Smart Chess Board

Group 10

Diego Garcia: Electrical Engineer

Noel Membribe: Electrical Engineer

My Ly Phan: Electrical Engineer

Damani Sinclair: Electrical Engineer

Motivation

- To create a remake of a classical game that could inspire more people to play by adding features that’ll make it more fun and creative.
- A smaller version of the wizard’s chess from Harry Potter.

Objectives

- Hands-free, Voice-Controlled Chess Board
  - Players use voice commands to move pieces.
- Electromagnet and XY-Plotter
  - Moves the physical piece to desired location.
- Player vs. Player

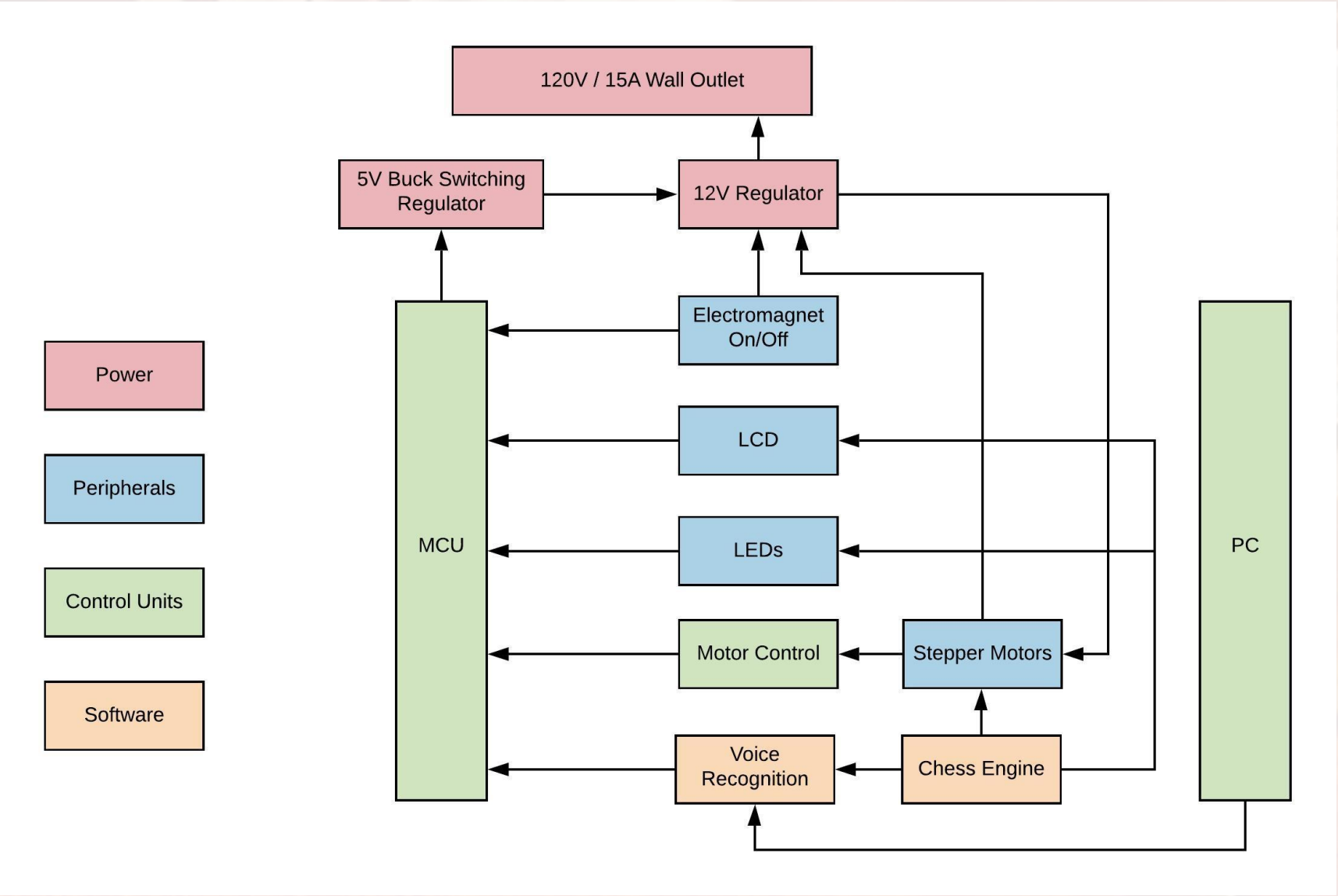
Requirements

- The project design approach and parts selected were chosen so that they comply with these requirements.

			Engineering Requirements				
			Dimensions	Processing Time	Weight	Power Consumption	Production Cost
			(-)	(-)	(-)	(-)	(-)
Marketing Requirements	Durable	(+)	↓				
	Easy to Use	(+)	↑	↑	↑		
	Portable	(+)	↑		↑	↑	
	Easy to Maintain	(+)	↑		↑		
	Reliable	(+)				↑	
	Cost	(-)	↑	↓	↓		↑↑
			< 62x62x20 cm	< 5 seconds	< 30 pounds	< 1000 Watts	< $800

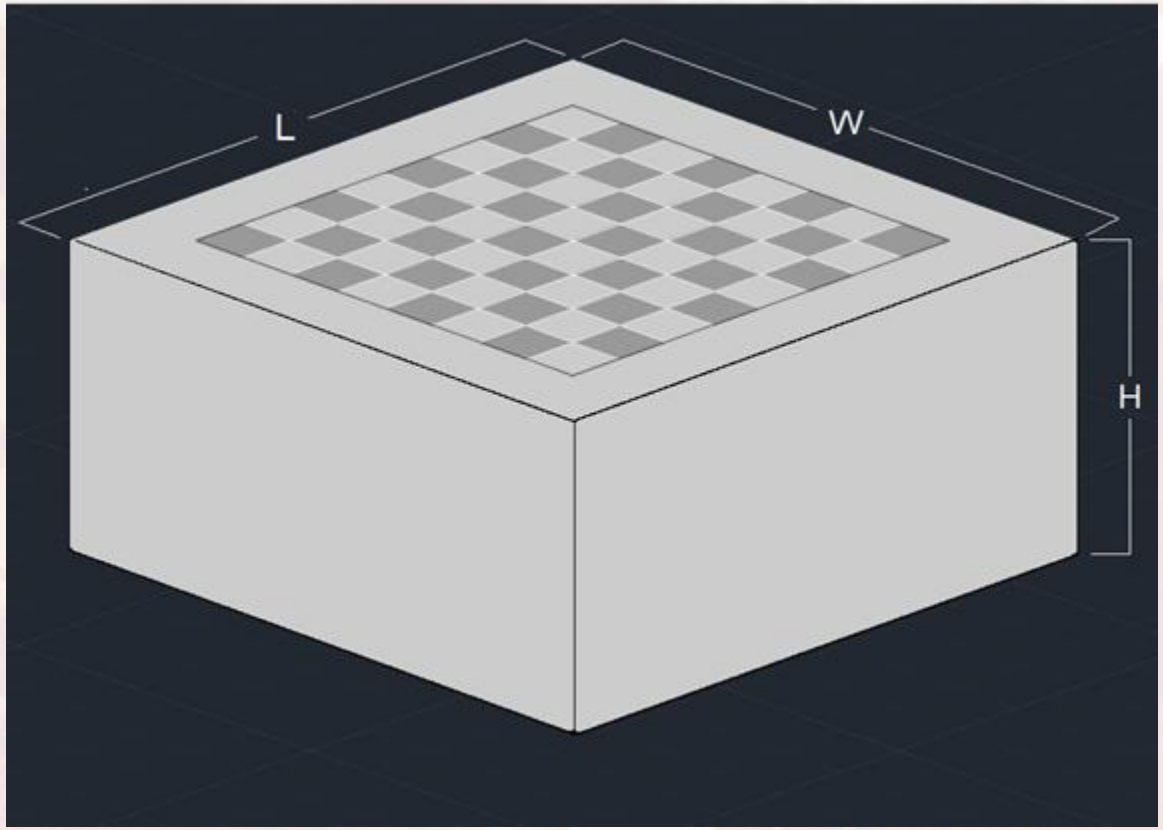
Strong positive correlation	↑↑
Positive correlation	↑
Negative Correlation	↓
Strong negative correlation	↓↓
Positive polarity	(+)
Negative polarity	(-)

Project Block Diagram



Chess Board Housing

- Length x Width x Height :
  - 635mm x 635mm x 254mm
- Volume :
  - 102,419 cm^3
- Weight
  - Enclosure – 12 lbs
  - Playing Surface – 3 lbs
  - Total – 15 lbs

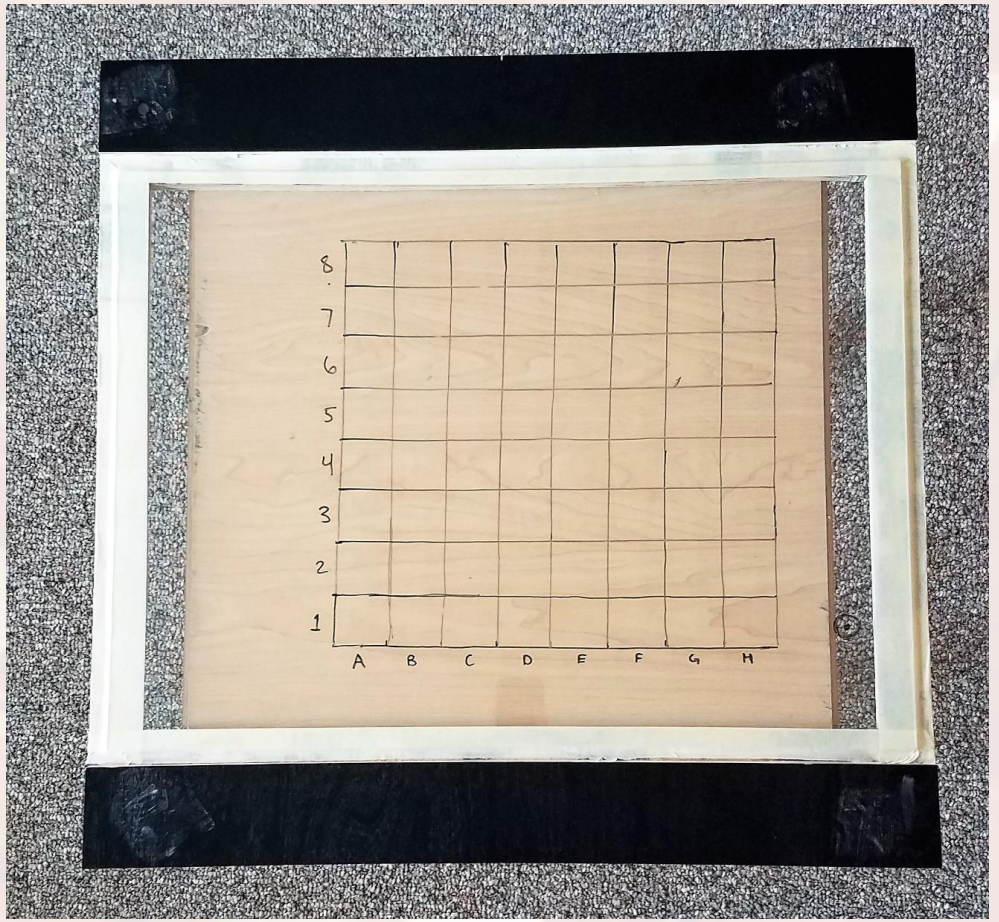


Chess Board Enclosure

- Sande Plywood
  - 4x8 sheet
  - Marine plywood
    - water resistant
    - Strong and light weight
- The enclosure houses all of the hardware and electrical components

