The Memrowave

Designing the microwave of the future

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The Project Goals

- The Goal of the project is to analyze possible design solutions to create
    - Automated Microwave
        - Using Barcode scanning
        - WiFi
    - Stream lined touch screen interface
    - Eliminate user error in cooking
    - Optimize Cooking through an online database

Requirements

- Developing a system that
  - Simple
  - Reusable
  - Long lasting
 - Works with local connection
  - Power efficient

Requirement	Constraint
Resolution LCD	480X272
Camera Frame Rate	24 Frames per second
LCD screen size	4″
GPIO pins on microcontroller	7 pins
Communication	I2C
Storage size	512MB
Max power consumption	1070W

Hardware Selections

- Selecting components to interface with microwave's subsystems.
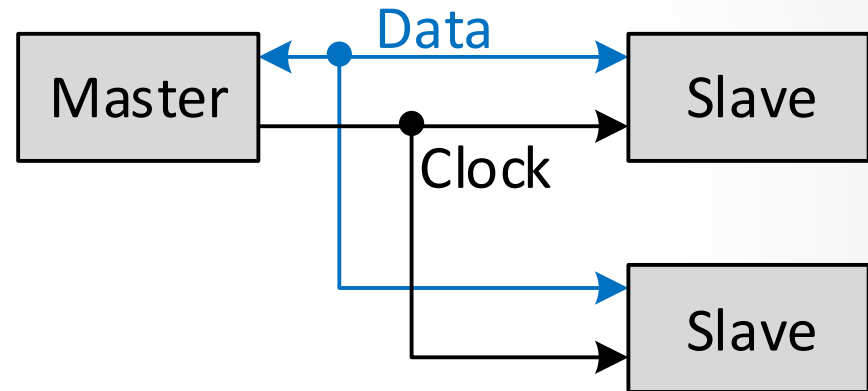
User Interface/Control

- Beaglebone Black
- AM3358 Sitara ARM Cortex-A8
- 1 GHz
- 512MB DRAM
- Android 4.2.2 Jelly Bean
- Linux Kernel 3.2
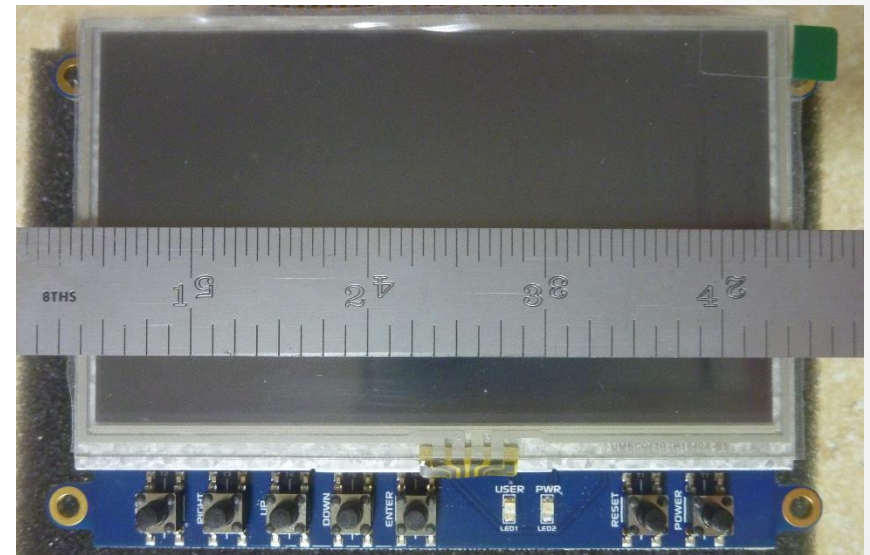- 5V, 460mA
- I2C master
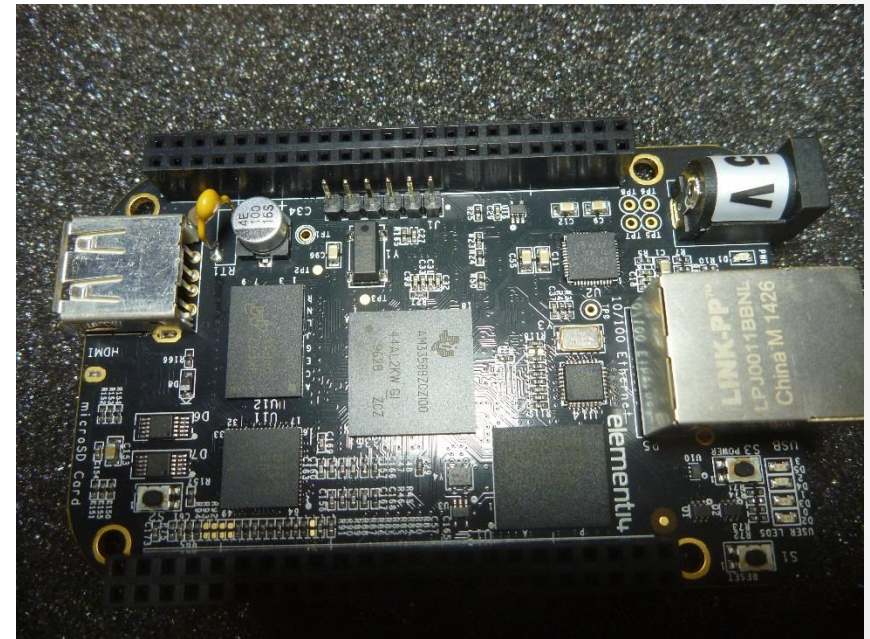
Inter-Integrated Circuit (I2C)

- Computer bus
- Serial communication
- Half duplex
- Multi-master
- Up to 1008 nodes (10-bit addressing)
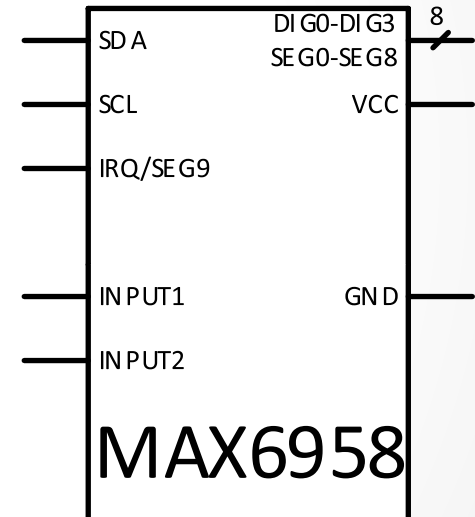- Single-ended signal
- 0.1-5.0 Mbit/s

Master

Data

Slave

Clock

Slave

LCD Touchscreen

- 4DCAPE-43T
- 4.3" TFT LCD
- 480x272 resolution (portrait)
- Resistive touch
- 5V directly from BBB
- Dimensions: 4.74x3.15"

