Smart Table
Group 34

MEMBERS

Ryan Mulvaney (EE)

Christopher Rodrigue (EE)

Phillip Murphy (CpE)

Jonathan Lundstrom (CpE)

Goals and Objectives

- Create a 32 x 16 digital display
- Application Program Interface (API)
- Fully self-contained
- Wirelessly controlled
- Scaleable

Features and Specifications

- Minimum 256 pixel resolution
- Software Functionality to include:
  - Various animations for startup, loading, and transitioning
  - Timekeeping, including time and date
  - Playing games
- Minimums 15 Hz refresh rate
- Minimum 3 apps
- Powered by 120v AC
- Wireless connectivity
- Production cost under $1,000

Project Overview

- Build a digital display
  - Resolution of 16x32 pixels @ 30Hz
- Powered by 120v AC
- Microcontroller drive the logic and processing
  - Microcontroller handles all processing for the various functions required
- Bluetooth communications
  - Bluetooth 2.1
- Android app for control
  - Essentially using an android device as the main controller for the table

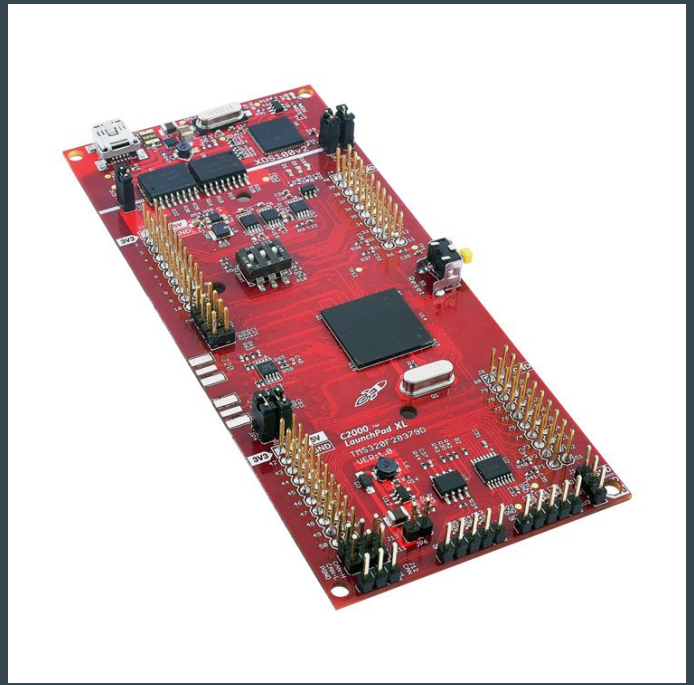
Microcontroller

Microcontroller Considerations

Microcontroller	Pros	Cons	Final Decision
MSP430FR6989	16MHz, 128KB Memory	Flash memory is locked to 8MHz	Passed over due to flash memory speed concerns
MSP430F6659	20MHz and overclockable, 512KB memory, 66KB ram	Possible not enough processing power	Passed over due to costly software functions
TMS320F28379D	200MHz Dual Core, 1MB flash, 204KB ram	Complex MCU	Picked for matching software needs

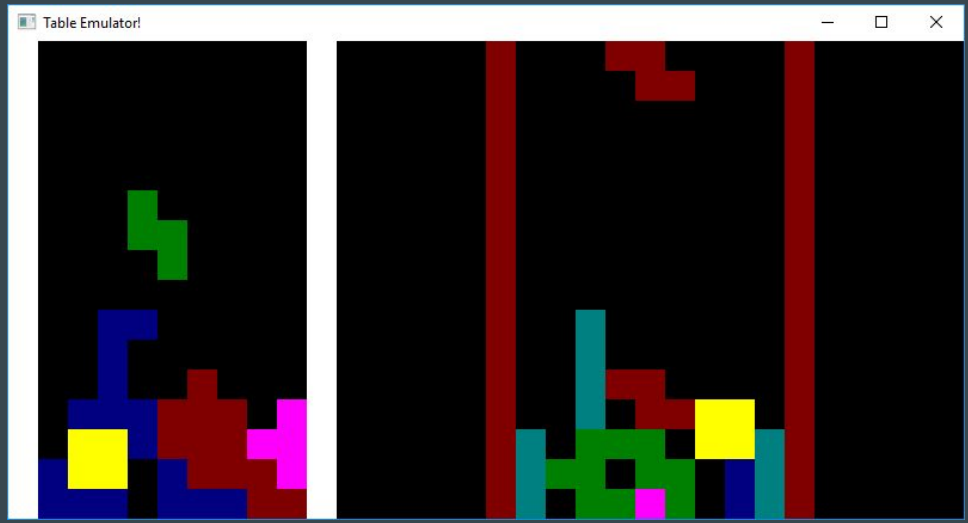
Microcontroller Specifications

- C2000 Delfino F28379D microprocessor
- 200MHz Dual-Core MCU
- Multiple Hardware Mathematic Accelerators
- Includes all the expected communications and analog subsystems
- Includes Enhanced PWM
- Power supply for Core 1.2V and I/O 3.3V
- Display Core
  - Non Buffered Video
  - Scalable to 87,040 LEDs (320 x 256)
- Application/Input Core
  - Prepares the next frame
  - Process interrupts for Bluetooth
  - Controls application flow



