ASSISTIVE CHESSBOARD

TEAM 37

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INTRODUCTION

- Chess is popular, but complicated
- Problem: Hard to learn
- Solution: Assistive Chessboard
  - Physical Board
  - Magnetic Sensing
  - LED signaling

OBJECTIVES

- Accurately detect piece type
- Display potential moves
- Signal invalid moves

SYSTEM OVERVIEW

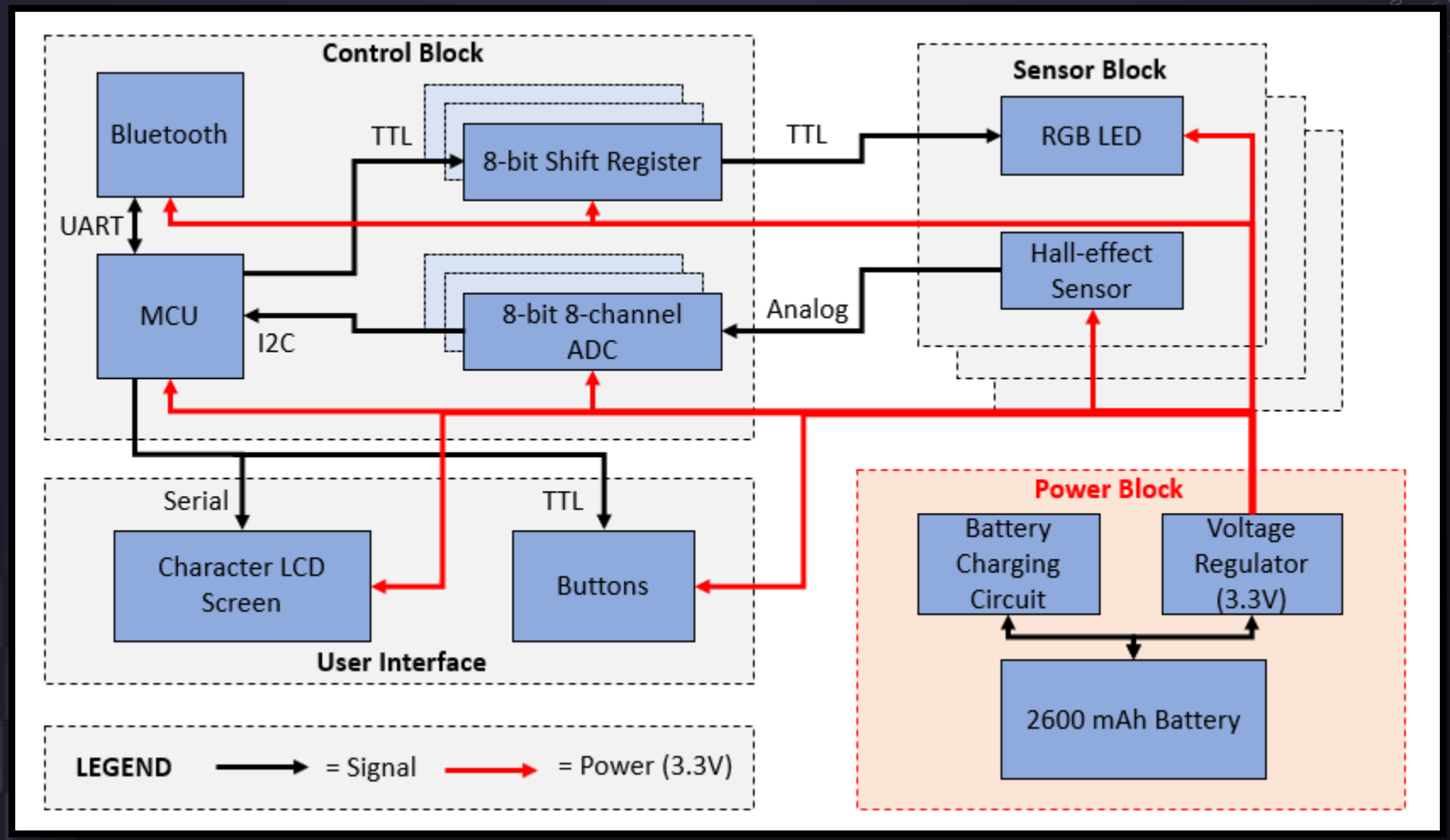
Hardware

- Sensor Boards (x64)
- Control Boards (x3)
- Power Board
- Bluetooth Module
- Chess Pieces
- Chess Board/UI
  - Machine Shop

Software

- MCU
- Bluetooth App

BLOCK DIAGRAM



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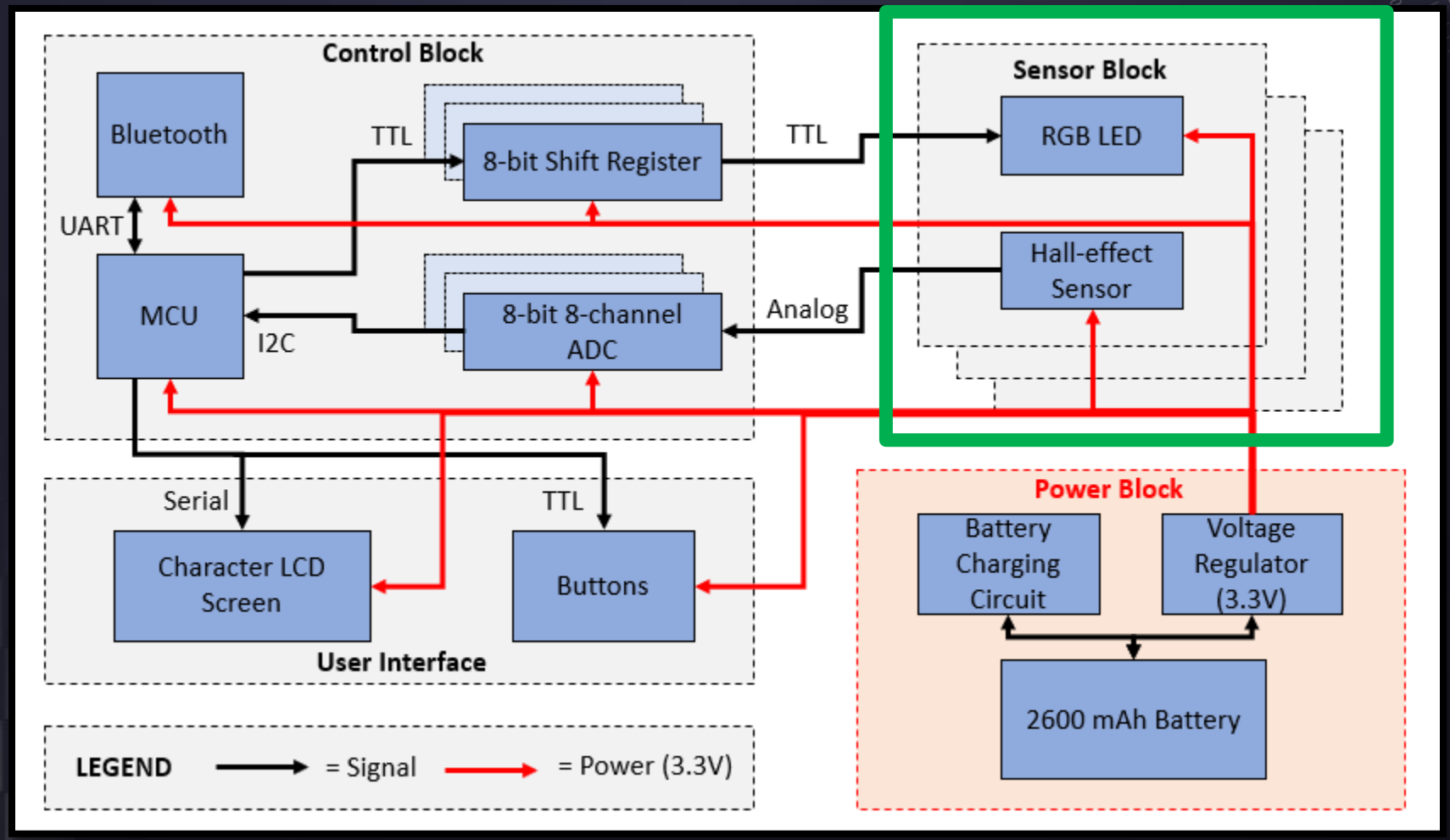
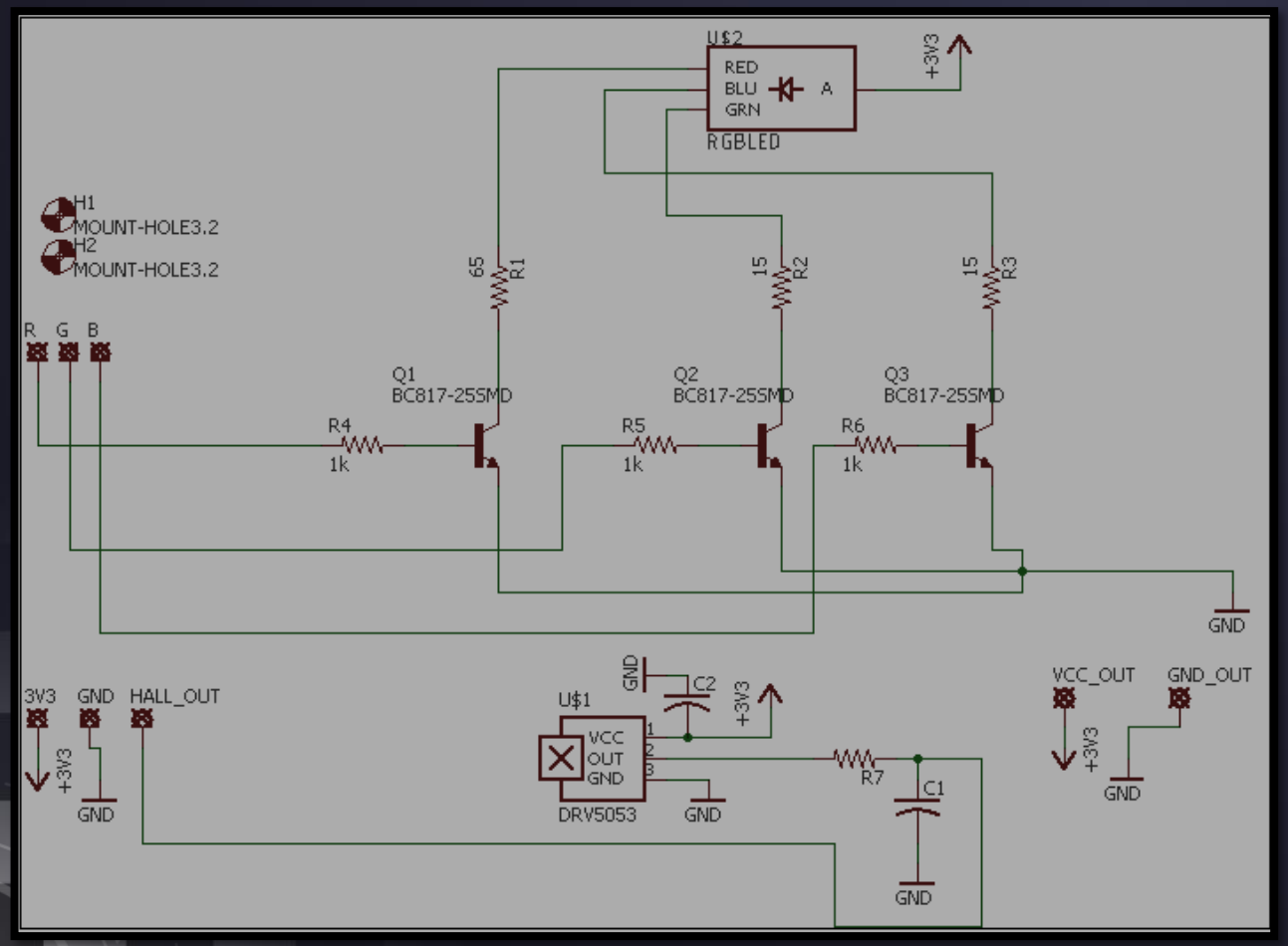
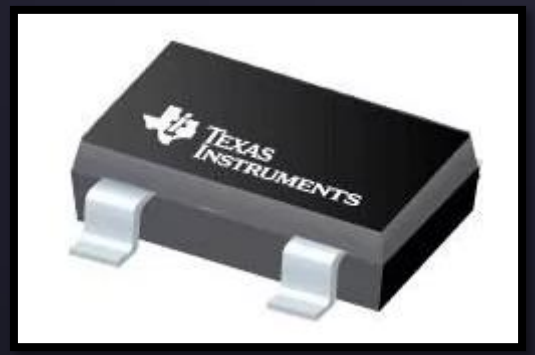