7-Segment LED Display

- MAX6958

- 4-digit, 9-segment LED display driver

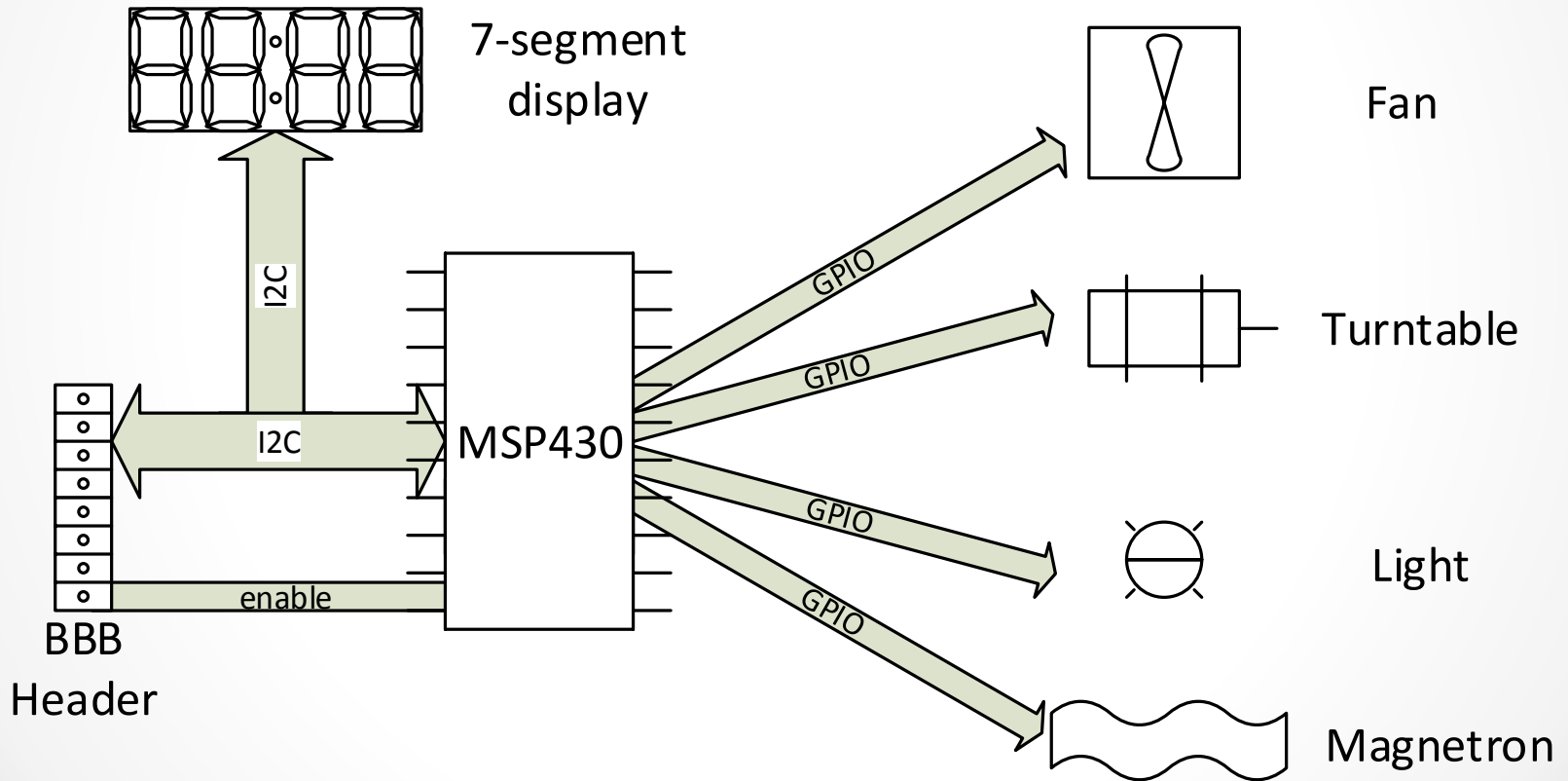- 16-pin PDIP

- 3V to 5.5V

- I2C slave

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            ┌─────────────────────┐
 ──────────┤ SDA       DIG0-DIG3 ├──/── 8
           │           SEG0-SEG8 ├──────
 ──────────┤ SCL             VCC ├──────
           │                     │
 ──────────┤ IRQ/SEG9            │
           │                     │
           │                     │
 ──────────┤ INPUT1          GND ├──────
           │                     │
 ──────────┤ INPUT2              │
           │                     │
           │      MAX6958        │
           └─────────────────────┘
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Microwave Interface/Control

- MSP430G2553 microcontroller

- 16MHz

- 16KB flash

- 1.8 - 3.6V, 330µA/MHz

- 20-pin plastic dual inline package (PDIP)