Microcontroller Application Testing and Integration

- Simulation can be utilized in place of functional hardware
- Pros
  - Easier debugging
  - No additional hardware
  - Allows code to be ported to other platforms
- Cons
  - Limited color options
  - Can’t test hardware specific issues
  - Requires hardware specific things to be abstracted



Microcontroller General Concerns

- Code Composer Studio issues
  - Programming multiple cores
  - Untested examples
  - Major changes between versions
- Architectural complexity
  - Multicore functionality
  - Layered interfaces
  - Did it work?
  - ESTOP0

Display

Display Types Considerations

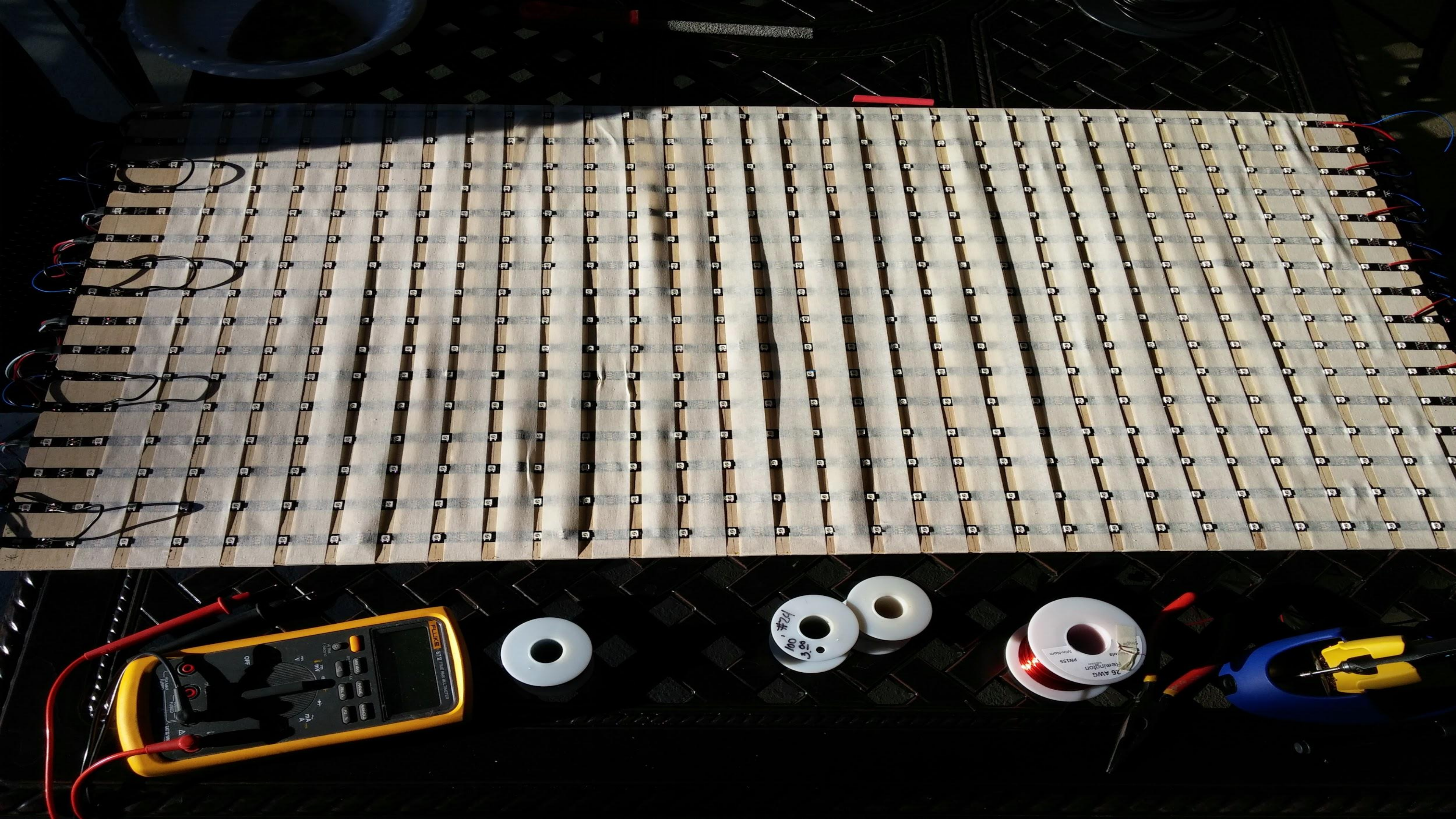
	Pros	Cons
Multiplexing	Refresh Rate, easy to debug	Wiring difficulty, minimum solder joints 2,048
SPI	Easily controllable, expandable	Number of control lines required, cost
WS2811/2812	Cheap, single data line for communications	Communication protocol overhead

Display Control Considerations

- The WS2812 LED strips are ideal because they are flexible and easy to implement due to the reduced amount of soldering involved
- The cost is competitive compared to other methods, especially factoring in soldering time for the various other methods
- Communication is relatively straightforward but not

Display Control Specifications

- WS2812 LED strips
- Each LED chip is digitally controllable and deals with its own power control and signal shaping
- 30Hz refresh rate
- Scaleable up to 1024 LEDs per run
    - This, however, is limited by the power required to run such a setup


FLUKE
26 AWG
Remington

Physical Build Considerations

- Size of LED strips, and working around spacing
  - The strips are a set length with a defined density, how does this affect the design?
  - What about excess space on the table design?