DESIGN: SENSOR BOARDS

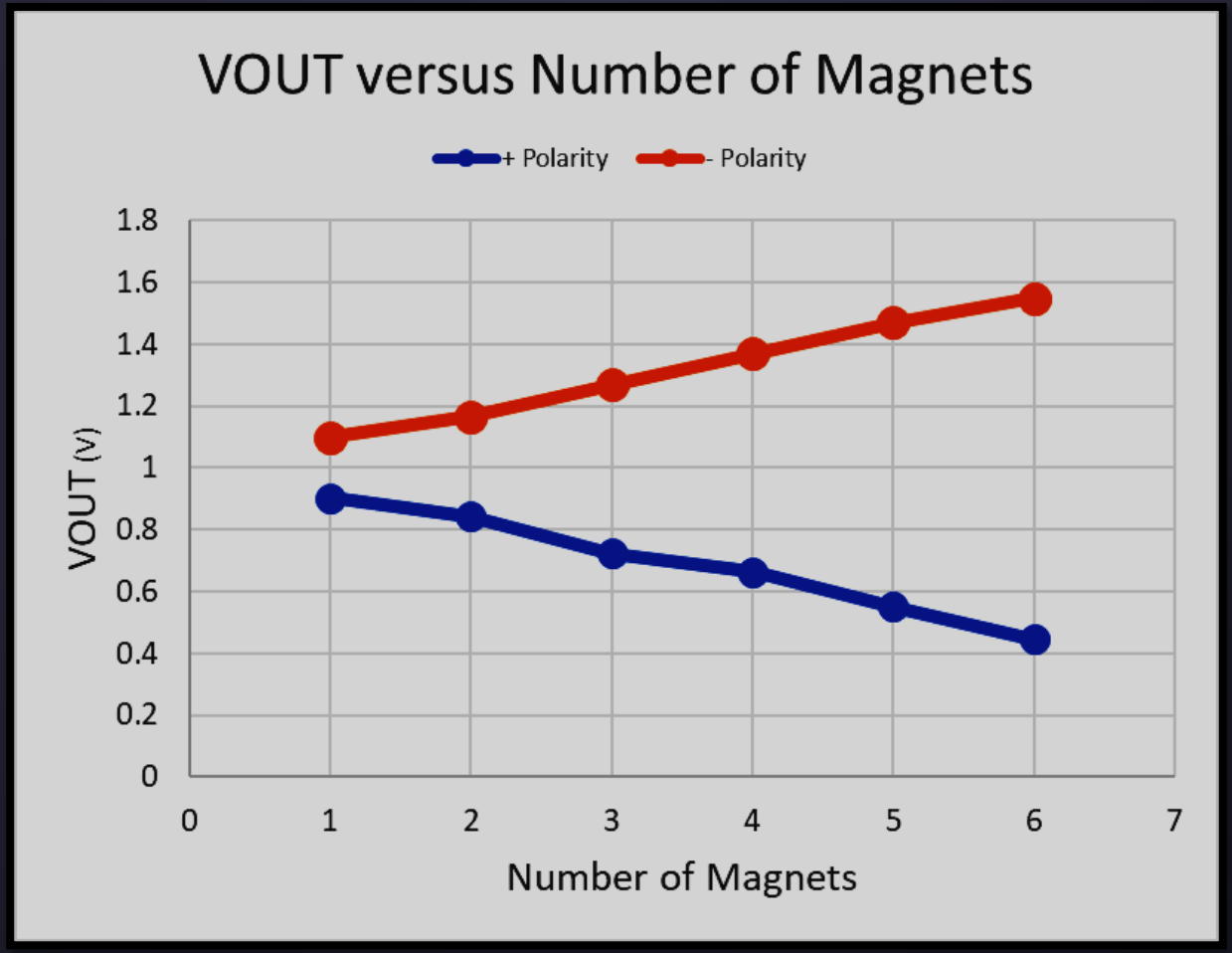


DESIGN: SENSOR BOARDS
HALL-EFFECT SENSORS

- Requirements:
  - Linear analog voltage output
  - Can distinguish polarity
  - 0-2 V output voltage range
- Selected sensor: TI DRV5053OA Hall-Effect Sensor [1]

