



Smart Digital Voltmeter Group 19

William Brumby
Gaston Mulsanga
Travis Ram
Vladimir Tsarkov

Electrical Engineering
Computer Engineering
Computer Engineering
Electrical Engineering

Motivation

- Traditional meters offer little assistance with recording data
 - A user must press “hold” button, remove measurement probes and record values
- Only one value displayed at a time
 - Continuously updating voltage, no measurements relative to time
- AC measurements only calculate RMS voltage
 - No minimum/maximum values

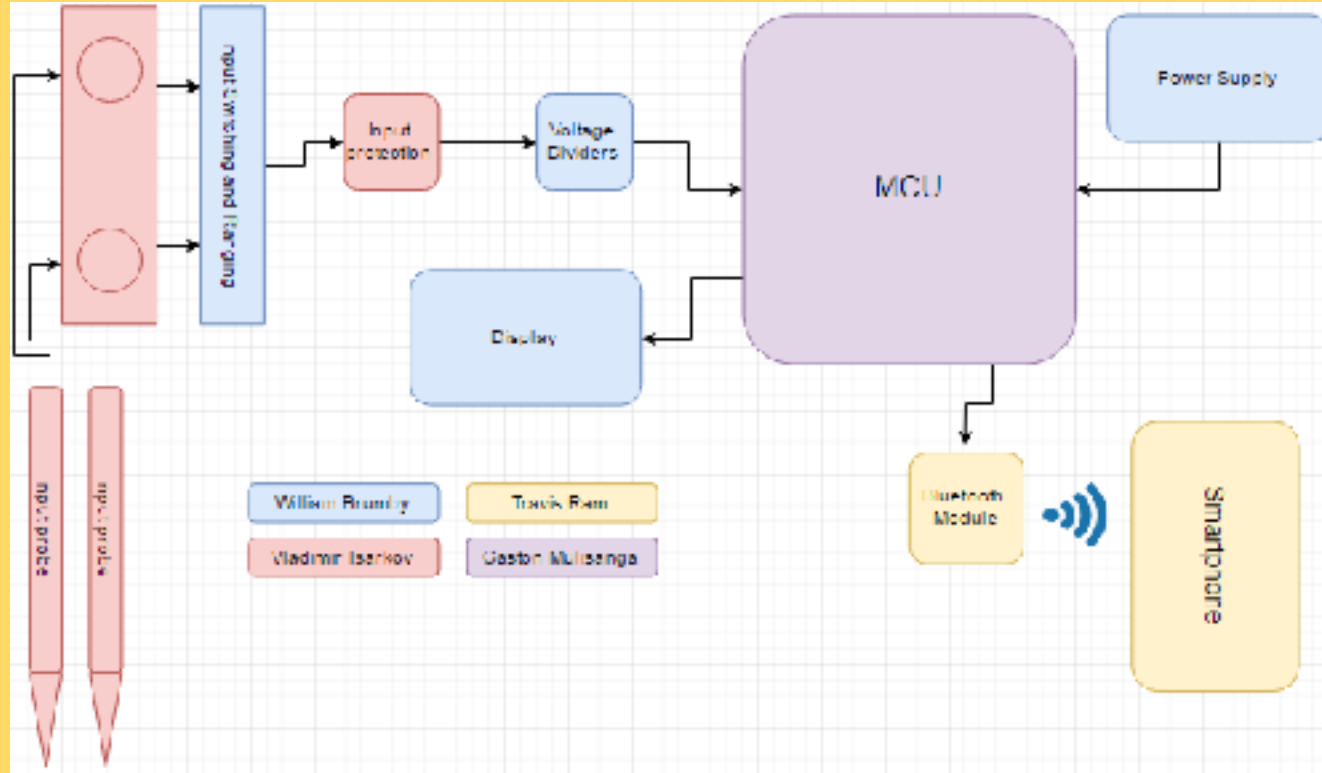


Goals and Objectives

- Lightweight and portable
- AC and DC voltage measurements
- Measurements to be wirelessly transmitted via Bluetooth to accompanying application on an Android device
- Application will record all values and let the user plot these values against time
- Device will display real-time, minimum, maximum, and mean voltage on an LCD screen
- Device will conform to all safety standards for modern meters
- Accuracy within 1% competition.