- Retrofitting a table or building from scratch
  - Which is both easier and has a cleaner result?
  - Cost of a normal table is around $100
  - Cost of building is around $100
  - Therefore other issues must be considered

Wireless Communications

Wireless Communication Considerations

- Need a method to wirelessly control the table
  - Bluetooth has several advantages over Wi-Fi and infrared
- Need to have high compatibility with mobile devices
  - Bluetooth is nearly universal
- Need to support two simultaneous users for multiplayer gaming
  - Thus, two modules are necessary

Wireless Considerations Cont.

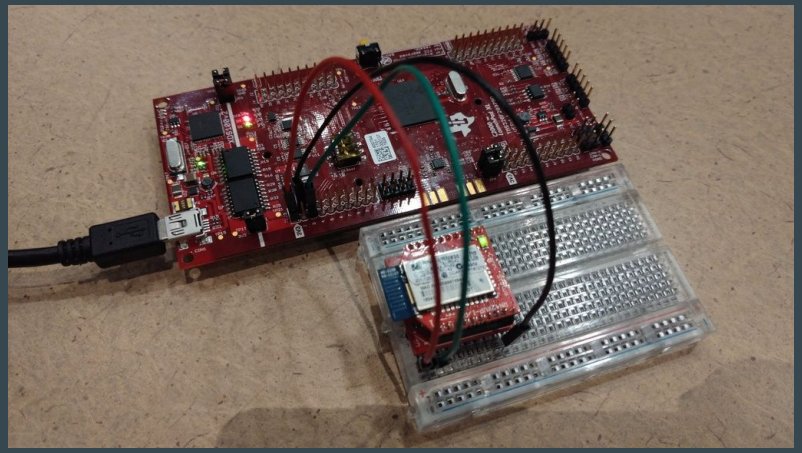
Bluetooth Modules	Pros	Cons	Final Decision
HC-05	Very inexpensive, most popular Bluetooth module among hobbyists	Low reliability due to cheap materials	Passed over due to reliability concerns
BlueSMiRF	Convenient 3.3-volt to 6-volt tolerance	Only available from one vendor	Passed over due to availability concerns
RN-42	Moderately priced, widely available	Only supports UART (no SPI or I2C)	Picked for reliability and hardware requirements

Wireless Communication Specifications

- RN-42 Bluetooth module
- Bluetooth 2.1; backwards compatible with Bluetooth versions 2.0, 1.2, and 1.1
- UART data connection interface
- Low power: 26 uA sleep, 3 mA connected, 30 mA transmit
- Integrated PCB trace antenna

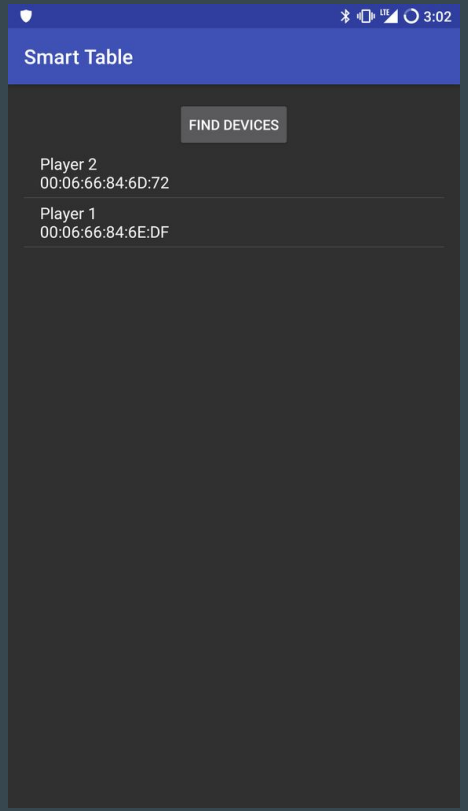
Wireless Communication Design

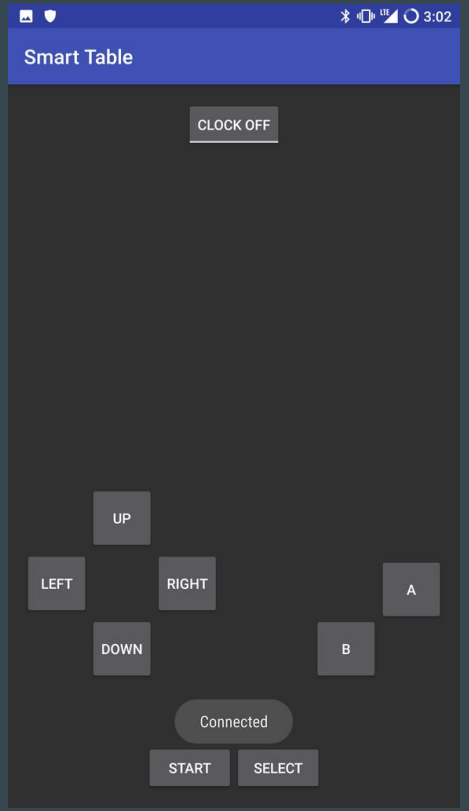
- The Serial Port Profile (SPP) is used to establish the connection to the external interface
- The microprocessor continuously polls for serial data received from the Bluetooth modules via UART
- Desired software function will be conditionally executed based on command transmitted by Bluetooth module