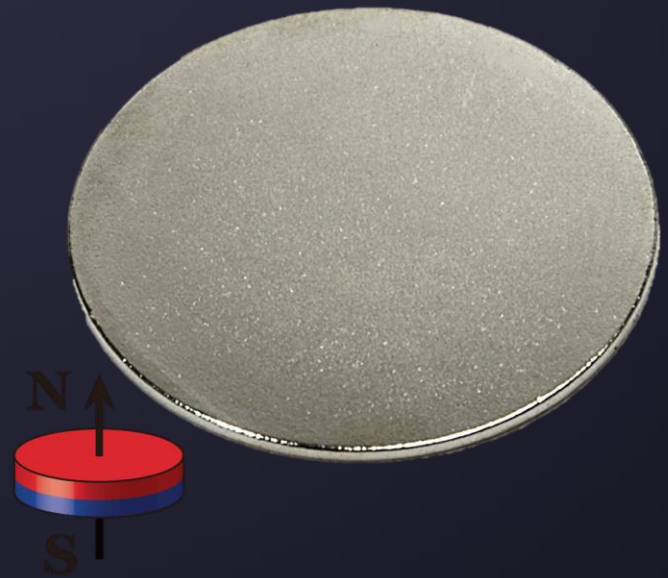


DESIGN: SENSOR BOARDS
HALL-EFFECT SENSORS

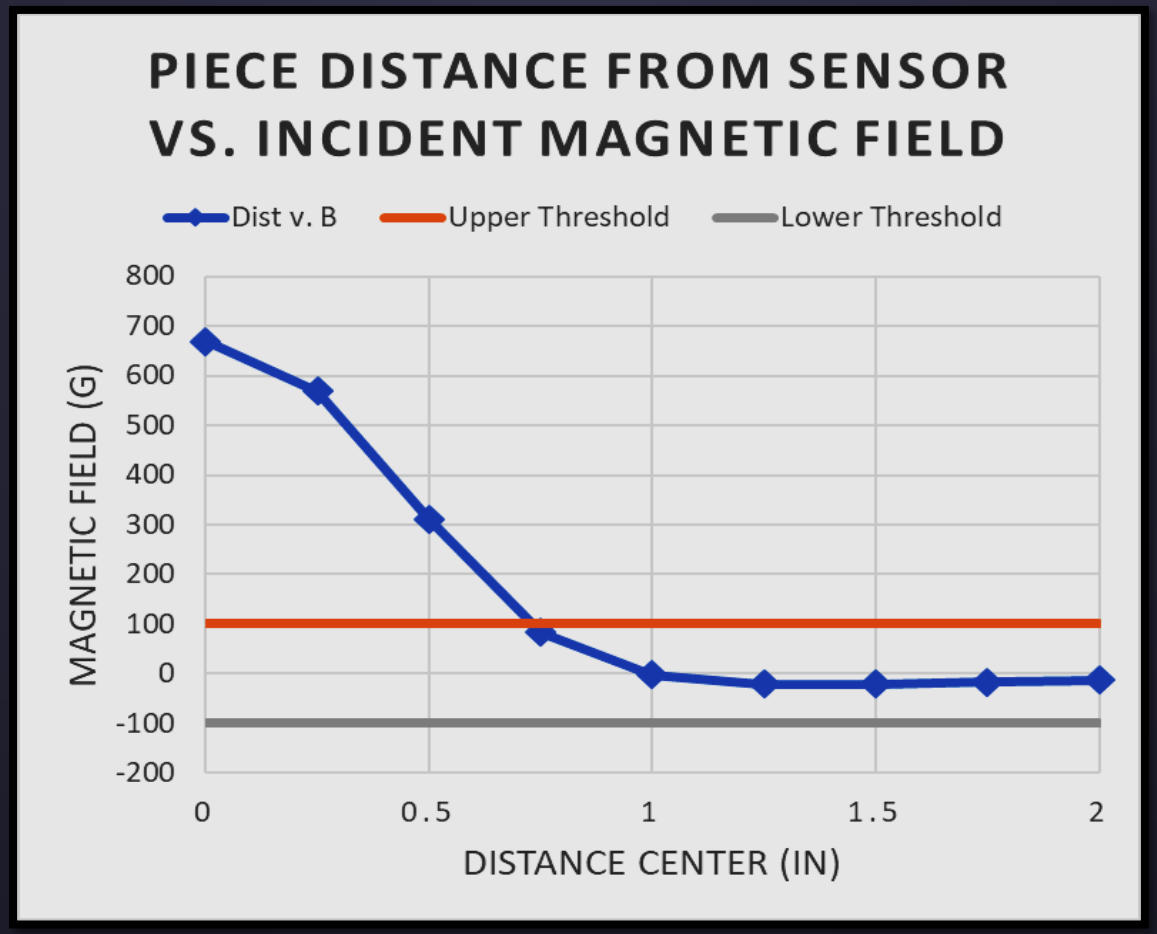


DESIGN: SENSOR BOARDS
MAGNETS

- Requirements:
  - Within Hall-Effect range
  - Avoid interference effects
  - Fits on chess piece
- Selected Magnets: N42 1” x 1/32” Neodymium Magnets [2]



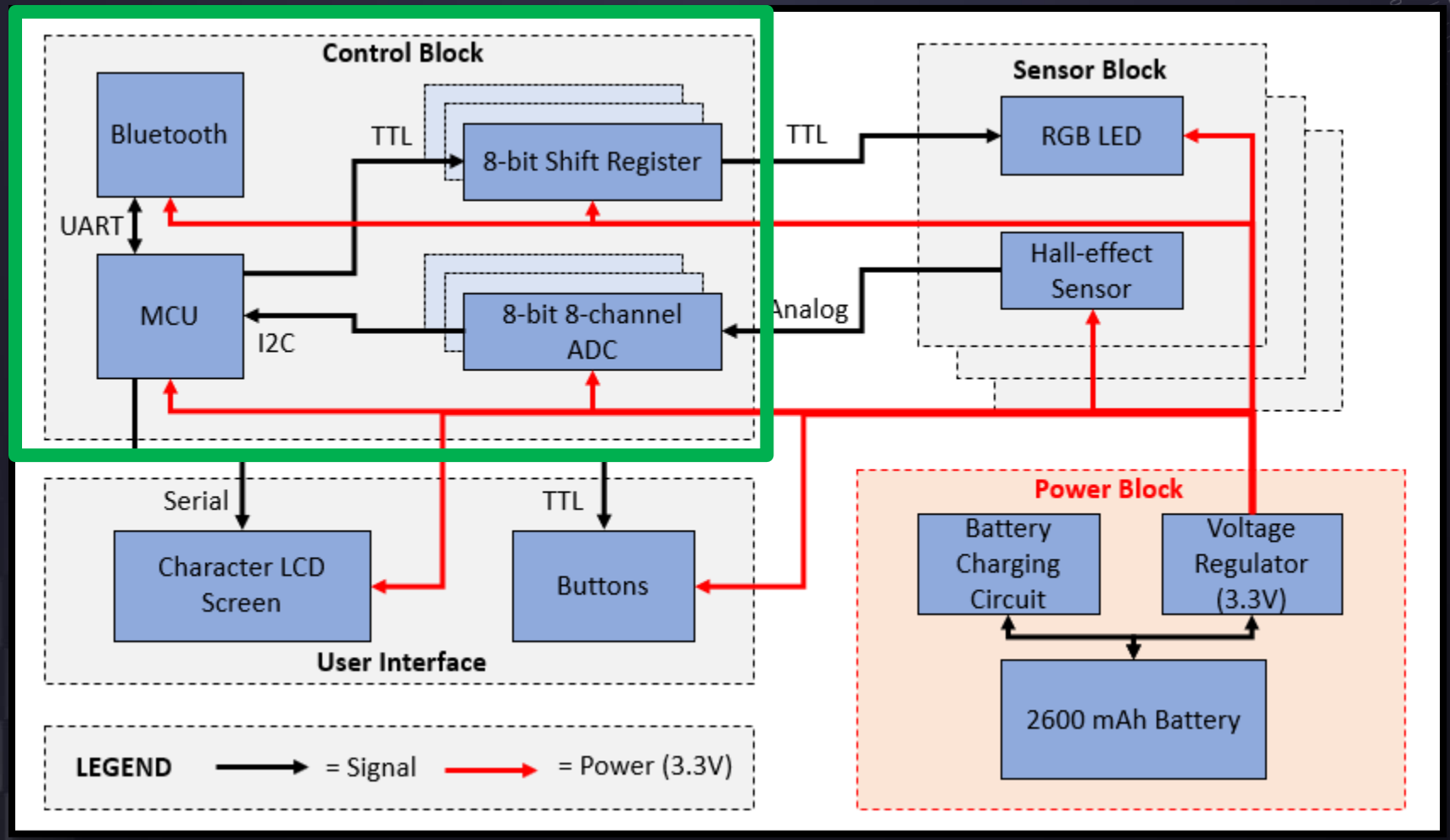
DESIGN: SENSOR BOARDS
MAGNETS



DESIGN SENSOR BOARDS
LEDS

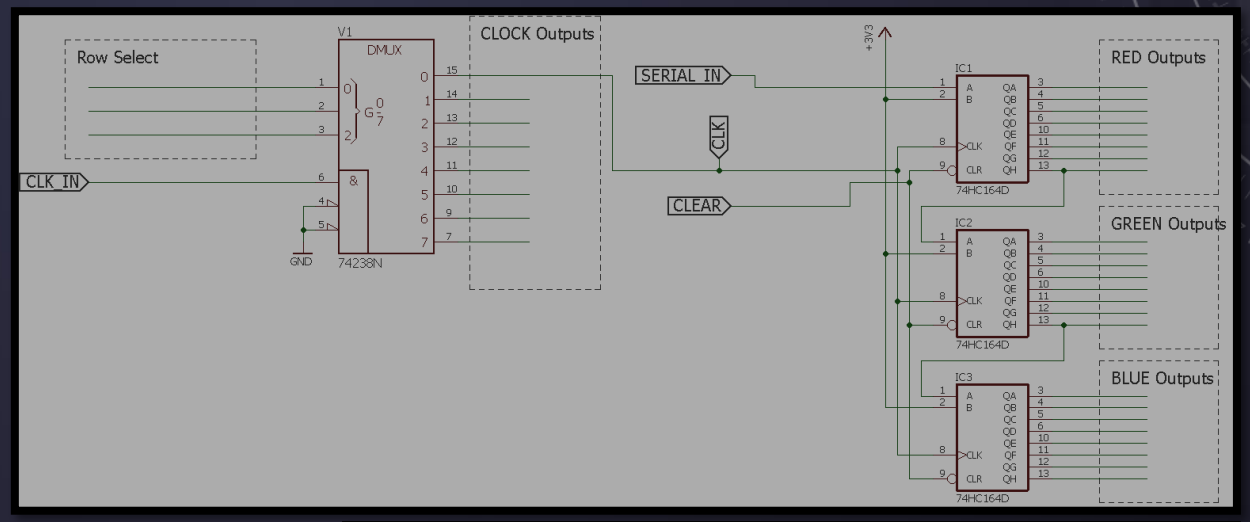
- Requirements:
  - 3 colors (RGB)
- Selected LED: Chanzon RGB LED [3]
- LED resistor calculation:
  - $R = \frac{V_{DD} - V_{LED}}{I_{LED}}$
  - $R = \frac{3.3\,V - 2.0\,V}{20\,mA}$
  - $R = 65\,\Omega$

