, 000 Canadian adults are visually impaired
- 49% of these people are non-senior
- Only 32% are employed[1]
- Urgent need for education in Braille
- Visually impaired people in most developing countries cannot afford Braille education

1. Canadian National Institute for the Blind

Current Products

- Very Expensive

  $1800-$5000
- Few people own one personally

Elementium

- Practical – focus on basic needs
- Functional – easy to use
- Affordable!

System Overview

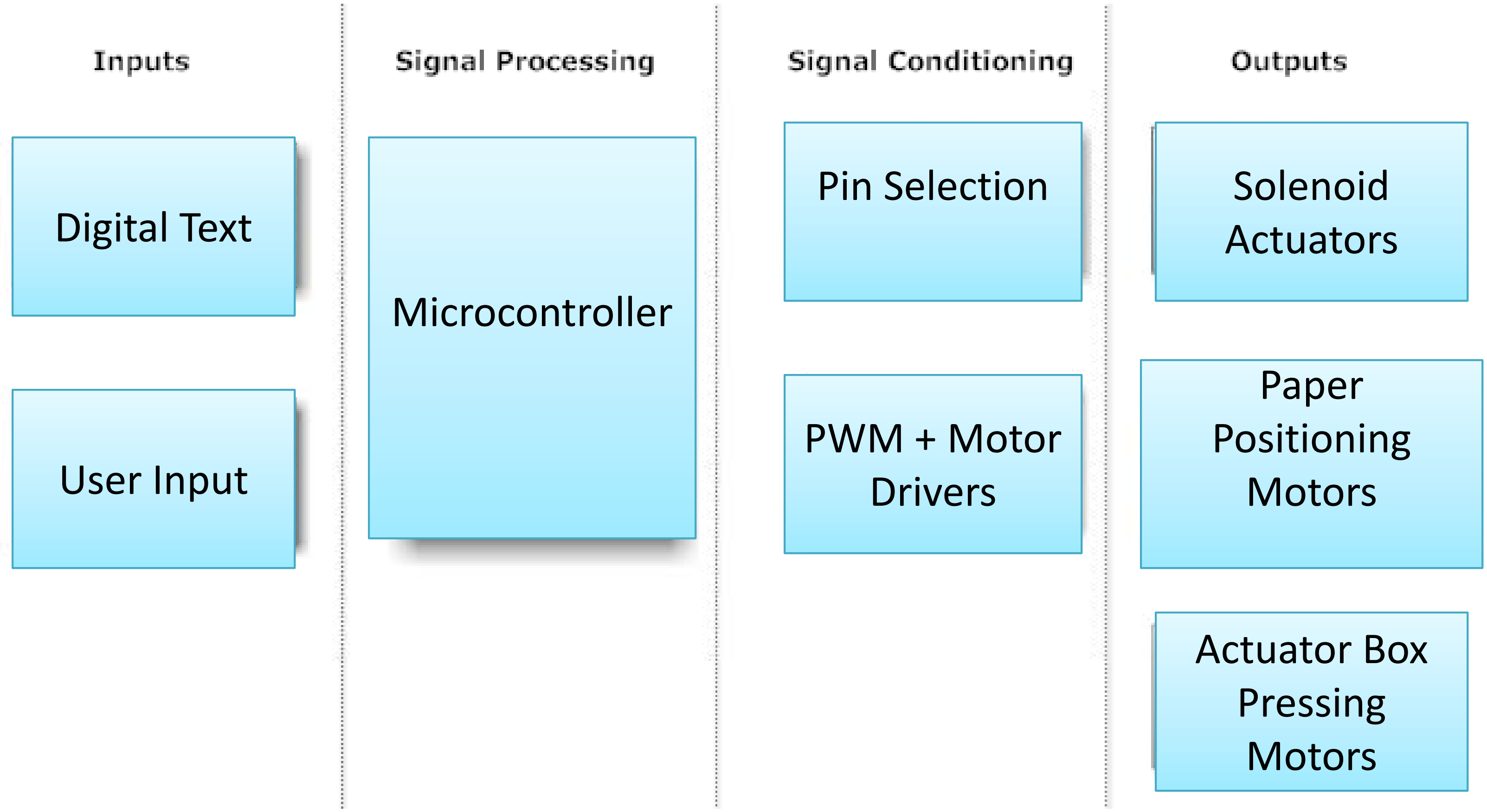


Figure 1: Block diagram of system stages

Braille Dots

- American Standard Sign[2]