- I2C, GPIO

- I2C slave
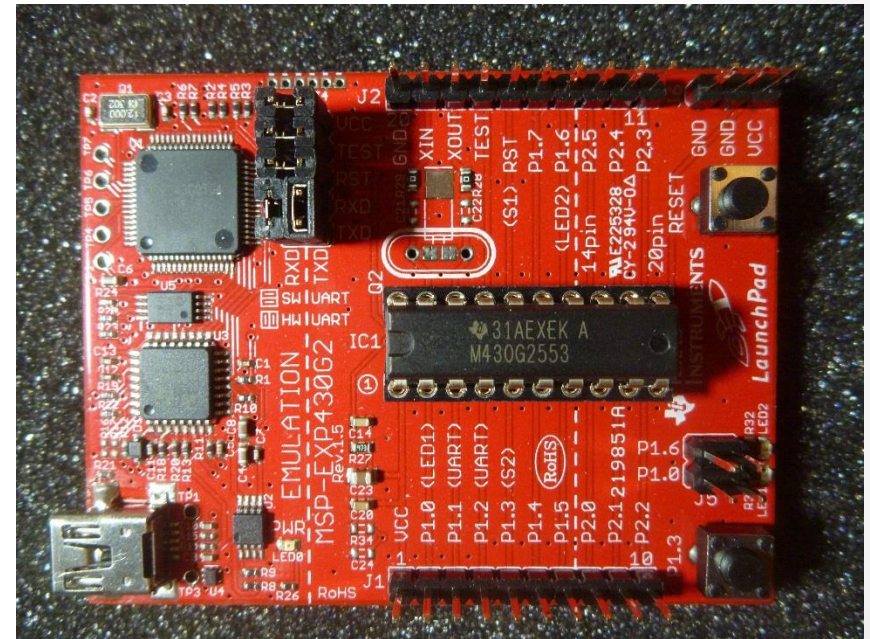
Microwave Interface/Control

Camera

- Logitech HD C270
- Video capture up to 1280 x 720 pixels
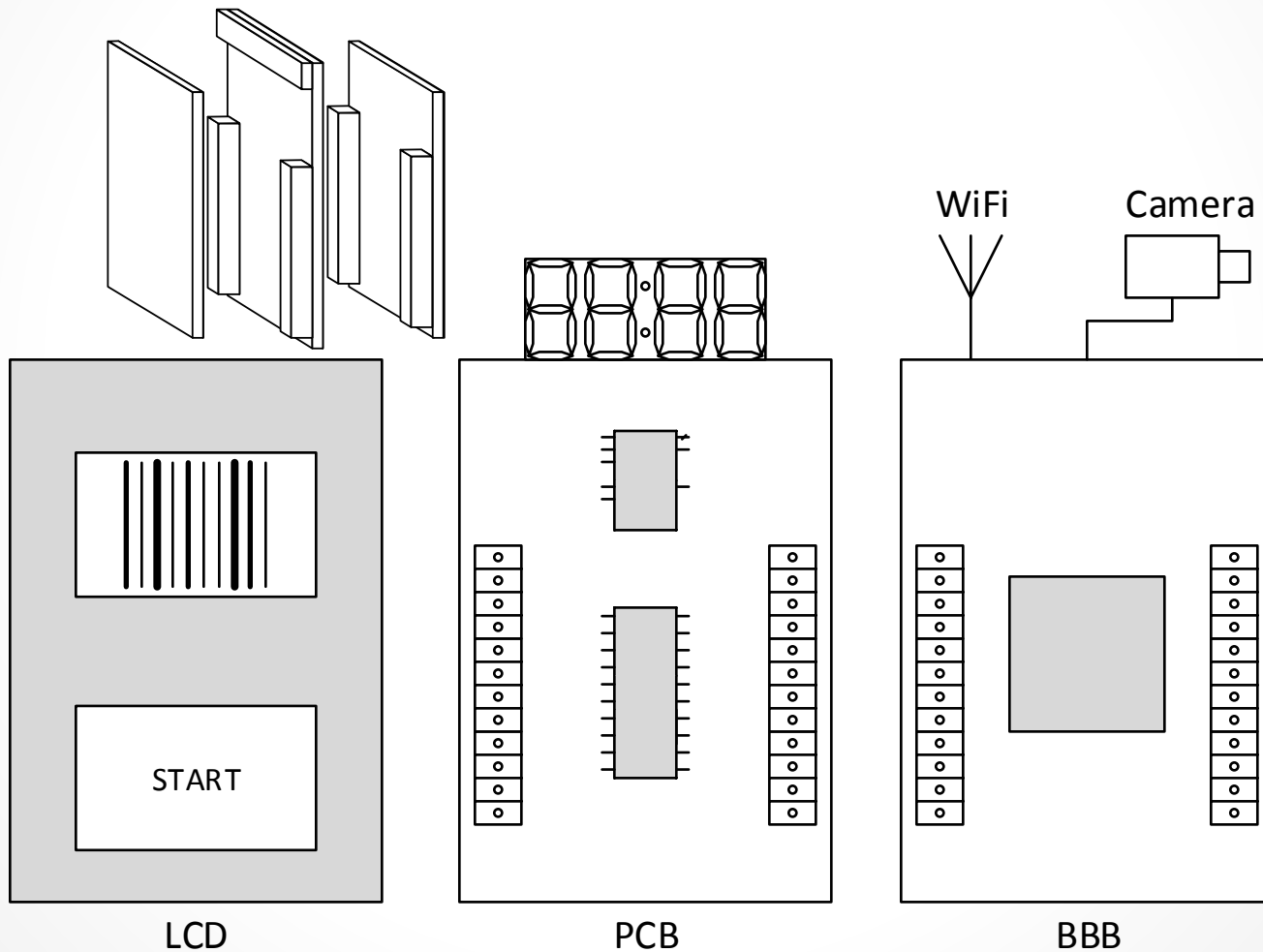- Photo up to 3.0 megapixels
- USB

Wireless

- UWN200
- MediaTek MT7601 (Ralink 7601)
- 2.4- 2.4835GHz, 802.11b/g/n
- 4" antenna
- USB

Boards

WiFi   Camera

START

LCD   PCB   BBB

Not intended to be to scale

Software Breakdown

- Selecting components to interface with microwave's subsystems.

Home Screen

- ## Act as Launcher replacement
  - Home button will bring up this screen
- ## Time Display
- ## 4 Options
  - Scan barcode
  - View favorite products
  - Open manual cook screen
 - Change Memrowave settings
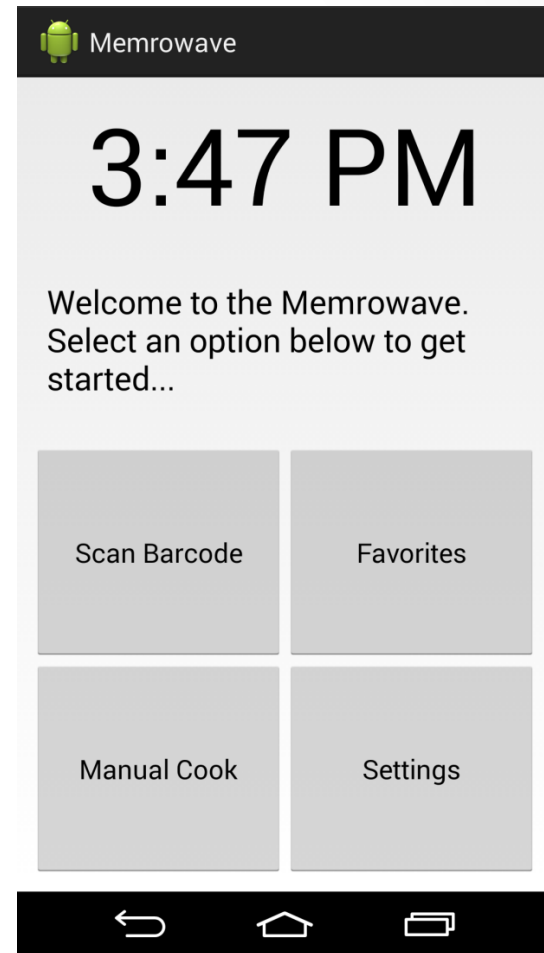
Barcode Scanner

- Barcode scanning accomplished using Zxing barcode library
- Align barcode in the viewfinder to automatically scan and decode it
- Scan result used to search for matching products
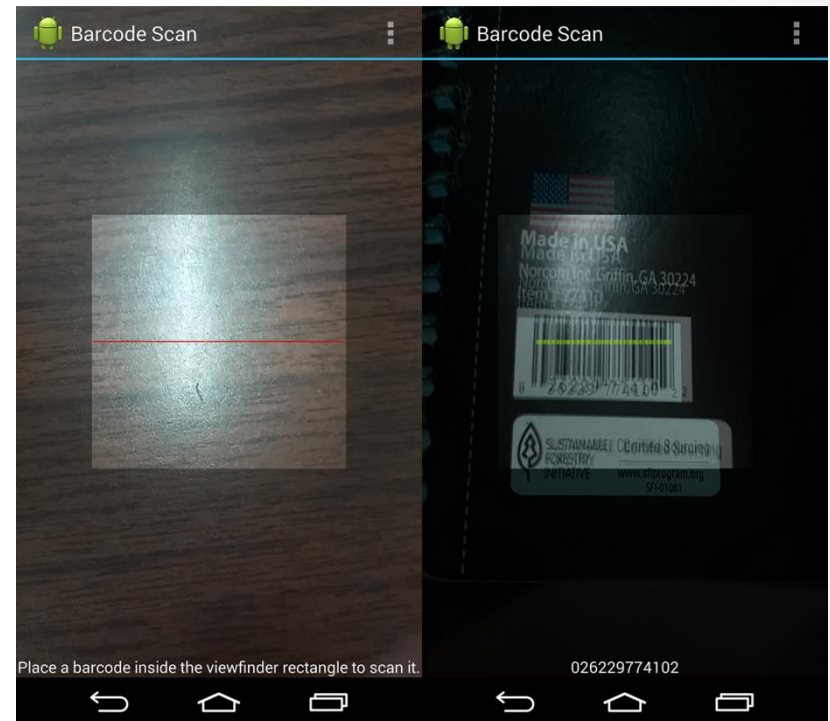
Product Database