Wireless Communication Integration

- An Android application serves as the user interface
- The buttons are mapped to arbitrary commands transmitted over the Bluetooth connection when pressed
- The button layout resembles modern video game controllers





Wireless Communication General Concerns

- Bluetooth pairing still has compatibility issues with some devices
- Baud rate mismatches make communication impossible
- Range is limited to approximately 10 meters
- Pairing with multiple devices simultaneously can cause confusion
- Flow control not needed

```
//ScibRegs.SCIHBAUD.all = 0x0000;  // 115200 baud @LSPCLK = 22.5MHz (90 MHz SYSCLK)
//ScibRegs.SCILBAUD.all = 0x0035;

ScibRegs.SCIHBAUD.all = 0x02;  // 9600 baud @LSPCLK = 50 MHz (200 MHz SYSCLK)
ScibRegs.SCILBAUD.all = 0x8B;  // 5SCI Asynchronous Baud = LSPCLK / ((BRR + 1) *8)
```

PCB and Power

PCB Specifications

- Board provided by AP circuits
- 2 oz copper, green board, white silkscreen
- Dimensions: 3.860 x 2.595 in
- One sided

PCB Manufacturing Considerations

- Board was initially slated to be built on a pick and place machine, however it was decided for price reasons to have board hand soldered
- The 5V supply has a separate plane in the bottom left hand side of the board to power the USB charger and the level conversion
- There is also a keepout area for the antennas of the bluetooth modules in order to reduce potential interference from the board copper pour