BLOCK DIAGRAM

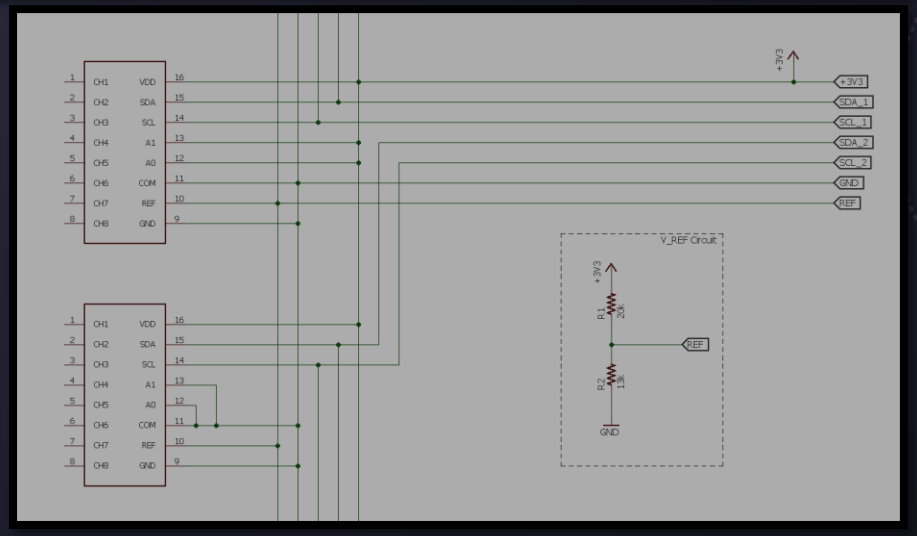


DESIGN: CONTROL BLOCK
SIGNAL INTERFACE

- Control LEDs

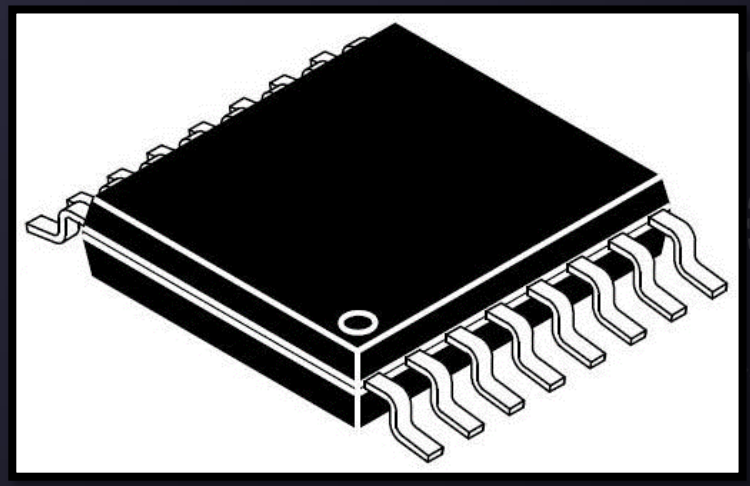


- Receive Hall-Effect readings



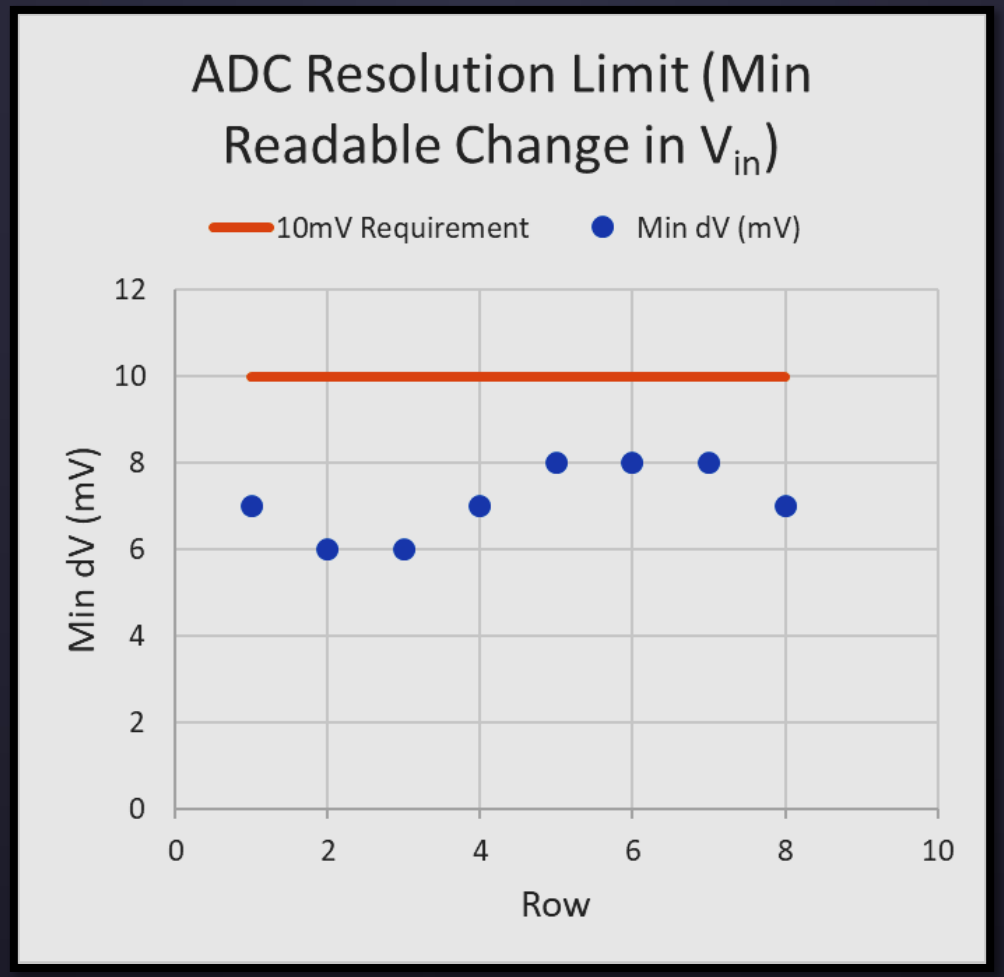
DESIGN: SIGNAL INTERFACE
HALL-EFFECT INTERFACE

- Requirements:
  - 0-2 V input range
  - 10 mV resolution
  - 8 input channels
  - I2C communication
- Selected ADC: ON Semiconductor's NCD 9830 [4]



