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[DESIGN DOCUMENT: IPOD BARCODE SCANNER]

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Introduction:

1.1 Technical Terms Definition

Terms	Description
ASCII	The American Standard of Code for Information Interchange encodes characters based on the English alphabet.
Barcode	An optical representation of a small piece of data which can be easily read by a machine.
iPod Touch	A small, lightweight, wireless-internet capable mobile device used mainly as a media player, personal digital assistant and game console.
iPod 30-in connector	Generation 4 iPod 30-pin connector. Distinctively large with 30-pins visible.
iPod Lightning connector	Apple corporation's new proprietary connector. Used on Apple's new iOS devices. This smaller connector has 8 pins and is reversible.
OEM Barcode Scan Engine (MDL 1000)	Original equipment manufacturers needing to add laser scanning capability to smartphones or any other portable devices can utilize this laser scan engine.
RS232	A standard used for serial binary data communication.
TRRS	A four contacts connector typically used for analog signals, primarily audio. Two channels are typically used for stereo sound output and an additional one for microphone input. They all share the same common ground.

1.2 Executive Summary

This project's client is Marshalltown Company, a leader in construction tool manufacturing. The goal of this project is to help implement a user friendly and cost effective product for the company's warehouse employees to use. This requires a design that effectively interfaces an inexpensive barcode scanner to an iPod Touch. The obtained barcode data will be fed into the iPod Touch through the TRRS audio jack. Transferring data using either the 30-pin connector or Lightning connector is a more expensive option and thus avoided. This device will have a hardware trigger used for initiating a scan which then transfers the barcode data to the iPod Touch automatically. A software library will also be created for iPod Touch so that it is capable of receiving the data through the TRRS audio jack.

1.3 Project Description

A barcode scanning engine will scan for a barcode when the push trigger is pressed and will send a serial signal to the microphone input of the iPod touch. The iPod touch will sample the signal provided by the barcode scanner as a stream of bits that can be interpreted into barcode values. The barcode scanning engine will be powered through the 30-pin connector or Lightning connector on the iPod touch. The iPod will have a utility that is listening for serial data. The utility will convert the stream of serial bits into meaningful barcode values. Once a barcode has been successfully read the utility pass the barcode information to Marshalltown's parent application.

1.4 Expected Deliverables

The expected deliverable to our client, Marshalltown Company, is a complete and functional design that can easily be implemented and manufactured. For software we will be delivering source code that can be used in conjunction with a current inventory iPod app our client has created. From a hardware standpoint, we will deliver at least one working printed circuit board as well as all of the design documents necessary to produce more in the future.

Design Details:

2.1 Functional Requirements

Upon discussions with our client the following are what we consider functional requirements:

Primary:

- Software designed will act as a utility that must conform to an existing inventory app the client has already made
- The design must use the TRRS audio jack for communication, not the 30 pin or the Lightning connector
- The system must be able to be used for 8 consecutive hours without being charged
- A physical hardware trigger must be used to initiate a scan
- The design must work for both 4th Generation and 5th Generation iPods

The following non-functional requirements were dismissed by the client for the request of an additional primary requirement that involved creating a design that is functional for both 4th Generation and 5th Generation iPods.

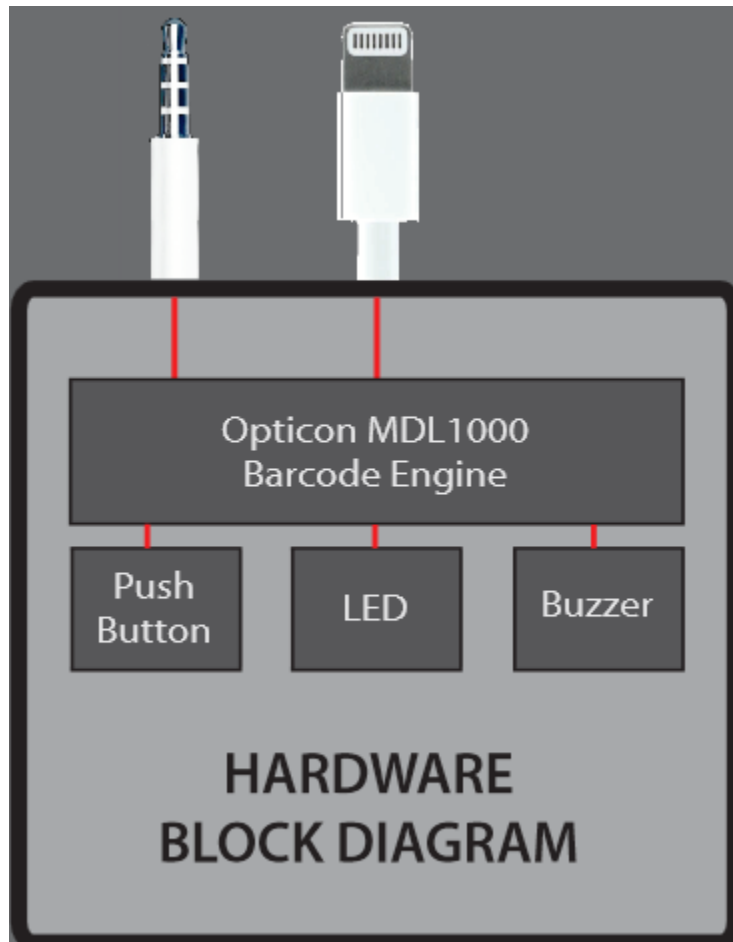
Without the non-functional requirements listed below, our client will still be able to use our design. However Marshalltown initially suggested the following ideas could be explored if possible.

