

# Digitalized Twister



**Kyle Siler-Evans  
Ryan Shannon  
Ryan Ullman  
Tyler Peters**

**ME307  
Mechatronics  
Colorado State University  
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## **Table of Contents**

Parts List  
Design Summary  
Design Details  
Console Design  
Encoder Flow Chart  
Game Board Design  
Design Evaluation  
Output Display  
Audio Output Device  
Manual Data Input  
Automatic Sensor Input  
Actuator  
Logic, Counting, and Control

## **Table of Figures**

Figure 1	Finished Project
Figure 2	Twister Functional Diagram
Figure 3	Rough Face-Plate Layout
Figure 4	Detailed Face-Plate Layout
Figure 5	CNC Machine
Figure 6	Graphical Display of Machine Code
Figure 7	Face-Plate with Electrical Components
Figure 8	Encoder Disk with Photo Interrupters
Figure 9	Box Dimensions
Figure 10	Solid Model of Box
Figure 11	Paper Model of Box
Figure 12	Finished Console Base
Figure 13	Console Assembly Model
Figure 14	Dimensions of Assembly
Figure 15	LED Display and Mount
Figure 16	Final Circuit Board
Figure 17	Encoder Pic Flow Chart
Figure 18	Console Face from Behind
Figure 19	Game Pad Sensors
Figure 20	Number / Color Scheme Layout
Figure 21	Back side of the Twister Board

## Parts List

<b>Component</b>	<b>Allied Electronics Pt #</b>
PIC16F877A	N/A
PIC16F84A	N/A
LCD	670-1116
Keypad	948-7874
Small Protoboard	977-1256
Large Protoboard	661-1550
10 MHz Oscillator	895-0685
4 Mhz Crystal	895-0677
Red Led	670-1245
Green Led	670-1244
Yellow Led	670-1247
Blue Led	670-1071
100 ft Black Wire	708-9891
Speaker	623-2048
2N3904	568-8253
TIP31C	263-0386
5V Voltage Regulator	263-0135
Breadboard	761-0160
1k Ohm resistors	296-6314
330 ohm resistors	296-6310
Twister Board	N/A
Copper sheet	N/A
25 Pin D-sub cable	N/A
.1 micro farad Caps	507-0352
12V wall transformer	928-9725
Backing for game board	N/A
Paint	N/A
Fasteners	N/A
Aluminum	N/A
Sheet Metal	N/A
DC Motor	793-0462
Diode	263-1538
Photo Interrupter	263-1361
22 picofarad caps	507-0372

## Design Summary

This design will be a take off on the classic Twister game. The game will be automated, and user-interactive. Players will start by entering the number of players using the keypad. The system will not start until the correct number of players is detected in the starting position. Once players get settled, the system will automatically start spinning the wheel. The players' positions will be determined with a position selection arrow, which is rotated by a DC motor. The final position of the arrow will be known through the use of photo-interrupters. On the game board, electric pressure sensors will detect where each player's hand or foot is positioned and will highlight that position on a grid of LED's. After each position selection, the players will have sufficient time to get into the newly assigned positions before the sensors are pooled and logic is performed. If the players' positions do not correspond to the positions determined by the position selection arrow, a buzzer will sound to signal the end of a round (Figure 1).



Figure 1

## Design Details

From the beginning, our design goals focused on converting the classic game of Twister into a fully automated game. Player positions are randomly selected using a DC motor, whose position is tracked with a photo-interrupter circuit; copper switches on the game board track the position of all players and ensure that lazy players don't drift from the assigned position; a sound chip issues auditory commands for the next move; and a LCD visually displays commands, provides user interface, and menu selection; a numeric keypad allows the user to enter the number of players and maneuver through the sound menu.

In order to track the positions of players on any of the twenty four possible positions (Figure 20), we used custom made normally open switches under each board position. We used a 25 pin serial connector (Figure 16) to electrically connect the game board with the electronics box. We chose a microchip PIC16F877A to be the "Board PIC" because of the large number of input/output pins, which are used to track the status of each of the switches. A 4 x 6 grid of LED's (corresponding to the 4 x 6 game board) are connected to the board switches to provide a visual display of where players are positioned (Figure 7).

A DC motor was used to spin the 'position selection arrow' and two photo-interrupters (Figure 8) were used to track its position. Two CD's were machined using a CNC mill and used as the photo-interrupter disks (Figure 8). A microchip PIC 16F84A was used to perform the necessary logic to correlate the signals received from the photo-interrupter circuit with game position (e.g. left hand blue). The PIC 16F84A is referred to as the "Encoder PIC".

The "Main PIC" is also a 16F877A PIC and is used as the central hub of our design. A LCD, sound chip, speaker, and numeric keypad are all controlled by the Main PIC. The Main PIC also communicates with the Board PIC and the Encoder PIC using the serial in and serial out commands.

Because we had a large number of input/output pins available to us on the Main PIC, we chose to directly connect the numeric keypad. Using three wires corresponding to the three columns and four wires corresponding to the four rows, the Main PIC is able to detect which buttons are pushed down.

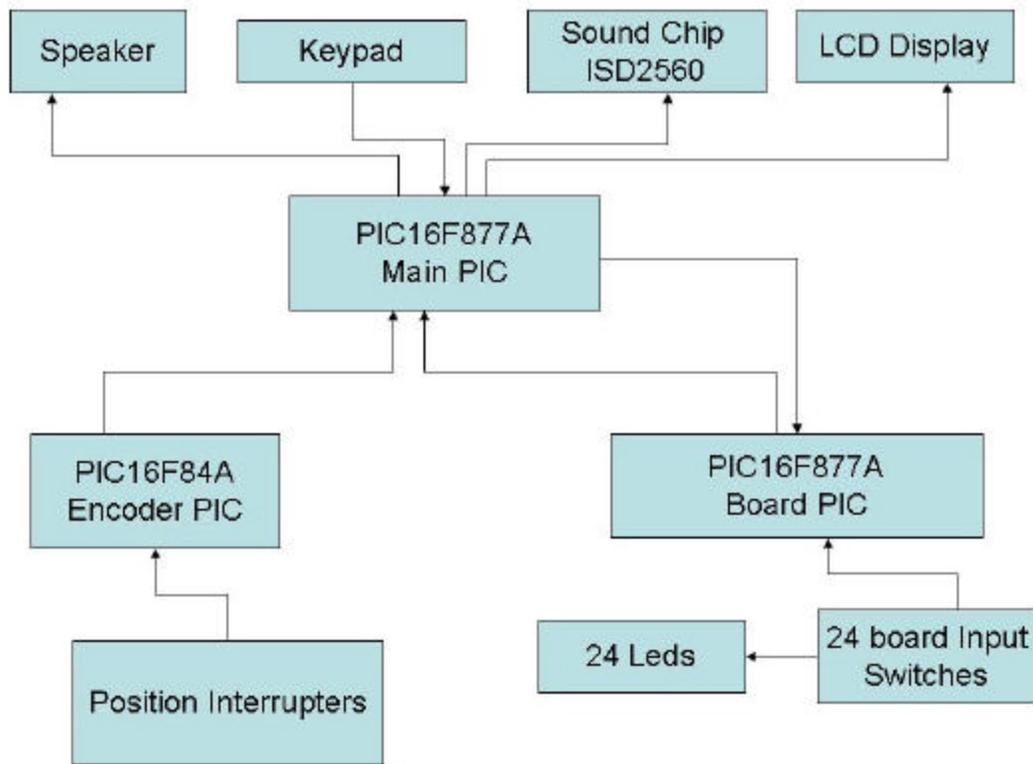
Through out the game, a sound chip issues verbal commands, instructing the players what to do next. The ISD2560 sound chip has a capacity of up to 60 seconds of digitally recorded sound. Sound selection is accomplished by sending a series of pulses to the sound chip, which 'fast forwards' to the correct sound.

A 4 x 20 LCD is also controlled by the Main PIC and displays information and instructions to the players. For additional aesthetic appeal, we programmed an opening screen which scrolls four lines of the text "Twister Extreme".

The basic function of Digitalized Twister is best demonstrated by the following example:

If the position selection arrow is spun by the DC motor and falls on 'left hand blue', the Encoder PIC will serial out a value of "My\_count" equal to 15 to the Main PIC. The Main PIC will send a series of pulses to the sound chip, which will vocally instruct the players to put their left hand on blue. The Main PIC will serial out a number to the Board PIC which implies the number of switches that should be pressed in each column (the number will depend on the number of players, which was selected at the beginning of the game using the numeric keypad, and the position selection from the Encoder PIC) . After a pause allowing the players to move to the correct position, the Board PIC will check if the number of switches pressed down is consistent with what was determined by the Main PIC. If the number is not consistent, the Board PIC will send an interrupt signal to the Main PIC, which will sound a buzzer and restart the program. If the players remain in the correct positions, the Main PIC will not receive an interrupt signal and after a given amount of time will send a signal to the Encoder PIC to start the motor.

As shown in the functional diagram (Figure 2), three PICs were used to serve specific purposes in Digitalized Twister. The main PIC was used to control the main user communications consisting of the liquid crystal display, sound chip, keypad, and the speaker. The main PIC was also responsible for the bulk of the calculations needed to determine if each player was in the correct position. The main PIC communicates with the encoder PIC and the board PIC serially to complete game functionality. The board PIC's sole purpose was to accept the serial values of how many switches should be pressed in each color column and constantly checks to make sure the correct number are down. If the correct number of switches were not pressed when they should be the board PIC then signals the main PIC to interrupt the program. This is because the system assumes some player has faulted. The encoder PIC is in charge of the spinner. When signaled from the main PIC, the encoder PIC spins the motor while the position is then read from the position interrupters to determine where the needle is. When the needle has stopped, the PIC then serials out where the needle has stopped to the main PIC. The main PIC then calculates the number of switches the board PIC needs to look for.



