Dwight Look College of
ENGINEERING
TEXAS A&M UNIVERSITY

Team 4: iPhone Multimeter
Final Presentation

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Project Overview

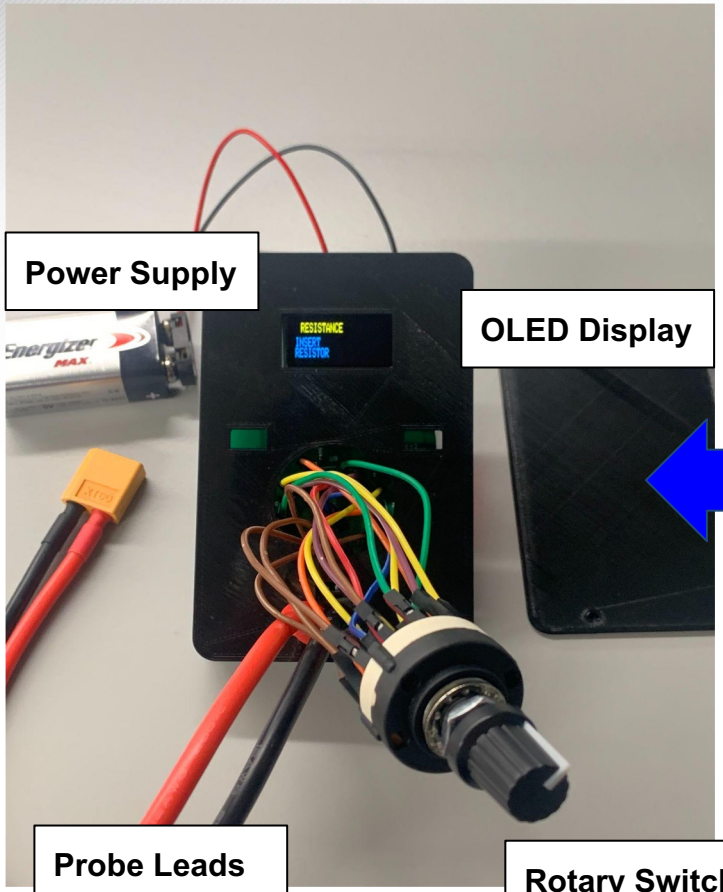
Problem Statement

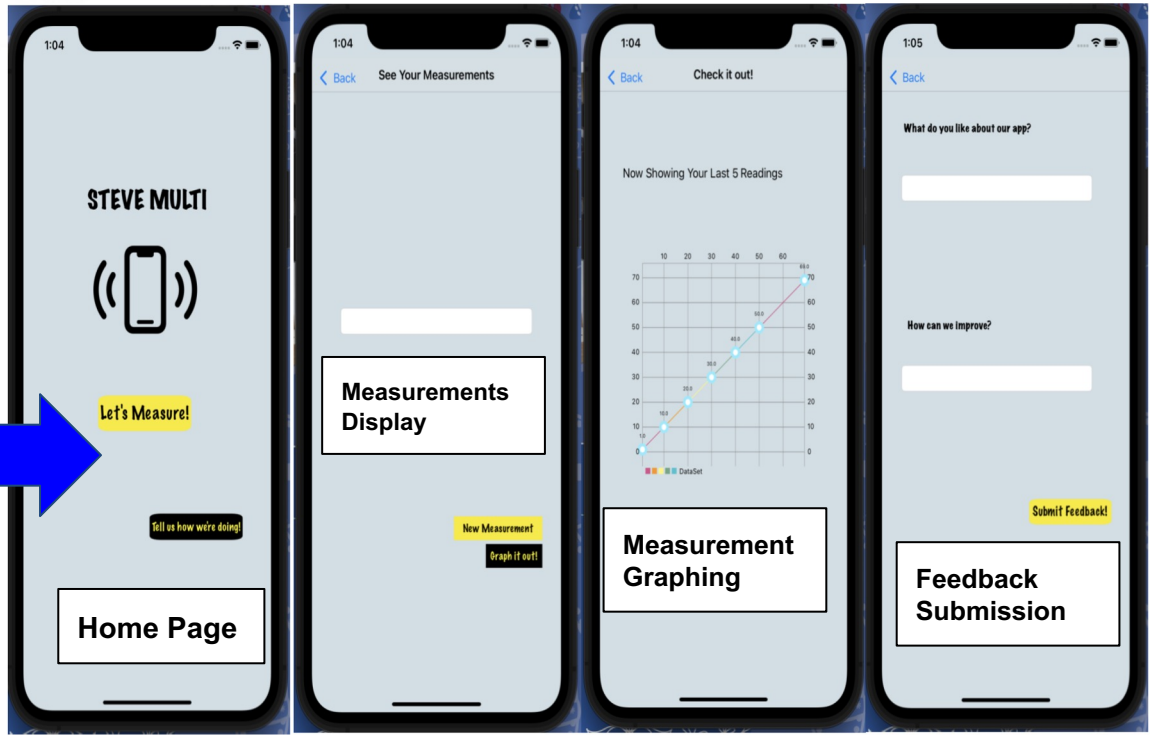
Commercial multimeters are designed with idea that primarily electricians and engineers will be using them. The many ports, symbols, and buttons tend to be overwhelming to new users and DIYers. Additionally, multimeter with greater capabilities tend to be bigger and more complex.