DESIGN: SIGNAL INTERFACE

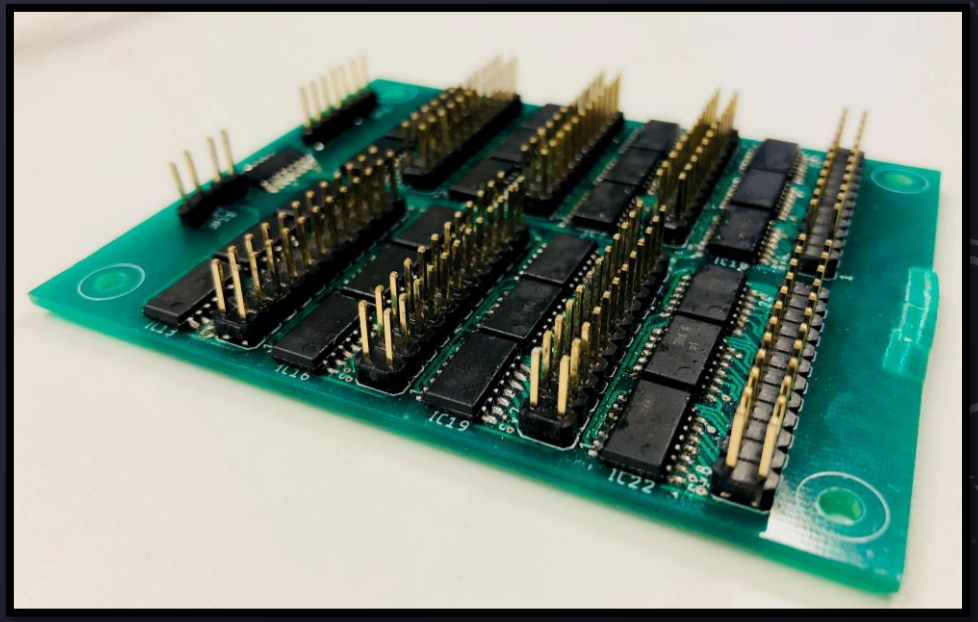
HALL-EFFECT INTERFACE



DESIGN: SIGNAL INTERFACE
LED SELECTOR CIRCUIT

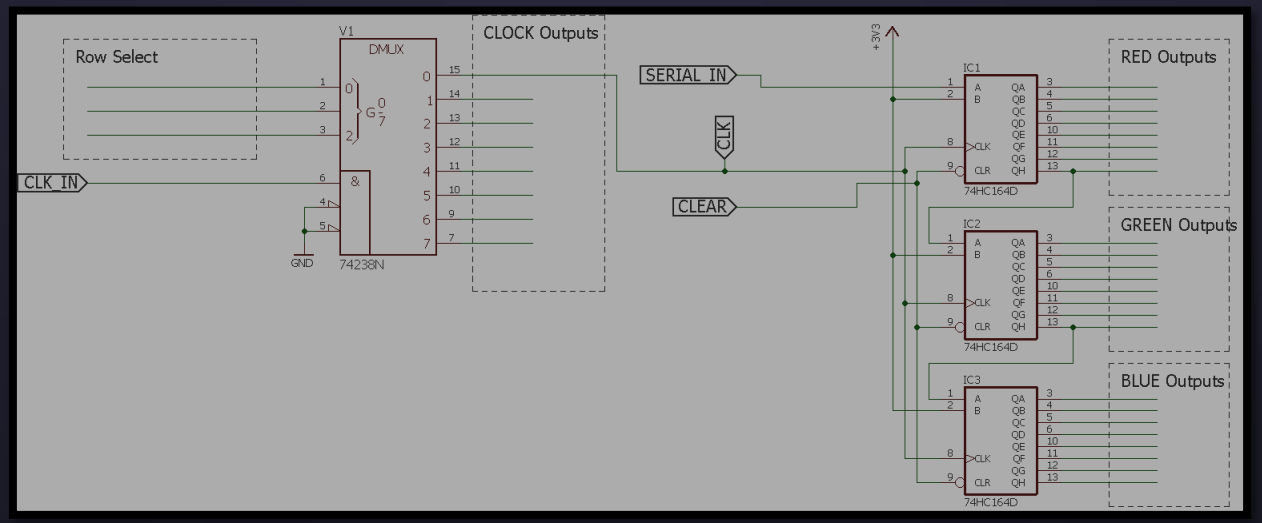
- Requirements:
  - 8-channel demultiplexers
  - 8-bit shift registers
  - Parallel output shift registers
- Selected Parts:
  - Demux: ON Semiconductor's MC74HC238A Demultiplexer [5]
  - Shift Registers: TI's SN74HC164 8-bit Shift Register [6]

Signal Sent	Total Correct	% Correct
High (3.3V)	64/64	100%
Low (0.0V)	64/64	100%



DESIGN: SIGNAL INTERFACE
LED SELECTOR CIRCUIT

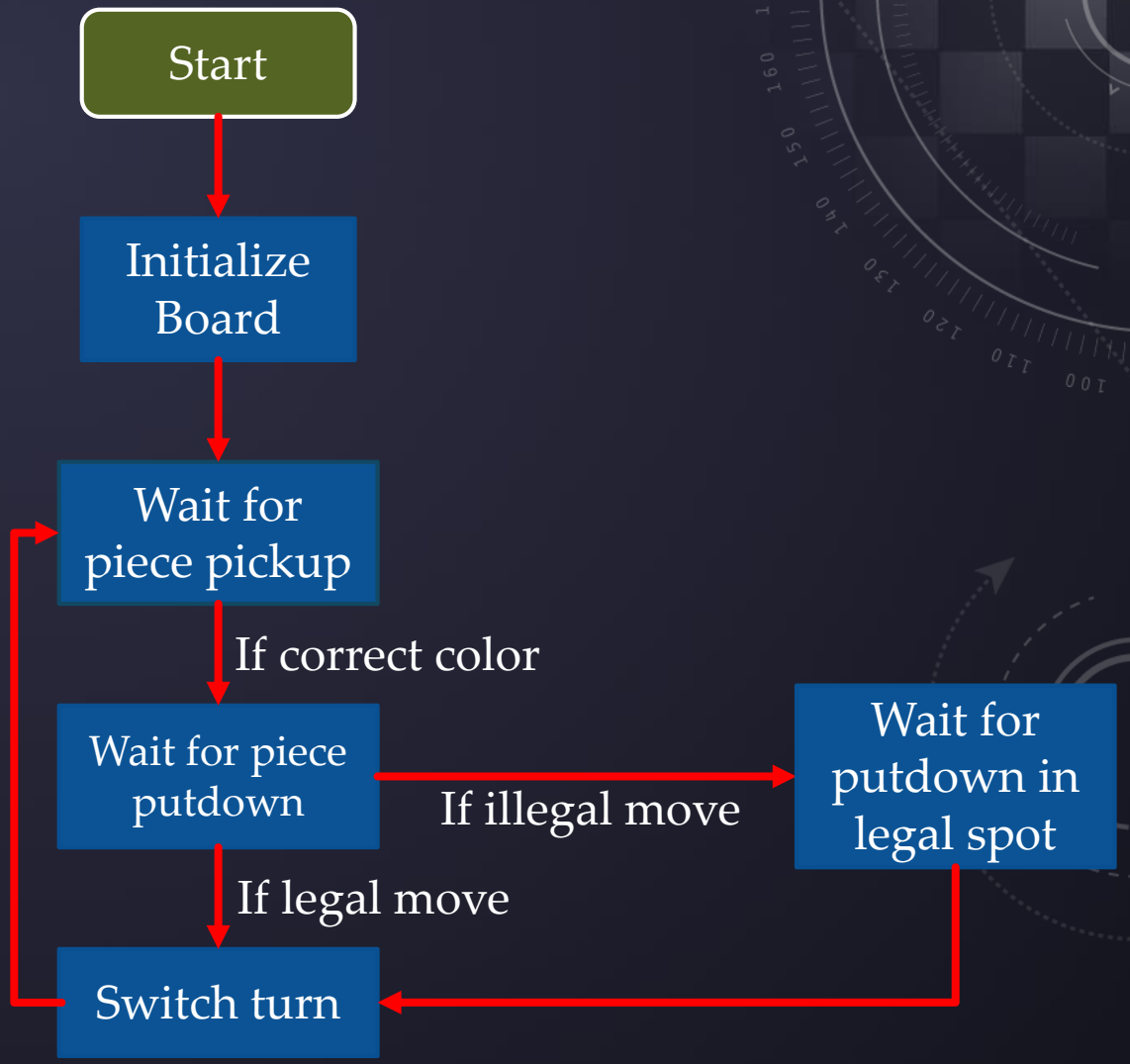
- Alternate Options:
  - Demultiplexer circuit: 33 MUXs, 192 latches
  - Shift register circuit: 24 SRs, 16 MCU outputs
  - Matrix LED control
- MUX and SR combination



DESIGN: CONTROL BLOCK

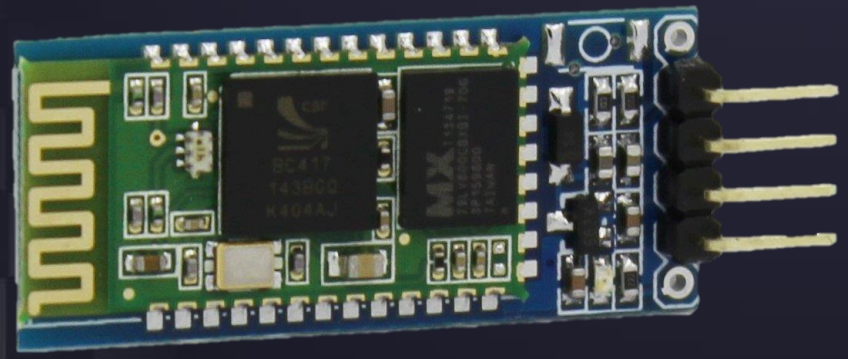
MCU

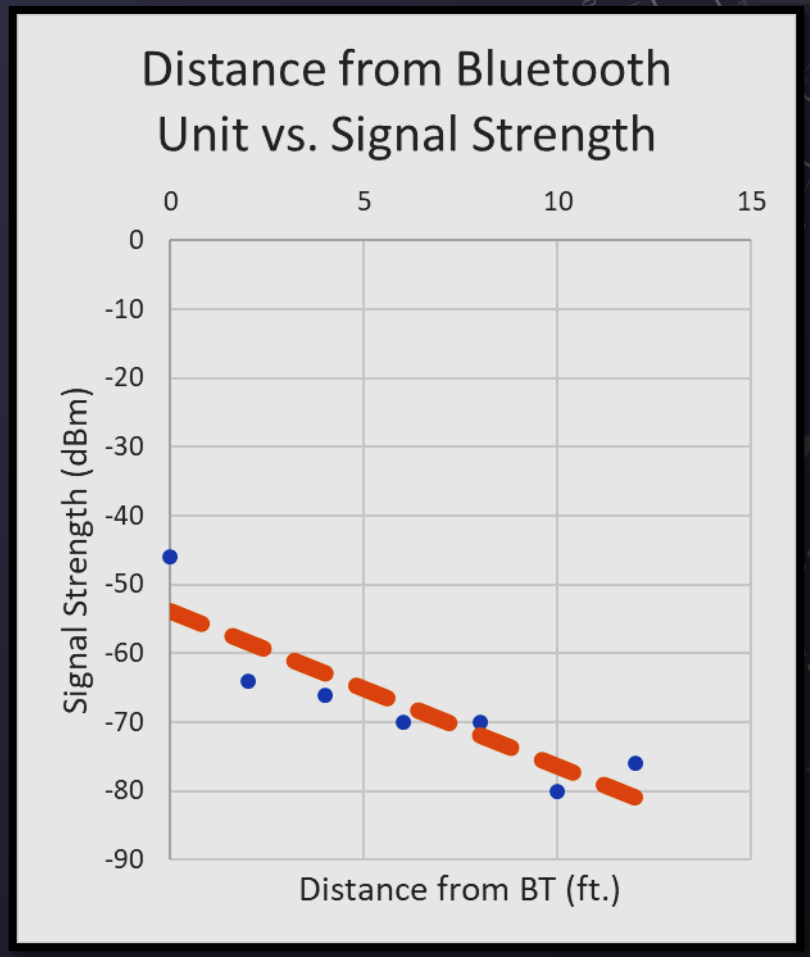
- Requirements:
  - UART to Bluetooth
  - GPIO to LED/LCD
  - I2C communication
  - At least 1 kB FRAM
- Selected MCU: TI's MSP430FR5962 [7]