Twister Functional Diagram

Figure 2

## Console Design

The first step in the design of the console was making rough sketches of component layout and spacing to see what arrangement would look best. After this, measurements of all of the electronics were made (such as LCD, LED's, Keypad, and motor) and laid out to make sure the spacing was indeed correct (Figure 3). Once the necessary corrections were made, a size for the face plate was determined (Figure 4). Research on materials and different milling techniques was done, and we found that an aluminum face plate with a sheet metal box would be easy, cost effective, and aesthetic. It was also found that since there were precise cuts and many holes to be drilled, milling on the CNC (Figure 5) would save time. Once this was realized the face-plate was drawn in Pro-Engineer and converted to a drawing file. TekSoft CAD\_CAM: ProCam 2003 Plus 2D was then used to convert the drawing into machine code for the CNC (Figure 6).

The face plate was cut using the CNC and the electronics were put in place to assure proper fit (Figure 7). The face plate was then taped off and painted. After the face plate was finished the encoder disks were milled (Figure 8). The disks were made of CD material. The milling also utilized the help of the CNC in order to provide accurate

spacing. The encoder disks were painted in order to enhance appearance, as well as to make sure no light was able to travel from one side of the disk to the other.

The final step in the manufacturing process was to make a box to hold the face plate as well as the actual components (Figure 9, 10). Care had to be taken to be sure the motor and the encoder disks would have enough room to fit in the box. We also had to be sure the rest of the components would fit into the console without interfering with each others fit or function. Because this was a first time working with sheet metal a paper diagram was constructed to give an actual space for the components to be tested to assure fit (Figure 11). Once we were sure the components would fit, the outline was traced and the box was cut and bent into shape. Once the shape was formed pop-rivets were used to secure the box's sides and holes were drilled in the top and back to fit the motor, sound cord, power cord, and the connection for the board. After everything was drilled and fitted the box was painted to match the twister theme and the components were finally placed and secured in the console (Figure 12).

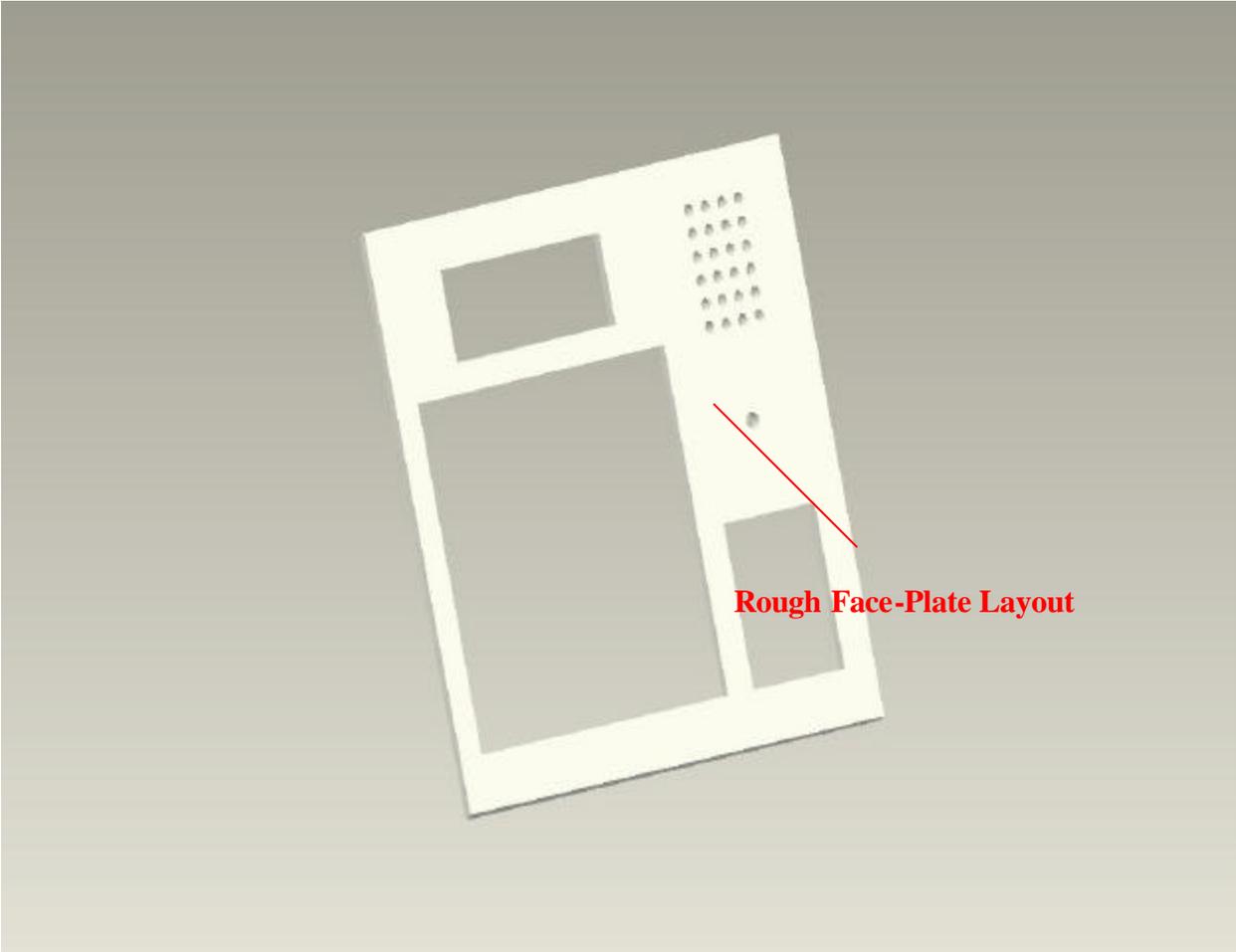
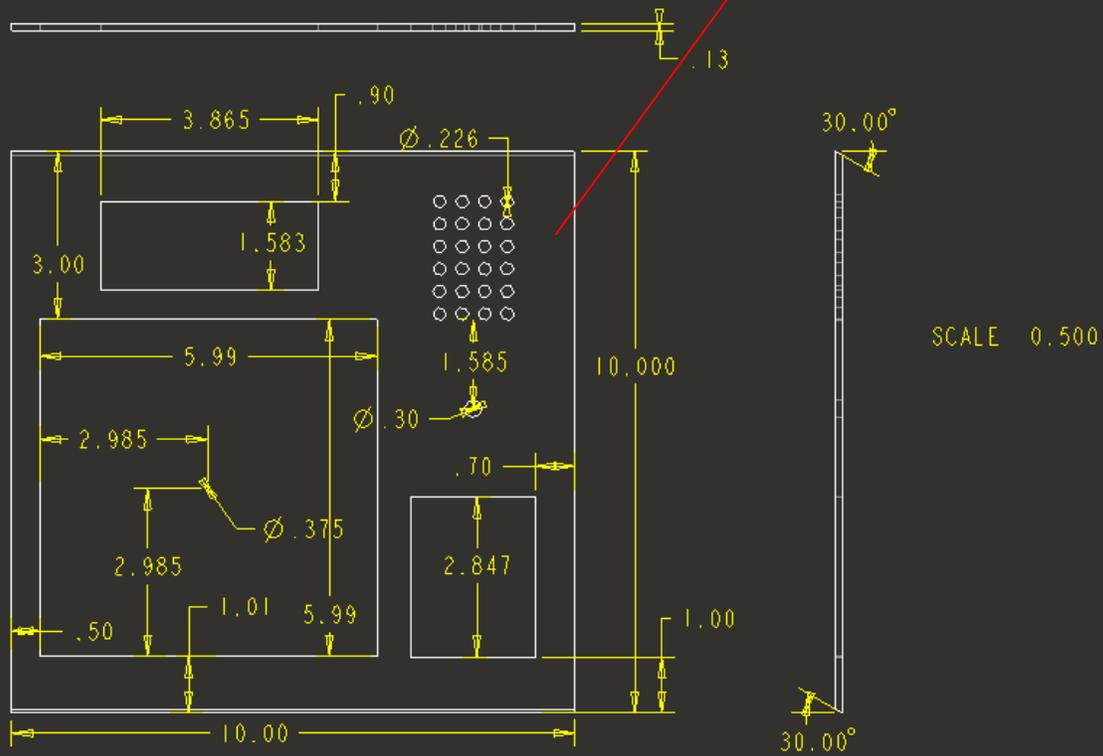