Non-Functional Requirements:

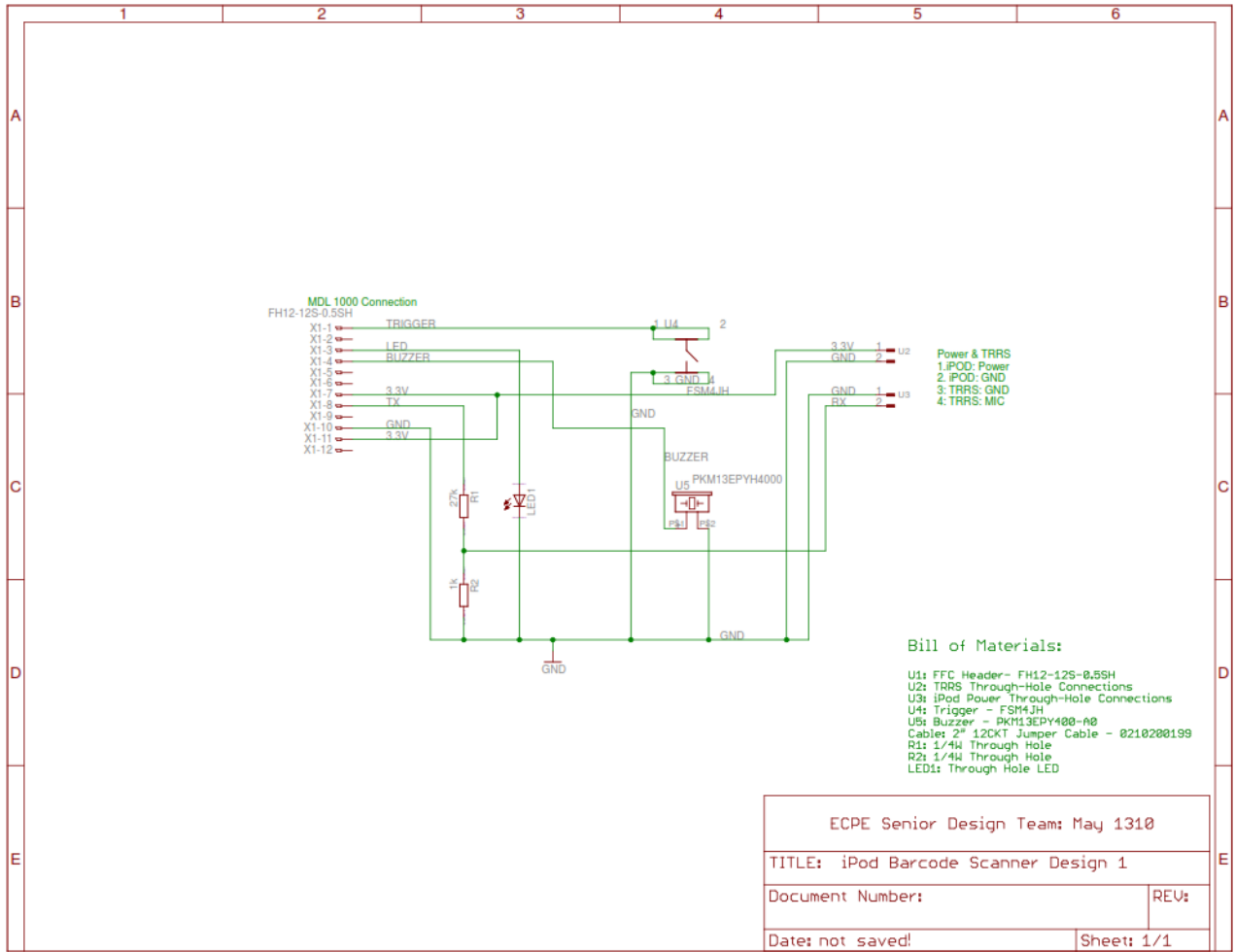
- If an external battery is used, find a way for this battery to charge the iPod when the iPod is not being charged and is running low on power
- The entire system must have a connected source of power (ie the user must be able to charge both the iPod and the power circuitry for the barcode engine together)
- Double level trigger for laser aiming followed by scanning
- Bi-directional communication through the TRRS audio jack to have the iPod trigger work as a trigger