- A local SQLite3 database will be used to store product information, including:
  - Product name
  - Product description
  - Location of product image
  - Cooking steps, with
   - Step description
    - Power level
    - Cook time
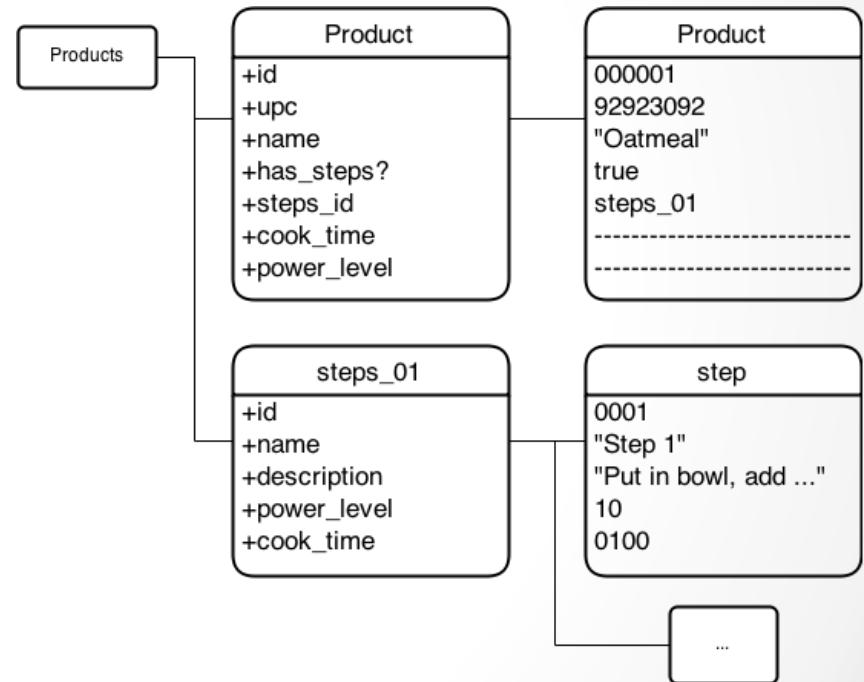
Product Description

- Displayed after a successful barcode scan, if a matching product can be found

- The user can modify the power level and cook time

- User can cook the product from this screen

Product Search

- Lists all products with matching barcode
- Search locations:
  - Favorites
  - Local database
  - Web database
- Selecting a product will bring up the Product Description screen, allowing the user to cook the product
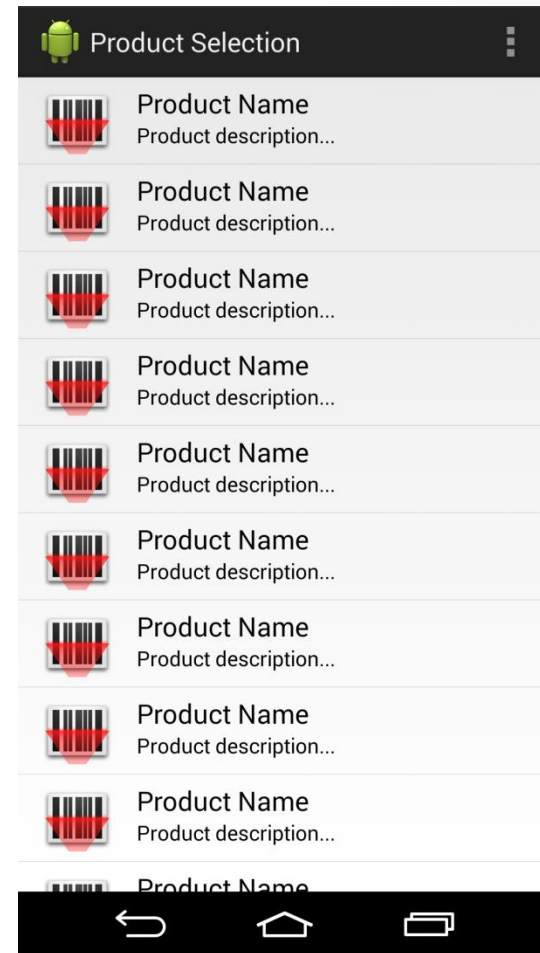
Favorites

- A table in the database will be used to store a list of favorite products
- Allows quick access to frequently used products
- Quicker than scanning a barcode
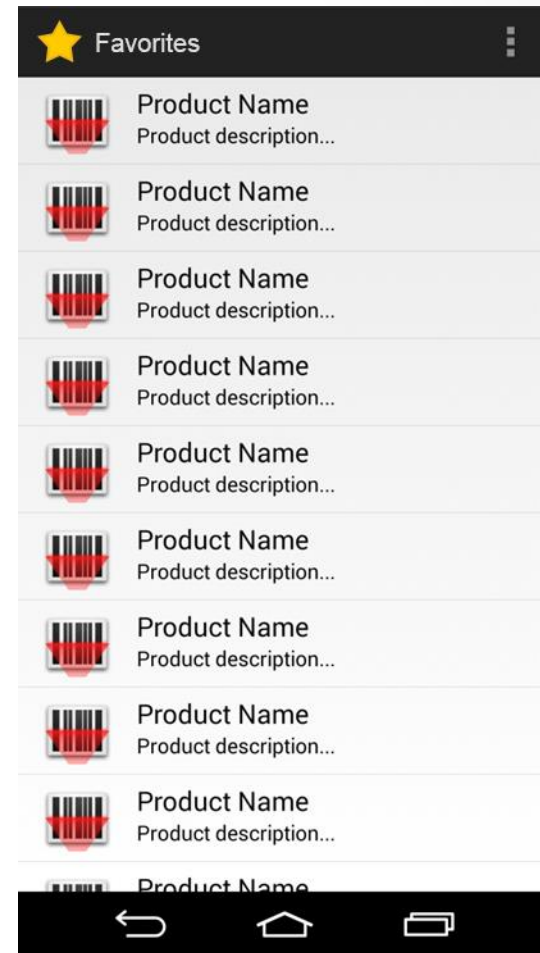
Notifications

- Remotely notify the user when the Memrowave is finished cooking
- Two options:
  - SMS notifications
    - Simple
    - Supports older phones
  - Push notifications
   - Requires a custom app on the phone
    - Android-only for now