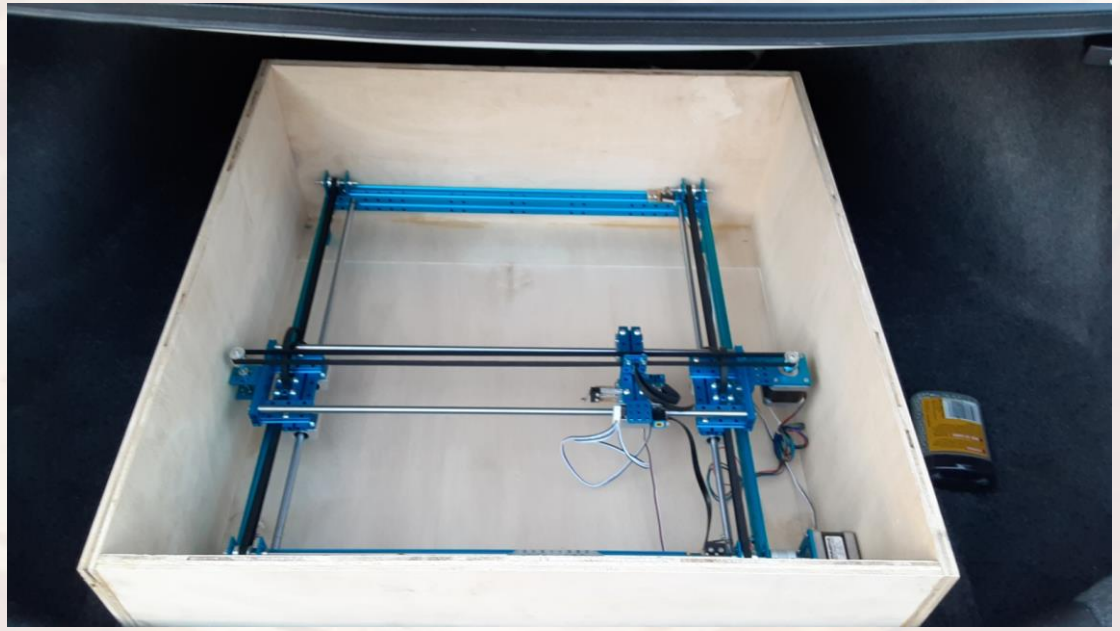
Chess Board Playing Surface

- The playing surface consist of a plexiglass chess board with a wooden boarder for each player.
  - 2mm thick plexiglass for ease of piece movement and sturdiness
- Plexiglass Surface
  - 635 x 475 mm
- Playing Surface
  - 300 x 300 mm
- Player Border
  - 80 mm



XY-Plotter Location and Position

- Location
  - Within the chess board enclosure
- Position
  - Positioned right side up with respect to designed orientation
  - Brackets used to mount XY-Plotter towards top
  - Electromagnet facing up towards the playing surface



Chess Piece Specifications

- Chess consists of 32 playing pieces in a complete set
  - 16 Chess pieces for each side

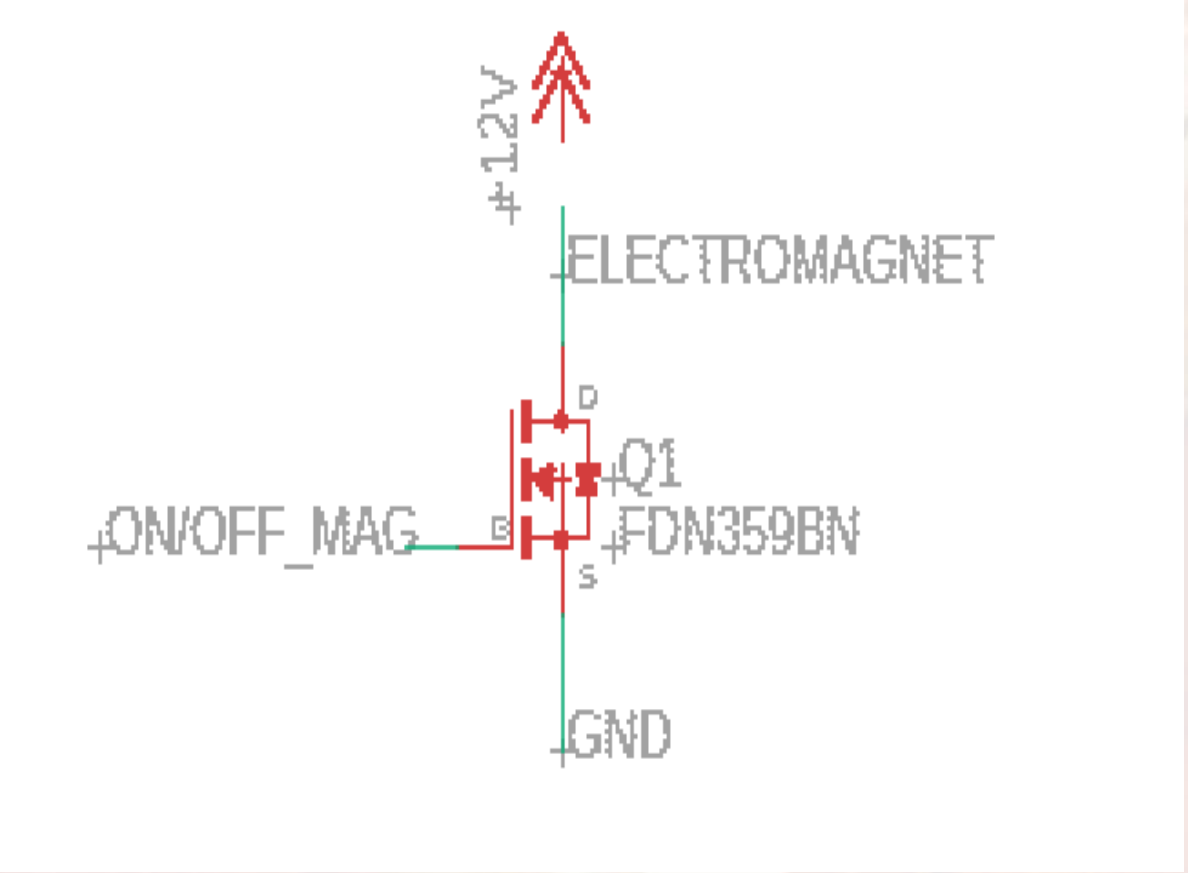
Piece	Height (mm)	Diameter (mm)	Weight/Piece (g)
King (2)	32.5	12.7	70.8
Queen (2)	31.75	12.7	62.5
Bishop (4)	26.98	12.7	50.0
Knight (4)	23.8	12.7	41.6
Rook (4)	20.64	12.7	37.5
Pawn (16)	19.8	12.7	33.3

Chess Piece Magnetization

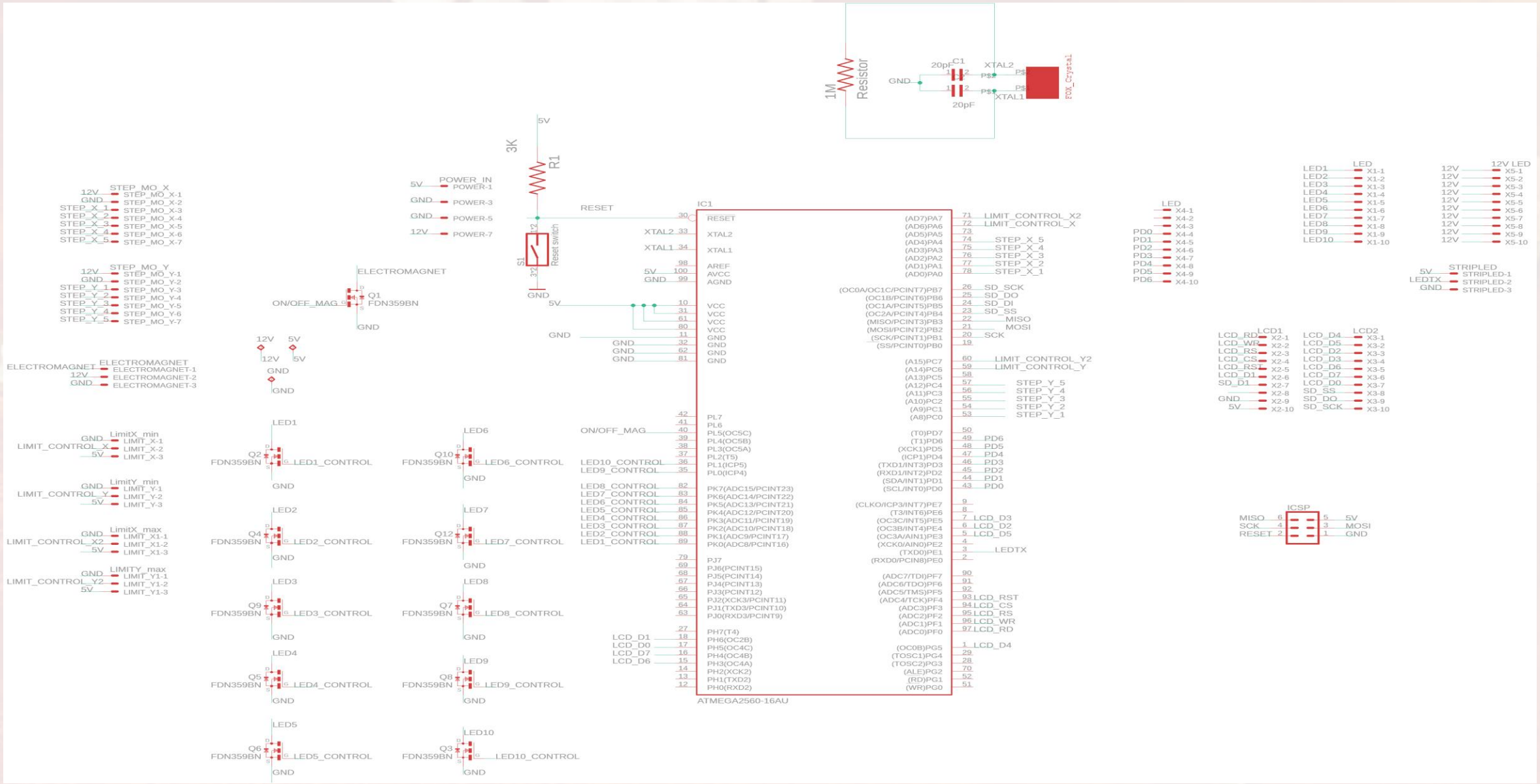
- Since the chess pieces are wooden, metal needed to be implemented to make the pieces attract to the electromagnet.
- A small steel washer was fitted to the base of each piece
- This allows the electromagnet to attract the pieces.