DESIGN: CONTROL BLOCK
BLUETOOTH

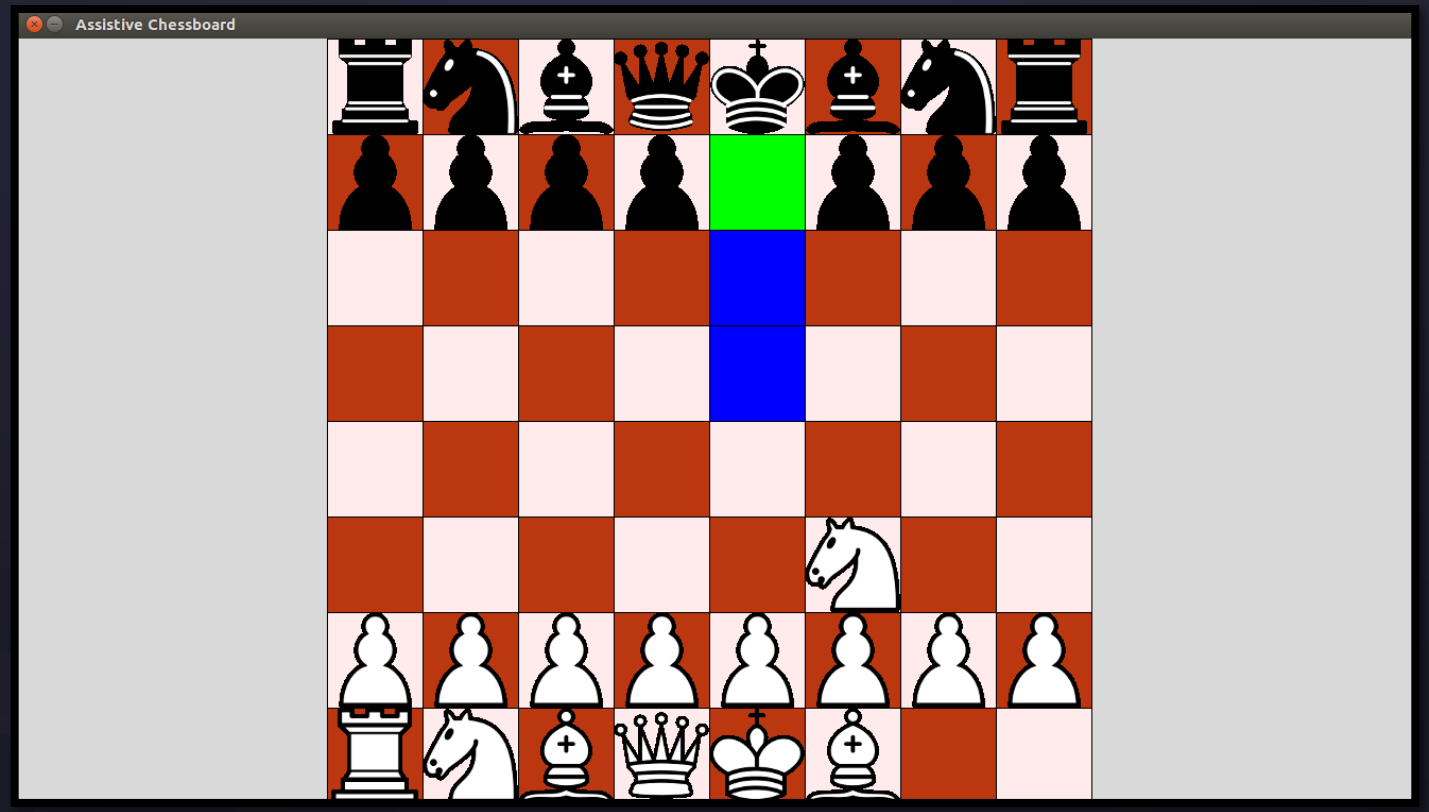
- Requirements:
  - UART interface
  - >10 foot range
  - Compatible with Bluetooth 2.0
- Selected Device: HC06 [8]





DESIGN: CONTROL BLOCK
BLUETOOTH APP

- Python app to interface with board
- Only receives info



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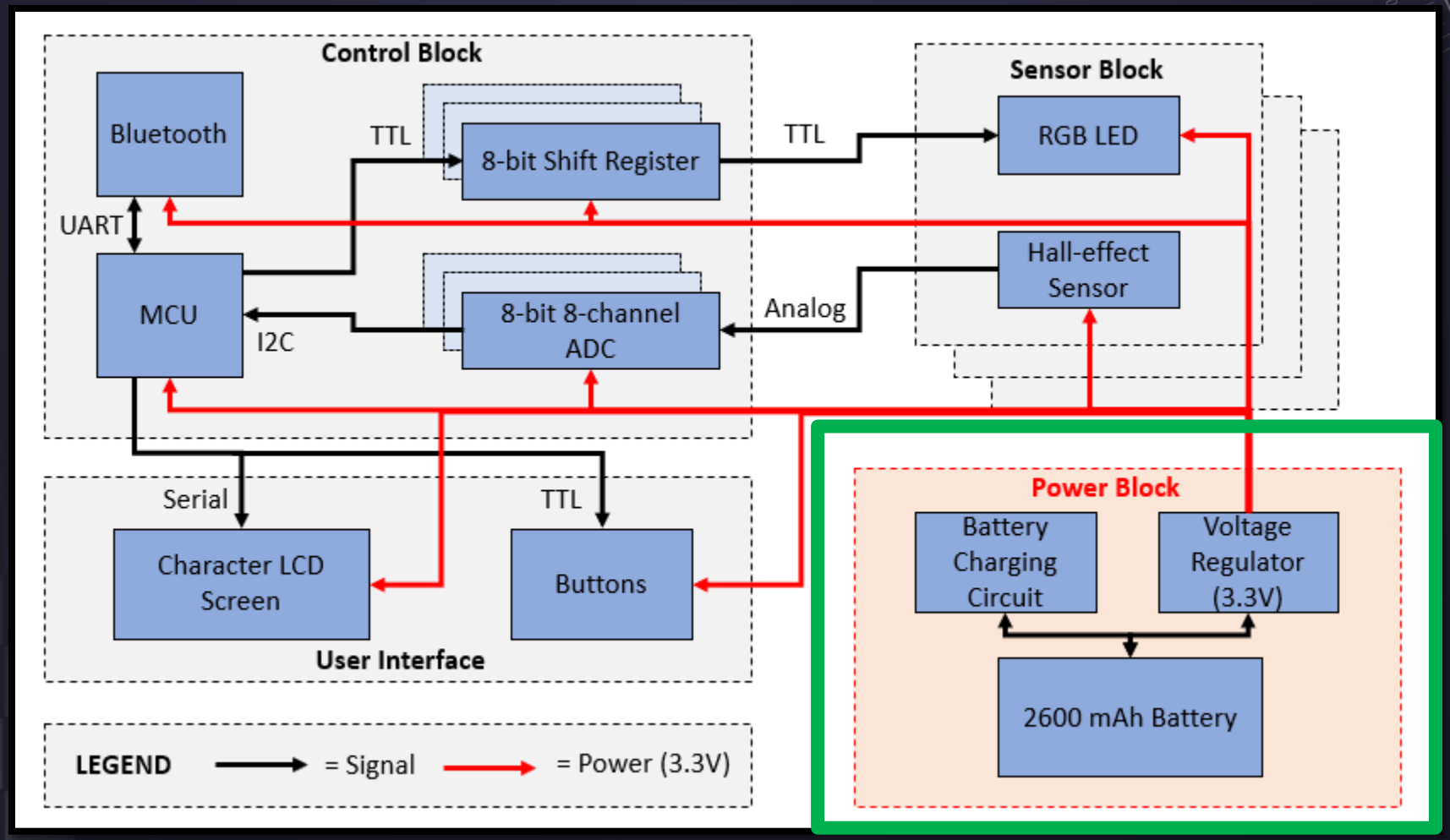