Figure 3

Detailed Face-Plate  
Layout to be converted  
into Machine Code



SCALE: 0.200 TYPE: PART NAME: CONSOLE FACE SIZE: A

Figure 4



**CNC Mill Machine  
Used To Mill  
Faceplate and  
Encoder discs**

Figure 5

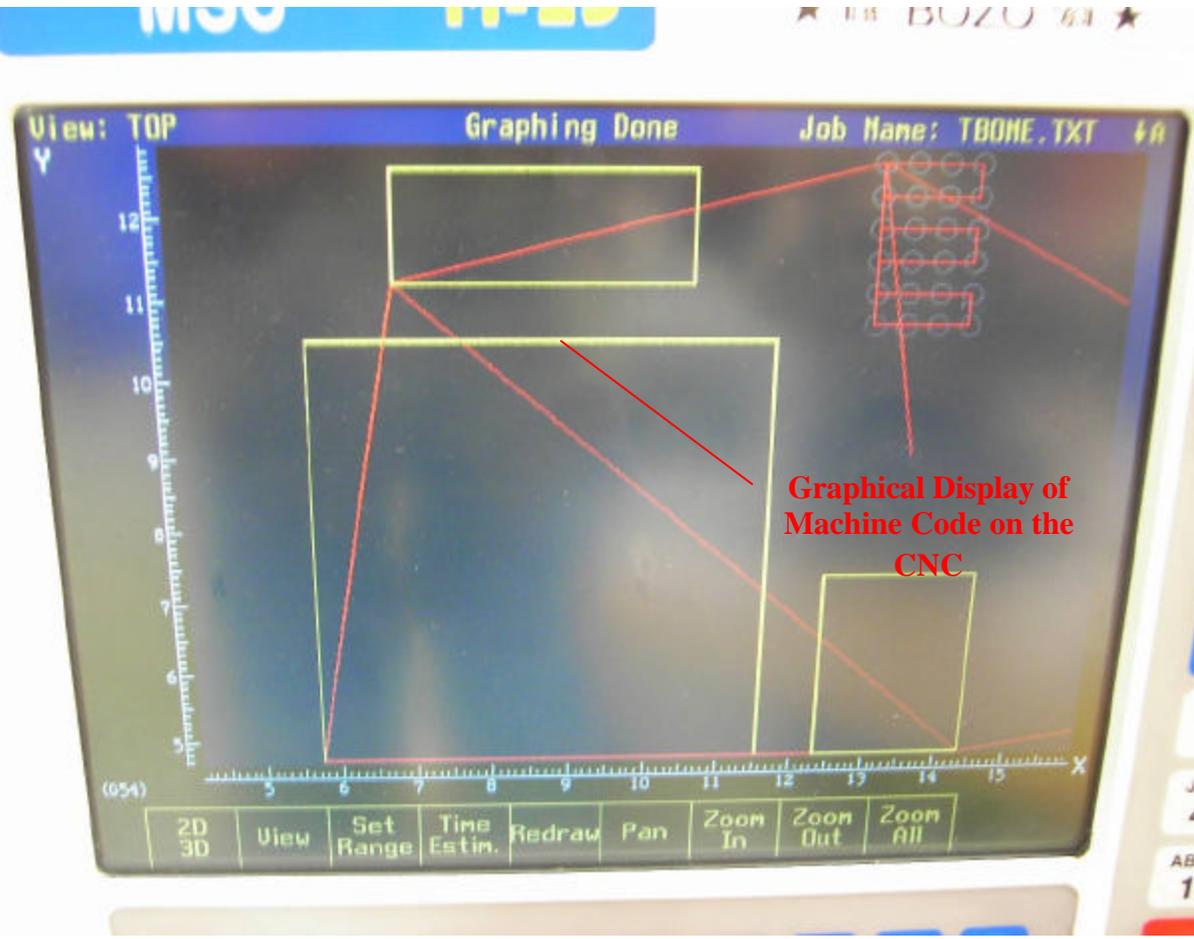


Figure 6

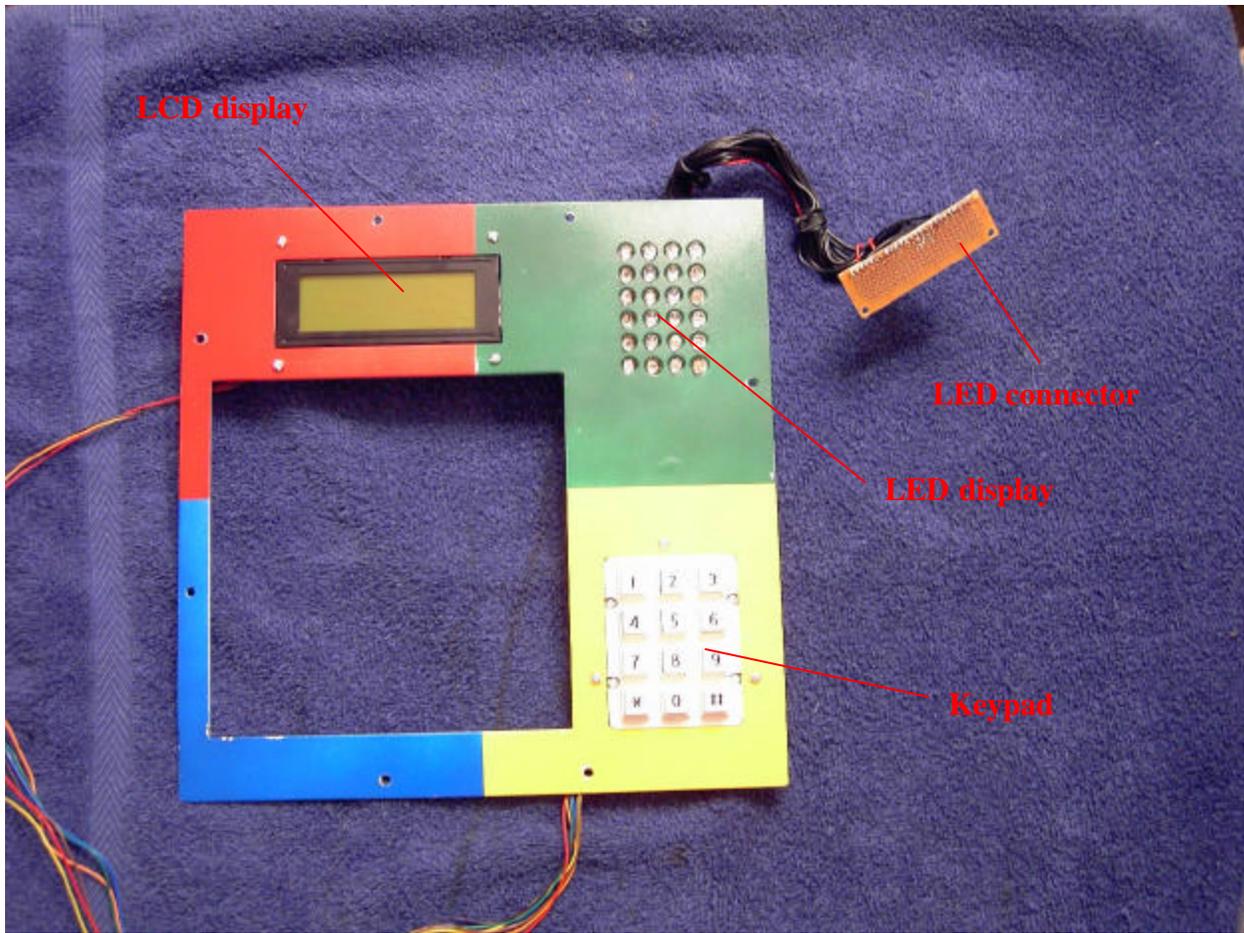


Figure 7

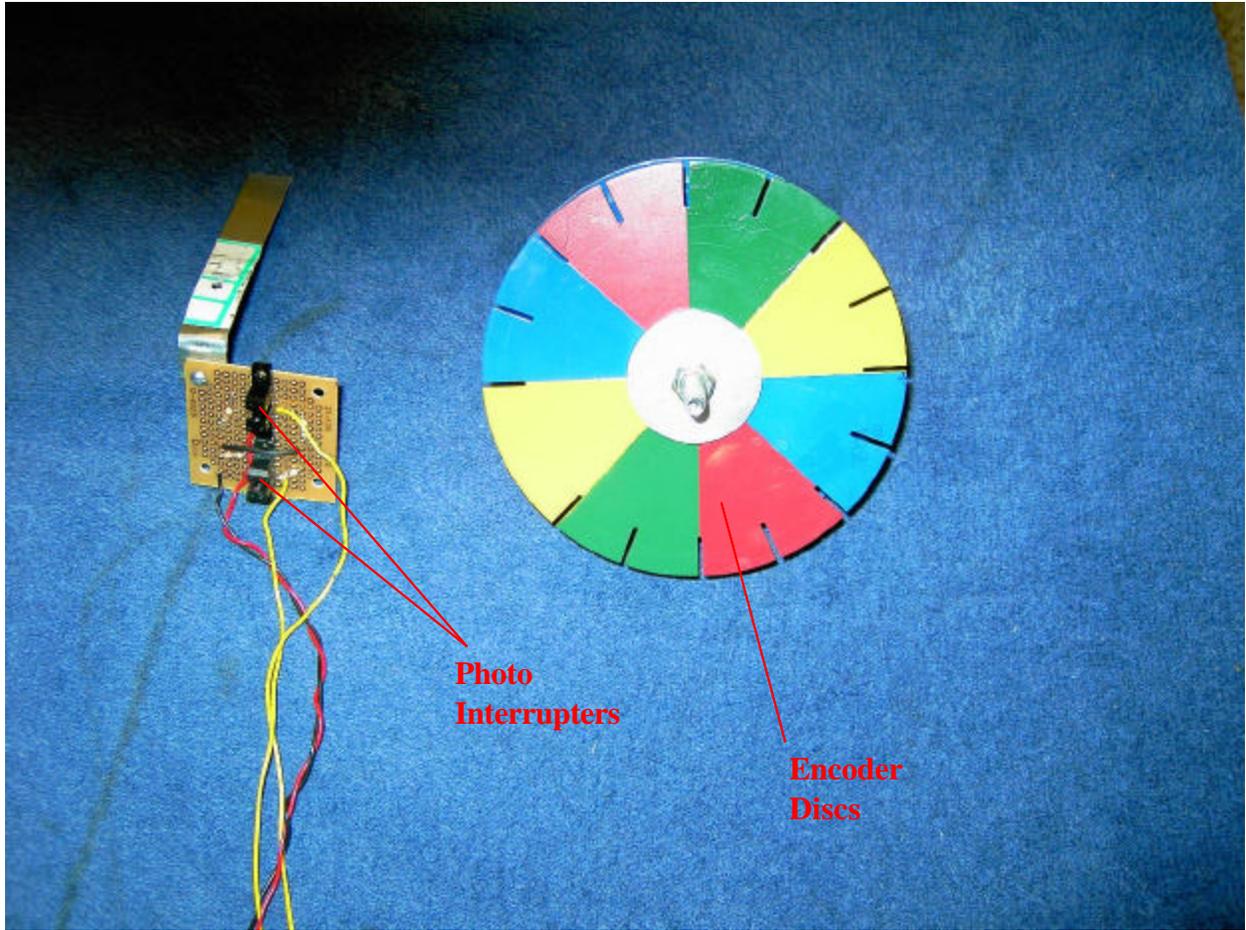
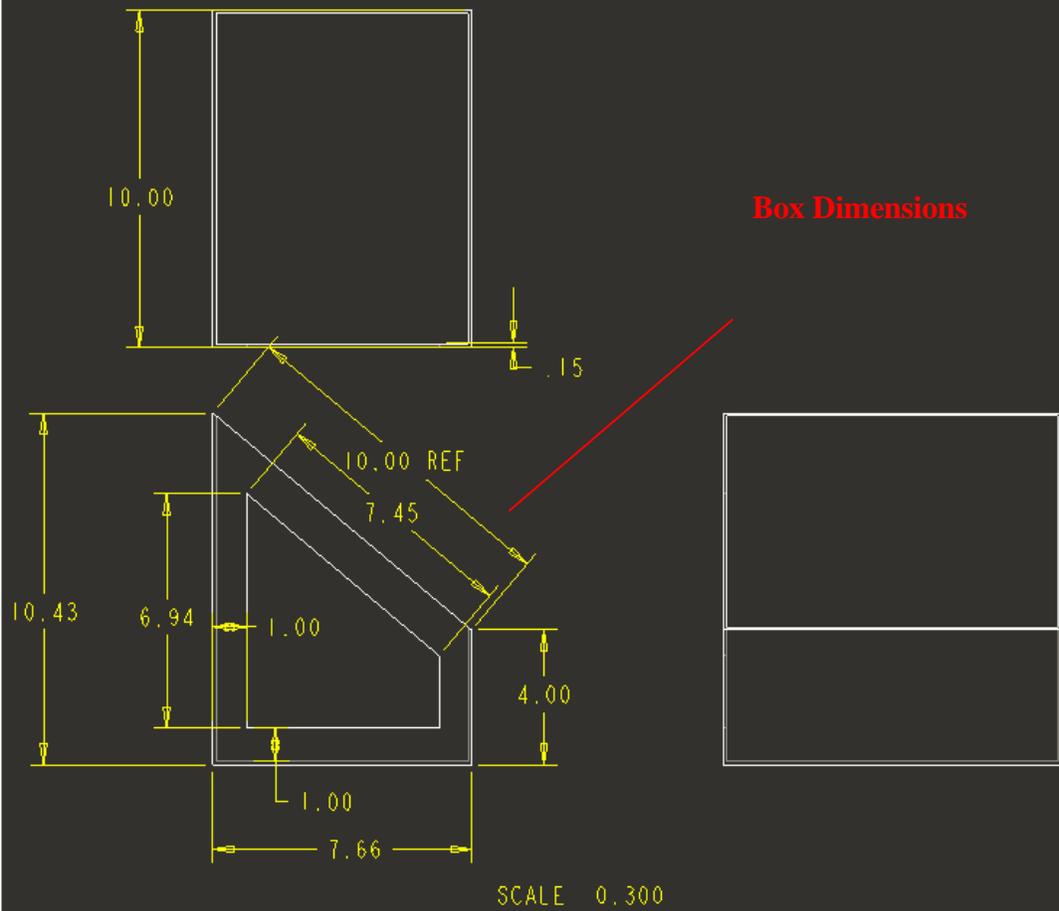