Our Solution

A small, low-cost multimeter that conveniently presents electrical measurements in real time. Data is presented via iPhone application & rendered via a probe circuit, which will provide measurements of DC voltage, amperage, resistivity, capacitance, and continuity of a live circuit. Our standalone multimeter will function to allow the user to store/view data right on their phone allowing home DIYers measure their parameters conveniently.

Integrated Project Diagram





Samson Kayira

Hardware Design Accomplishments

Multimeter features

- Ammeter
  - ACS712 amplifier used to measure current (5 A model)
  - Capable of detecting negative current flow
  - Switch functionality used to separate ammeter from rest of measurement system

- Capacitance Meter
  - Auto-scaling functionality
  - Functional measuring from 0 to 1 uF

Product Encasing

Measurement mode switching functionality

- Rotary Switch

Results & Validation

Capacitance	Expected (uF)	Observed (uF)
	0.1	0.116
	10	10.11
	22	20.8
	33	34.3
	47	45.6
	100	103.4
	220	220.86
	1000	974.6

Mean %Error	5%

Current	Expected (mA)	Observed (mA)
	10	10.3
	100	101
	500	497
	1000	1002.8
	1500	1508
	2000	1990
	2500	2503
	3000	2998

Mean %Error	1%

Major Challenges and Solutions

Challenges Encountered	Solutions
Initial design utilized push buttons for measurement mode switching which left no room for external 16 MHz crystal	Altered our design to include a rotary switch which left us with extra pins to use for the crystal
Measuring a current source with the ACS712 would short the entire subsystem circuit	Successfully implemented a sliding-switch mechanism that would isolate the current measurement mode from the rest of the measurement system
MCU that were assembled on PCB were blank chips that lacked the necessary bootloader code for arduino	Used an arduino UNO as an ISP to burn bootloader onto an arduino nano. We desoldered that chip and used it as a replacement on one of PCBs

Daveon Douglas

Hardware Design Accomplishments

Multimeter features

- Voltmeter
  - DC Voltage up to 10V
  - Differential Voltage measurement (Validation In Progress)
- Resistance Meter
  - Auto-scaling functionality
  - Functional measuring from 0 to 1 MΩ
- Continuity Meter
  - Continuity tester of live circuits, wires, and resistors.

PCB Design

- Power supply on/off switch

Measurement mode switching functionality

- Rotary Switch (i.e switching between measurables and separating current)

Hardware Test & Validation

Resistance	Range Measured	Validation	Percent Error (%)
	0 Ω - 2 kΩ	✓	<5%
	2 kΩ - 20 kΩ	✓	<1%
	20 kΩ - 200 kΩ	✓	<1%
	200 kΩ - 1MΩ	✓	<1%

Voltage	Range Measured	Validation	Percent Error (%)
	10 mV - 1 V (+)	✓	<5%
	1 V - 15 V	✓	<3%
	Negative Voltage	In Progress	-
	AC Voltage	✗	-

System Comments

- Rotary encoder enables mode switching between measurables
- Auto-scaling (i.e. mV, V, Ω, kΩ) capable
  - Resembles traditional multimeter
- AC voltage lacked adequate testing in prototype
- Differential Voltage validation in progress

Measurable	Validation	Percent Error (%)
Continuity	✓	0%

Major Challenges and Solutions

(Daveon Douglas)