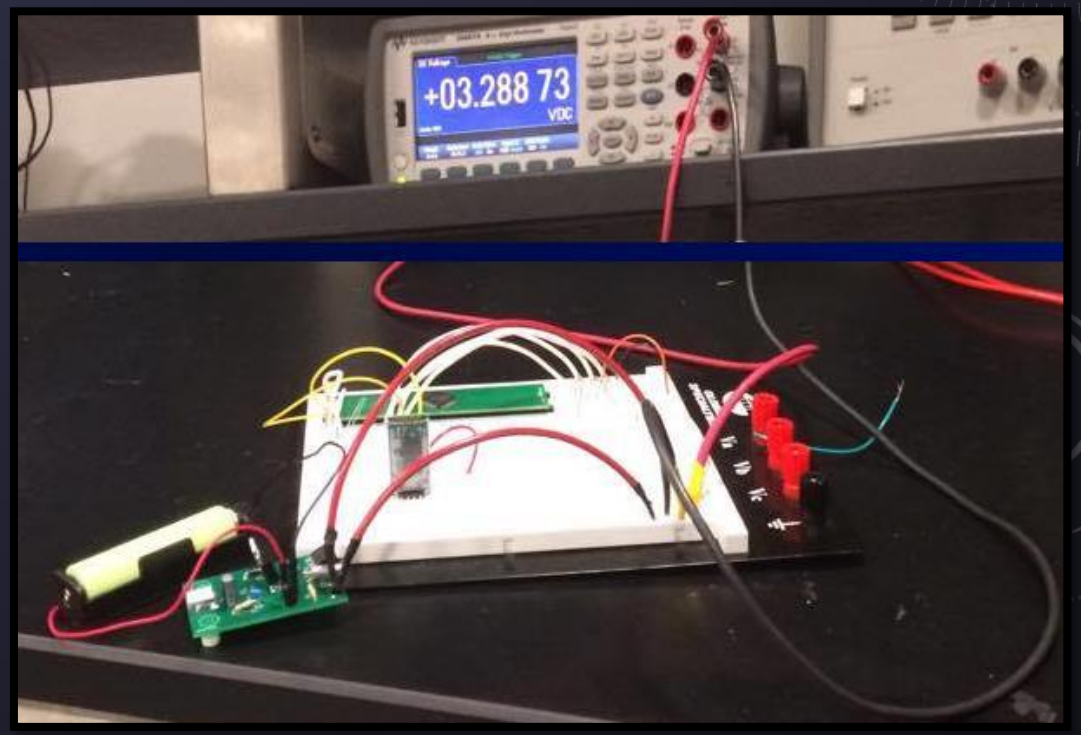
DESIGN: POWER

CONSUMPTION CALCULATIONS

Part	Current per Part	# of Parts	Max Current Consumption	Average Current Consumption
Hall-Effect Sensor	2.7 mA	64	172.8 mA	172.8 mA
LED	20 mA	192	3840 mA	80 mA
8-bit ADC	16.5 mA	8	132 mA	132 mA
MCU	1.8 mA	1	1.8 mA	1.8 mA
Bluetooth	150 mA	1	150 mA	150 mA
8-bit SR	80 µA	24	1.92 mA	1.92 mA
LCD Screen	20 mA	1	20 mA	20 mA
Total			4318.52 mA	558.52 mA

DESIGN: POWER

- Requirements:
  - Battery: >3.5V; >2400mAh (4hrs op.)
  - LDO: Limits to 3.3V and >4A
  - Charging: Safely charges Li-Ion
- Selected Parts:
  - Battery: SparkFun 2600 mAh Li-Ion battery [9]
  - LDO: TI TPS755 Low Dropout Voltage Regulator [10]
  - Charging: Maxim MAX1551 Charger [11]



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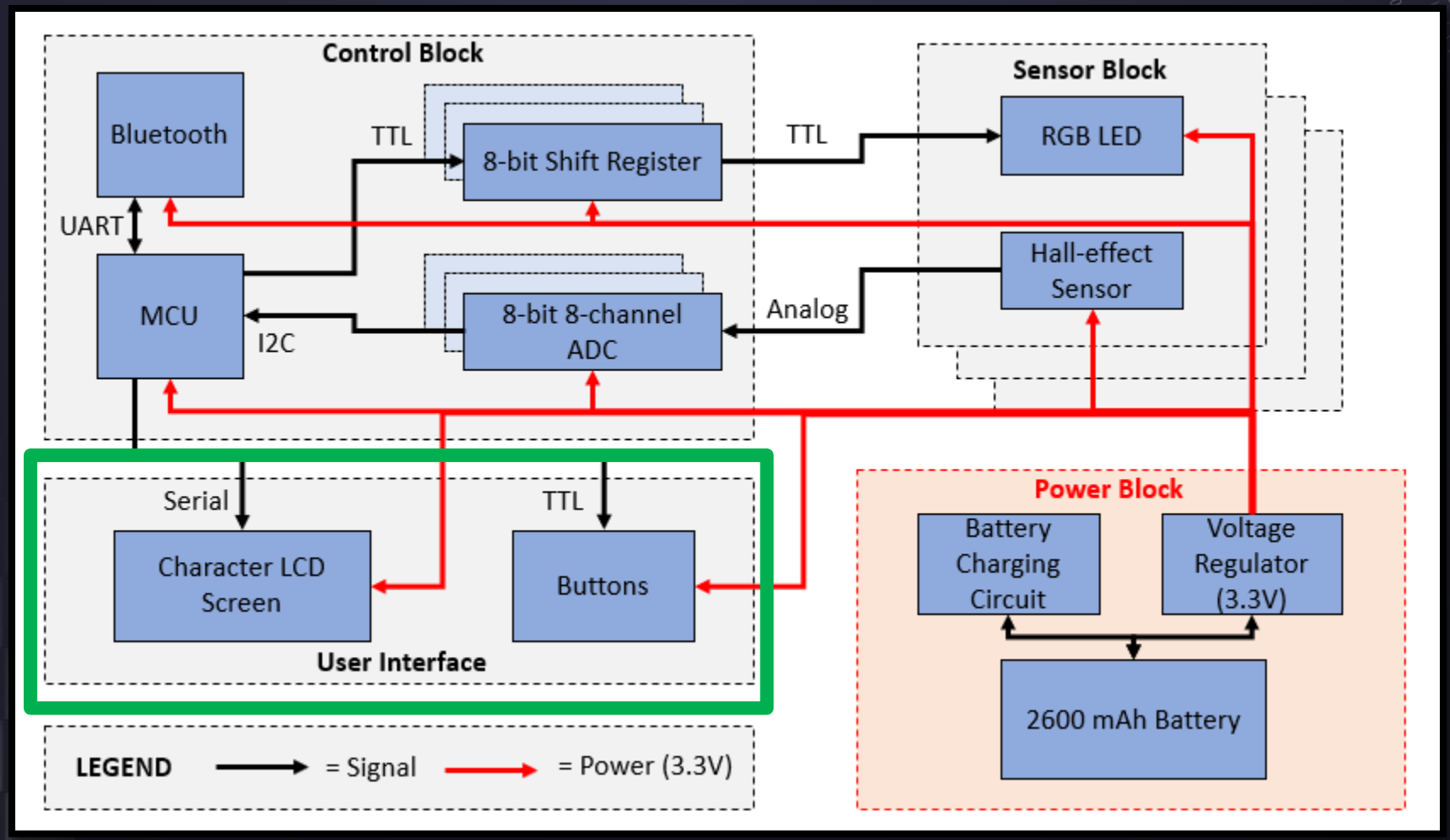
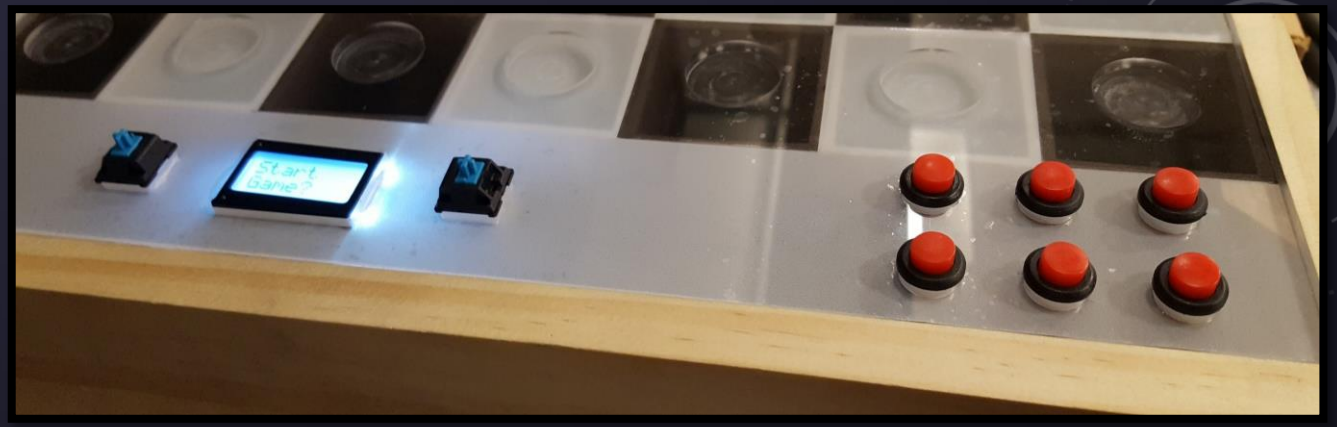


DESIGN: USER INTERFACE

- Requirements:
  - Buttons: Easily pressable
  - LCD: Serial communication with MCU
- Selected Parts:
  - Switches: Cherry MX Blue Switches [12]
  - Buttons: uxcell Buttons [13]
  - LCD: Newhaven 2x8 LCD Display [14]