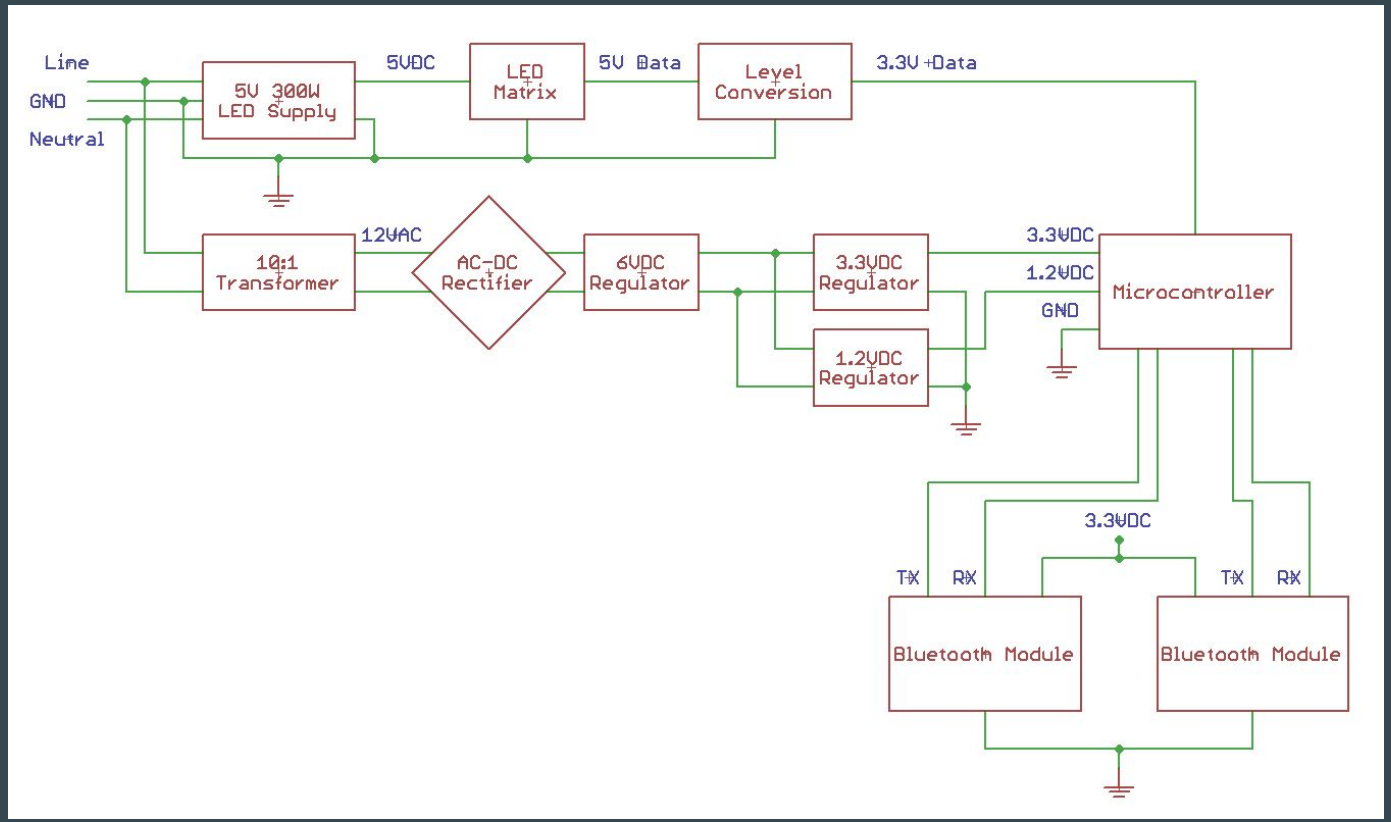
Power Supply Specifications

- On board supply: 1 amp max, 500 mA to each of the two lines
  - 3.3VDC and 1.2VDC lines
- Off board supply for LED matrix: 5V 300W supply to handle display
  - Each LED can sink a maximum of 60 mA, 60mA * 512 LEDs = 30.72 A
  - 5v supply can source up to 60A

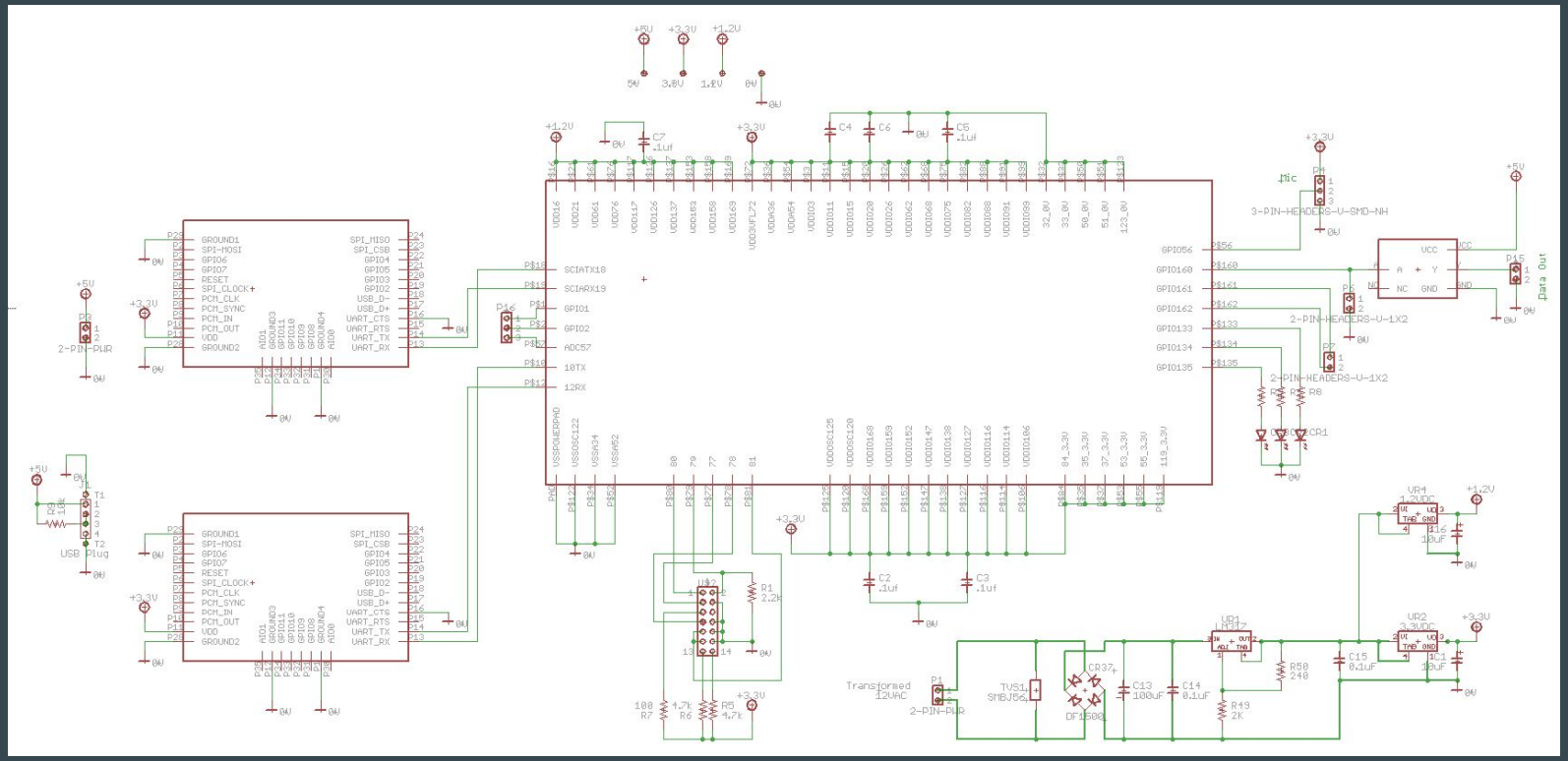
Power Supply Considerations

- Initially considered supplying the LEDs from an on board power supply, however heat and size considerations were prohibitive
- Power supplies on boards should be well heat sinked on both top and bottom of board, along with a large external heat sink
- Total power consumption for the LED matrix is at max 153.6W, which is around half of the total potential supply from the 300W supply