2.2 Hardware Requirements

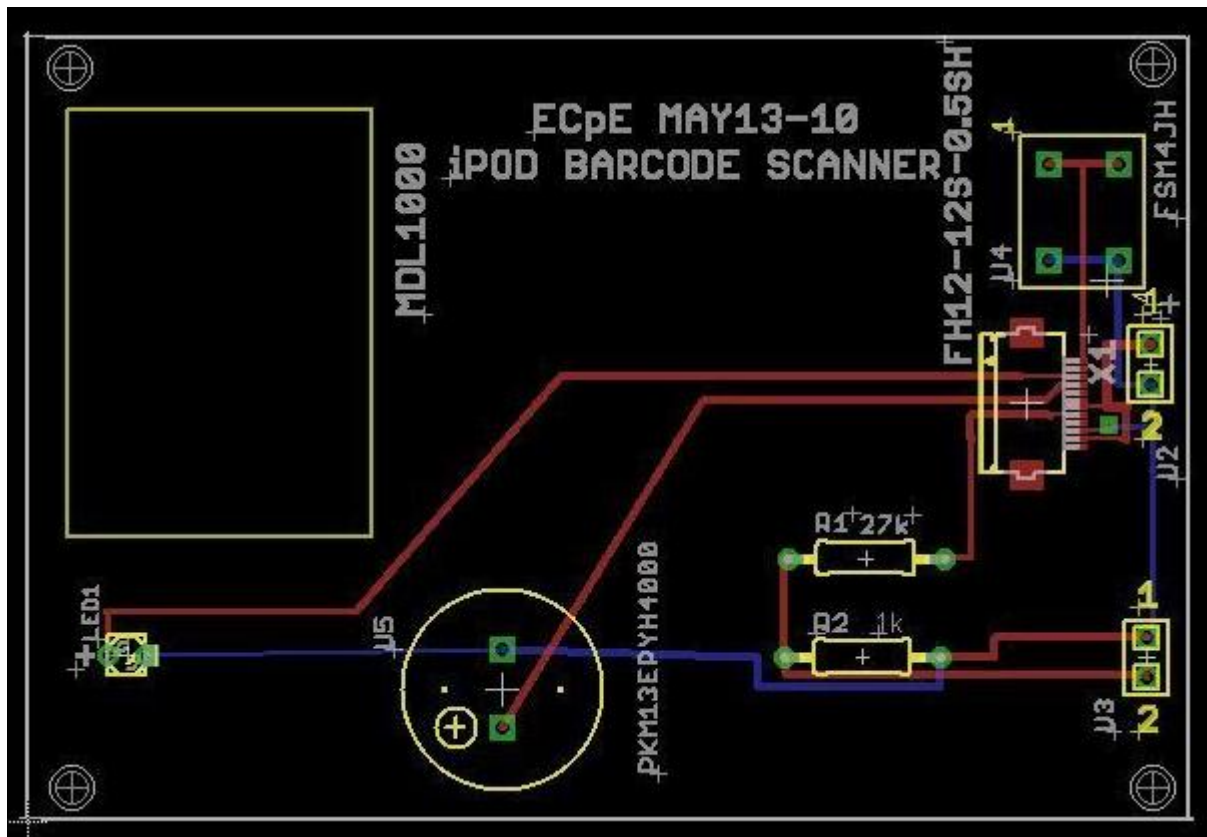
The MDL 1000 laser scan engine will read a barcode after a trigger is pressed. Upon a successful scan, the engine will release RS232 serial data corresponding to the barcode values. The voltage of this serial data will be lowered and then sent to a male TRRS audio jack to be mated with an iPod touch. Power will be taken from the 30-pin connector or Lightning connector on the iPod Touch.