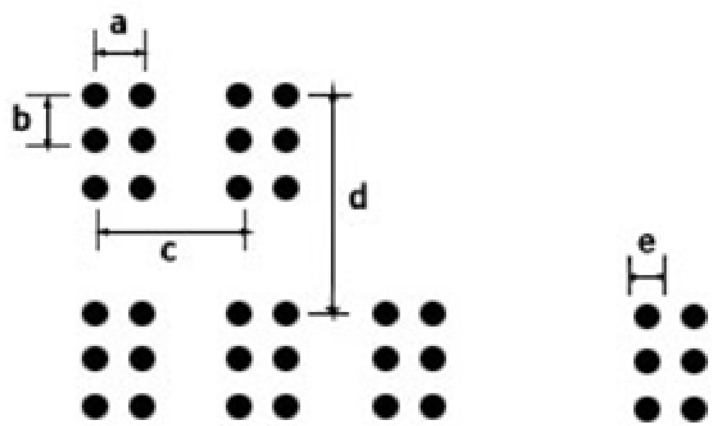


Figure 2: Standard Braille cell dimensions

Horizontal dot to dot	Vertical dot to dot	Cell to cell	Line to line	Dot base diameter	Dot height
a	b	c	d	e	
2.28 mm	2.28 mm	6.09 mm	10.16 mm	1.5 mm	0.5 mm

2. Canadian Braille Authority

Previous Mechanical Design Ideas

- Electromagnetic linear actuators (miniature) used to emboss directly
- Electromagnet + Strong rare earth magnet pair
- Commercial electromagnetic linear actuators + Moving Shuttle

- Why we abandoned the ideas?(After Experiments)
  - Strength
  - Resources availability
  - Precise Production of units required
  - Cost

Mechanical Design Concept

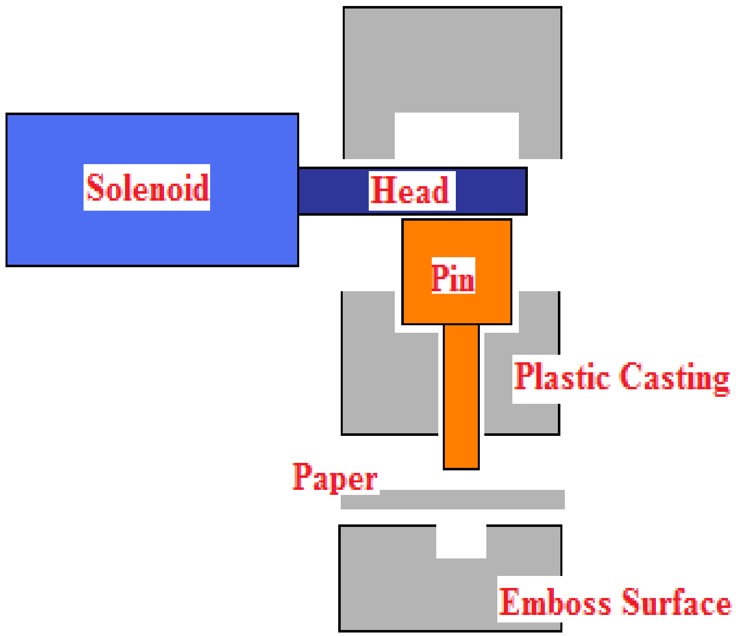


Figure 3. Graphical concept Embossing Mechanism

Mechanical Design – Pin Selection Mechanism

- Electromagnetic linear actuators used horizontally
  - Energized actuators block corresponding embossing pin
  - Non-energized actuators allow unused embossing pins to move freely vertically
- Why we designed in that way?
  - Limitations of the miniature solenoid (Strength)
  - Limitations of the microcontroller (Current Supply)
  - Cost(Reduce extra cost of electronics parts)(Current Amplification Network)