Figure 8



**Box Dimensions**

SCALE: 0.143 TYPE: PART NAME: BOX SIZE: A

**Figure 9**

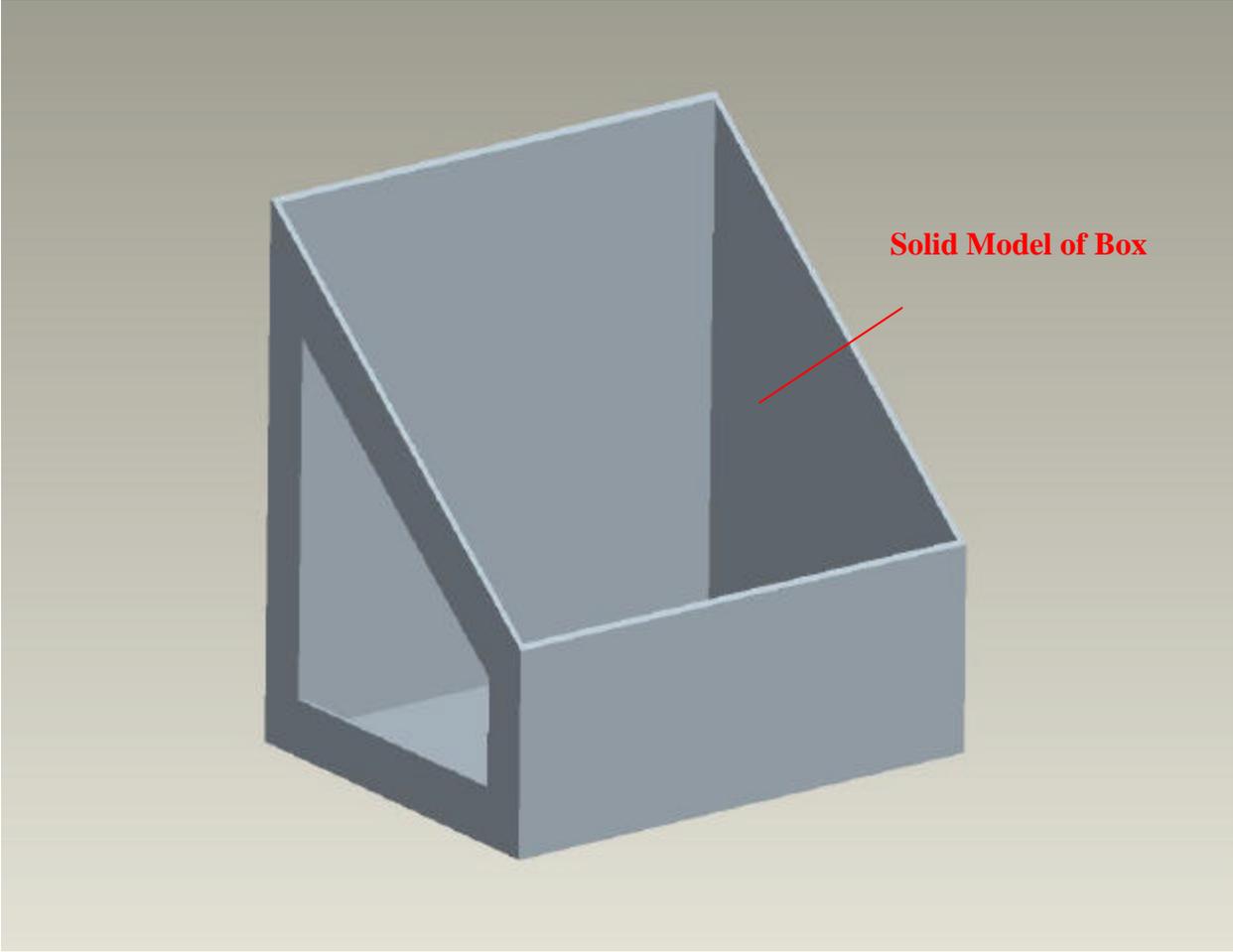


Figure 10

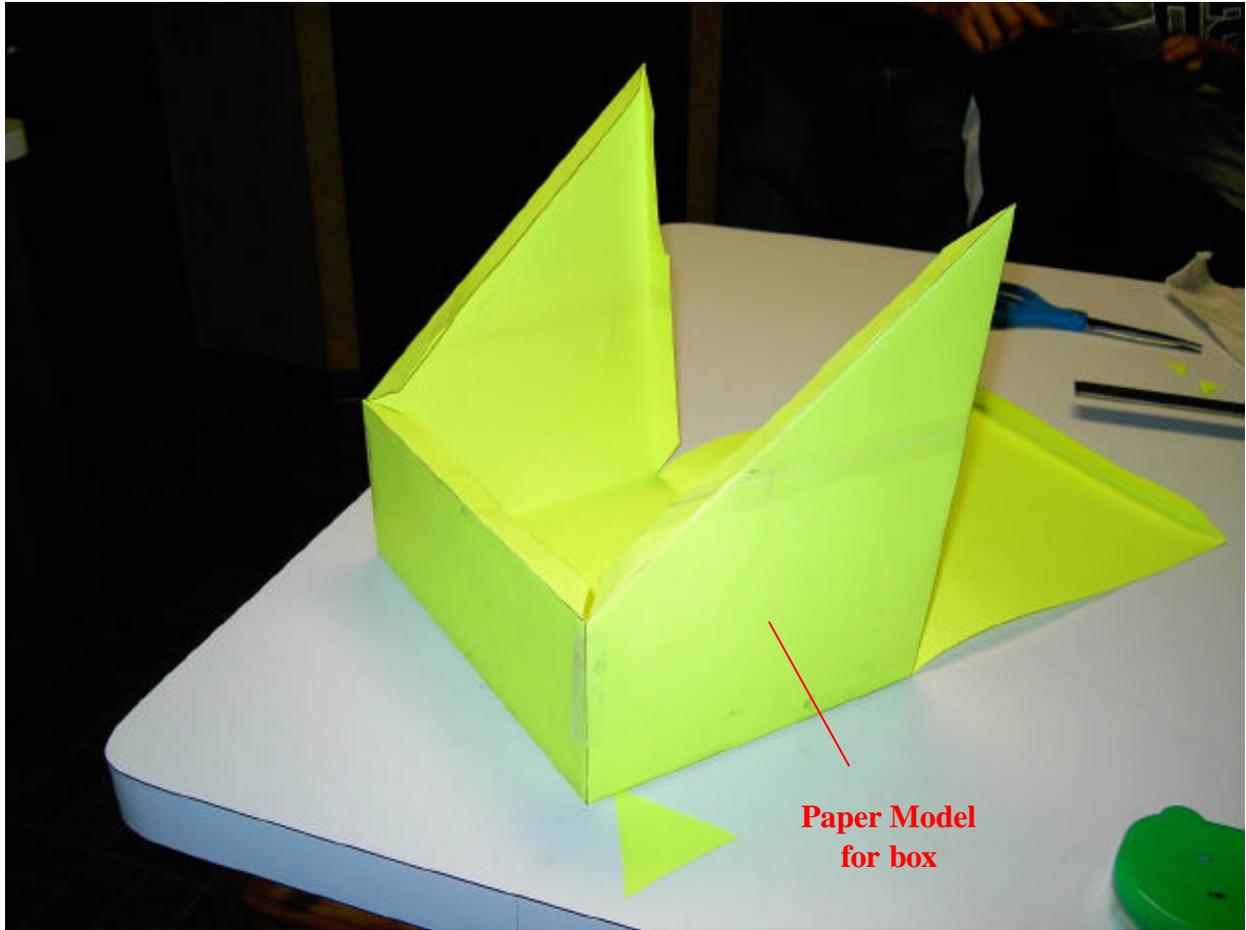