2.3 Schematic Diagram

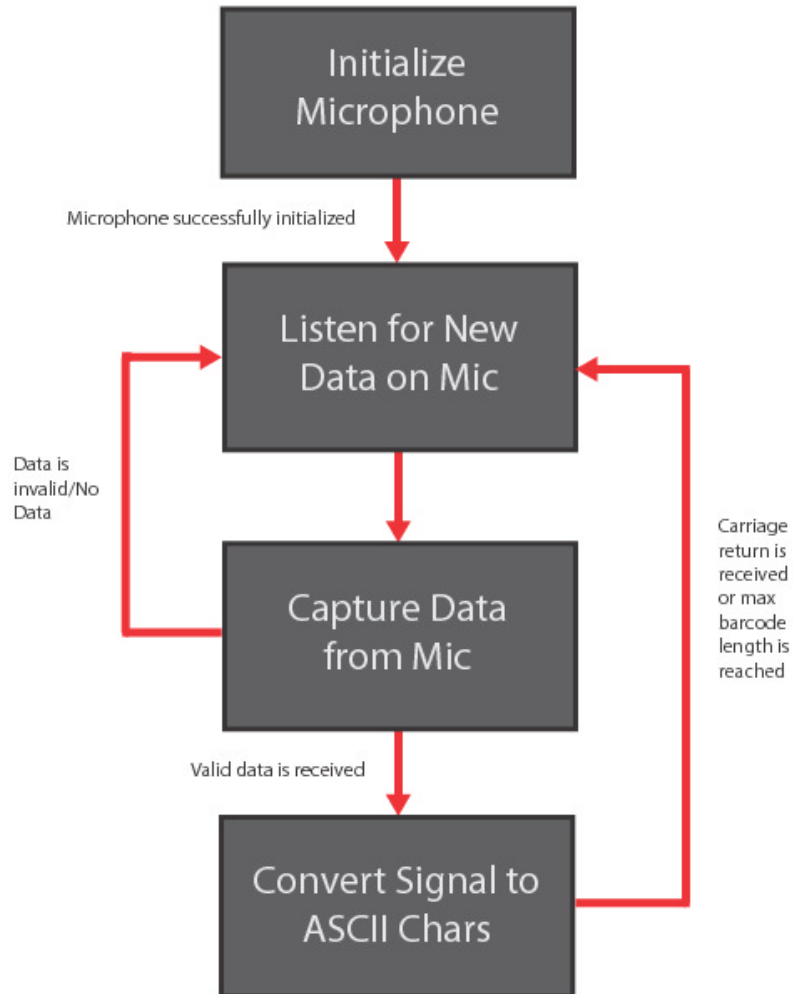


2.4 PCB Layout



2.5 Software Requirement

The iPod touch receives serial signal from the barcode scanner engine through the audio jack. The iPod touch software will decode the audio signal and pass the barcode value to Marshalltown's parent application.



2.6 User Interface

There will be no user interface for this project. The software for the iPod Touch will be a generic library that will support the functionality to receive communications from the barcode scanner. There will be a test application that will be developed for the iPod Touch. However, this will only consist of a single text box used to display the received barcode.

2.7 Design Considerations and Tradeoffs

When designing the barcode scanner we had to make several important decisions that would reduce total cost and development time.

- We have eliminated the requirement of a microcontroller. Thus, saving not only the cost of the microcontroller itself but also power it would have consumed. The barcode scanner still remains fully functional without the microcontroller. Removing the microcontroller maximizes data transfer speed.
- Another consideration that we made was choosing the correct barcode scanner. We needed a scanner that was small enough that an iPod Touch case could be built around it. It also needed to be low in power consumption so that the iPod Touch would have maximum battery life. We decided on the Opticon MDL1000. This scanner fits our requirements and does not have extra functionality that would increase the cost of the device.
- Although Marshalltown company originally wanted a design that implemented the 4th generation iPods. As Apple introduced a new generation of iPod to the market, Marshalltown Company made the decision to create dual compatibility a functional requirement and dismiss the non-functional requirements set out in the beginning of the project.