Block Diagram

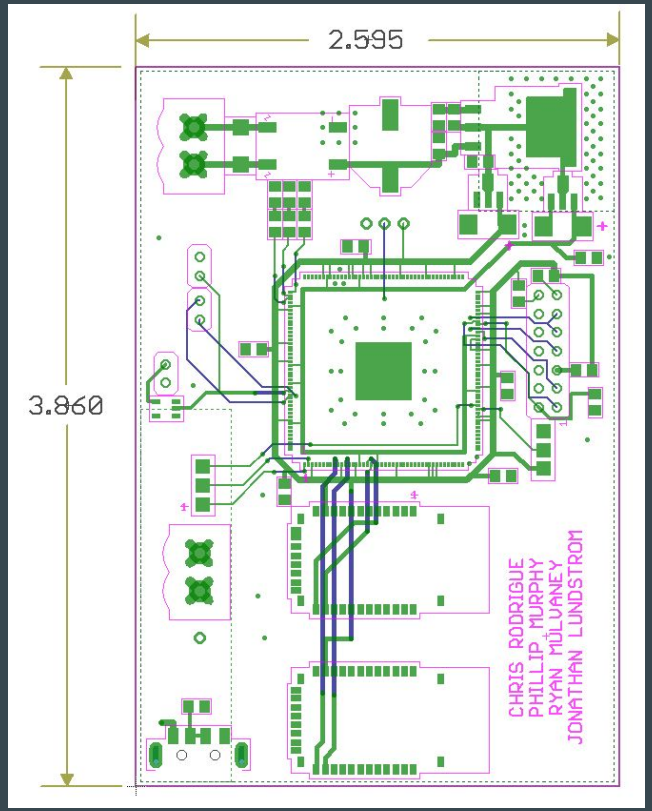


Schematic


+5V
+3.3V
+1.2V
2-PIN-PWR
USB Plug
3-PIN-HEADERS-U-SMD-NH
2-PIN-HEADERS-U-1X2
Mic
Para Out
Transformed 12VAC
2-PIN-PWR
SMBJ5O
DF1508
LM317
3.3VDC
1.2VDC
SCIATX18
SCIARX19
GPIO1
GPIO2
ADC57
10TX
12RX

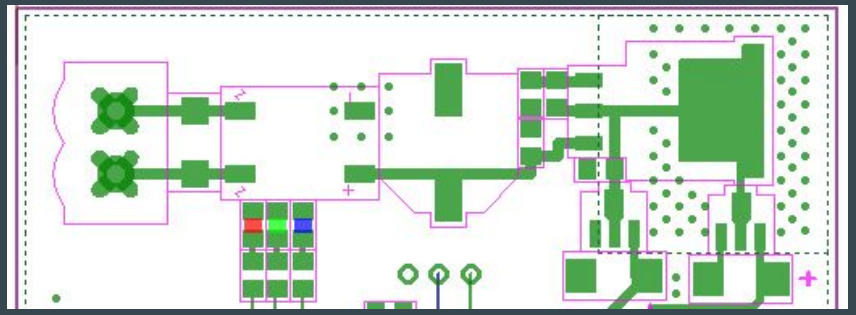
Board Layout

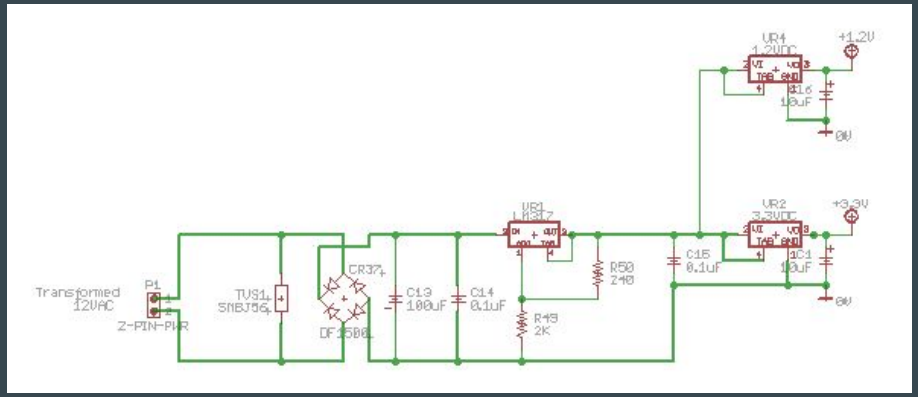
- Created in Eagle
- Design centered around micro in center of board
- Two main heat sinks on board
  - One for top right regulators
  - One for Micro
- Two bluetooth modules toward bottom of board to allow for two player compatibility
- Keepout area in bottom right for antenna transmission



Power Supply Design

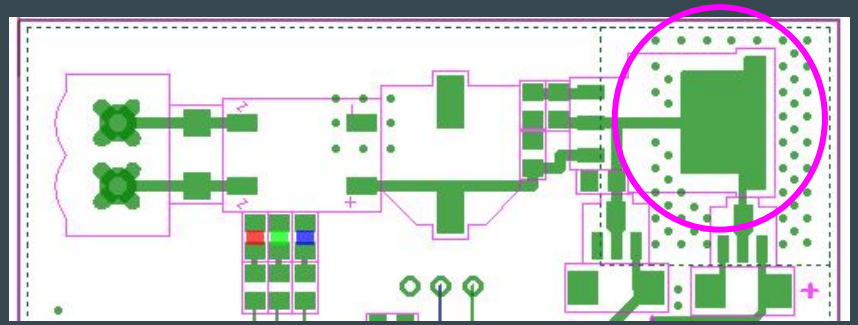
- Input of 12VAC from transformed wall power
- On board rails supply 3.3V and 1.2V to the Micro and bluetooth module
- Coupling capacitors in place in order to prevent AC interference
- Ground of the board will be connected to the Earth ground pin of the wall outlet. This ensures that references are all taken appropriately
    - This is important for communication and level conversion accuracy