Challenges Encountered	Solutions
Initial design utilized push buttons for measurement mode switching which left no room for external 16 MHz crystal.	Altered our design to include a rotary switch which left us with extra pins to use for the crystal.
Measuring AC/differential voltage (optional) in simulation was successful but implementation into prototype testing unsuccessful	Successfully implemented a DC voltage design (required) and partially validated differential measurement in PCB
Difficulty assembling PCB with small SMD components and MCU programming issues.	Utilized Arduino UNO as an ISP to burn bootloader onto an Arduino Nano. Desoldered Nano chip to replace blank chip supplied by manufacturer
MCU derived power from battery without means of disconnect.	Implemented Power ON/OFF switch into battery supply design. Incorporated buck/boost converter to allow user to any battery size.
PCB design flaw for rotary switch dimensions. Pins holes are few mm off of rotary switch.	Soldered M-to-F wires from PCB to rotary switch directly

Frontend Design Accomplishments

(Genesis Munoz)

iPhone Application Features

- User friendly UI
- NSTransportSecurity
  - Implements privacy and data integrity across application
  - Permits arbitrary web loads while maintaining protection elsewhere in app
- Pop-up Notifications (Alerts) to Notify if:
  - Feedback was successfully sent to database
  - Connection to server failed
  - Insert query failed
- Measurement Graphing
- Text-field Submission box

MySQL Database

- Receive and Retrieve Capable
  - Local web server communicates to database via PHP web service containing SQL queries
  - Data sent by application to database is password protected to ensure safe transfer
- Filters out non-numerical data from insertion

Major Challenges and Solutions

Challenges Encountered	Solutions
No graphics extension/module native to iOs applications existed to graph measurements.	Found, added, and used a functional public Swift graphs package for the project workspace.
Pages on application couldn't interact (send queries) directly from Swift code.	Hosted a local web server that application can connect to run PHP web service that would take care of sending queries to database.
Initial method of inserting data to database from Feedback page would not always go through.	PHP code was re-written to handle errors pertaining to database connection. Pop-up alerts also added to inform user of causes of error in transmitting data.

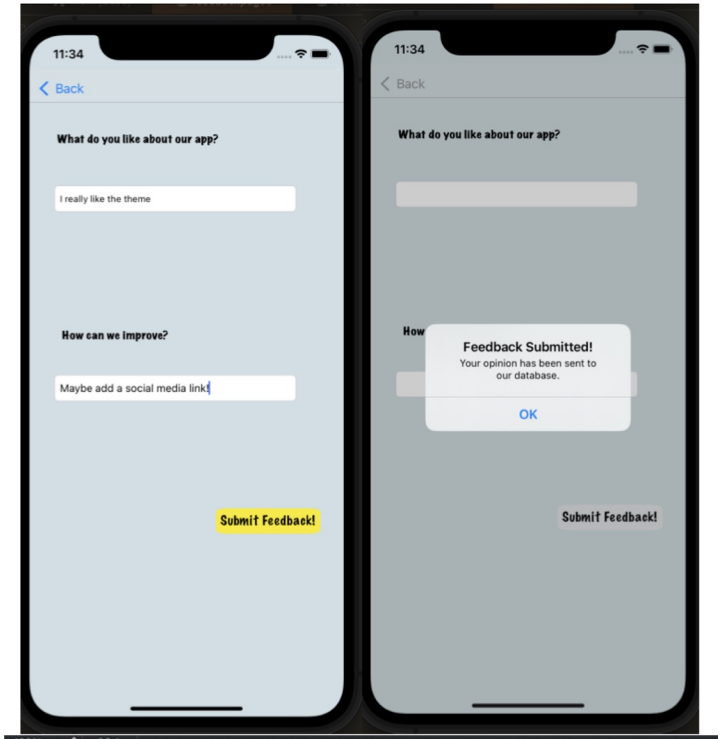
Frontend Results and Validation

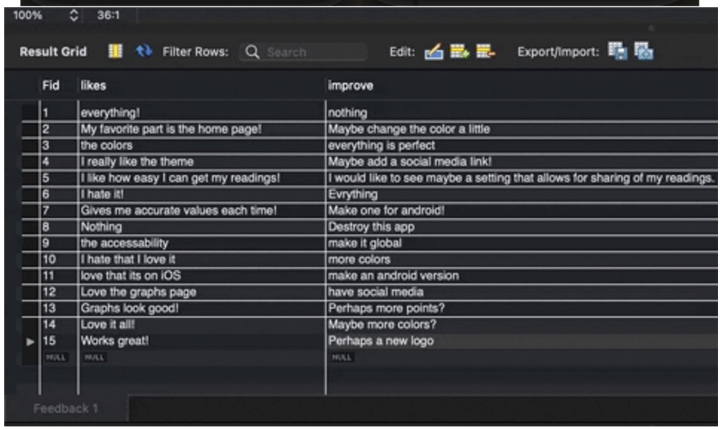
Application Validation

Aspect Ratio Testing
Functional Display Range: 1080x1920px -1242x2688px
Transition Speed Testing
Avg. time per page: 670ms
Point Value Range Testing
In progress

Database Validation

Data Insertion Testing
Avg. time per new query: 20 micro secs
Data Retrieval Testing
Avg. time per new query: 0.00054ms
Database Capacity Testing
In progress
Server-Database Communication
New data is visible on SQL after insertion initiated in app.