Mechanical Design – Pin Selection

Figure 4. Plunger is at default position, the corresponding pin is clear

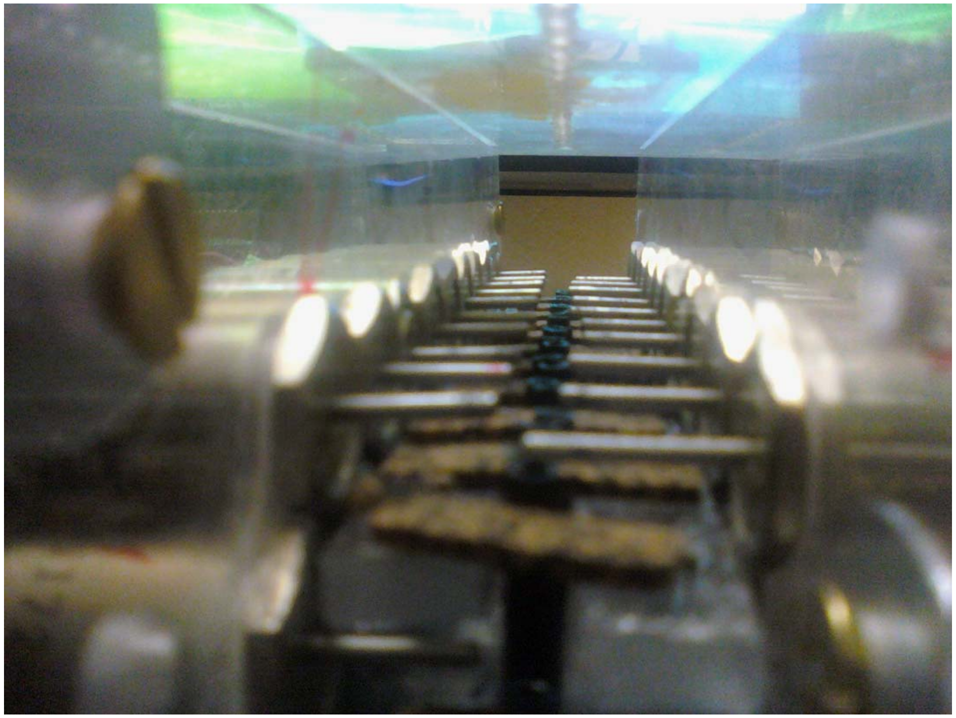


Figure 5. Plunger is at active position, the corresponding pin is locked

Mechanical Design – Change in Press mechanism

- Previous Idea – Motor lift
- Why we changed?
  - Not enough Torque generated to lift the actuation enclosure
  - Hard to provide guided motion
  - Not enough pressure from the weight of the actuation enclosure alone
- Advantages in current mechanism
  - Reduced force required to press

Mechanical Design – Emboss Mechanism Flow

1. When pins are configured(selected)
2. Press Motor will push the enclosure of the pins
3. All pins will hit the embossing surface
4. Selected pins will emboss on the paper surface
5. Unselected pins will be pushed upward against the paper tension
6. Motor will release the push of the enclosure of pins
7. Pins will be reset to default position by gravity