Electromagnet Specifications

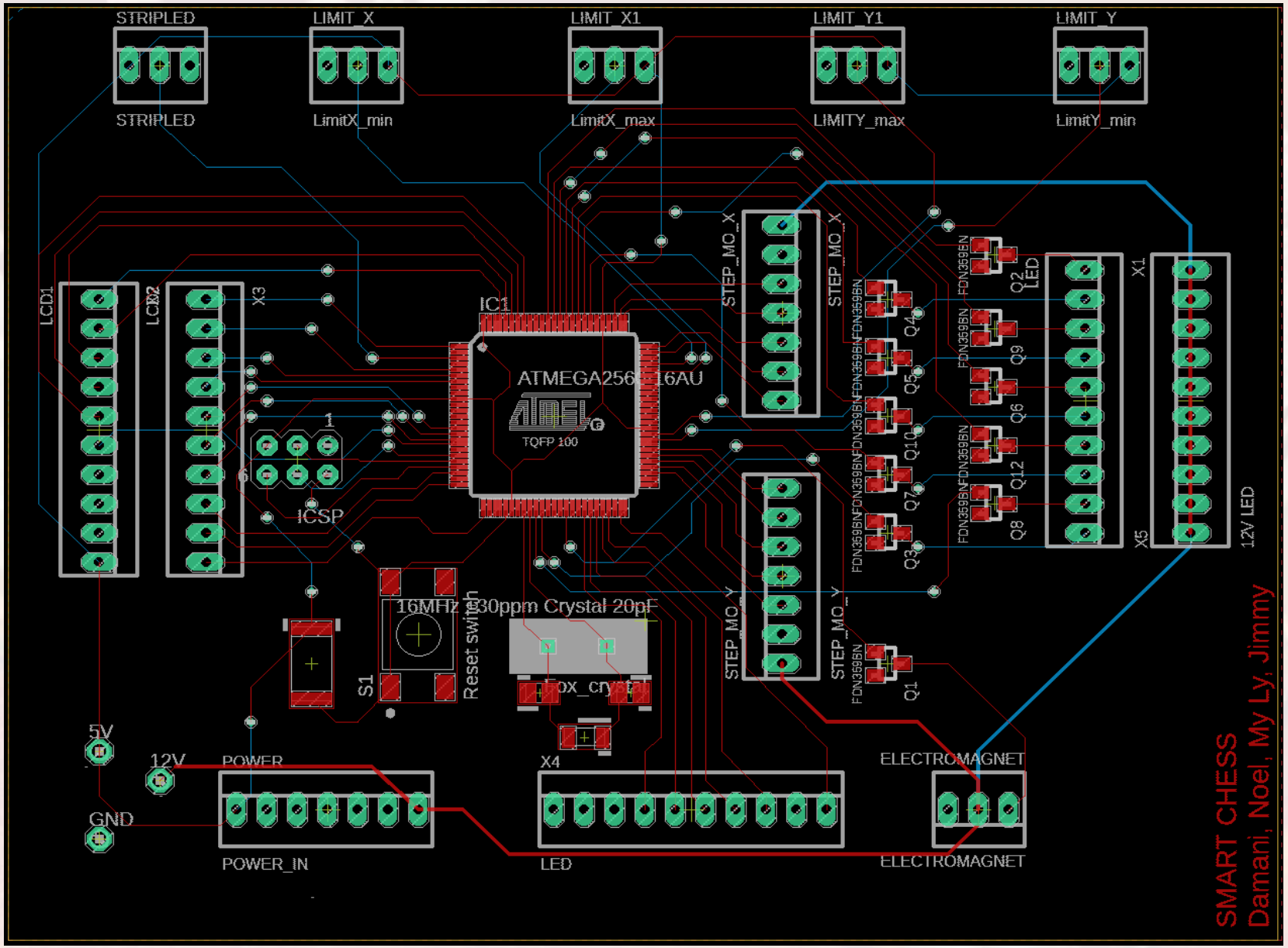
- 12V electromagnet
  180N lifting force magnet
- Used in conjunction with a MOSFET in order to easily switch the electromagnet on and off
- N-channel Power MOSFET capable handling a Drain-Source voltage of 30V , and a current of 2.7A



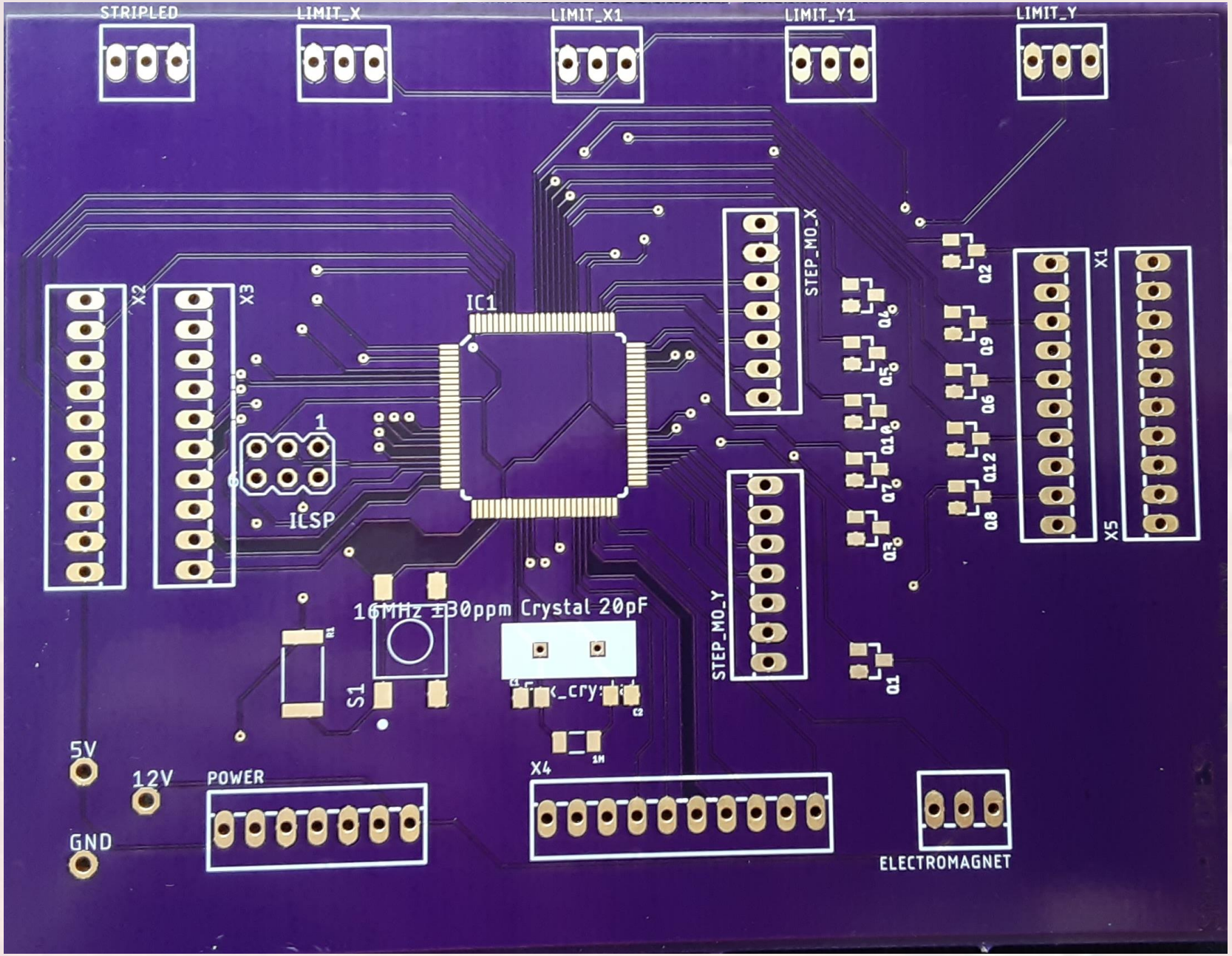
Schematic


1M
Resistor
20pF
C1
GND
XTAL2
XTAL1
20pF
FOX_Crystal
3K
R1
5V
RESET
Reset switch
S1
GND
IC1
ATMEGA2560-16AU
RESET
XTAL2
XTAL1
AREF
AVCC
AGND
VCC
GND
ON/OFF_MAG
LED10_CONTROL
LED9_CONTROL
LED8_CONTROL
LED7_CONTROL
LED6_CONTROL
LED5_CONTROL
LED4_CONTROL
LED3_CONTROL
LED2_CONTROL
LED1_CONTROL
LCD_D1
LCD_D0
LCD_D7
LCD_D6
LIMIT_CONTROL_X2
LIMIT_CONTROL_X
STEP_X_5
STEP_X_4
STEP_X_3
STEP_X_2
STEP_X_1
SD_SCK
SD_DO
SD_DI
SD_SS
MISO
MOSI
SCK
LIMIT_CONTROL_Y2
LIMIT_CONTROL_Y
STEP_Y_5
STEP_Y_4
STEP_Y_3
STEP_Y_2
STEP_Y_1
LEDTX
LCD_RST
LCD_CS
LCD_RS
LCD_WR
LCD_RD
LCD_D4
STEP_MO_X
STEP_MO_Y
POWER_IN
ELECTROMAGNET
Q1
FDN359BN
ON/OFF_MAG
LED
LED1
LED2
LED3
LED4
LED5
LED6
LED7
LED8
LED9
LED10
Q2
Q4
Q9
Q5
Q6
Q10
Q12
Q7
Q8
Q3
LimitX_min
LimitY_min
LimitX_max
LimitY_max
LCD1
LCD2
ICSP
MISO
SCK
RESET
MOSI
12V LED
STRIPLED
STRIPLED-1
STRIPLED-2
STRIPLED-3