Project Planning:

3.1 Project Progression

In the first semester of senior design our team was able to make significant progress. By the end of the first semester our team completed proof of concept and had a working demonstration. This was due to several factors. One being that our team was able to eliminate the need for a microcontroller. This simplified the design and shortened the amount of time to create a working design. The second was that Marshalltown Company was able to provide many of the necessary developmental tools needed to create a design like a development Opticon MDL1000 testing circuit, a Cypress microcontroller kit, and an array of breadboard electronics.

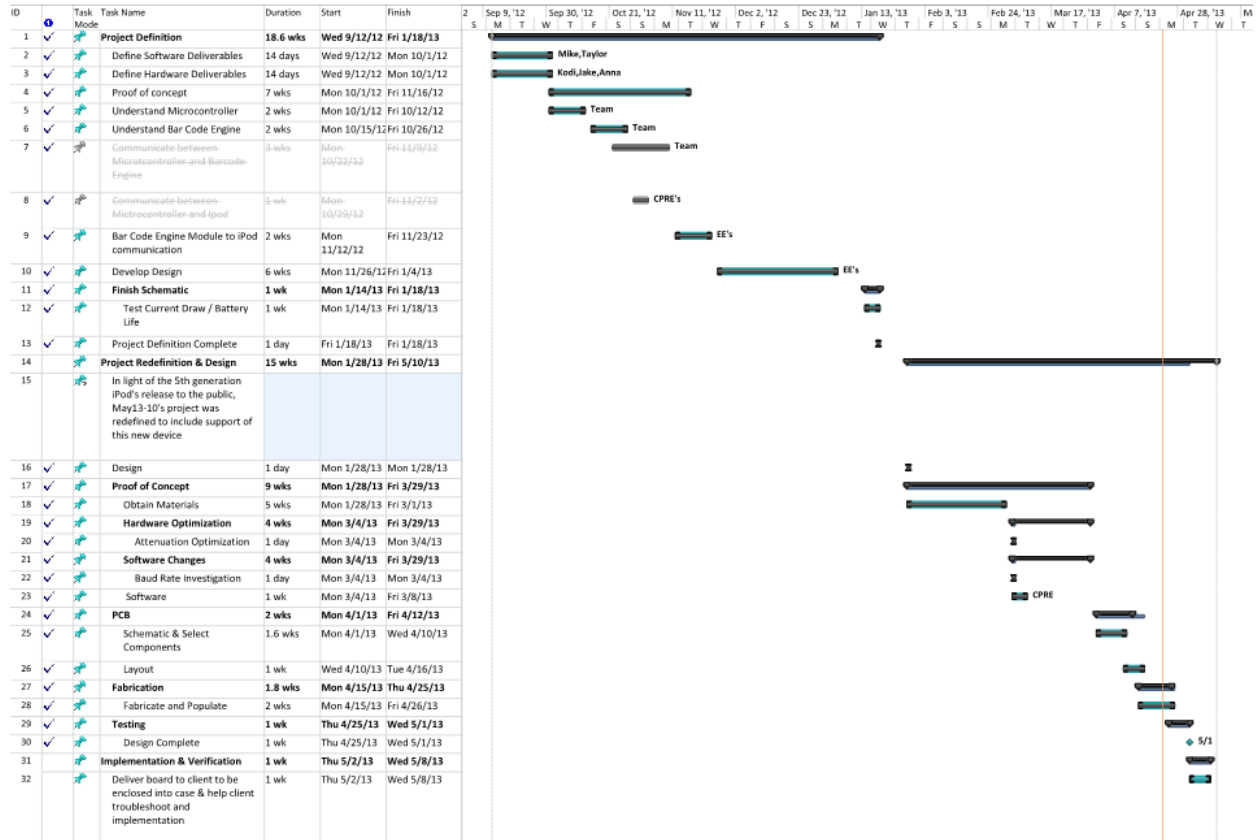
In the second semester our team chose to change the project significantly in the third week. Apple Corporation introduced a new generation of the iPod Touch to the public. Given that Marshalltown would eventually need to invest in over twenty iPods to use this design in their warehouse it became obvious that compatibility among both generations would allow for Marshalltown to invest in the most up-to-date Apple hardware instead of outdated hardware. From the third week of school it took five weeks to procure a new iPod and the necessary Lightning connector. From then it took about three weeks to optimize our design to work with the new iPod. From there it took about two weeks to design a printed circuit board (PCB). Once the boards were manufactured, populated, and verified for functionality all project deliverables were met.