Mechanical Design – Emboss

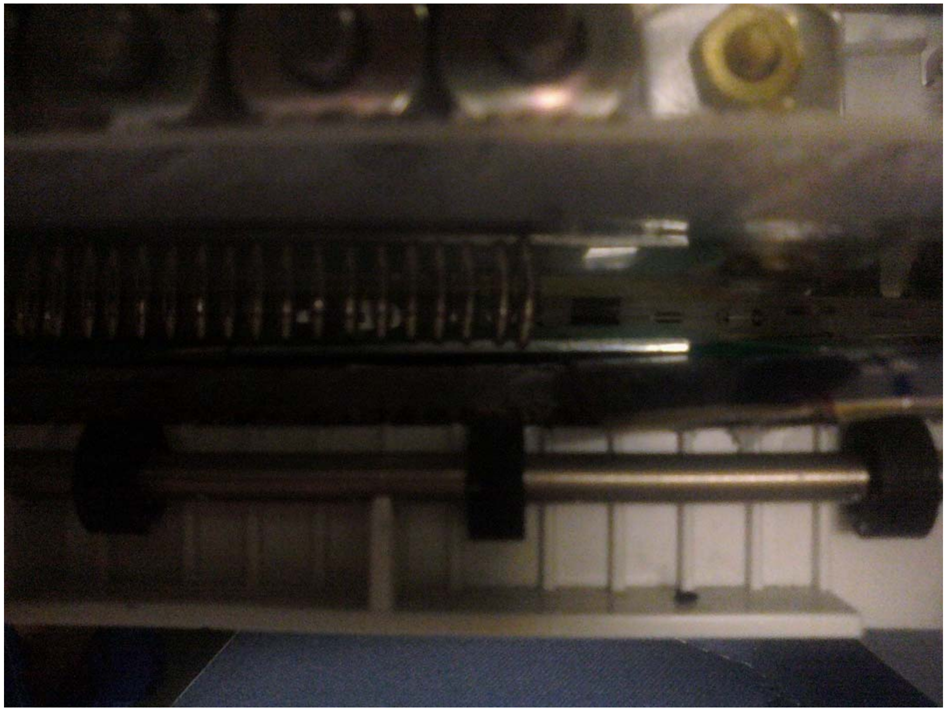


Figure 6. Actuator enclosure is in default position and pins are above the embossing surface

Figure 7. Actuator enclosure is pressed and pins make contact with the embossing surface

Mechanical Design – Emboss

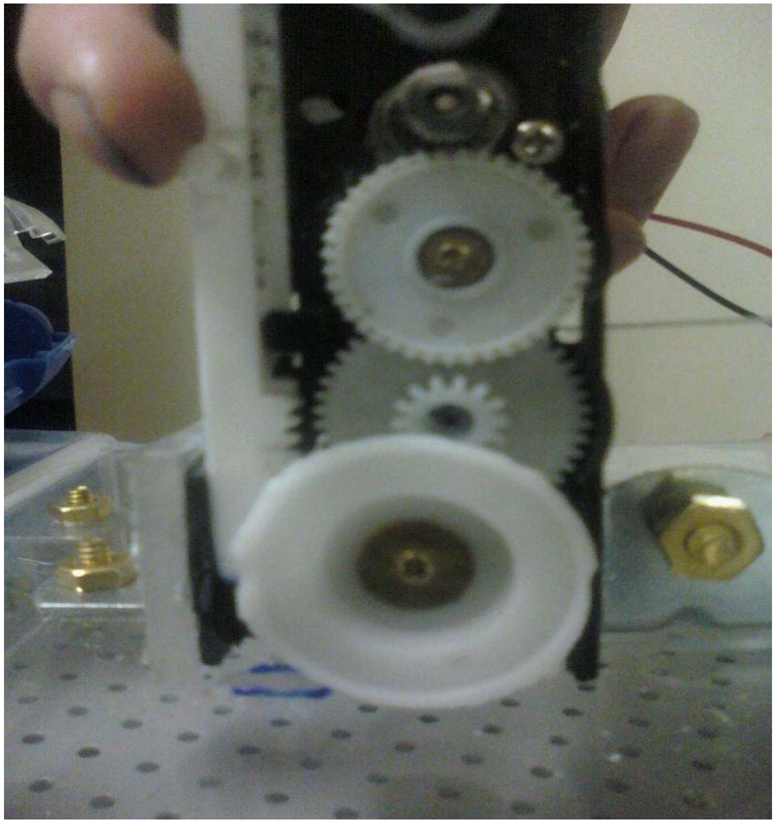


Figure 8. DC motor drives the gear network and linear motion moves the actuation enclosure vertically