Figure 11

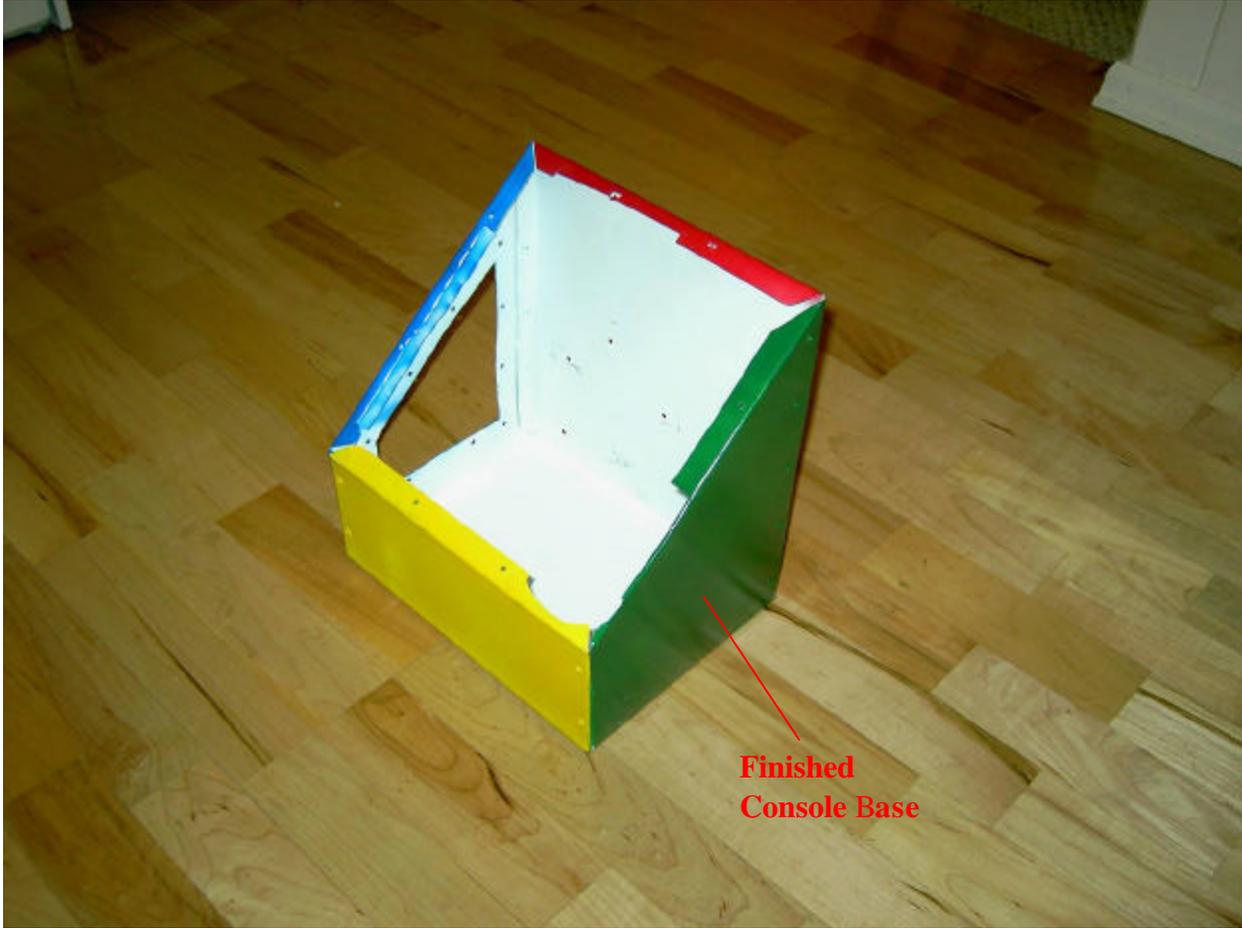


Figure 12

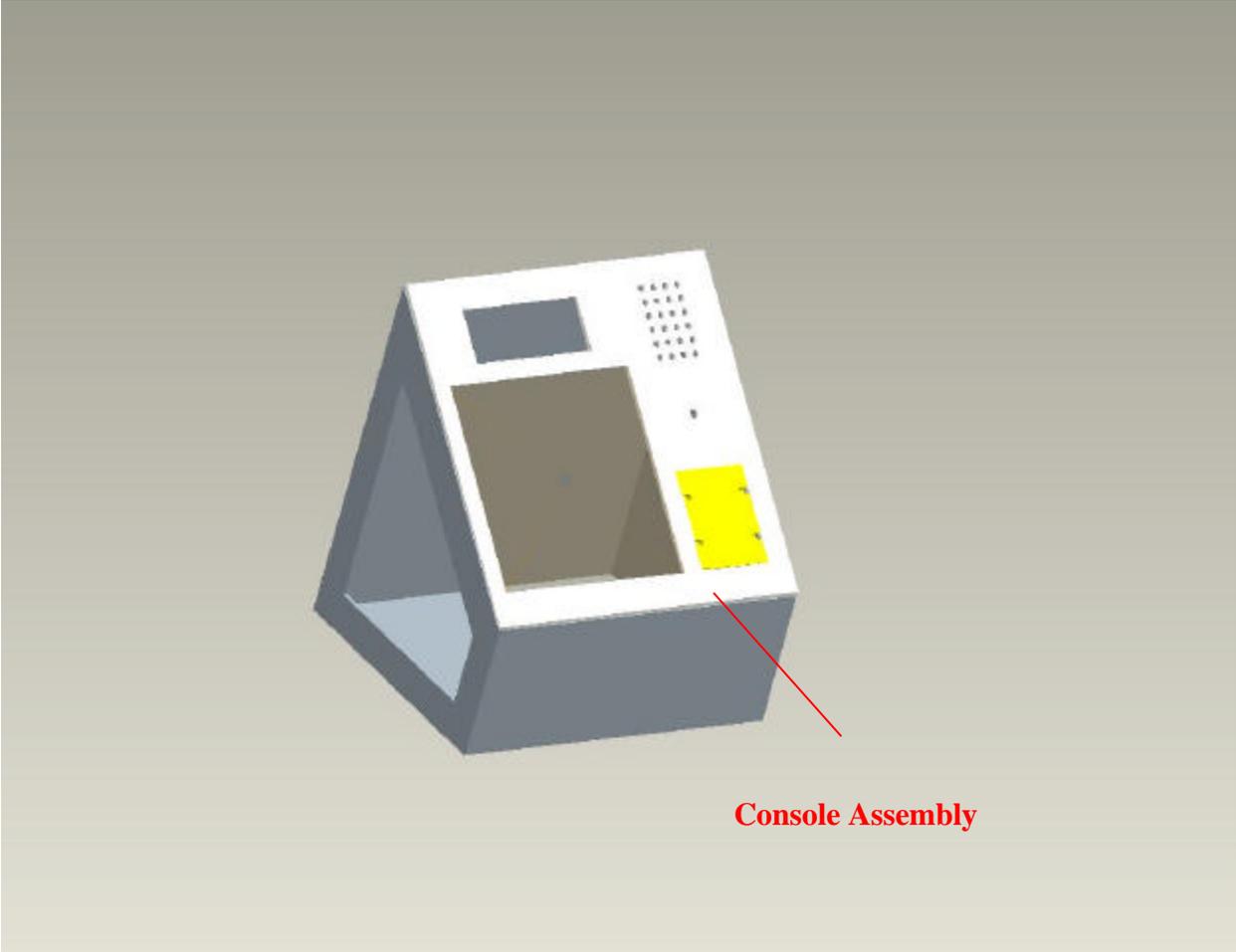
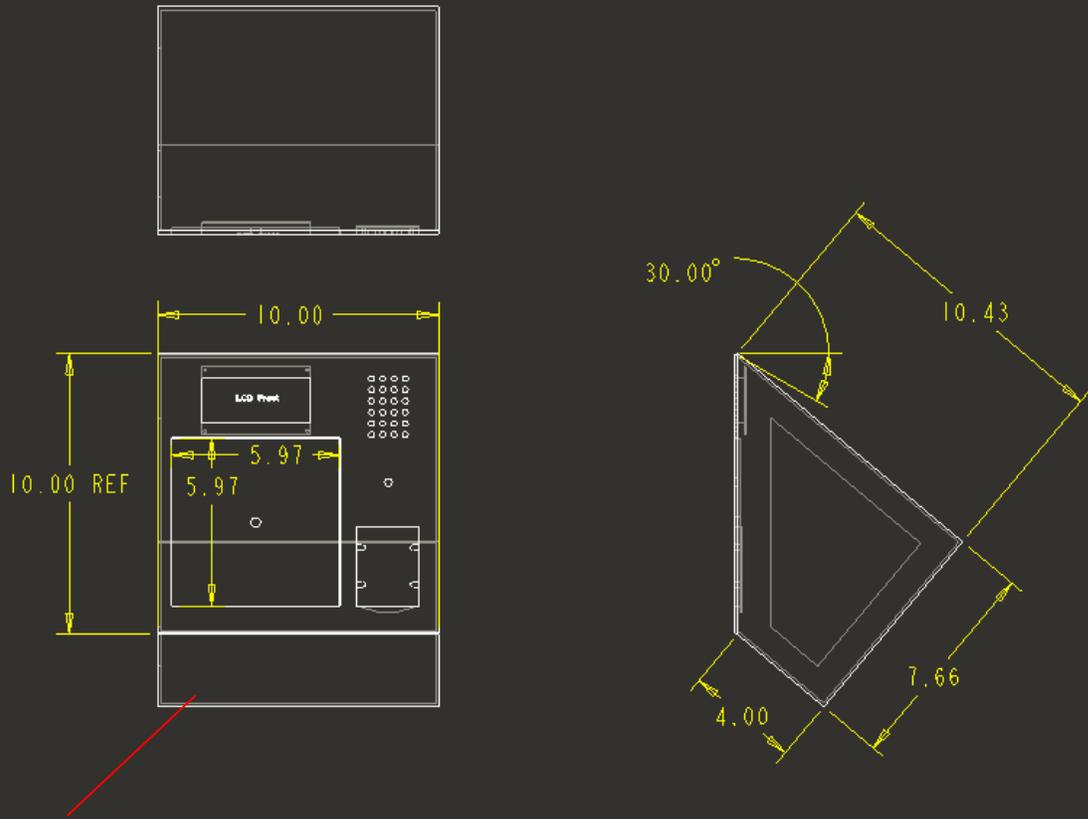