Backend Design Accomplishments

iPhone Application

- Easy to connect bluetooth UI
  - connects automatically when the app is connected
- ranged tested up to 30 feet

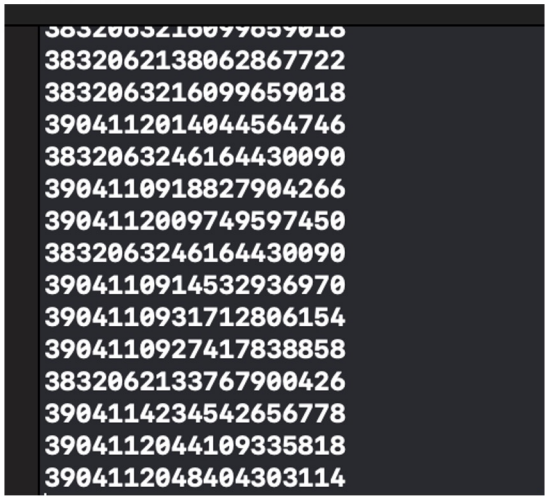
Major Challenges and Solutions

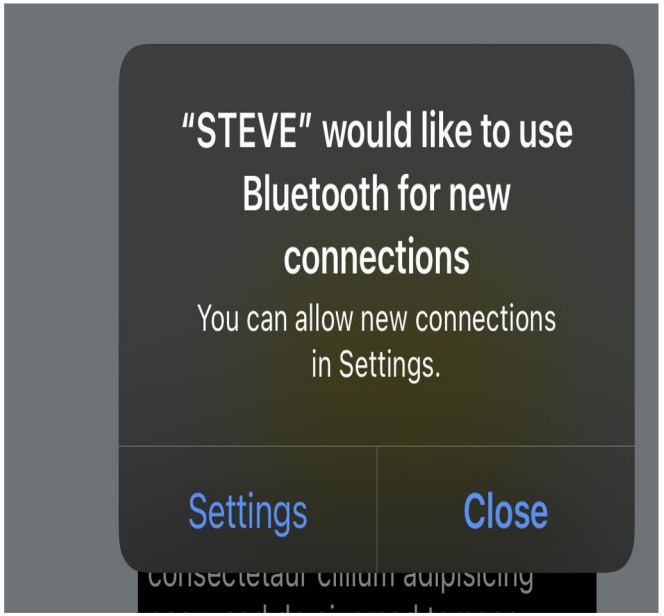
Challenges Encountered	Solutions
Bluetooth application can't be tested directly on iphone simulator	plugged in iphone directly to mac to test bluetooth functions
Converting the data value from the BLE device to print out on the code	research what the values being printed out on the console. Used the conversion within app to translate the numbers being printed.

Backend Results

Application

Range Testing
Stayed connected up to 30 Feet
Receiving Data
Verified and testing with another application to see if values are the same as our application. Ongoing testing is being done to ensure values are correct
Error Notification
Lets user know when bluetooth is disconnected





Integrated System Results

- Multimeter showcases full functionality
  - Simple, small, & low-cost design.
  - OLED display screen with bluetooth connectivity to iPhone App.
  - Traditional Multimeter Design; single lead probes, mode-switching & battery powered
  - Automatic unit conversion.
  - 0.001 sec response time/data retrieval (voltage, resistance, continuity, & current)
  - Low discharge time in capacitance measurement
  - Detects when no resistance is being measured and prompts user to insert component
- Graphical User Interface showcases full functionality
  - Application Graphs Measurements
  - Transmits Data Securely to Database

Conclusion

- Current status
  - Integration complete pending Bluetooth Testing and Validation
  - Validation of certain measurable features in progress
    - Differential Voltage pending
- Issues
  - Feature Postponement
    - Unit conversion
    - Transmission of Measurements from Backend Subsystem to Database