PCB


STRIPLED
LIMIT_X
LIMIT_X1
LIMIT_Y1
LIMIT_Y
STRIPLED
LimitX_min
LimitX_max
LIMITY_max
LimitY_min
LCD1
LCD2
X3
IC1
ATMEGA256
16AU
TQFP 100
ICSP
STEP_MO_X
STEP_MO_X
STEP_MO_Y
STEP_MO_Y
FDN3596N
Q4
Q5
Q10
Q7
Q3
Q9
Q6
Q12
Q8
Q2
LED
X1
X5
12V LED
16MHz ±30ppm Crystal 20pF
Reset switch
S1
5V
12V
GND
POWER
POWER_IN
X4
LED
ELECTROMAGNET
ELECTROMAGNET
SMART CHESS
Damani, Noel, My Ly, Jimmy

PCB


STRIPLED
LIMIT_X
LIMIT_X1
LIMIT_Y1
LIMIT_Y
STEP_MO_X
STEP_MO_Y
X1
X2
X3
X4
X5
IC1
ICSP
16MHz ±30ppm Crystal 20pF
S1
5V
12V
GND
POWER
ELECTROMAGNET

Testing

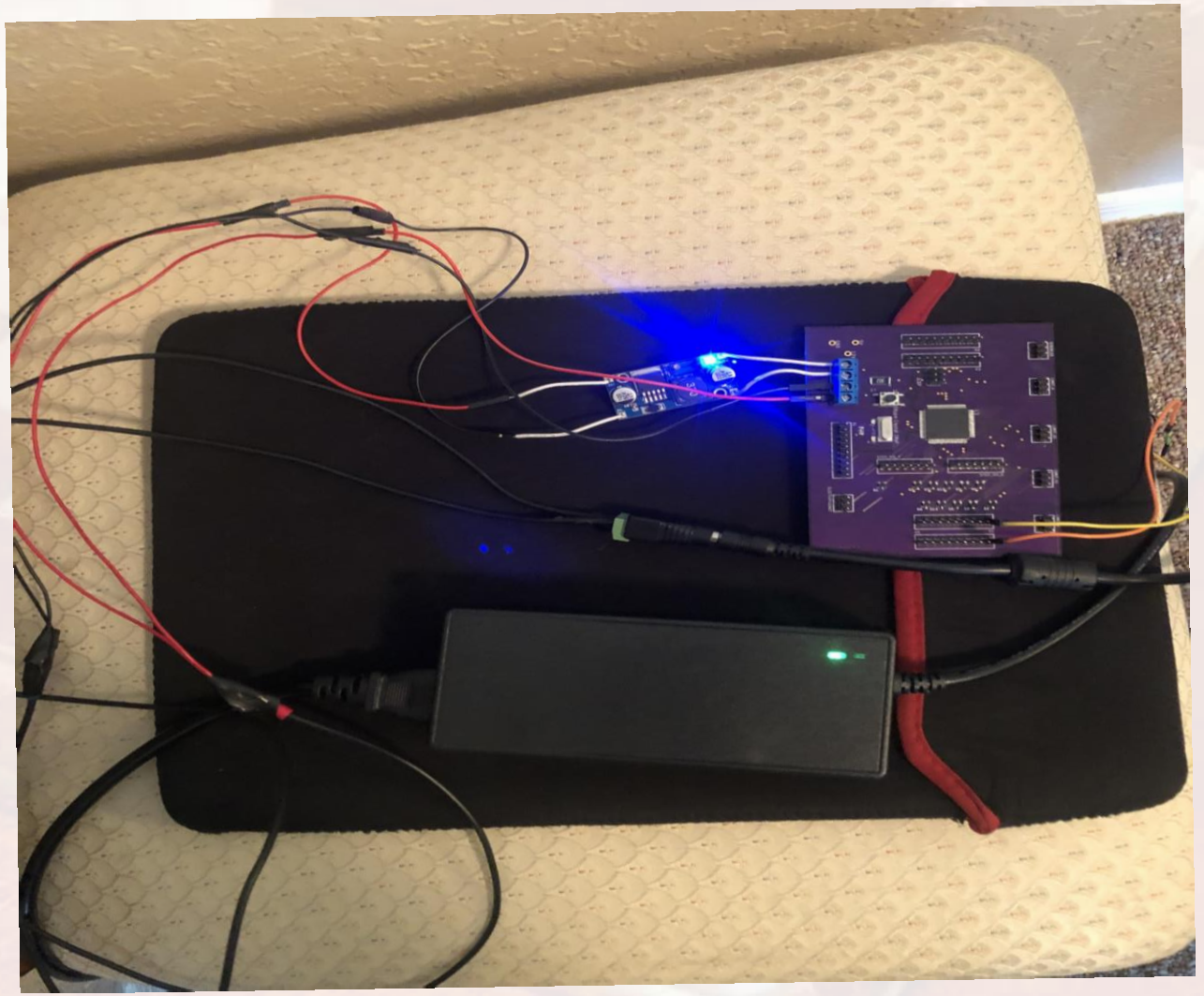
Electromagnet	Size	Cost
12V Peak Force 50N	25*20mm/1*0.8inch	$8.57
12V Peak Force 500N	50 x 27 mm /1.97 x 1.06 in.	$20.34
12V Peak Force 180N	34 x 18 mm / 0.7 x 1inch	$11.53

Power System

- A 120V AC wall outlet will be used to power the project
- A DC adapter will convert the 120V AC into 12V DC
- A buck regulator drops the 12V down to 5V
- A 12 V power rail on the PCB will power components such as the Electromagnet
- A 5V source will be provided from the regulator to power other components such as the microcontroller, LCD and the LEDs

Power System

- From the DC adapter both 12V and ground split into two wires
- One 12V wire is routed to a buck switching regulator to drop the voltage down to 5V, then used to power the microcontoller
- The other 12V rail is sent directly to the PCB board to power specific components.

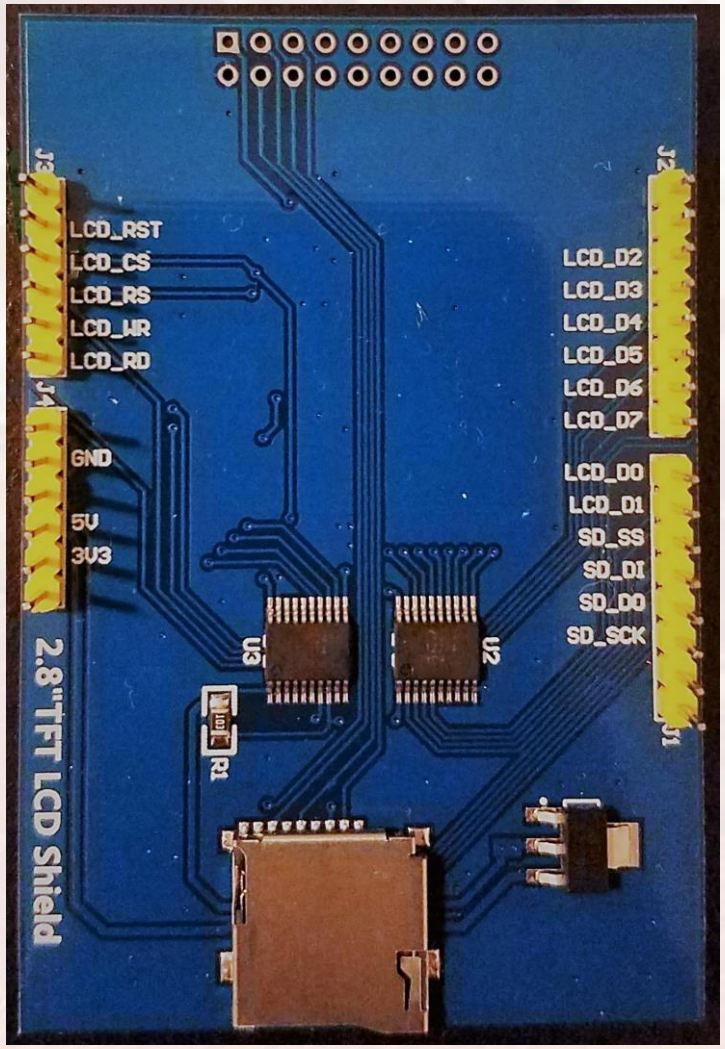


LCD

- ELEGOO Uno R3 (ATmega2560 Compatible).
- Comment display.
- Approximately $15.