Figure 13



**Dimensions of Assembly**

SCALE 0.250

SCALE: 0.111 TYPE: ASSEM NAME: ASM0001 SIZE: A

**Figure 14**

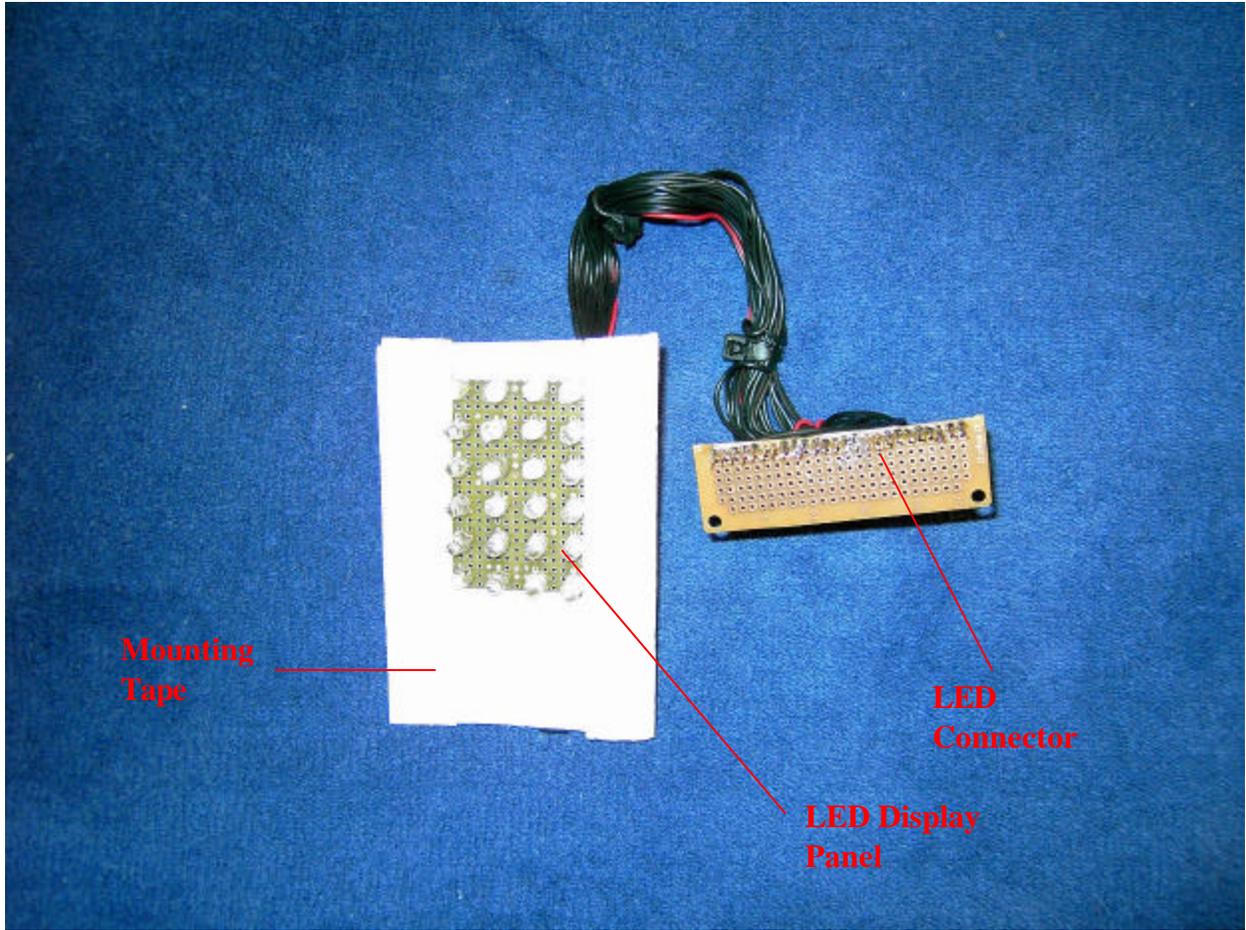


Figure 15

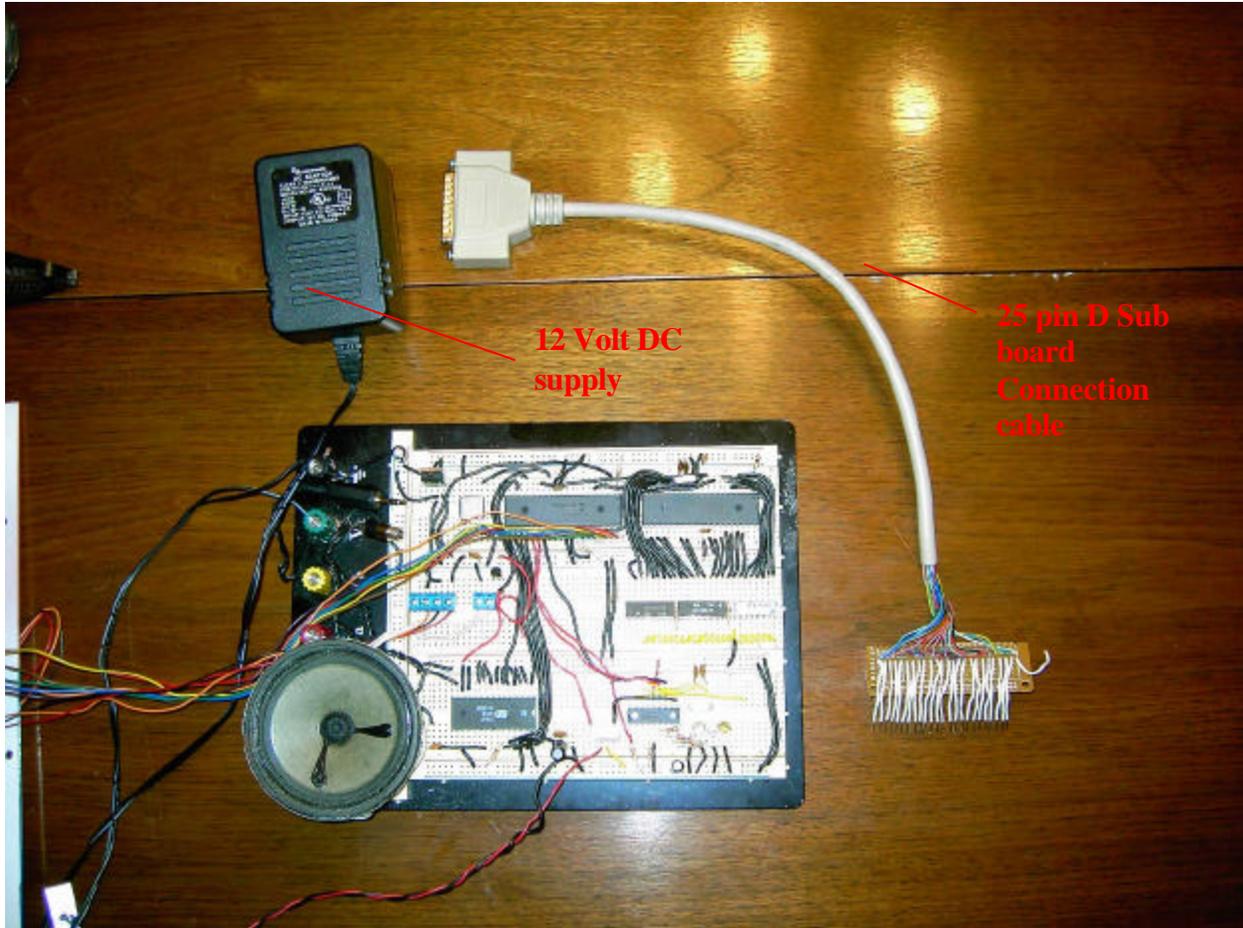


Figure 16

## Encoder

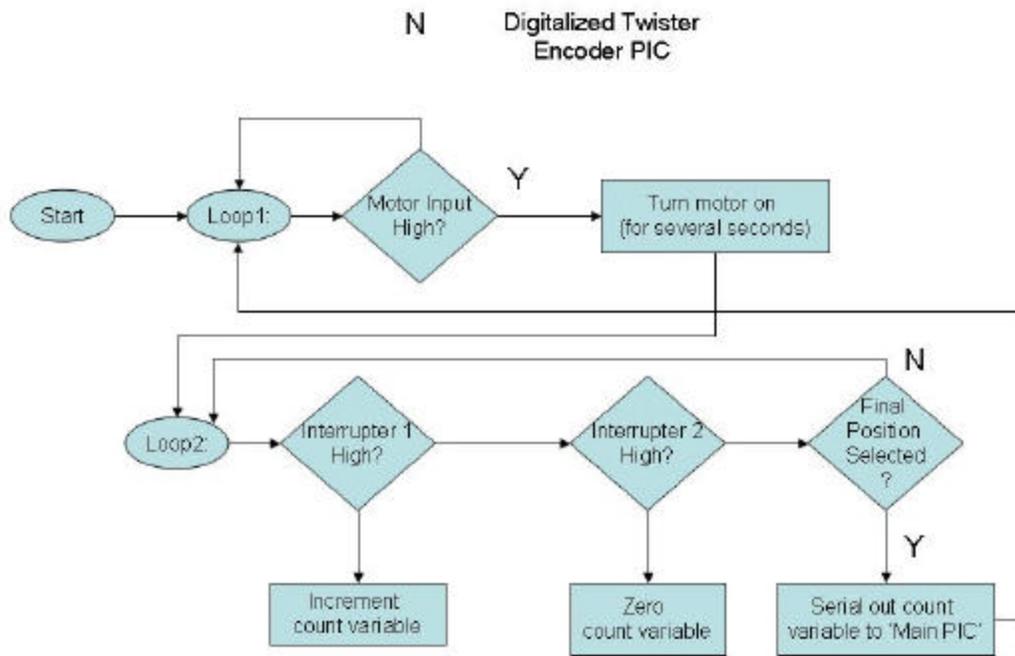


Figure 17

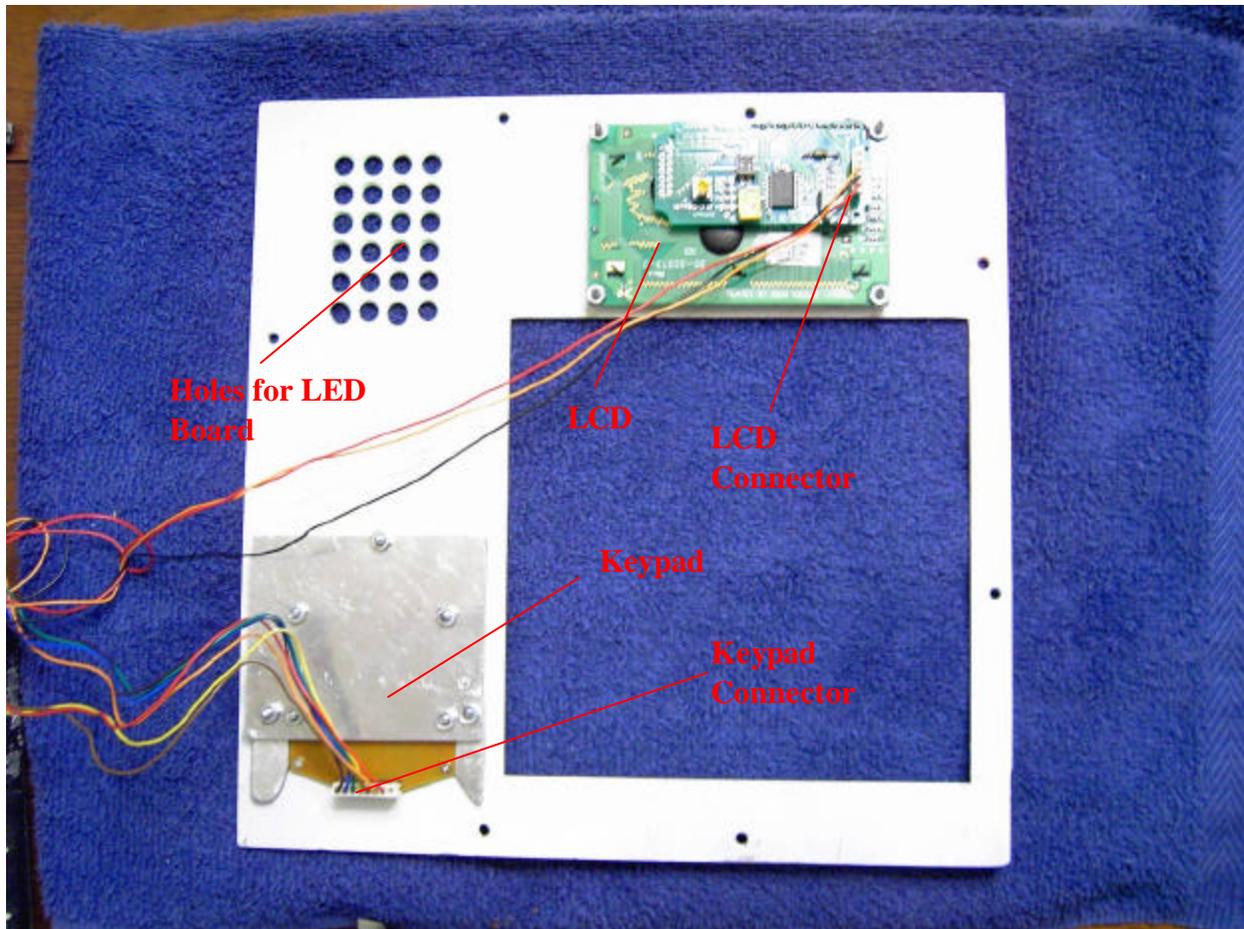


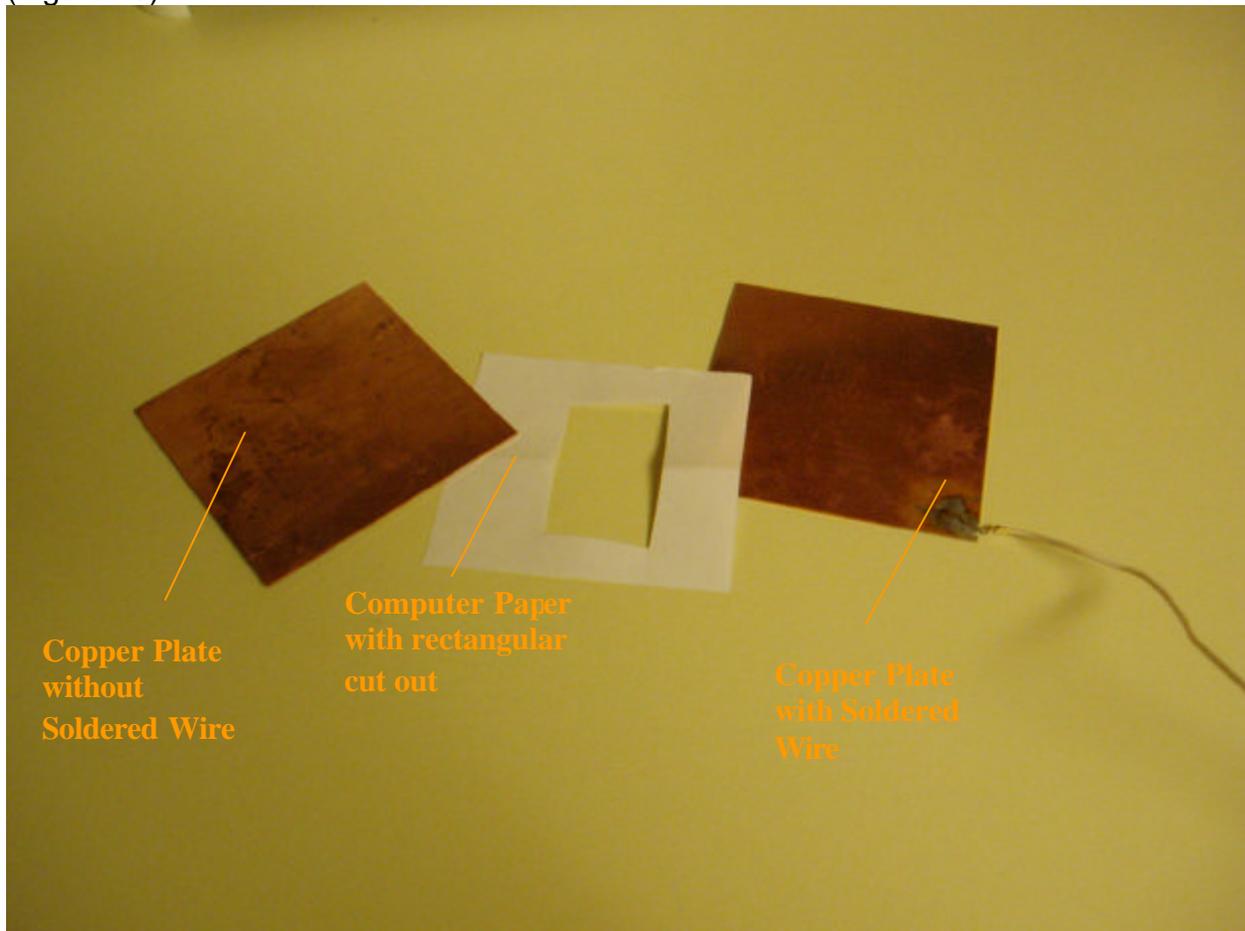
Figure 18

## Game Board Design

We desired that our Twister game board have a number of design considerations. First, we wished to use a standard Twister game board. Secondly, we wanted to maintain the fold-ability of the original game board while successfully placing the appropriate sensors necessary to communicate with our PIC's. In addition, we had to consider cost. Finally, we needed to utilize a sensor that would not fail due to fatigue given the cyclic loading natural of the game. What was finally implemented successfully fulfilled our design criteria as stated above.

Given the design criteria for our sensors we had to focus on something simple yet responsive. What we ended up implementing in our final design consisted of two three by three inch parallel copper plates separated by a standard piece of computer paper with a rectangle cut out in the center of the square-cut paper. The cut out allowed the circuit to be completed when small amounts of pressure was applied to the plates, all the while remaining open when uncompressed, and remaining responsive under cyclic loading conditions. Ideally, we would have liked to use copper circles cut to the same size as a colored circle on the original game board. However, due to the high