User Profiles

- Store user-specific settings:
  - Username
  - Favorites list
  - Phone number for SMS notifications
 - Push notification settings
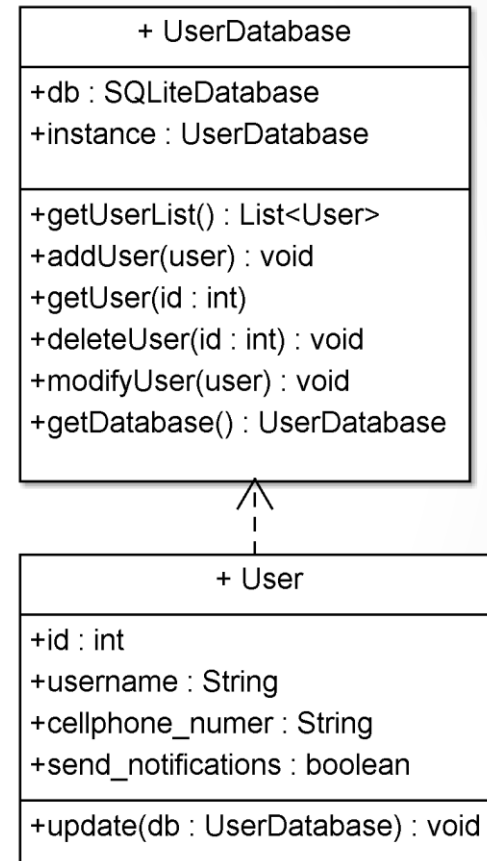
Manual Operation

- Some items don't have convenient barcodes
- Some users will prefer complete control over microwave operation
- Allow the user to manually set cook time and power level like a standard microwave
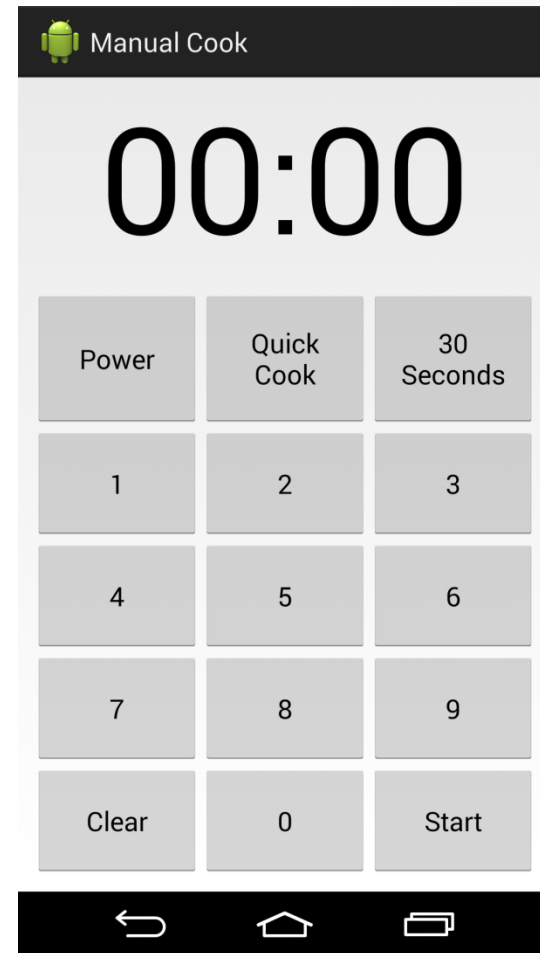
Cook Screen

- Displayed while the Memrowave is cooking
- Must remain on the screen to continue cooking
  - Avoid situations where the user cannot stop the microwave
- Three main operations
  - Pause
  - Cancel
  - Add 30 seconds
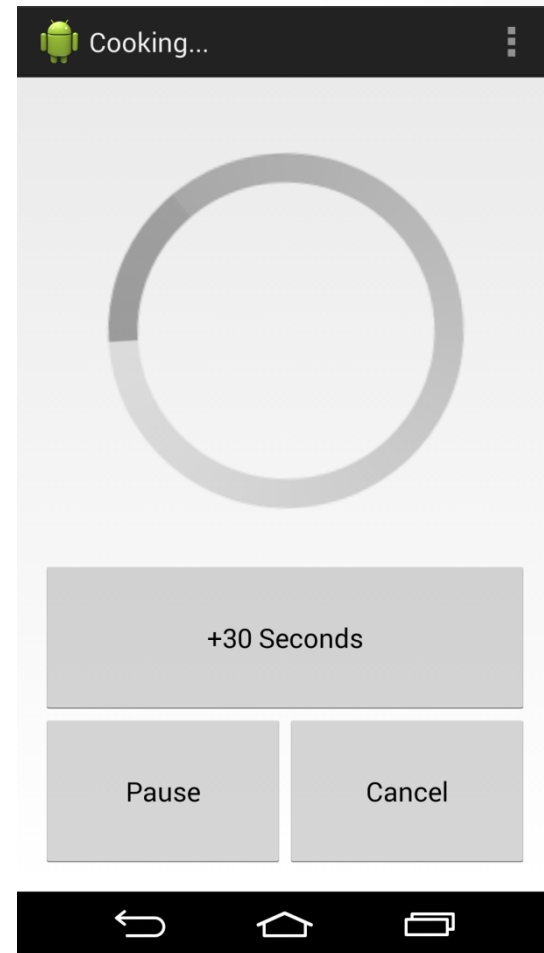
New Product

- User can manually add product entries
- Built in camera can be used to take a picture of the product and scan the barcode
- User will manually enter cook time and power level
- Product will be saved to the local database

Web Database

- Implement a web database of products, so users will not have to manually enter product information
- Product settings can be cached to the Memrowave's local database
- Using MongoDB for the database
- Node.js + Express for the web server
- REST API will deliver JSON-formatted data

Powering systems

- Powering DC elements in the Memrowave

Structure

DC Components

- Beagle Bone Black
  - LCD Display
  - WIFI Module
    - Camera
- 7 Segment Display

AC Components

- Internal Light
- Turntable Motor
  - Cooling Fan
- Magnetron Transformer

AC Power

- All components require 120 V.
- Reuse of the most of the microwave's original wiring layout.
- Adjustments will be made to door switches and magnetron relay.

DC Components

Component	Operating Voltage	Max Operating Current(mA)	Power(W)
BeagleBone Black	5	500	2.5
LCD Display	5	250	1.25
WIFI Module	5	500	2.5
Camera	5	500	2.5
7 Segment Display	5	600	3
MSP430	3.3	500	1.65
		Total Power	13.4

DC Power Supply

- Maximum of 15 watts of power delivery
- Switching Regulator Design
- Minimize use of microwave real estate

Switching Regulator Design

- Maximum current requirement of 3 A.
- Allows for a more compact design.
- More efficient, 80-95%.
- Requires more components.
- EMI filtering/RF Considerations.