Specifications	Description	Units
Display Type	2.8 inch TFT LCD Module	-
Glass Type	TFT	-
Display Resolutions	240 x 320	Pixels
Backlight	4 chip Highlight white LEDs	-
Control IC	ILI9341	-
Interface	8 Bit Parallel Interface	-
PCB Module Size	78.22 x 52.7	Millimeters
LCD Area (W x H x T)	50 x 69.2 x 2.5	Millimeters
Active Area (W x H)	43.2 x 57.6	Millimeters
Module Weight	1.67	Ounces
Power Voltage	5	Voltage Direct Current
Current Consumption	120	Milliamperes

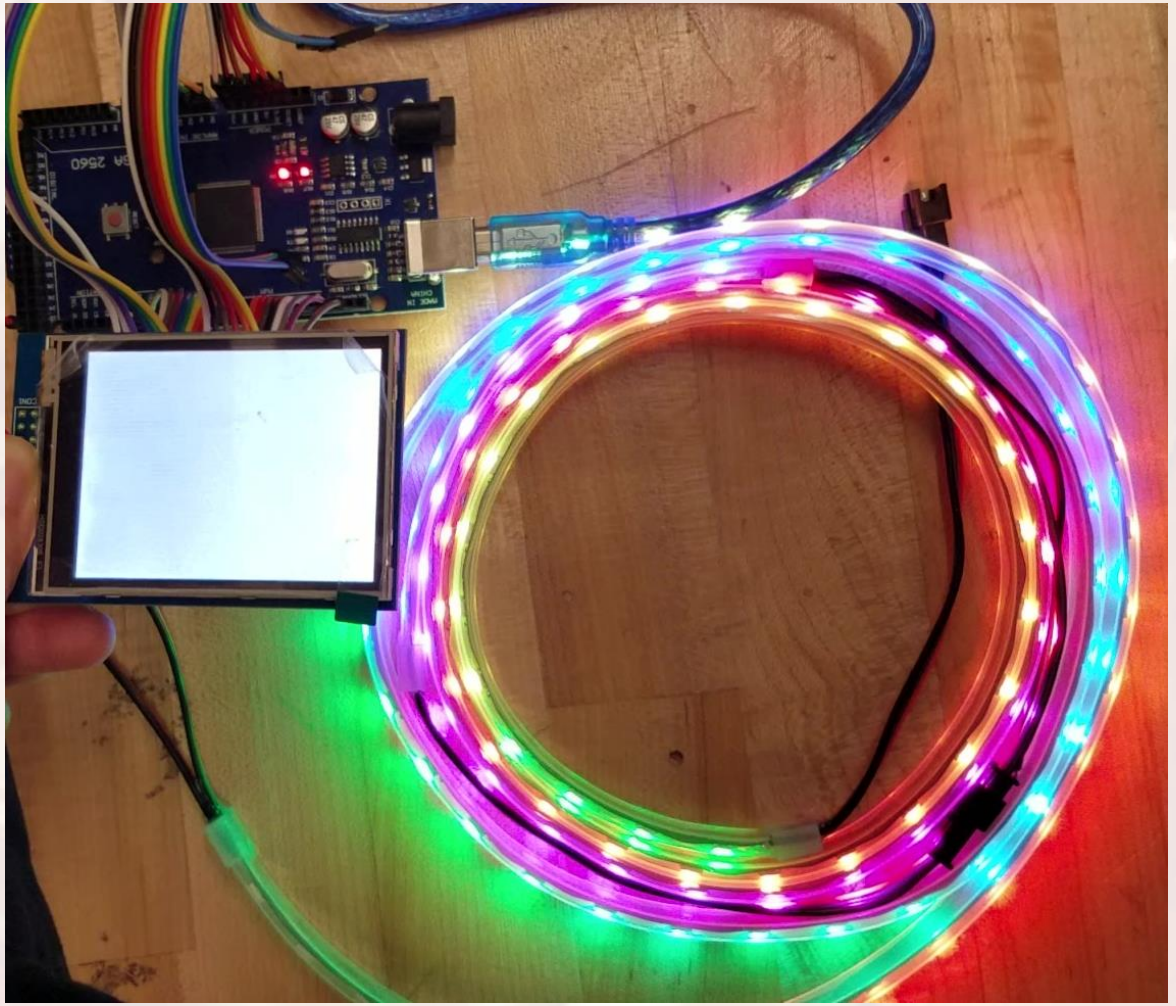
LCD Interface Definition



LCD Pins	Arduino 2560 Pin	Instruction
LCD_RST	A4	Reset Signal
LCD_CS	A3	Chip Select
LCD_RS	A2	Command/Data Select
LCD_WR	A1	Write Signal
LCD_RD	A0	Read Signal
GND	GND	Power GND
5V	5V	Power VCC
3V3	3.3V/NC	Not Connected
LCD_D0	8	LCD Data Bit0
LCD_D1	9	LCD Data Bit1
LCD_D2	2	LCD Data Bit2
LCD_D3	3	LCD Data Bit3
LCD_D4	4	LCD Data Bit4
LCD_D5	5	LCD Data Bit5
LCD_D6	6	LCD Data Bit6
LCD_D7	7	LCD Data Bit7
SD_SS	10	SD-Card Chip Select Signal
SD_DI	11	SD-Card SPI Bus MOSI Signal
SD_DO	12	SD-Card SPI Bus MISO Signal
SD_SCK	13	SD-Card SPI Bus SCLK Signal

LEDs

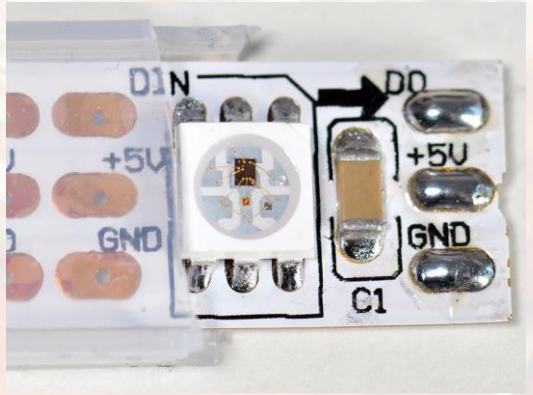
- Other projects used them to learn the game.
- For aesthetics and more entertaining game.



LEDs

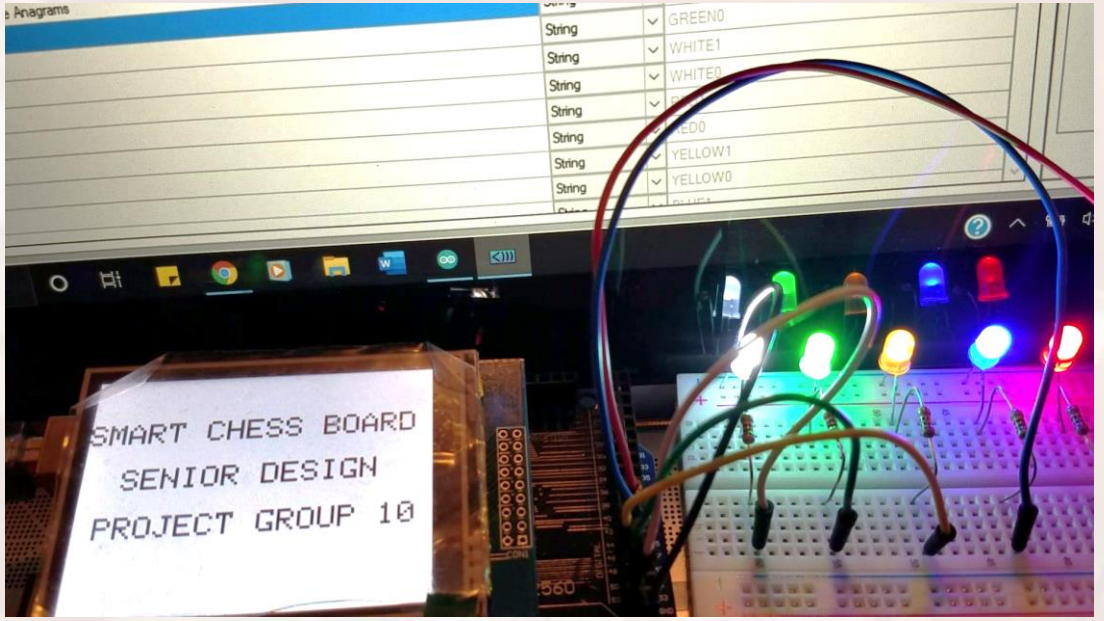
- NeoPixel by Adafruit
- Each LED chip can be addressed and controlled individually.
- Low power consumption, bright, flexible, and low temperature.
- Approximately $25 per strip.

Specifications	Description	Units
Model	WS2812 Strip 5050 RGB Chip	-
Input Voltage	5	VDC
LED Quantity	60 Piece RGB SMD 5050	Per Meter
Wavelength	R: 650 ; G: 520 ; B: 460	Millicandela
Product Dimension (L x W x H)	1000 x 10 x 3	Millimeters
Lifespan	>50,000	Hours