costs of copper plating and difficulty in manufacturing, we elected to use smaller square shaped sensors. A standard twister board consists of 24 circles, thus 48 square plates had to be manufactured (Figure 21). A wire was soldered to each of these 48 plates. (Figure 19)



**Figure 19**

One of the two wires in each sensor was tied to ground while the other was connected to a specific wire in the 25 Pin D-sub (Figure 21). Each pin number on the 25 Pin D-sub was connected to one of the sensors and a diagram was generated and used in the

code writing process. (Figure 20)

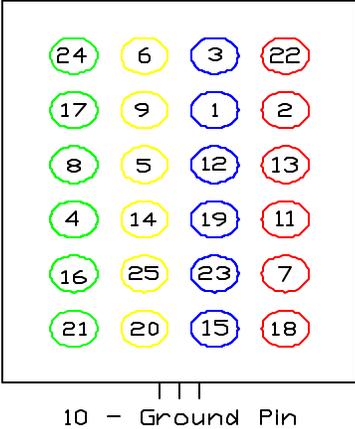


Figure 20

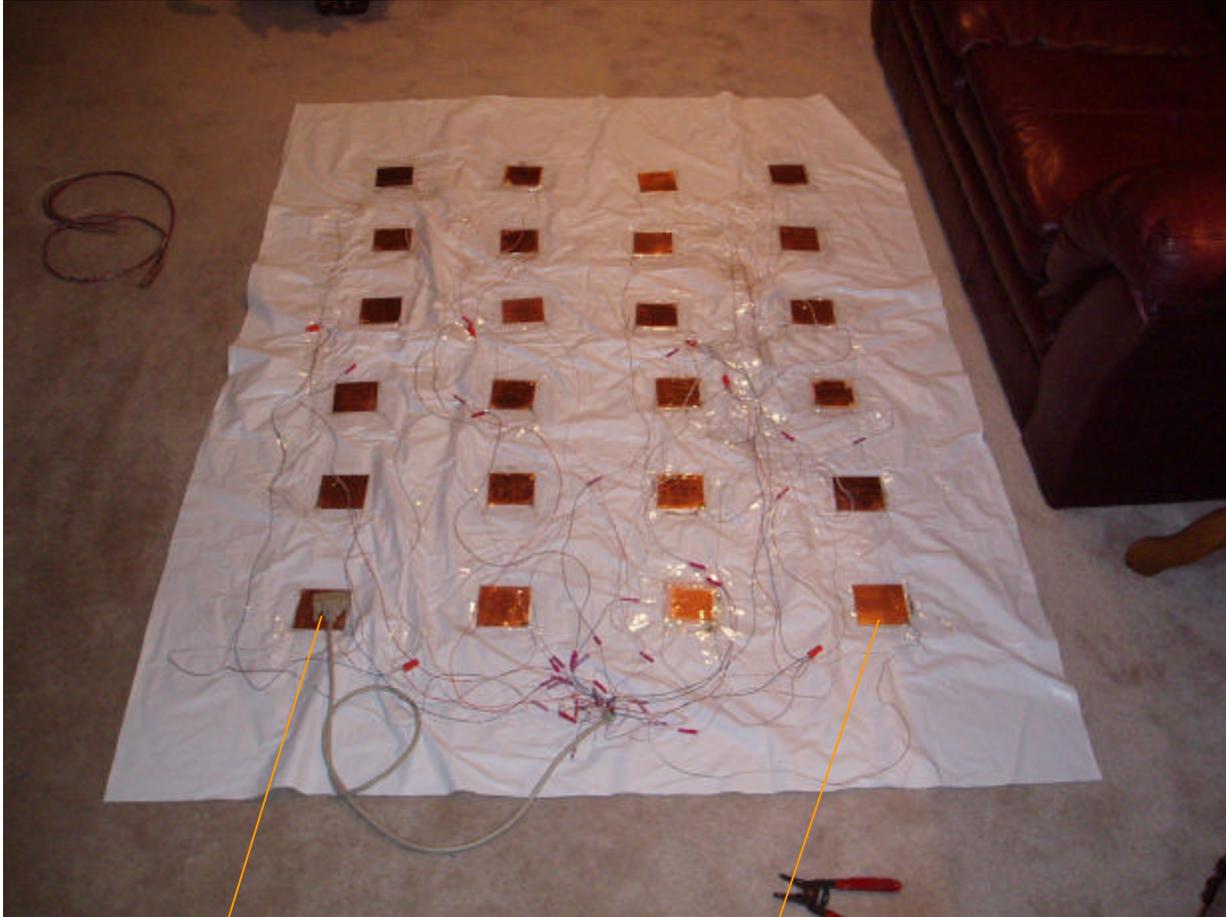


Figure 21

25 Pin D-sub

1 of 24 pressure sensors

## Design Evaluation

Digitalized Twister was designed around the functional element categories of Colorado State University's Mechatronics course. The title of the category and what was implemented in Digitalized Twister to meet the requirements are listed below.

### Output display:

- *LCD*: A LCD is used throughout the game to ask for user input and display messages to the players.
- *LED*: A grid of LEDs will display the positions of players on the game board.

### Audio output device:

- *TS2560 Sound Chip*: Used to create 18 synthesized voice sounds used for directing the players' movements.
- *Buzzer*: internal speaker provides sound for when a player falters and when the wheel spins.

#### **Manual Data input:**

- *Numerical Keypad*: At the start of the game, the system requires that the number of players be entered; this was accomplished with a numerical keypad.
- *Pressure Buttons*: 24 Custom made buttons used to track positions of players on the game board.

#### **Automatic sensor input:**

- *Two Photo-interrupters*: Two photo-interrupters used to track the position selection arrow.