Project Block Diagram



Distribution of Work

	Voltage Dividers and Ranges	MCU	Power Supply	Input Protection	Phone App	PCB	Bluetooth Module
William	P		P	S		S	
Gaston		P			S		P
Travis		S			P		S
Vladimir	S		S	P		P	

P = Primary Role

S = Secondary Role



Specifications

Software Specifications		
	MCU	Android
Hardware platform	Atmel	LG V10
Software Platform	Arduino Version 1.8.1	Android 6.0/7.1 Marshmallow

Hardware Specifications	
Hardware	Technical Specifications
Battery	9 Volts
MCU	ATmega328P
LCD Display	20x4 RioRand
Bluetooth module	HC-06



Specifications

Component	Technical Specifications
Battery	9 Volts
Battery Life	9 hours running
Max AC Frequency	Up to 100 Hz
Bluetooth module	Range up to 30ft
Accuracy	Within 1% of other meters
Input Impedance	10M Ω
Safety Rating	CAT II

Voltage Ranges	Percent Error
millivolts	~0.01%
1V-10V	~0.5%
10V-100V	~0.1%
100V-1000V	~1.0%
AC millivolts	~3.0%



Reasons For The Technology Chosen

Microcontrollers			
	Arduino	MSP 430	Raspberry Pi
Hardware	MCU	MCU	General purpose Computer
Programming Languages	Arduino Programming language	C	C/C++/python
IDE	Arduino (Crossplatform)	CCS (windows Only)	Multiple IDE's
Bluetooth	Supported (multiple modules)	Support not adequate	Bluetooth dongle
Power	(3.3-5) V	(1.8-3.6) V	5.1V
Cost	\$10	\$10	\$35





Reasons For The Technology Chosen

Software Platform		
	Android	Iphone
Users	More users	Less users
Programming Language	Java	Swift/Object-C
IDE	Android Studio (Crossplatform)	CCS (windows Only)
Bluetooth	Compatible with Bluetooth Module	Not Compatible with HC-06
Cost	Free	Not Free



Reasons For The Technology Chosen

	
No certification needed, uses standard BT protocols	Proprietary technology, MFI Certification, licensing.
Supports All MCU Bluetooth Modules	Specific Modules supported



Why Bluetooth®?

Wireless Communication	Speed	Range	Network Type	Notes
Infrared	115.2 Kbps	10 meters	Star	Must have line of sight.
Wifi	250 Mbps	32 meters	Star	Connection limited to wifi hotspots.
NFC	424 Kbps	A few cm	P2P	Devices need to be in close proximity of each other.
ZigBee	250 Kbps	50 meters	Mesh	Low power consumption, but more optimal for large networks.
Bluetooth	25 Mbps	10 meters	Star	Simple to operate/single button press.