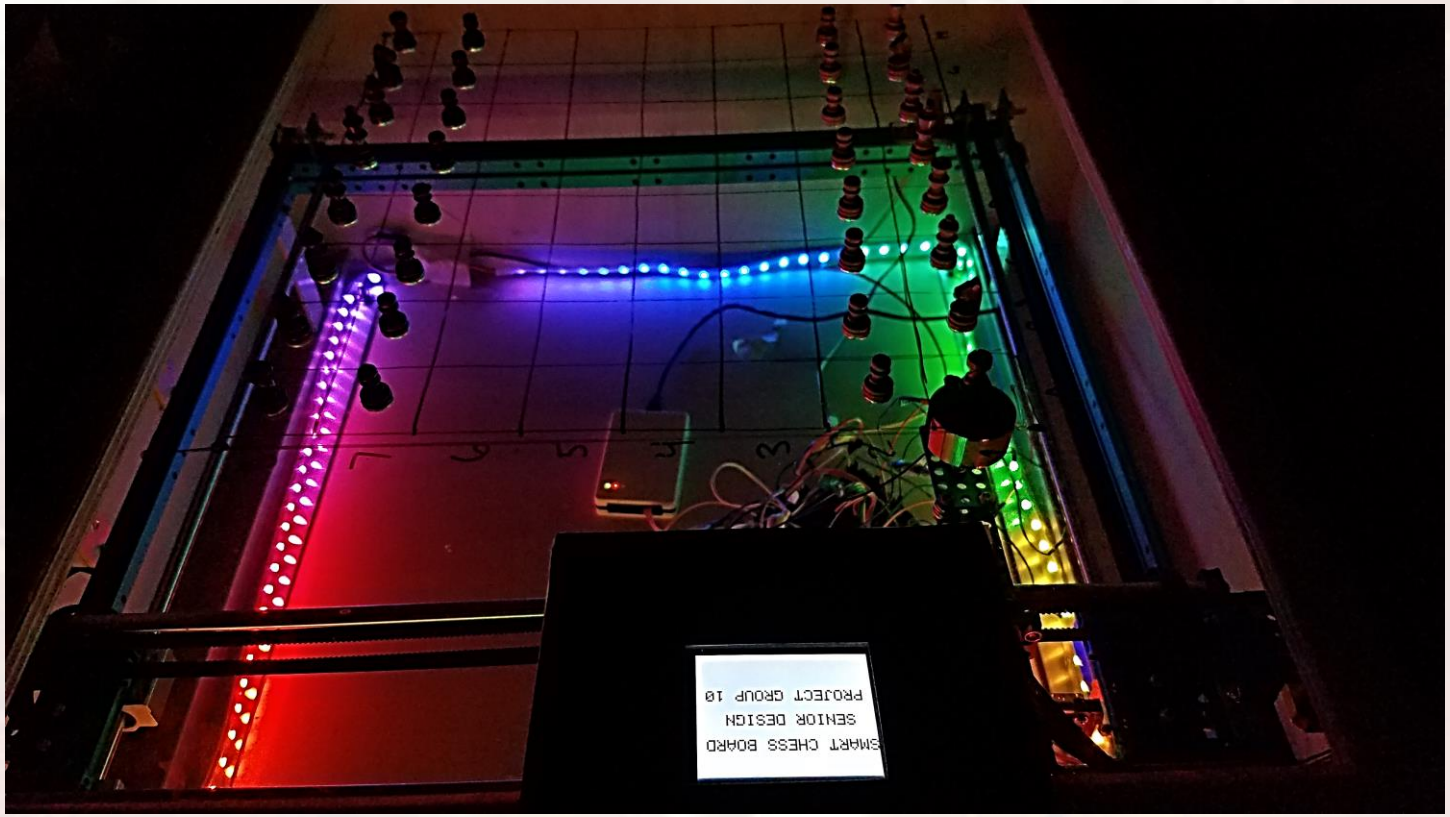
LEDs and LCD

- Single LEDs and LCD combination compatible with BitVoicer, unlike RGB strip.
- EDGELEC 12V DC LED
  - Prewired.
  - 7.9 inch wire.
  - Assorted colors.
  - 56 pieces for approximately $7.



Features

- LED strip used to light interior.
- Individual LED used to light up when electromagnet is turned on; off when electromagnet is turned off.
- LCD displays the project.



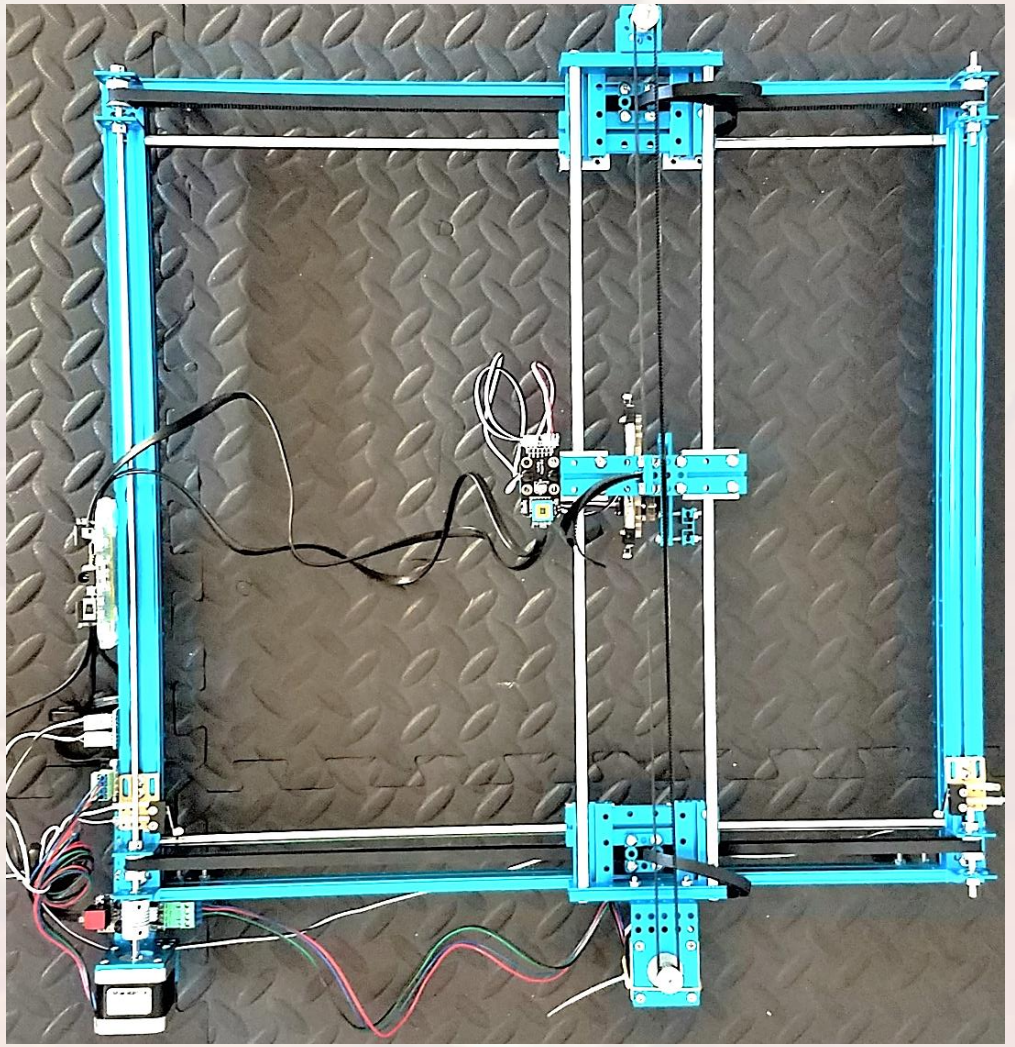
Microcontroller Specifications

- ATmega2560-16au
- Low power 8-bit microcontroller
- Executes powerful instructions in a single clock cycle
- Achieves throughputs approaching 1 MIPS per MHZ
- Approximately $14

Microcontroller Information	
CPU speed	16MHz
Program Memory Size	256KB
RAM Memory Size	8KB
Number of I/O's	86
Embedded interface	I2C, SPI, USART
Supply Voltage Max	5.5V
Supply Voltage Min	4.5V

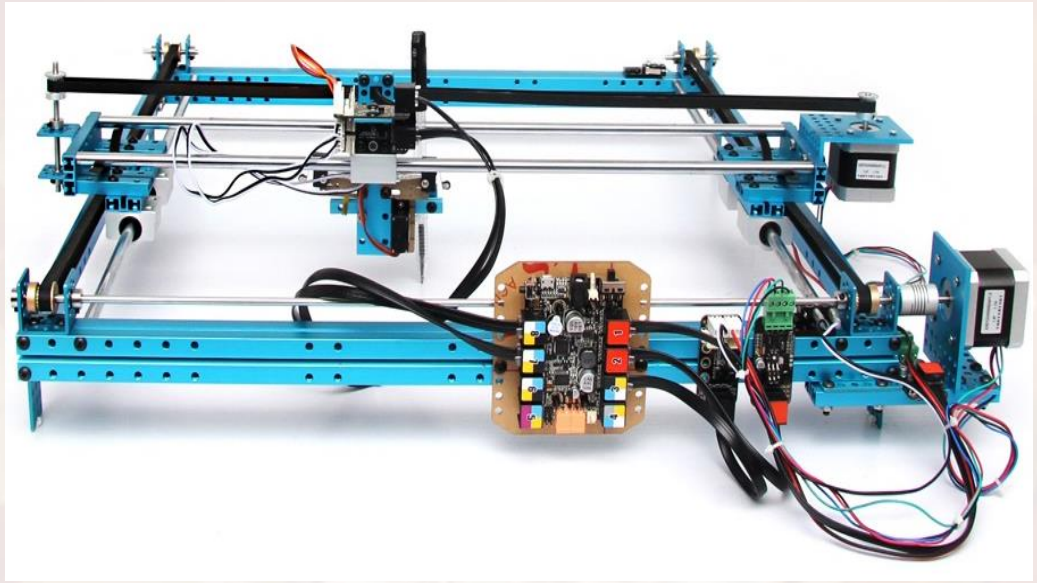
Piece Movement System (XY Plotter)

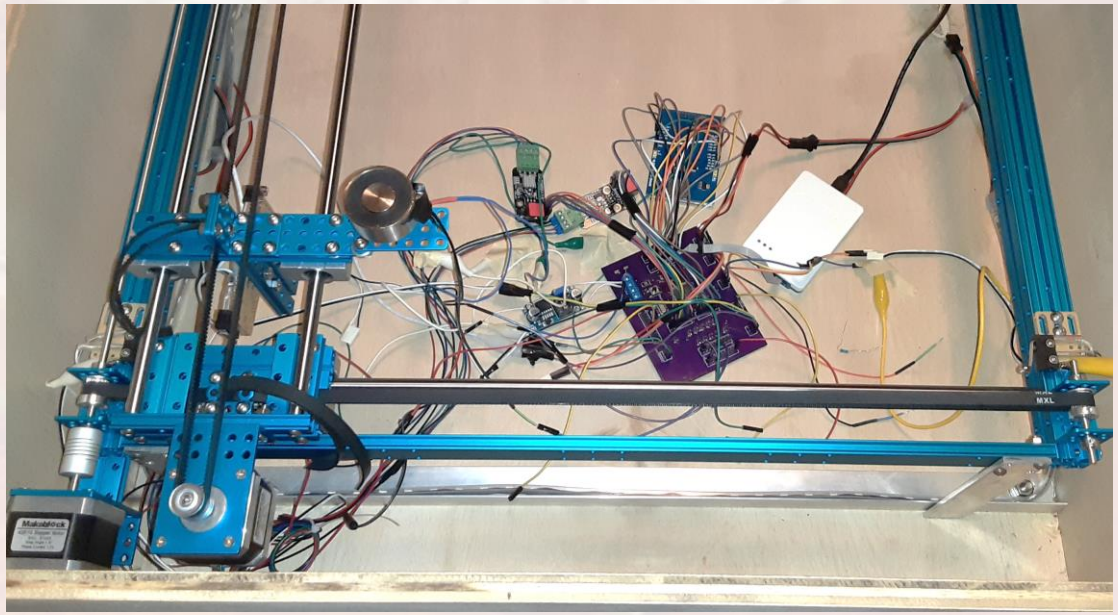
- The XY-Plotter Robot Kit V2.0 from Makeblock was used to move the pieces across the board.
- XY Plotters are typically used to draw images from a bitmap by attaching a writing utensil.
- An electromagnet was attached instead, and the chess board was placed over the plotter. The electromagnet moves the magnetized chess pieces.