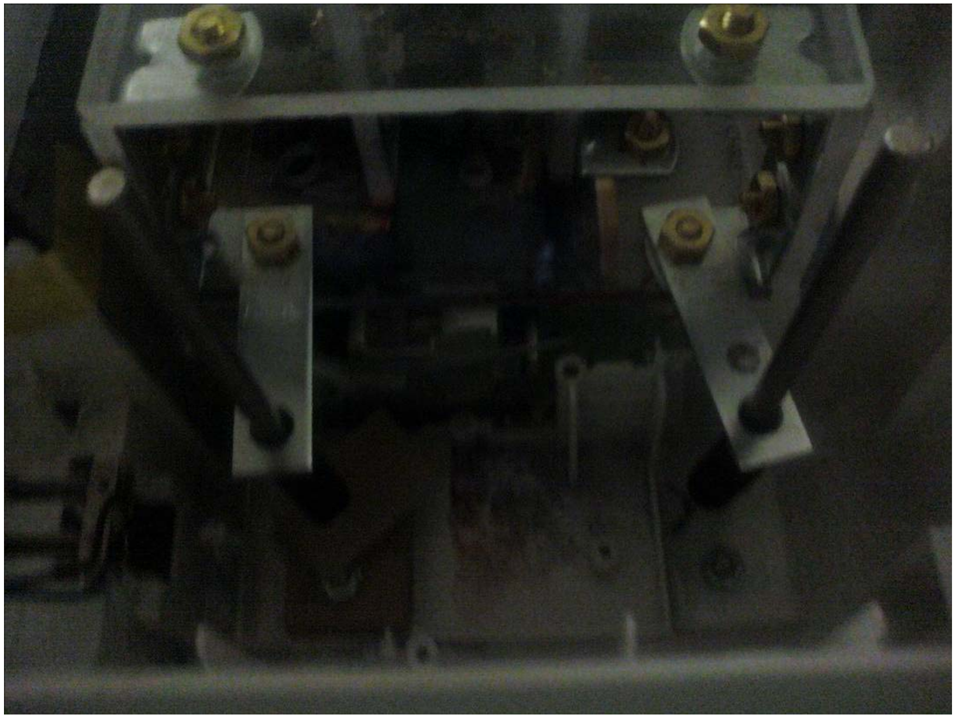


Figure 9. Individual poles with springs guide the actuation enclosure in correct vertical path

Mechanical Design – Emboss

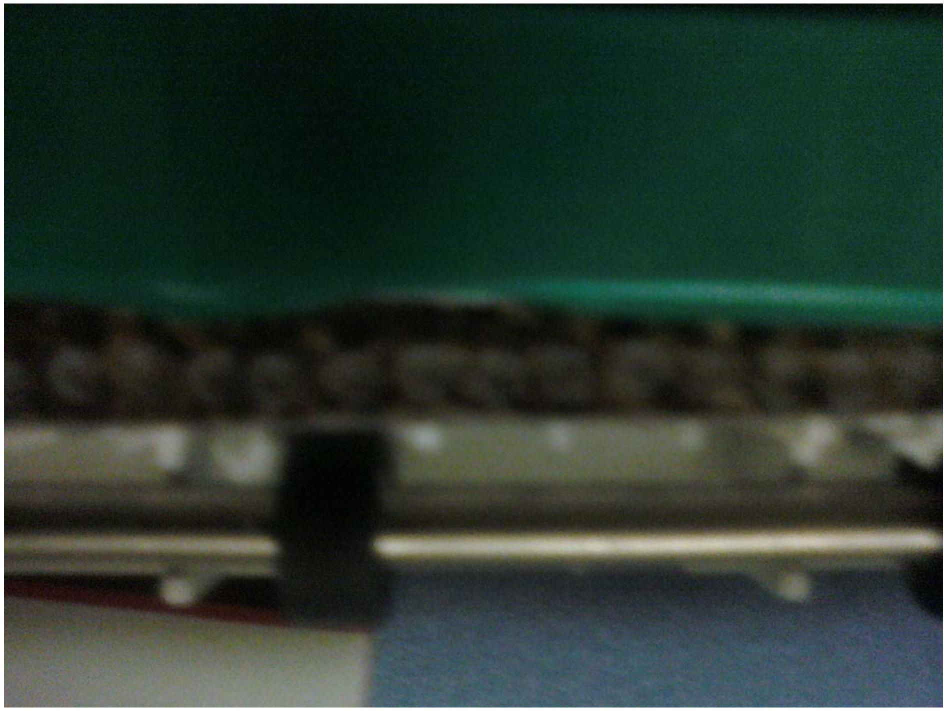
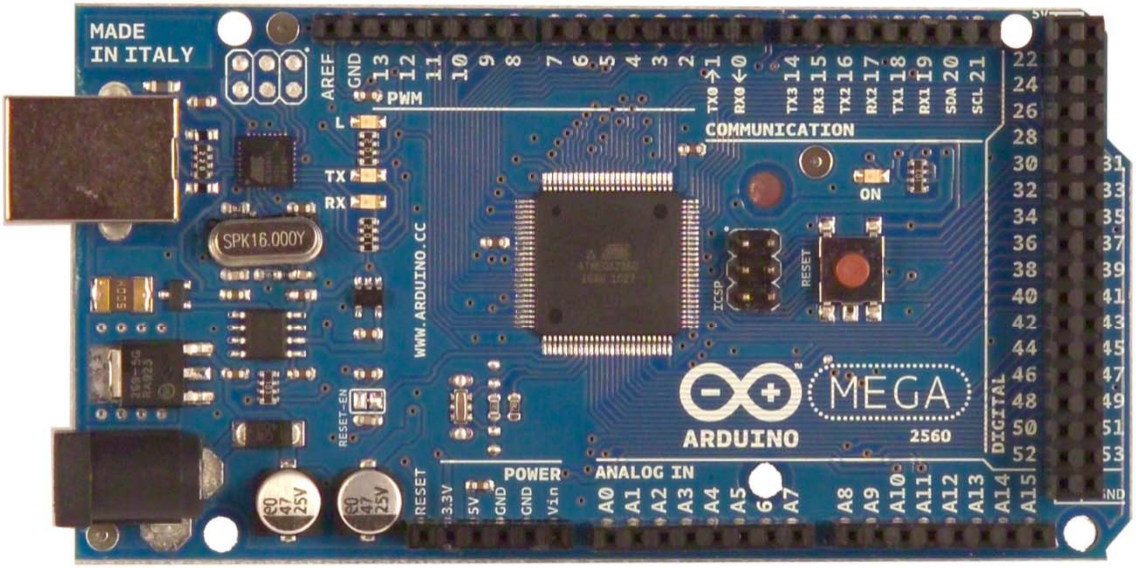