3.2 Tasks

Task Name	Duration	Start	Finish
Project Definition	18.6 wks	Wed 9/12/12	Fri 1/18/13
Define Software Deliverables	14 days	Wed 9/12/12	Mon 10/1/12
Define Hardware Deliverables	14 days	Wed 9/12/12	Mon 10/1/12
Proof of concept	7 wks	Mon 10/1/12	Fri 11/16/12
Understand Microcontroller	2 wks	Mon 10/1/12	Fri 10/12/12
Understand Bar Code Engine	2 wks	Mon 10/15/12	Fri 10/26/12
Communicate between Microcontroller and Barcode Engine	3 wks	Mon 10/22/12	Fri 11/9/12
Communicate between Microcontroller and iPod	1 wk	Mon 10/29/12	Fri 11/2/12
Bar Code Engine Module to iPod communication	2 wks	Mon 11/12/12	Fri 11/23/12
Develop Design	6 wks	Mon 11/26/12	Fri 1/4/13
Finish Schematic	1 wk	Mon 1/14/13	Fri 1/18/13
Test Current Draw / Battery Life	1 wk	Mon 1/14/13	Fri 1/18/13
Project Definition Complete	1 day	Fri 1/18/13	Fri 1/18/13

Project Redefinition & Design	15 wks	Mon 1/28/13	Fri 5/10/13
In light of the generation 5 iPod's release to the market, May13-10's project was redefined to include support of this new device			
Proof of Concept	9 wks	Mon 1/28/13	Fri 3/29/13
Obtain Materials	5 wks	Mon 1/28/13	Fri 3/1/13
Hardware Optimization	4 wks	Mon 3/4/13	Fri 3/29/13
Attenuation Optimization			
Software Changes	4 wks	Mon 3/4/13	Fri 3/29/13
Baud Rate Investigation			
Software	1 wk	Mon 3/4/13	Fri 3/8/13
PCB	2 wks	Mon 4/1/13	Fri 4/12/13
Schematic & Select Components	1.6 wks	Mon 4/1/13	Wed 4/10/13
Layout	1 wk	Wed 4/10/13	Tue 4/16/13
Fabrication	1.8 wks	Mon 4/15/13	Thu 4/25/13
Fabricate and Populate	2 wks	Mon 4/15/13	Fri 4/26/13
Testing	1 wk	Thu 4/25/13	Wed 5/1/13
Design Complete	1 wk	Thu 4/25/13	Wed 5/1/13
Implementation	1 wk	Thu 5/2/13	Wed 5/8/13
Deliver board to client to be enclosed into case & help client troubleshoot implementation	1 wk	Thu 5/2/13	Wed 5/8/13

3.3 Gantt Chart



Project Details:

4.1 Standards

TRRS is a standard for a connector that carries analog signals. It is mainly used in audio devices, such as the iPod Touch. We will be using this standard because that is the connector that the iPod Touch supports. The RS-232 wire that will be connected to the audio and microphone input of the TRRS jack in the iPod Touch. This will allow serial data to be transferred across the TRRS jack so that it can be translated into readable data by the iPod Touch.

RS-232 is a standard for serial communication between devices. The Opticon MDL-1000 will send the data stored in a barcode that is scanned to the iPod Touch using RS-232. The iPod Touch does not have a traditional RS-232 port. Instead we will read the serial data directly from the iPod's microphone input and translate the data into characters that is readable by the iPod Touch. Universal Asynchronous Receiver/Transmitter (UART) is used in conjunction with RS-232 standard. This protocol gives a specific sequence to signify the start and stop of data.

GS1 Standard for Universal Product Code (UPC) - Barcode symbology used for tracking trade items in stores in the most common form, UPC-A, consisting of 12 numerical digits uniquely assigned to each trade item. This standard defines the formatting and encoding of UPC. This standard is used by the Opticon MDL-1000 module to read barcodes and translate them so that they can be sent via serial communication.

IPC/EIA J-STD-001 -Requirements for Soldering Electronics and Electronics Assemblies - This standard provides requirements and specifications for the manufacture of soldered electronics. When manufacturing our preliminary PCB's, this standard will be used to ensure that components that have been soldered are soldered correctly. This will provide insight and guidance as to insure functional quality and understanding when the hardware is assembled.