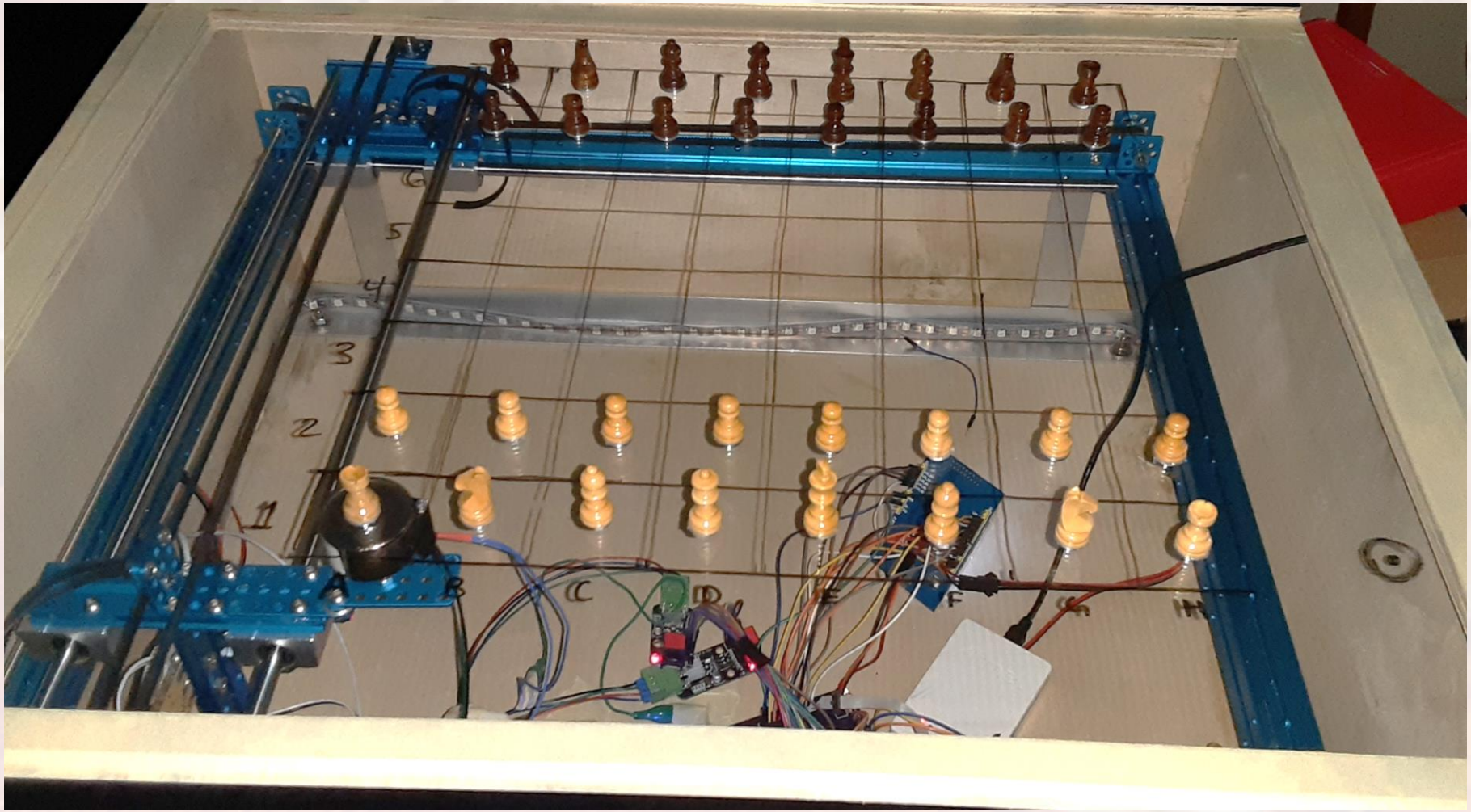
XY-Plotter Robot Kit V2.0

- The kit consists of:
  - x2 Stepper Motors
  - x2 Stepper Motor Drivers
  - x4 Limit Switches
  - Beams, Belts, Motor Shafts
  - Many other parts which went unused
- The final product is a highly customized system controlled by an Atmel2560 chip on a personally designed PCB.