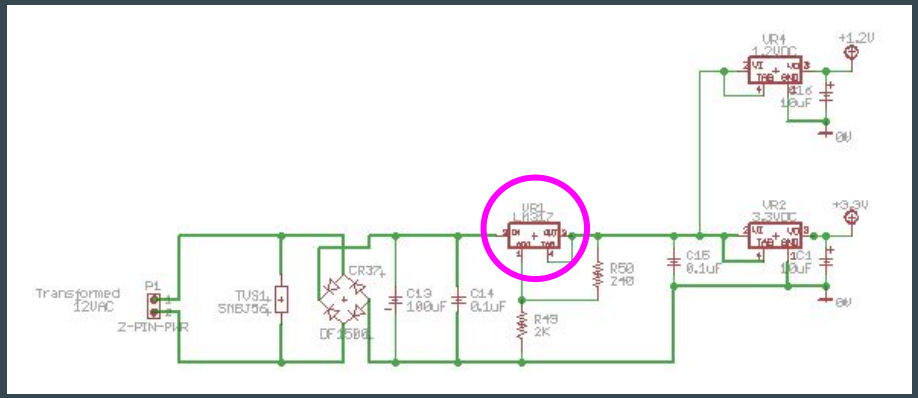




Heat concern

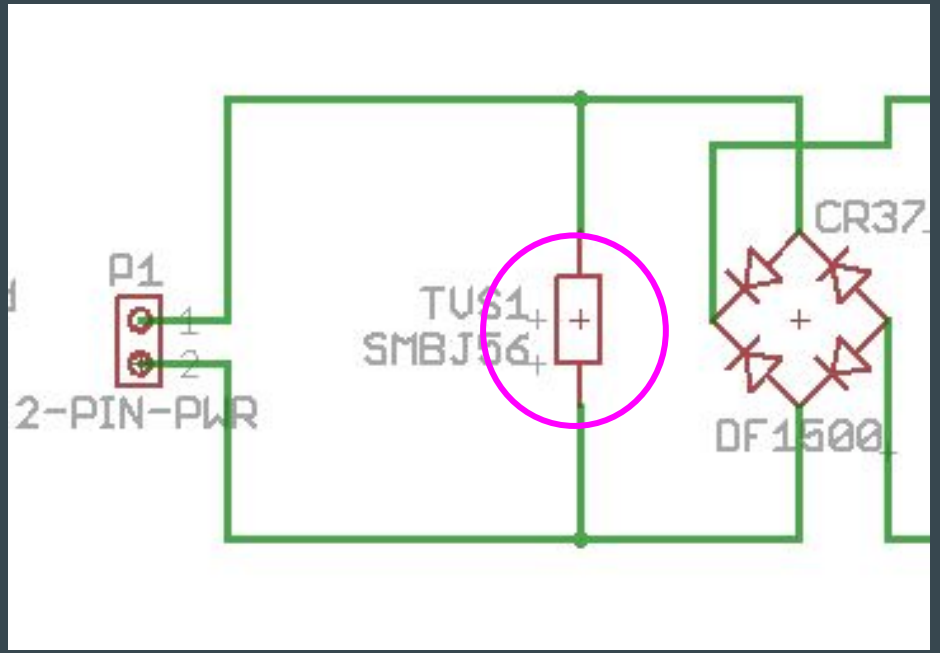
- There are three large power consuming devices on the board, two bluetooth modules and the microcontroller
  - Bluetooth module consumes 40 mA ea max
  - Microcontroller consumes 440 mA max
- This results in a maximum current dissipation of .52A at any given time across the 6V regulator
- This results in a dissipation of 1.56W of power by the regulator, which should raise the temperature of the regulator by 7.8 °C according to the regulator's thermal resistance
  - In a previous board rev, the regulator was dissipating 11.4W, resulting in a 57 °C increase