ASCII – American Standard Code for Information Interchange (ASCII) is a standard in character-encoding set by the American National Standards Institute. This standard is set on the English alphabet and creates a common way of representing text in communication. In this particular project the values communicated from the TX signal of the Opticon MDL1000 are represented in binary values that correspond to the ASCII table.

4.2 Testing and Results

a. Scanner Testing

1. Test scan a variety of barcode types and conditions

Marshalltown sent us 9 sample barcodes that represent the most common types and formats that they use and the scanner scanned all of them without difficulty. The Opticon MDL1000 also has documentation which states that it supports the following barcode types: Barcode (1D): JAN/UPC/EAN incl. add on, Codabar/NW-7, Code 11, Code 39, Code 93, Code 128, GS1-128 (EAN-128), GS1 DataBar (RSS), IATA, Industrial 2of5, Interleaved 2of5, ISBN-ISMN-ISSN, Matrix 2of5, MSI/Plessey, S-Code, Telepen, Tri-Optic, UK/Plessey.

2. Test scanner range to determine a maximum scanning distance (excluding additional exit window material)

To get an accurate measurement of how long the lease will scan, we started at 1cm and kept moving the barcode back one centimeter at a time. The scanner was accurate up to 30 centimeters, but could not detect a barcode past that distance.

b. Battery Testing: Intermittent Scanning

Procedure:

In order to ensure that the iPod will have enough battery for an 8-hour shift, our team will simulate how a worker would use the iPod and scanner during a typical shift. The test will consist of scanning a barcode 10 consecutive times followed by a 5-minute break with the screen turned off. This will be repeated for 4 hours and every 15 minutes the battery percentage will be recorded.

Battery Testing	
Form of testing	Battery Percentage(5% intervals)
Initial Battery	100%
3 Hours of intermittent scanning	100-95%
5 Hours of intermittent scanning with screen left on	40%

Results:

At the end of the first 3 hours we had a final battery percentage of 100%. We are confident that the iPod will last a minimum of 8 hours. Since the scanner drains such little power from the iPod we found that Apple's advertised battery life for the iPod is an accurate representation of the battery life with the scanner attached. Apple advertises that their iPods can have a life of 40 hours of music playback and 8 hours of video playback. Since our scanner uses the microphone input having the scanner attached resembles music playback the closest.

The day after the intermittent testing was completed we used the iPod during a senior design demo that lasted 5 hours. During this time we kept the iPod screen on the entire time and performed approximately 5 scans every 5 minutes. At the end of the 5 hours the battery of the iPod was at 40%. By having this additional testing we can confidently say that the iPod will last a minimum of 8 hours.

4.3 Cost

The cost of the components to our device will be under \$150. Given that the barcode engine module is \$100 for quantities less than 10,000, this leaves the rest of the design to be less than \$50. The current product available to our client is \$500 and the main goal is to create product that is cheaper than this.

Quantity	Part	Price
1	Connector: FH12-12S-0.5SH55	\$2.29
1	Buzzer: PKM13EPYH400	\$0.58
1	12 FFC Ribbon Cable: 210200119	\$2.53
1	SWITCH TACTILE: EVQ-11L07K .02A 15V Switch	\$0.29
1	LED: Standard Through Hole 5mm LED, (LED is optional - design will work without LED)	\$0.30*
2	Resistors: Standard 1k and 27k Through Hole Resistors from the kit provided	\$0.50*
1	Lightning/30-pin connector	Proprietary/\$3*
1	TRRS Audio Jack	\$2.00*
		\$11.99
		*estimated amount

OPERATING MANUAL: IPOD BARCODE SCANNER

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Overview

The iPod barcode scanner is a physical hardware accessory for Apple's iPod touch. Along with its accompanying iOS software library, barcode data can be read directly into the iPod. It provides a robust and reliable laser barcode scan engine that draws power directly from the iPod touch. It requires no external power or batteries to operate.

Features

- A physical hardware trigger to initiate a scan
- A buzzer sounds upon successful scan
- Scans both numbers and capital letters
- A visible laser beam for more accurate positioning
- Data communicated through the microphone input makes it cost effective

Setting Up the iPod Barcode Scanner

Step 1

Incorporate the barcode scanning source code into the current Marshalltown inventory app.

Step 2
















Plug the 3.5mm TRRS male audio connector of the interface into the iPod touch

Step 3

Plug the 30-pin (4th Generation) or Lightning (5th Generation) connector of the interface into the iPod touch

Step 4

Program the Opticon MDL 1000 scan engine using the following table. Be sure to complete the required section. Start by scanning SET. This should set the scan engine into programming mode and a continuous alternating beep should be heard. At this point, scan any amount of barcode settings as necessary. Commit the new configurations to memory by scanning the END barcode. Texts shown in bold in the following table are default configurations.