Analog vs Digital Voltmeter

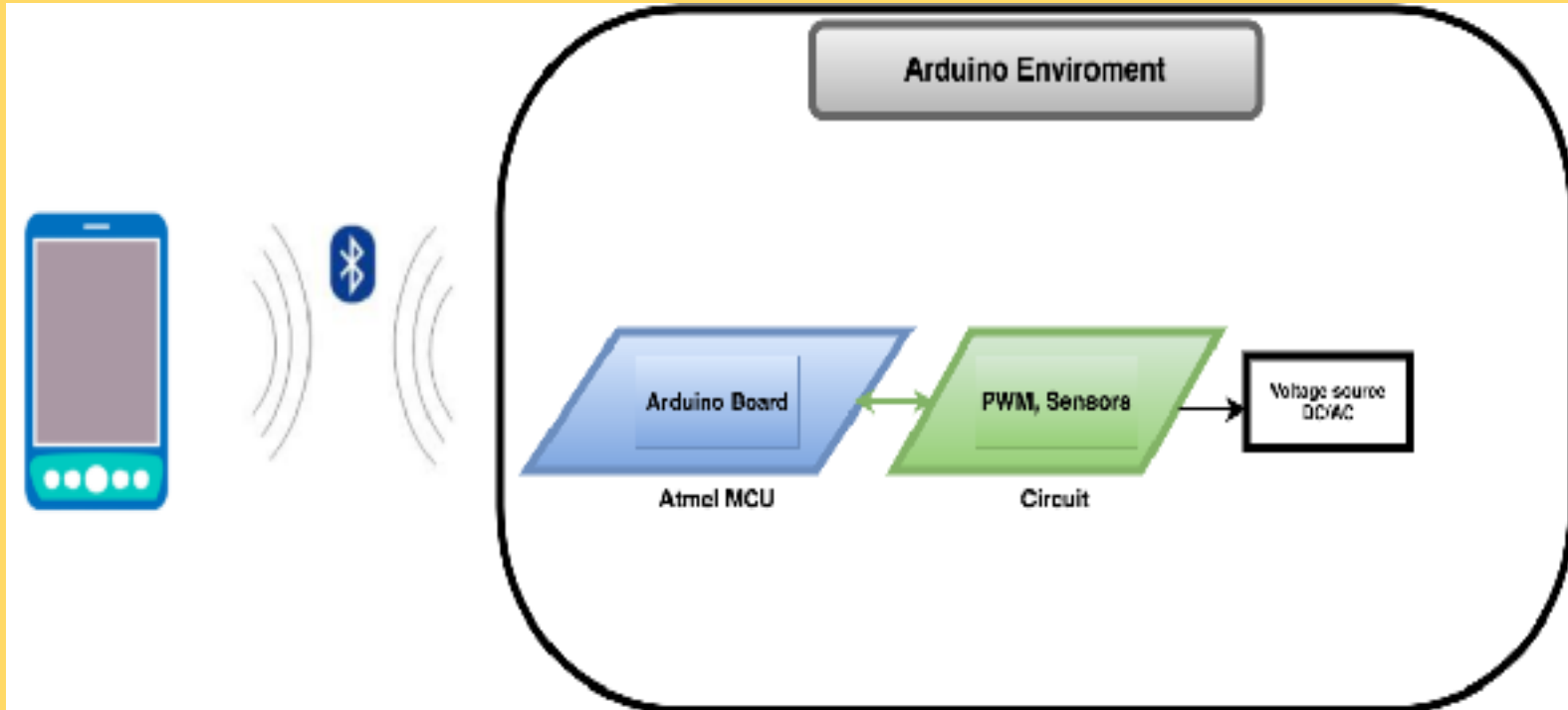
Analog	Digital
actually see the magnitude of the voltage	50x more impedance = more accurate high resistance circuits
convenient when comparing voltages	less bulky
	digital display
	avoids parallax
	measure AC and DC
	fast
	more durable