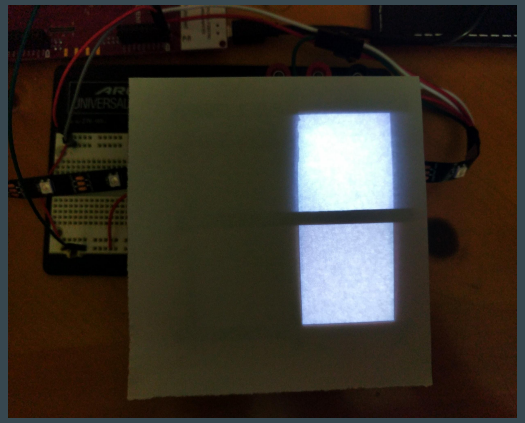
Power Supply General Concerns

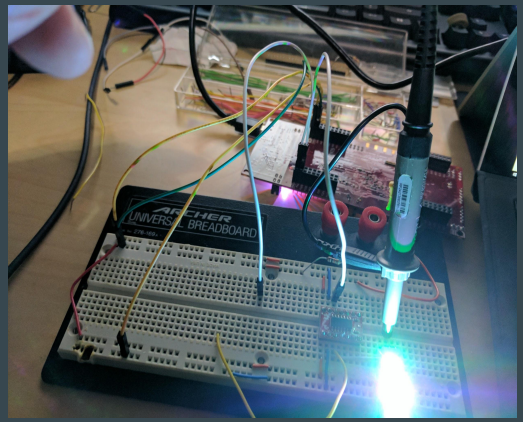
- Noise in the data line can interrupt the data transmission, however it does not appear at this time that there will be a problem.
  - If an issue arises, steps to isolate the data line properly can be taken in future revisions
- TVS will protect sensitive and expensive components on board such as the microprocessor and bluetooth module



Testing and Integration

- Several test points exist on the board in order to perform testing of the supply and data lines.
- Much of the testing has centered around software, however it is important to ensure that the board is providing the proper power to the relevant subsystems
- Board will be mounted to the table, along with the 300W supply



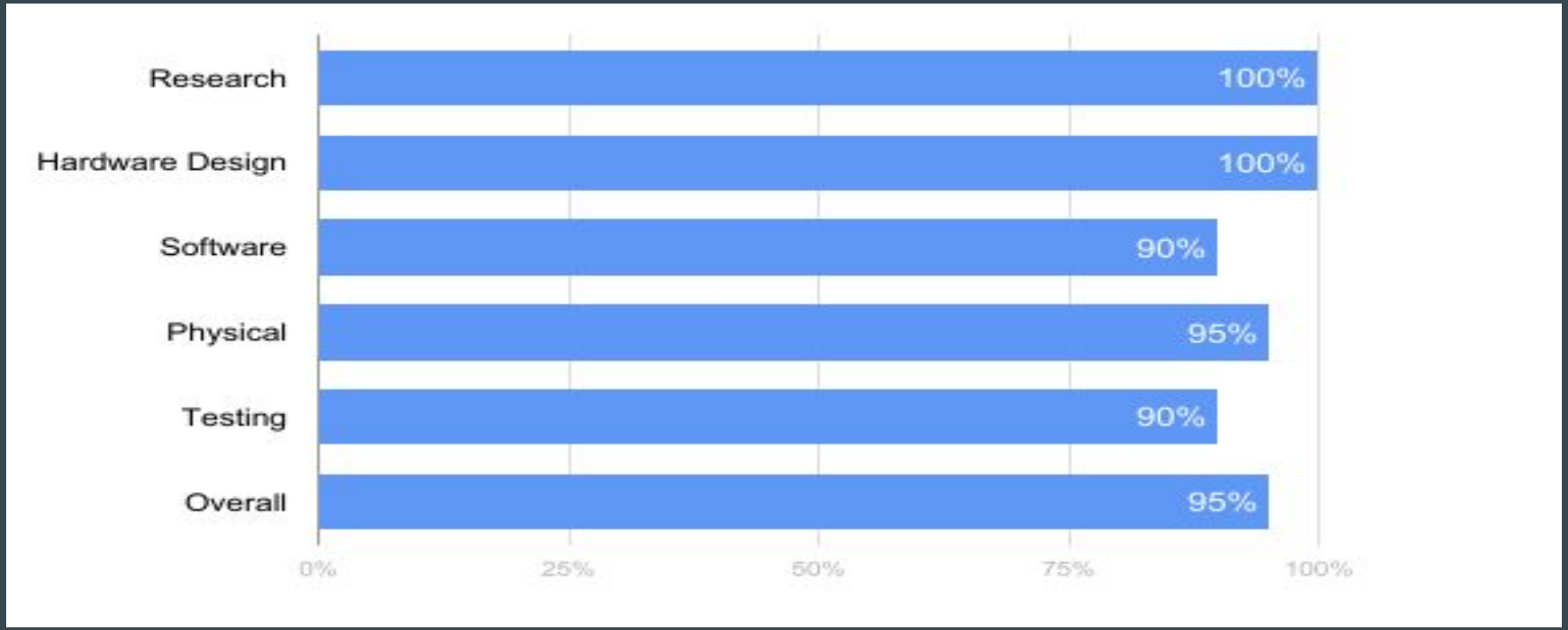


Administrative Content

Division of Labor

	Primary	Secondary
Display Control	Phillip Murphy	Jonathan Lundstrom
Microcontroller Applications	Jonathan Lundstrom	Phillip Murphy
Wireless Communication	Christopher Rodrigue	Ryan Mulvaney
Power Supply	Ryan Mulvaney	Christopher Rodrigue

Progress Chart



Budget

Item	Real Cost
Power Supply	$59
PCB	$120
LEDs	$60
Bluetooth	$25
Misc Parts	$10
Table	$150
Total	$424

Special thanks

- I-con systems
  - Provided assistance with board manufacturing
- Daniel Mulvaney
- David Lundstrom