Resonant Controller: UCC28710

- Built by T.I.
- Constant voltage and constant current regulation.
- Over-voltage and Over-current Protection functions.
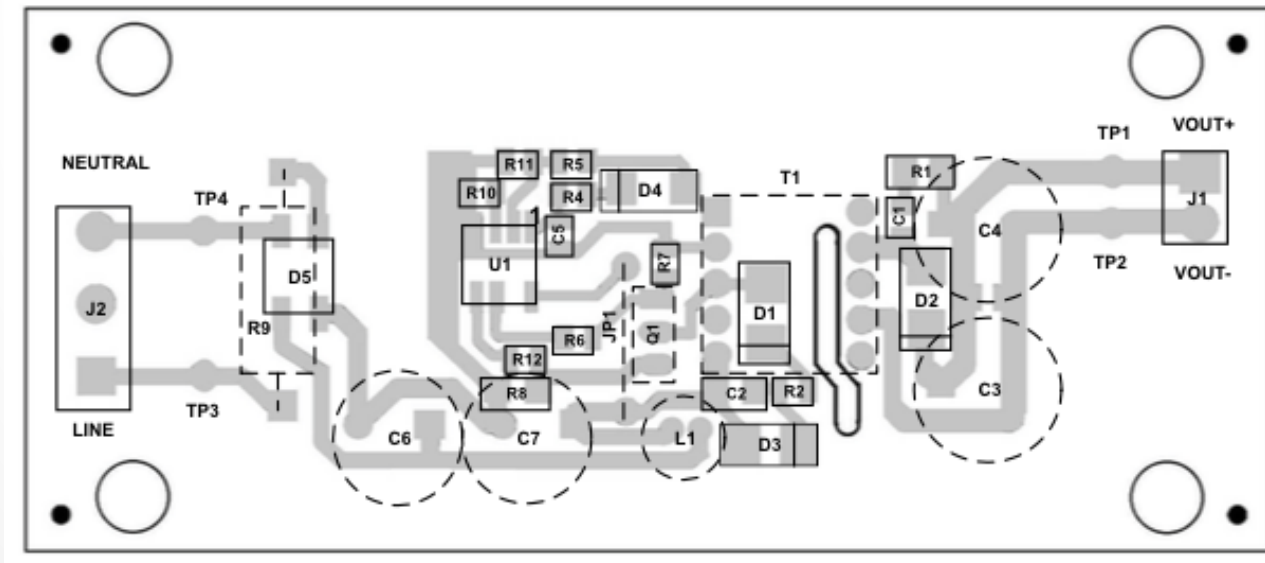- At least 78% efficiency for our system.

Schematic
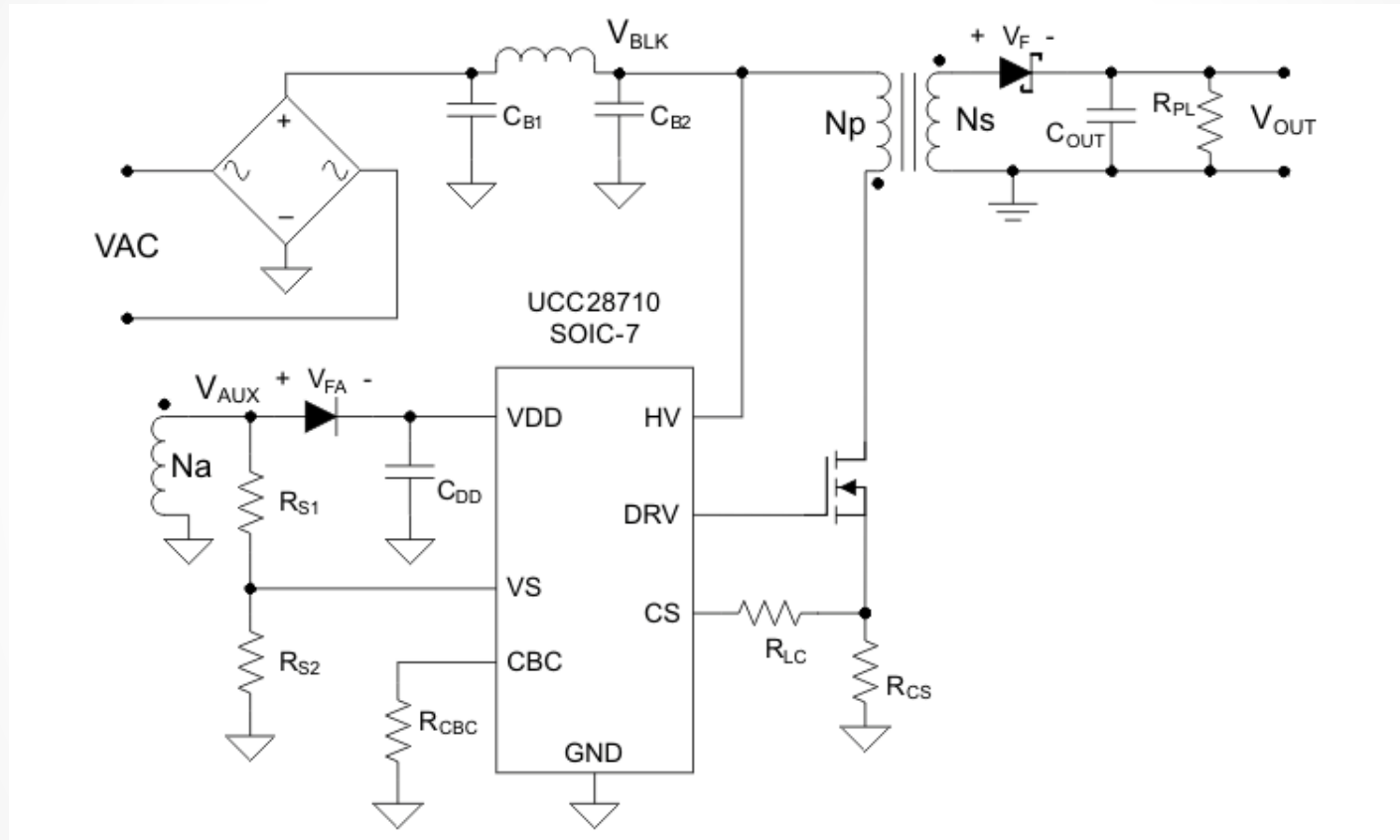
Power PCB

- Eagle 6.5 Pro by CadSoft
- Proposed Layout by TI
- Compact as possible with acceptable robustness

Considerations

- Placing components as close to resonant controller's pins as possible.
- Avoid mounting semiconductors under magnetics.
- Placement and Shielding are key to proper operation.