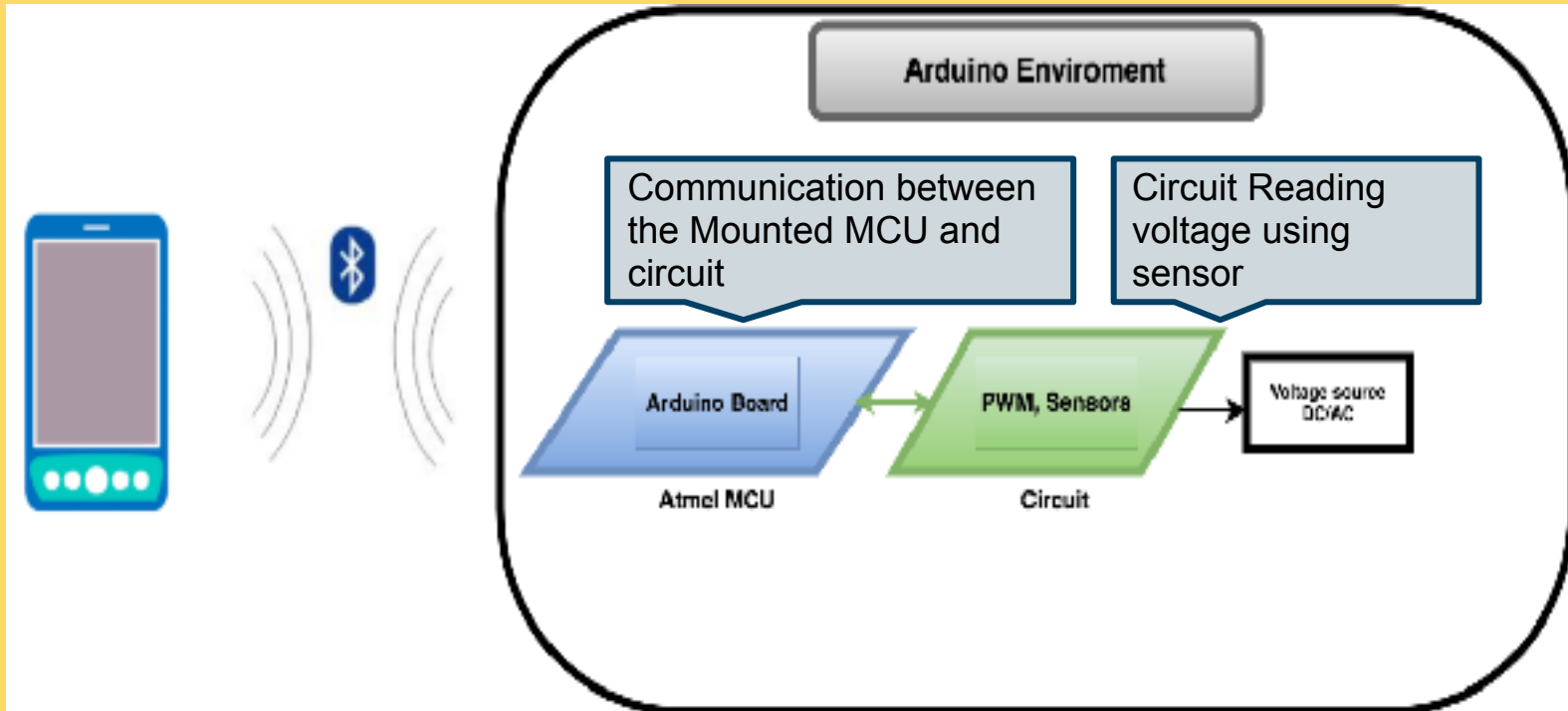
Analog vs Digital Voltmeter



MCU and Android Transmission Block



MCU and Android Transmission Block



MCU Software Flowchart

Microcontroller Software structure

- Check to see if we are receiving voltage



MCU Software Flowchart

Microcontroller Software structure

- If we are unable to read in voltage,
- Troubleshoot the software and hardware
- Make sure the sensors are correctly measuring the voltage



MCU Software Flowchart

Microcontroller Software structure

- Calculate the V_{max} , V_{min} , avg, RMS
- Internally in the program



MCU Software Flowchart

Microcontroller Software structure

- Calculate the V_{max} , V_{min} , avg, RMS
- Internally in the program
- **Display the values on the LCD mounted on the circuit**



MCU Software Flowchart

Microcontroller Software structure

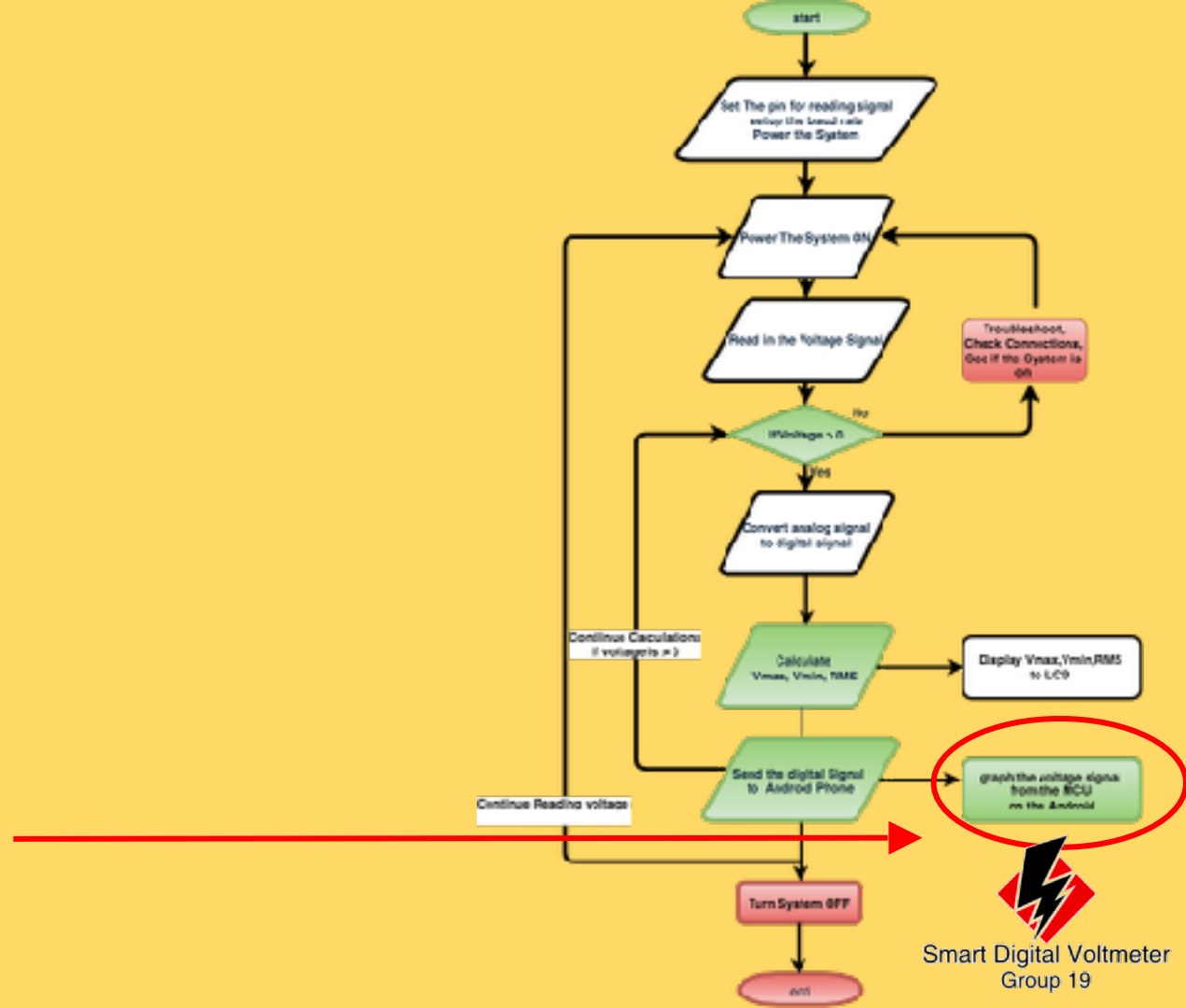
- Once the values have been Calculated,
- Send them over to the Android application via Bluetooth
- Done Automatically