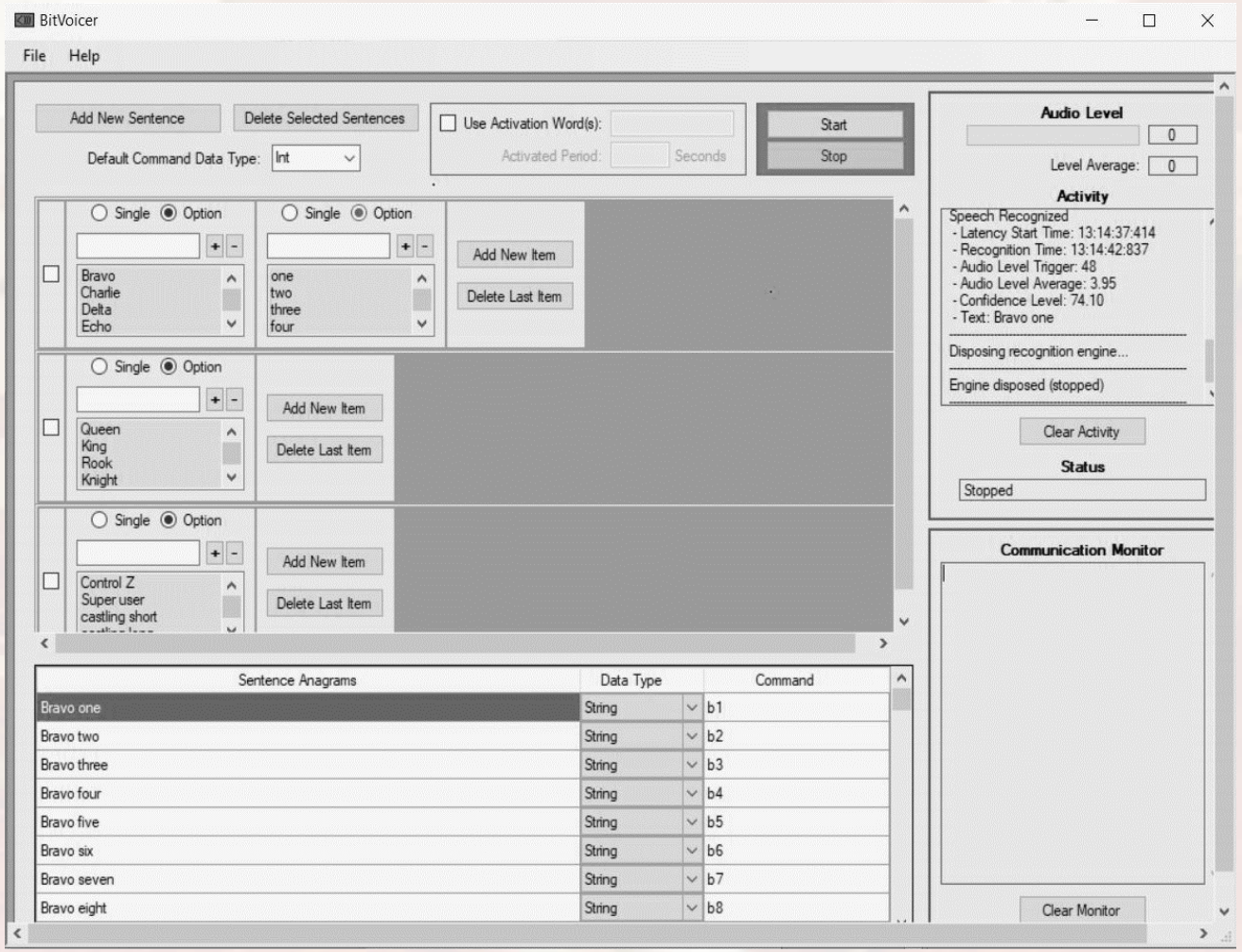


Piece Movement System



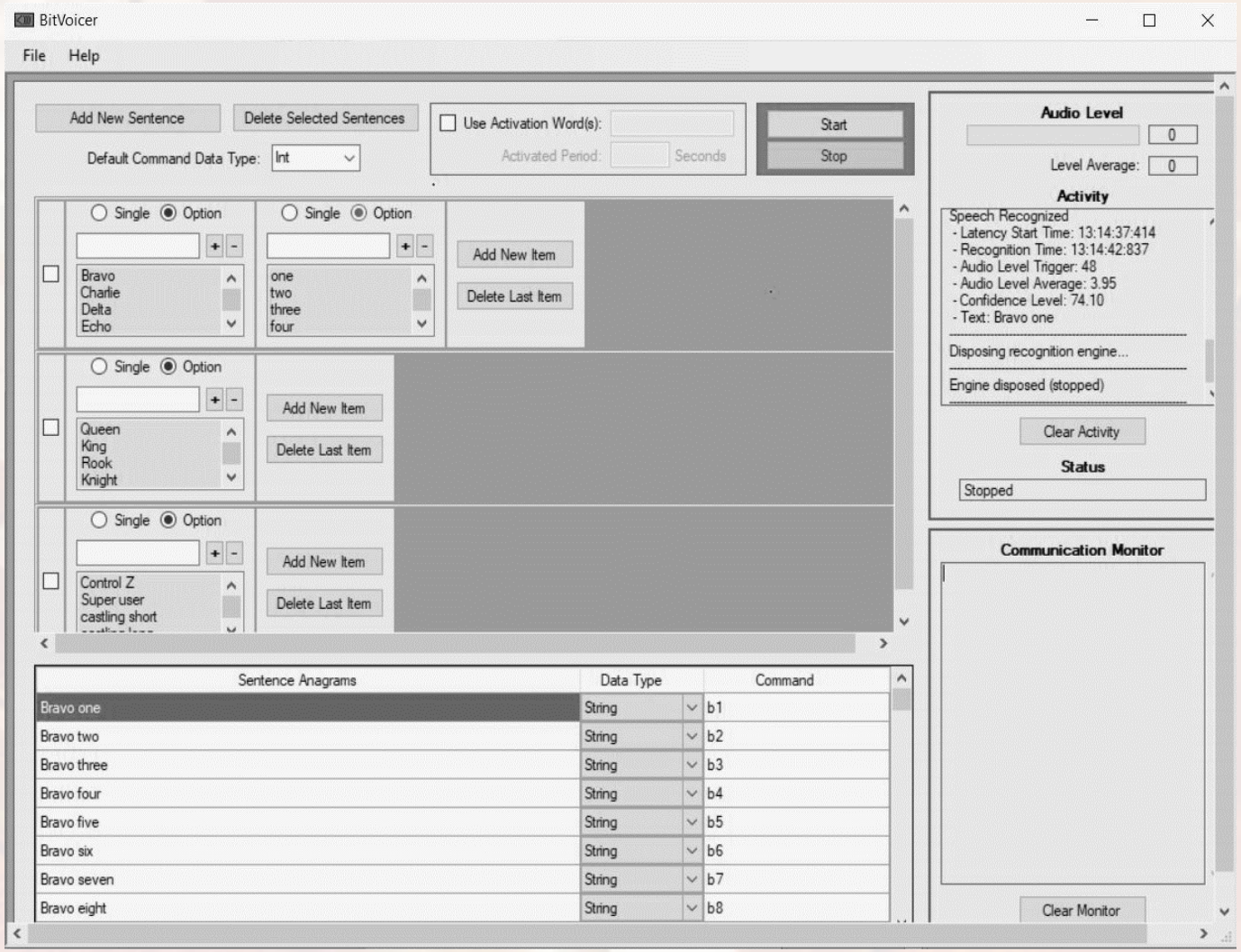
Voice Recognition Software (BitVoicer)

- BitVoicer is an app that analyzes audio streams and identifies words or sentences.
- Only relevant words are recognized.
- Audio is compared to the library of relevant words and the closest sounding sentence is chosen.



BitVoicer

- Recognized words are converted to commands and sent to a microcontroller as serial data.
- The microcontroller is programmed to read this data and activate the appropriate response from the XY plotter system based on what is read.



Programming

All of the programming was done in C++ and using the Arduino IDE. Below is a list of all the functions used in the code and a short description:

- setup()
  - Executes any time the Arduino turns on or is reset. It sets up all the wiring for the components and initializes serial communications.
- SerialEvent()
  - Whenever data is sent from BitVoicer, reads the data and calls other functions.
- loop()
  - This is the main function in the program. It runs continuously and restarts the SerialEvent function when the program exits out of it.
- move1()
  - Moves to destination square with magnet off, no offset. Turns magnet on when it arrives

Programming

- sendToGraveyard()
  - offsets and sends piece to graveyard, then goes back to zero
- move2()
  - Moves to source square with magnet off, no offset. turns magnet on when it arrives, always assumes you start at (1,1) which is A1, because it zeroes after the zeroGraveyard
- move3()
  - Moves to destination square with offset, with magnet on. turns magnet off when it arrives
- move4()
  - Moves to source square with magnet off, no offset. turns magnet on when it arrives, used to move w/o capturing, uses last known location (x3,y3)
- zero()
  - Moves to zero position, which is (1,1) or A1.

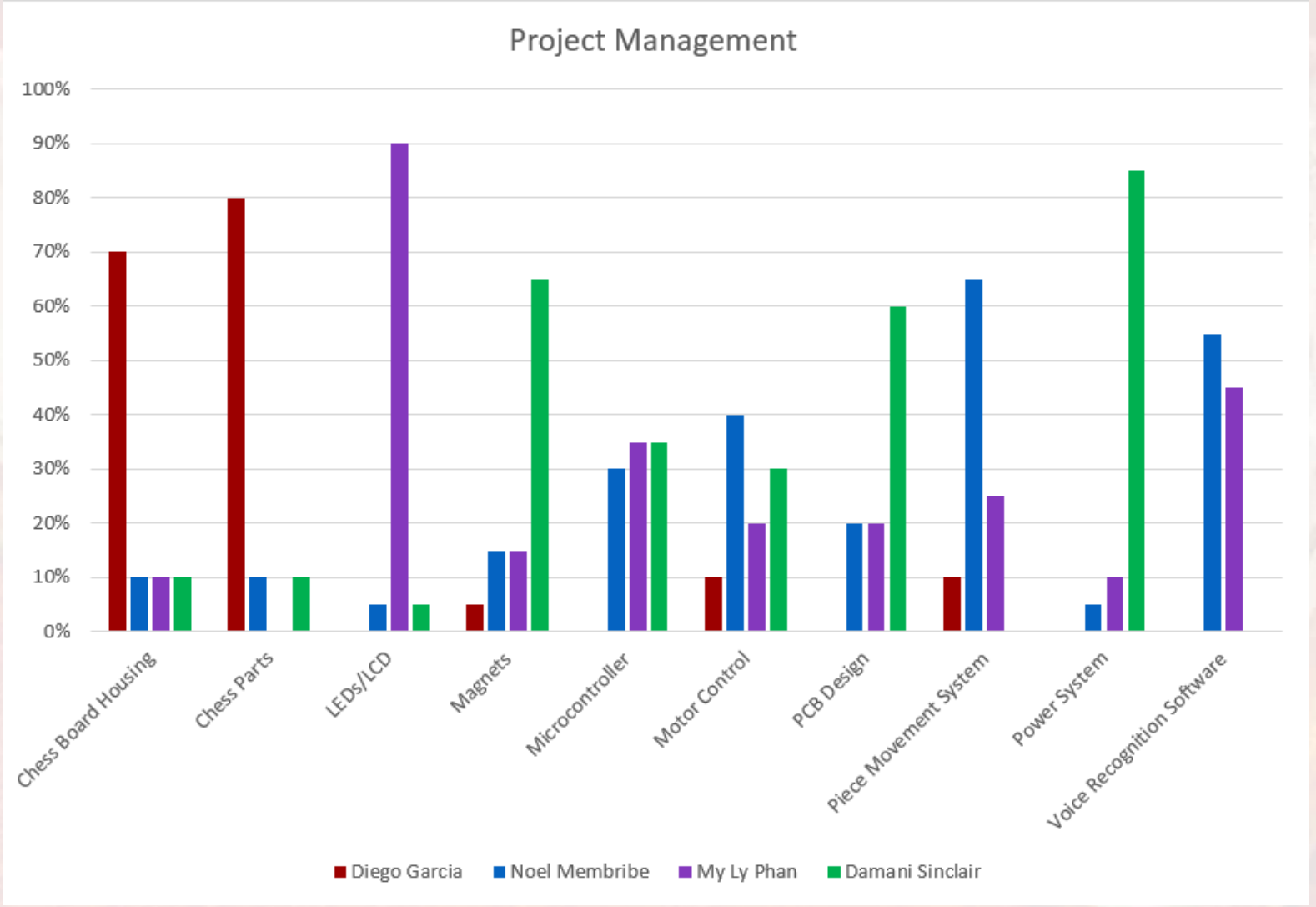
Programming

- offsetPiece()
  - Moves piece diagonally from the center of the square to one of the corners; this offsets prevents the piece from bumping into another while it’s traveling,
- offsetPiece2()
  - Moves it back to the center after it finishes moving.
- moveLinear(int stepPin, int delayTime)
  - Moves the magnet in a single direction. Called in other functions
- moveDiagonal(int delayTime)]
  - Moves the magnet in two directions at once. Called in other functions
- movePieceDiagonal(int xsteps, int ysteps)
  - Moves a piece to a specified location.

Programming

- movePiece(int steps, int dirPin, int stepPin)
  - Moves a piece to a specified location in one direction.
- graveyard()
  - Used to move a piece to the graveyard location once it has been captured. Once it gets there, it does a de-offset to move the magnet back to center.
- zeroGraveyard()
  - Moves the magnet back to zero after a piece has been sent to graveyard.
- graveyardNoOffset()
  - Moves the magnet to graveyard without offset and without turning it on; used for testing and troubleshooting
- reeset()
  - Moves the magnet to zero and resets all the variables that store piece locations. Used to reset the game without needing to reset the microcontroller.

Project Management



Project Budget and Financing

Item	Price	Quantity	Tax & Shipping	Subtotal
Plywood	$35.95	1	$2.52	$38.47
Plexiglass	$29.78	1	$2.08	$31.86
Chess Piece Set	$15.00	1	-	$15.00
ATmega 2560 Microcontroller	$10.24	3	$11.14	$41.86
Generic Sunfounder Development Board	$13.99	1	-	$13.99
XY-Plotter	$299.99	1	-	$299.99
Electromagnet	$11.53	1	-	$11.53
Voltage Regulator	$2.20	1	$4.81	$7.01
Standard Power Outlet	$6.86	1	-	$6.86
PCB Manufacturing 1st Design	$20.00	5	-	$20.00
PCB Manufacturing Final Design	$67.35	3	-	$67.35
LEDs/Cosmetic Lights	$50.00	2	-	$50.00
LCD Screen	$14.99	1	-	$14.99
Miscellaneous	$150.00	-	-	$150.00
Total				**$768.91**

Conclusion

- The final product consists of a system that resembles a game of chess, with the capability to have the players issue voice commands and have the pieces move without any physical contact during play.
- This was implemented by using an electromagnet mounted on an apparatus where it is controlled via stepper motors. These stepper motors are controlled by a microcontroller that is analyzing serial data coming from a voice recognition software.
- The main objectives were achieved. However, in a future project or with more time there are many extra features that could be added to this project.