Figure 10. Embossing Surface,
It shows pre-configured
hemispheric holes aligned in
exact measurement

Mechanical Design – Paper Feed / Paper Positioning

- We used parts from an obsolete printer for this mechanism
- Microcontroller controlled motor driver sends electrical signals to drive DC motor for the mechanism(gears network)
  - Counter Clockwise: Feed a paper into roller position
  - Clockwise: moves the paper with precision
- Guide paper on the embossing surface
  - Paper lift
  - Aluminum metal sheet
    - Low friction
    - Flexibility

High Level Design - Microcontroller



Arduino Mega 2560

Microcontroller – Arduino Mega 2560

- Why we choose this particular model
  - Sufficient Number of IO Pins
  - Current Management
  - Includes USB Interface
  - Provides Programming Software

- Functions
  - Receives Data from PC and sends command signals to actuators and motor controller
  - Receives User Inputs and changes the state of process

High Level Design – Motor Controller

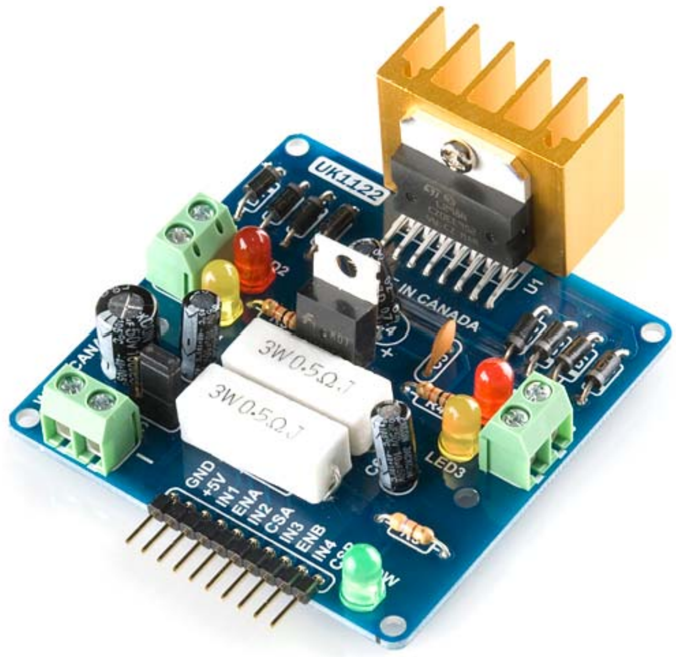
Adafruit Motor Shield – Replaced to meet mechanical requirements

Motor Controller – Adafruit Motor Shield

- Why we need a motor controller(driver)
  - Motors used for the mechanical design requires a lot of torque which must be produced by a motor with a high current supply that cannot be supplied by the microcontroller alone
  - Conversion of microcontroller command signals to Pulse Signals to feed in the motors

- Functions
  - Receives command signals from microcontroller
  - Provides adequate current to run motors

High Level Design – Motor Controller



L298 H-Bridge Dual Bidirectional Motor Driver

Motor Controller – L-298 Motor Driver

- Why we chose this motor controller(driver)
  - The controller allows the user to independently control two motors of up to 2A each bi-directionally
  - Direct control from the microcontroller command signals
  - Heat sink, Schottky EMF protection diodes, voltage regulator
  - Displays Current feed with incorporated 4 direction LEDs