SET/END	
Required	
9600 baud rate serial	
8 data bits serial	
No parity serial	
1 stop bit serial	
Optional	
2 seconds read time	
Indefinitely	
Buzzer duration 200	
Buzzer duration 400	
Buzzer loudness: Maximum	
Buzzer loudness: Loud	
Buzzer loudness: Normal	
Disable good read LED indicator	
Good read LED indicator duration: 0.2 s	
END/SET	

Using the iPod Barcode Scanner

Step 1

Power on or activate the iPod touch. At this point, the iPod barcode scanner should be powered on. The buzzer will beep twice. There is no physical power trigger on the iPod barcode scanner. The iPod barcode scanner turns on whenever the iPod touch’s screen is activated. The unit will power off when the iPod touch’s screen deactivates. This happens because the iPod touch automatically cuts off the power supply.

Step 2

Launch the barcode scanner software library app on the iPod touch.

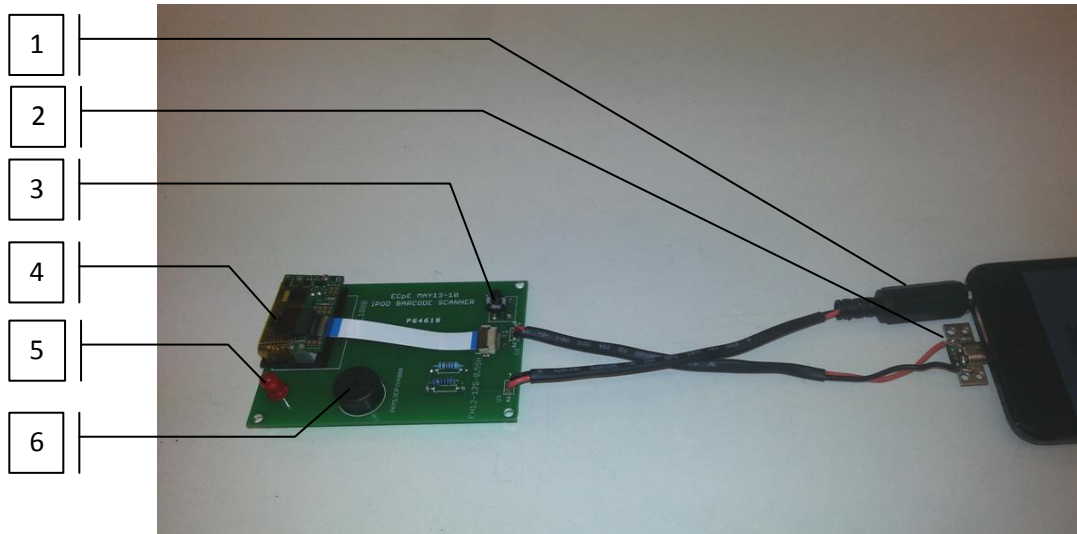
Step 3

Position and point the iPod barcode scanner’s laser towards and barcode label and press the trigger. The buzzer should beep when a scan is successful and the barcode data should show up on the software library app.

Package Contents

Opticon MDL 1000 Barcode Scan Engine
Interface unit that also houses the barcode scan engine
Barcode scanner software library app

Components Description



Item	Description
1. 3.5mm TRRS male audio connector	Data path for barcode scanner to iPod touch
2. 30-pin/Lighting connector	Power supply from iPod touch to barcode scanner
3. Trigger	Initiates a barcode scan
4. Opticon MDL 1000 Barcode Scan Engine	The scan engine where the scan laser source originates
5. LED indicator	Lights up when the scan engine is activated
6. Buzzer	Beeps once when a successful scan is completed. Beeps twice when power is on.

Supporting Hardware

- Apple iPod Touch 4th Gen
- Apple iPod Touch 5th Gen

Specifications

- Printed Circuit Board (PCB) Dimensions: 2" x 3"
- Supported Barcode Characters: All numerical and all upper case letters
- Operating Voltage: 3.3V
- Maximum Scan Distance: 12" (excluding additional exit window material)

Current Consumptions	
Initialization Current Draw	71mA
Trigger Current Draw	123mA
Read Current Draw	61mA
Idle Current Draw	.737mA