Electrical Hardware

- The microwave's new power source
  - Powering the Memrowave
- Use of relays to control microwave's electronics
- Circuit Design
- Printed Circuit Board

Controlling AC elements

- The Memrowave functions normally
  - Components are only on when needed
  - Power distributed effectively
  - Safe operation

- Make use of switches
  - Reuse mechanical switches for the ovens door
  - Order Relays to control power
  - Relay control via MCU

Door Switch

- The mechanical switch in the door will be reused
  - This will always for the light to be switched on when the door is open
  - This switch will also protect a user from the magnetron when the door is open

- Provides the user with familiar interfaces

Relays

- The Memrowave's operation will using two Solid State Relays
  - Known as a SSR

- Lower current components will be switch via Solid State Relay - 8A
  - These elements are:
    - Light
    - Fan
    - Turntable
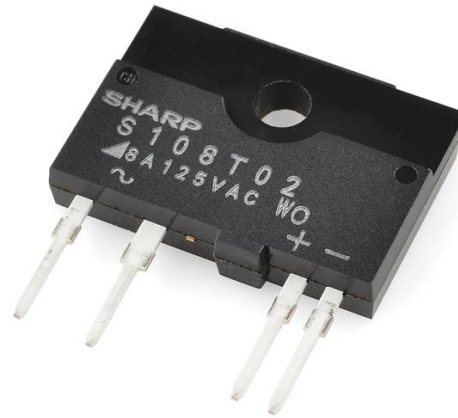
Magnetron's Relay

- The magnetron's transformer draws a 9Amp current
  - Switching requires a more robust relay

- A 40Amp relay will be mounted to the microwave to solve this issue
 - This relay won't fit on the PCB
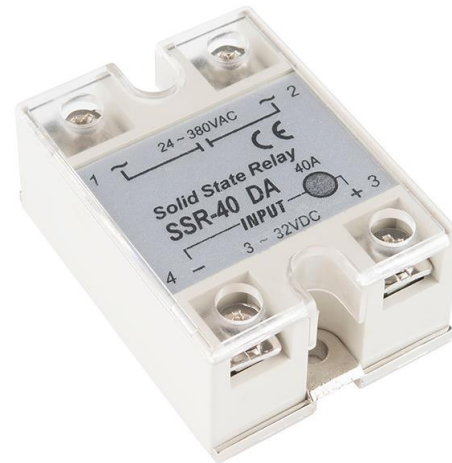
Control system

- In order to switch the relays we will utilize an MSP430 microcontroller
  - The MSP430 will be mounted to the PCB
  - The GPIO pins will output an on and off signal

- The MSP430 output sufficient current to efficientlly when operating relays
  - This is done through use of transistors
  - Make use of Three GPIO pins
    - Magnetron
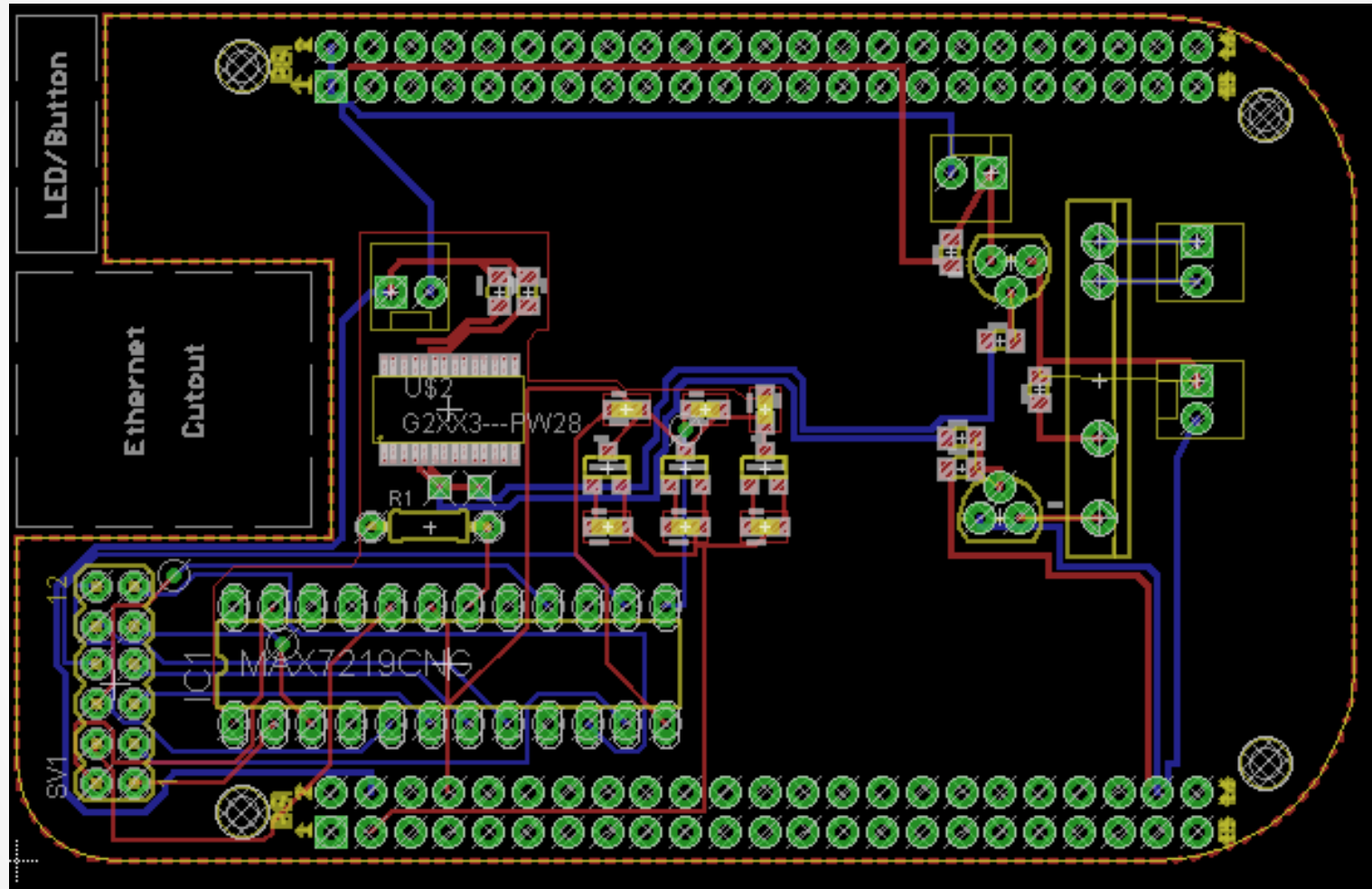   - Fan/Light/Turntable
    - 7-segment display

Power Levels

- Magnetron is required to operate at different power levels
  - For simplicity levels 1-10