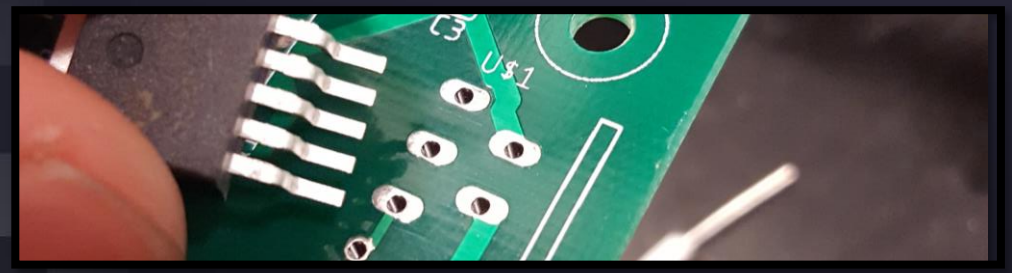
BRINGING IT ALL TOGETHER

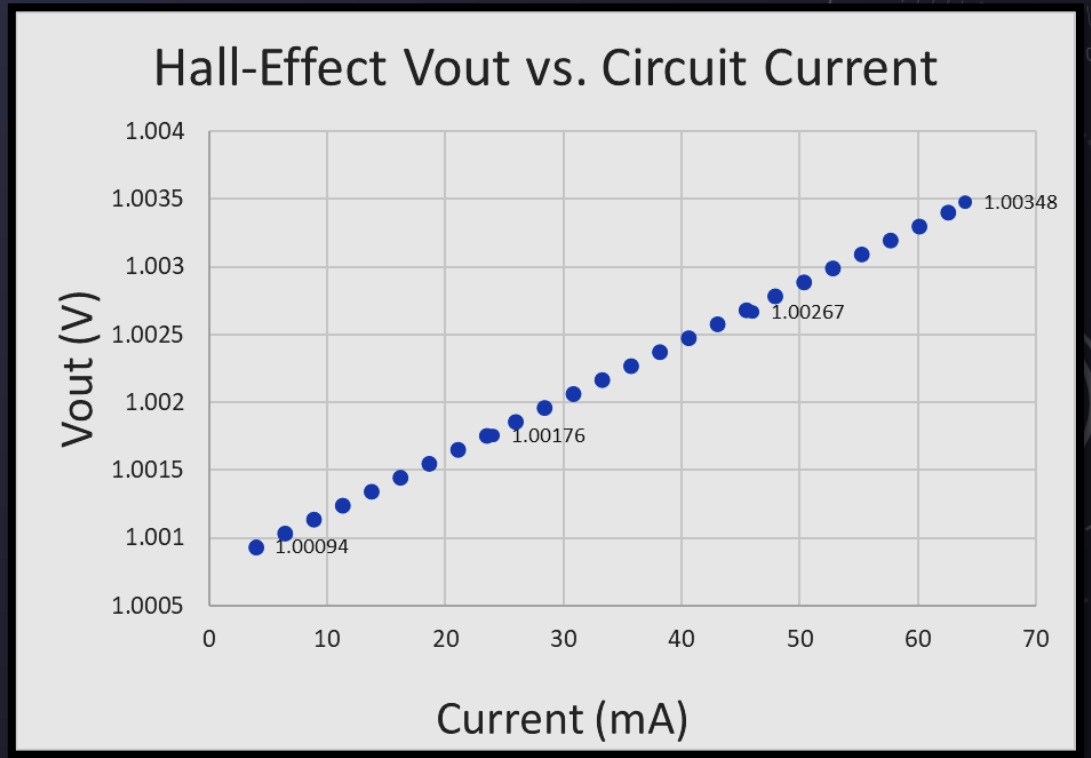
CONCLUSION
WHAT WORKED

- Sensor block read and displayed board
- Control block sent and received data
- Power block regulated power to system
- User interface is reactive

CONCLUSION
WHAT DIDN'T WORK

- Hall-effect output affected by current
- LED Selector circuit suffered a failure
- Chess pieces were unwieldy
- Improper PCB footprints
- Minor gameplay bugs





CONCLUSION
FUTURE IMPROVEMENTS

- Hardware:
  - Closer sensors for weaker magnets
  - More sensors per square; can uncenter pieces
  - Different sensing methods
  - Grid LED Selector
- Software:
  - Skill challenges
  - AI opponent
  - Wireless play

QUESTIONS?

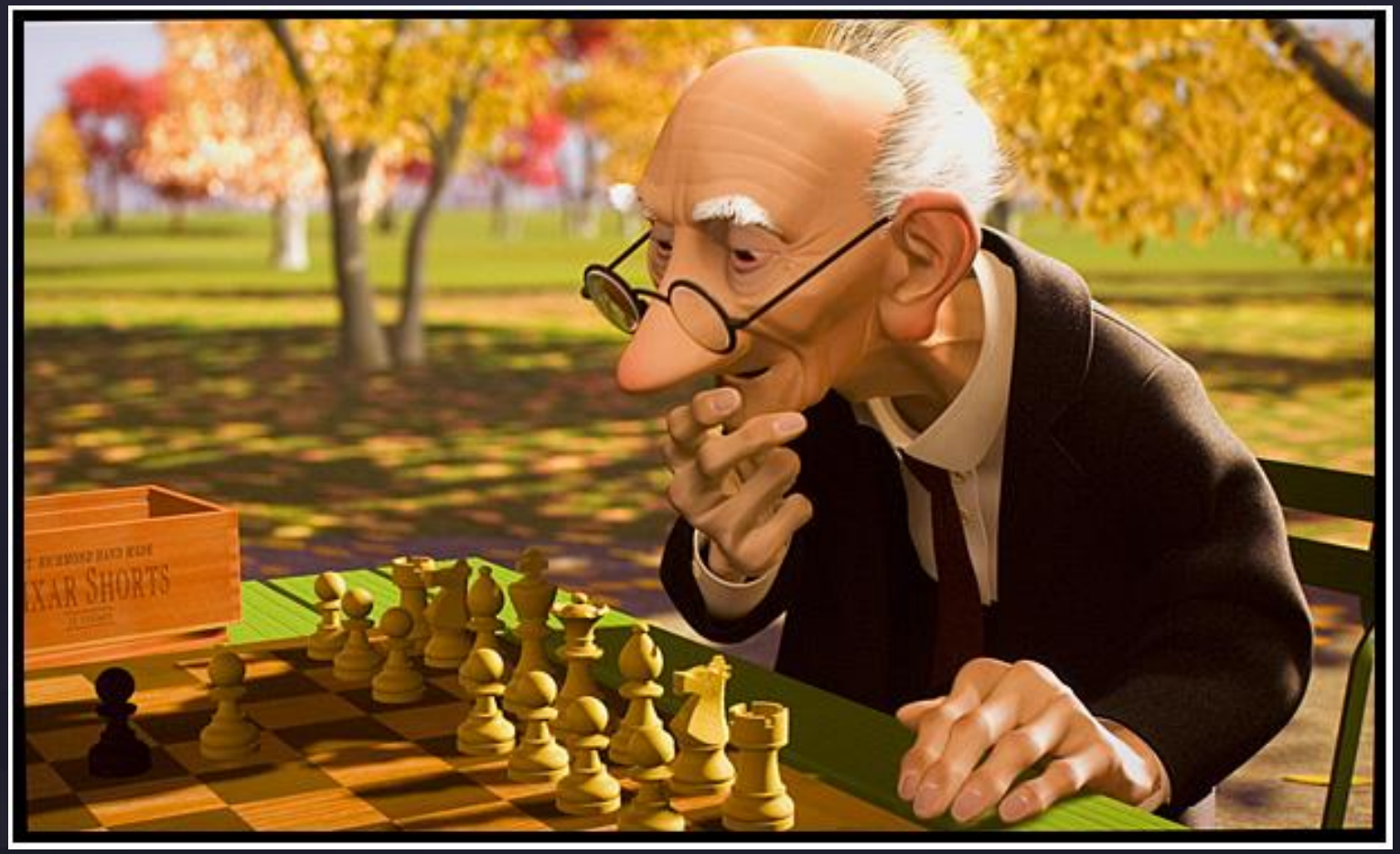


Image Source: http://pixar-animation.weebly.com/uploads/8/7/6/3/8763219/3623372_orig.jpg

SOURCES

[1] http://www.ti.com/lit/ds/symlink/drv5053.pdf

[2] http://www.magnet4sale.com/n42-1x1-32-neodymium-rare-earth-disc-magnet/

[3] https://www.amazon.com/Tricolor-Multicolor-Lighting-Electronics-Components/dp/B01C19ENFK/

[4] http://www.mouser.com/ProductDetail/ON-Semiconductor/NCD9830DBR2G/

[5] http://www.mouser.com/ProductDetail/ON-Semiconductor/MC74HC238ADR2G/

[6] http://www.mouser.com/ProductDetail/Texas-Instruments/SN74HC164NSR/

[7] http://www.mouser.com/ProductDetail/Texas-Instruments/MSP430FR5962IZVWR/

[8] https://www.amazon.com/Pass-Through-Communication-Compatible-Atomic-Market/dp/B00TNOO438

[9] https://www.sparkfun.com/products/12895

[10] http://www.mouser.com/ProductDetail/Texas-Instruments/TPS75533KTTT/

[11] http://www.mouser.com/new/maxim-integrated/max1551max1555/

[12] https://mechanicalkeyboards.com/shop/index.php?l=product_detail&p=1041

[13] https://www.amazon.com/dp/B0094GP7SQ/

[14] https://www.digikey.com/product-detail/en/newhaven-display-intl/NHD-0208AZ-FSW-GBW-33V3/2773587