High Level Design - Software

- User Software
  - Programmed in Java using Netbeans IDE
  - Receives user input, translates ASCII text file to Braille output in binary string form
  - Three modules: Graphical User Interface, Communication Establishment, Conversion
  - Sends the data output to microcontroller via serial communication when microcontroller requests using thread notification scheme
- Translation Process

High Level Design - Software

- Microcontroller Programming
  - Programmed in C
  - Receives corresponding Braille data output from client PC
  - Controls press motor, paper positioning motor, pins selection
  - Respond to the user inputs via Interrupt Service Routine embedded

Material Specifications

- Inexpensive electromagnetic linear actuators (40)
- DC Motors –From the obsolete printer
- Prototype contains retrofitted and inexpensive materials
  - Most materials would require custom build
    - Pins: Metal nails -> ball point pen head
    - Structural support: Plexi glass

Power

- Requires no extra power management circuitry
- Powered by a DC 12V adapter (3.3A)
- Voltage regulation circuitry already interfaced
- Fuse mechanism

Mechanical Design Materials- Solenoids

LEDEX STA 1cm X 2cm PUSH + Custom Return Spring

Mechanical Parts – Solenoids

- Why we choose this particular model
  - Miniature(1cm)
  - Able to operate in small current(40mA)
  - Long life time(25 million cycles)
  - Unit Price($1.75)

- Functions
  - Receives a signal from microcontroller and push its plunger above corresponding emboss pin, preventing the pin to move when pressed

Financial Outlook

- Total expected expenditure:
  - $400
- Breakdown of expenditure:

Item	Cost($)
R&D Costs	79.84
Actuators	109.1
Electronics	119.64
Structural Materials	160.51
General Supplies	32.2
Shipping	151.7
Total	652.99

Cost of Device

- Cost of device:

Item	Qty	Cost($)
Microcontroller	1	$64.95
Pins	40	$31.84
Switches	3	$3
Enclosure	1	$20
Motor Driver	1	$19.95
Solenoids	40	$70
Total		$209.74

Project Organization

Timeline

Name	Begin date	End date	Duration
Documentation	9/20/10	12/9/10	58
Project Proposal	9/20/10	9/23/10	3
Functional Specification	9/23/10	10/14/10	15
Design Specification	10/14/10	11/14/10	22
Written Progress Report	11/15/10	11/18/10	3
Group Presentation	11/18/10	12/2/10	10
Post Mortem	12/2/10	12/9/10	5
Hardware Design	9/27/10	10/27/10	22
Braille dot raise system	9/27/10	10/27/10	22
Mechanical design integraton	10/11/10	10/16/10	5
Power Supply Network	10/18/10	10/20/10	2
Software Design	9/21/10	10/26/10	25
Conversion program	9/21/10	10/21/10	22
Data transfer	10/21/10	10/26/10	3
Microcontroller Interface	9/27/10	11/10/10	32
Embedded program	9/27/10	11/10/10	32
CPLD Network	10/11/10	10/16/10	5
User Input	10/18/10	11/2/10	11
Testing & Modifcations	10/27/10	11/20/10	18
Hardware Testing	10/28/10	11/4/10	5
Software Testing	10/27/10	11/4/10	6
Microcontroler Testing	11/10/10	11/20/10	8

Timeline (cont)

- Week #46, 'design specification' delayed by half a week
- Hardware design was extended by approximately 4 weeks due to the delay of mechanical deign.
- Testing Modification started in week #47 instead of week # 43

Teamwork

- Few issues amongst group members
  - Sharing of information
- Patience and openness key qualities
- Friendships established before project began
  - Complementary personalities

What We Learned

- Improved documentation skills
- Hands on experience with software design
- Gained experience with hardware design
- Improved practiced mechanical skills
- Improved soldering skills
- Improved team-work skills
- Engineering product development cycle

Challenges

- Mechanical Precision
- Alignment
- Building Structure
- Selection of right materials

Conclusion

- Very Challenging project
- Tested skills learned in previous courses (software/hardware design)
- Tested brand new skills (mechanical design)
- Excellent opportunity to experience research and design
- Produced a working product

Acknowledgements

- Dr. Andrew Rawicz - SFU Engineering Science
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Questions?