#### **Actuator:**

- *DC Motor*: One DC motor was used to rotate the position selection arrow.

#### **Logic, Counting and Control:**

- Digitalized Twister is a 'smart' version of the classic game we all know and love. In order for our Digitalized Twister game to successfully function, we relied heavily on the logic, counting, and control provided by our peripheral interface controller (PIC).

Our design used two photo-interrupters to track the resting position of the position selection arrow. The first photo-interrupter was used to determine which of the 16 possible segments (left or right hand or foot on red, yellow, green, or blue) the arrow falls on. This was tracked using a counting variable. Rather than continually incrementing up for multiple rotations, we used a second photo-interrupter to zero the stored value every revolution. The second photo-interrupter will also save us the trouble of defining the starting position of the selection arrow. Our successful photo-interrupter system required a carefully thought out program using counting and logic. In addition to counting and logic we required two 40 pin PICs to go along with one 18 pin PIC. These PICs are required to serial to each other throughout the cycle of our game. Thus, our logic system is quite extensive. Additional use of logic, counting, and control was used in tracking the players' positions on the board. Because of our photo-interrupter system, the PIC will 'know' which positions on the board should be occupied. If a player fails to get into, or maintain, the proper position, Digitalized Twister detects the failure and activates a buzzer, signaling the end of the round.