- Since the magnetron is on its own pin we can control power through pulse width modulation
  - Coded into the microcontroller.
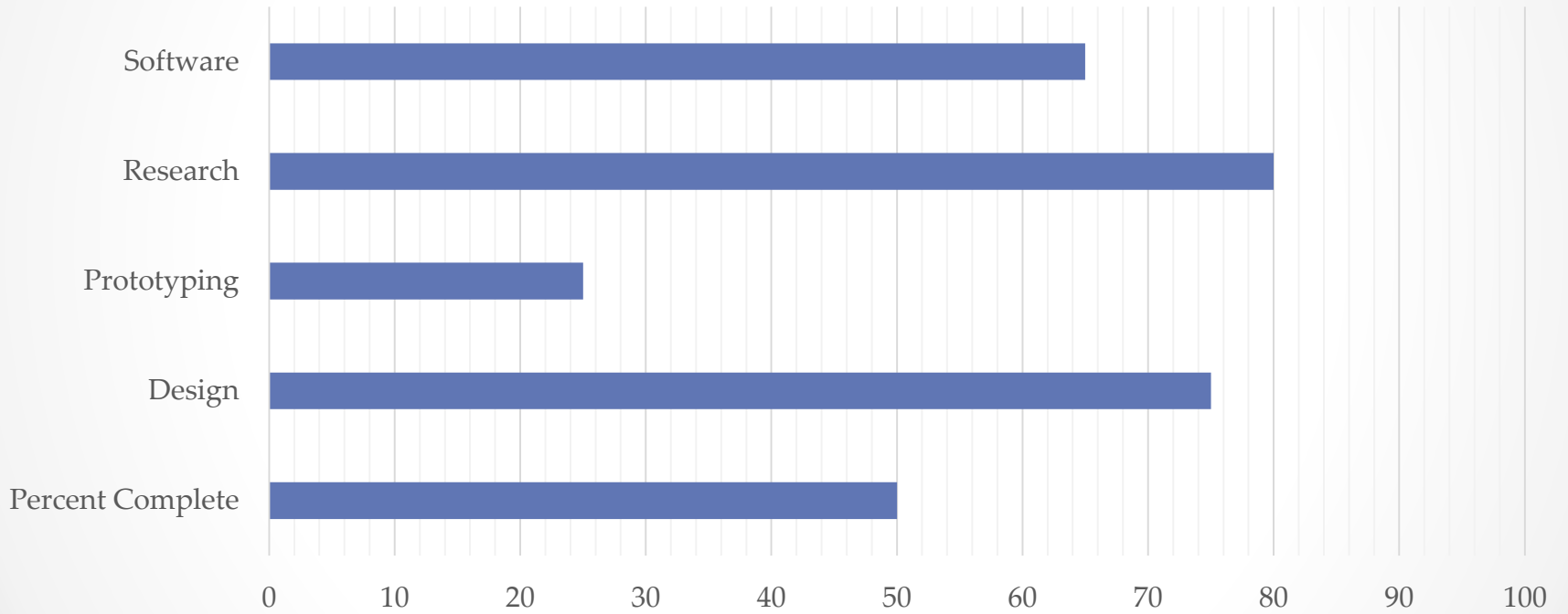
PCB Schematic
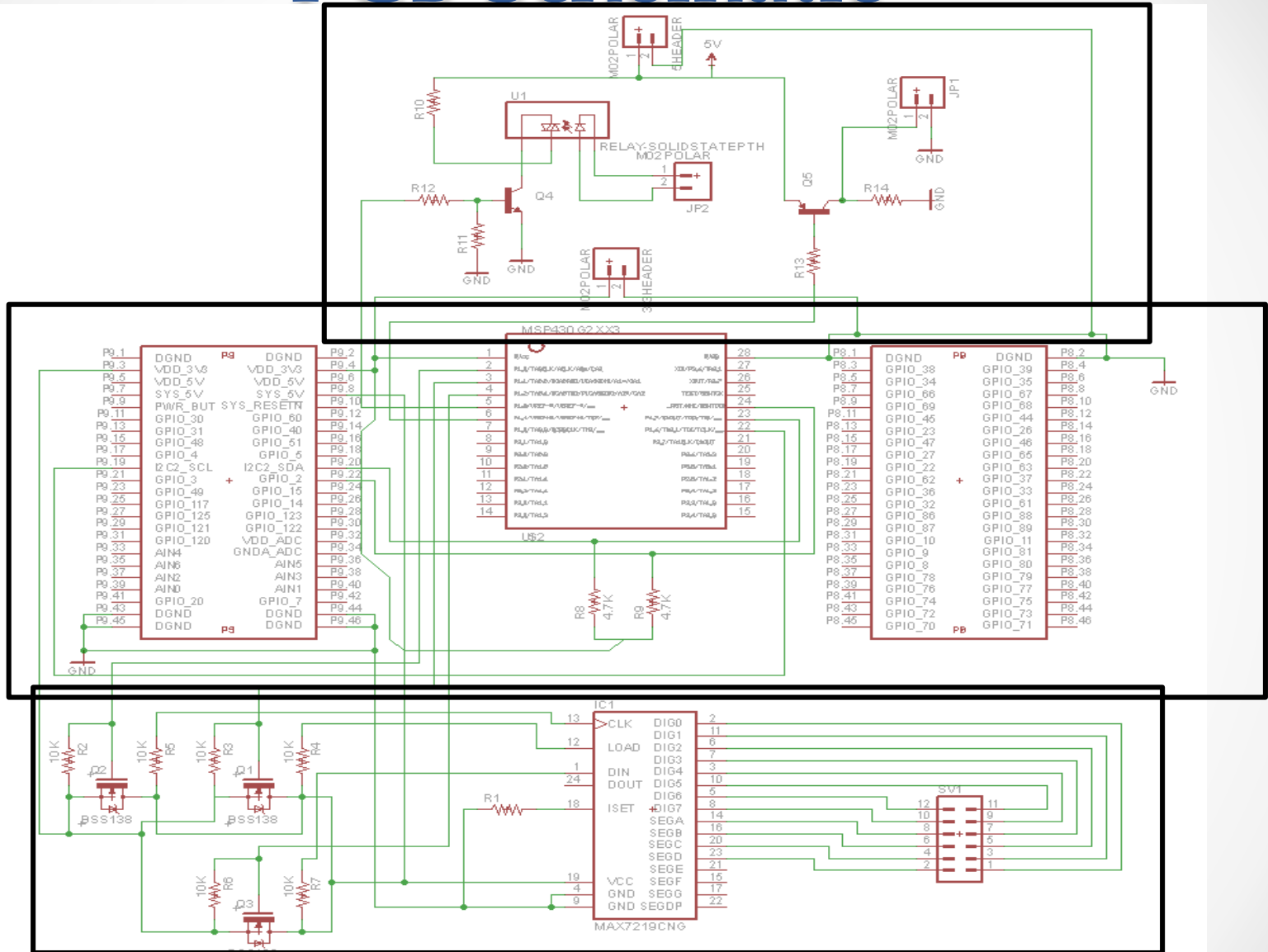
Control PCB

Administration

- Budget
- Progress
- Labor Distribution
- Challenges
- Milestones

Budget

ITEM	Estimated Cost	Actual Cost
Beagle Bone Black	$50	$50
Camera	$40	$40
LCD Screen	$100	$60
Microwave	$250	$ 0
Power supply	$10	$25
Microcontroller	$11	$0
Relays and Misc.	$10	$27
PCB fabrication	$60	$60
WIFI	$25	$14.99
Total	$556	$276.99

Progress

Distribution

	Power/PCB management	User interface/App	Control system/PCB	Software
Winston		X		X
Andy		X		X
Darren	X			
Joseph			X	

Challenges

- First time working with PCB designs
- Inexperience with eagle schematic
- Limited space for elements
- Integrating Wi-Fi and camera with Android hardware abstraction layer.
- Transformer Design

Milestones

- Test control circuits on bread board
- Test switching regulator on bread board
- Order PCB

Questions ?