MCU Software Flowchart

Microcontroller Software structure

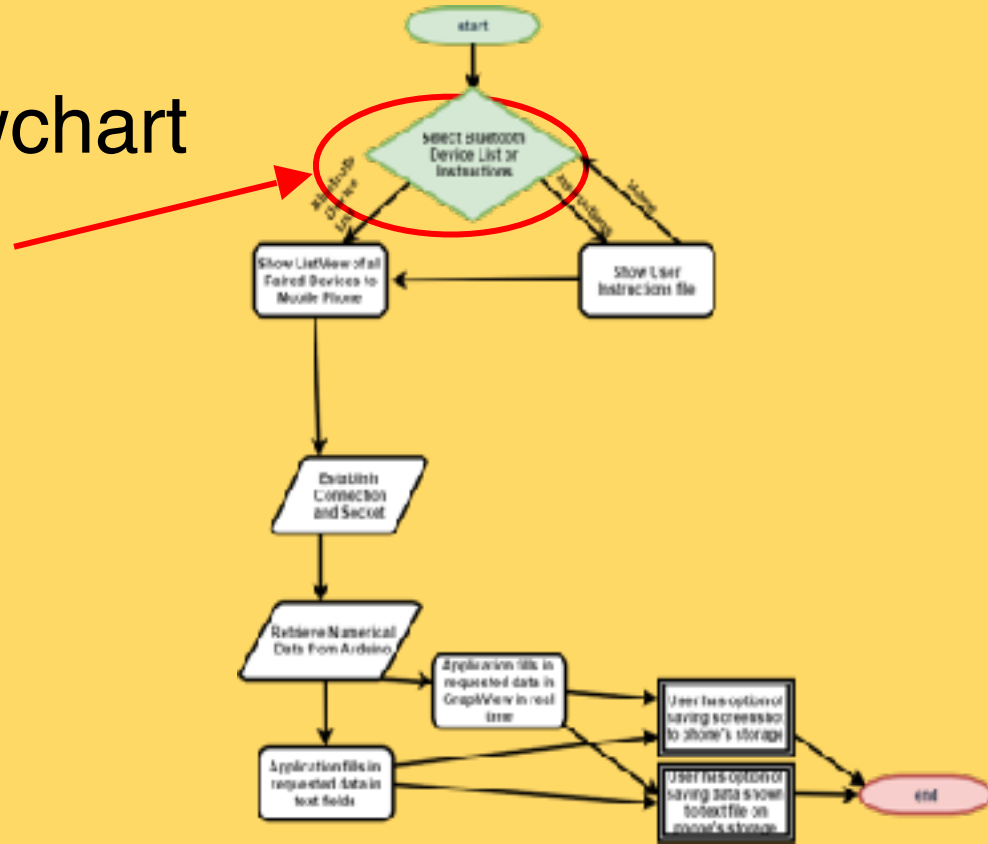
- Display the Received values and data on the Android application
- Plot the Voltage on the graph



Android Software Flowchart

Application Software Structure

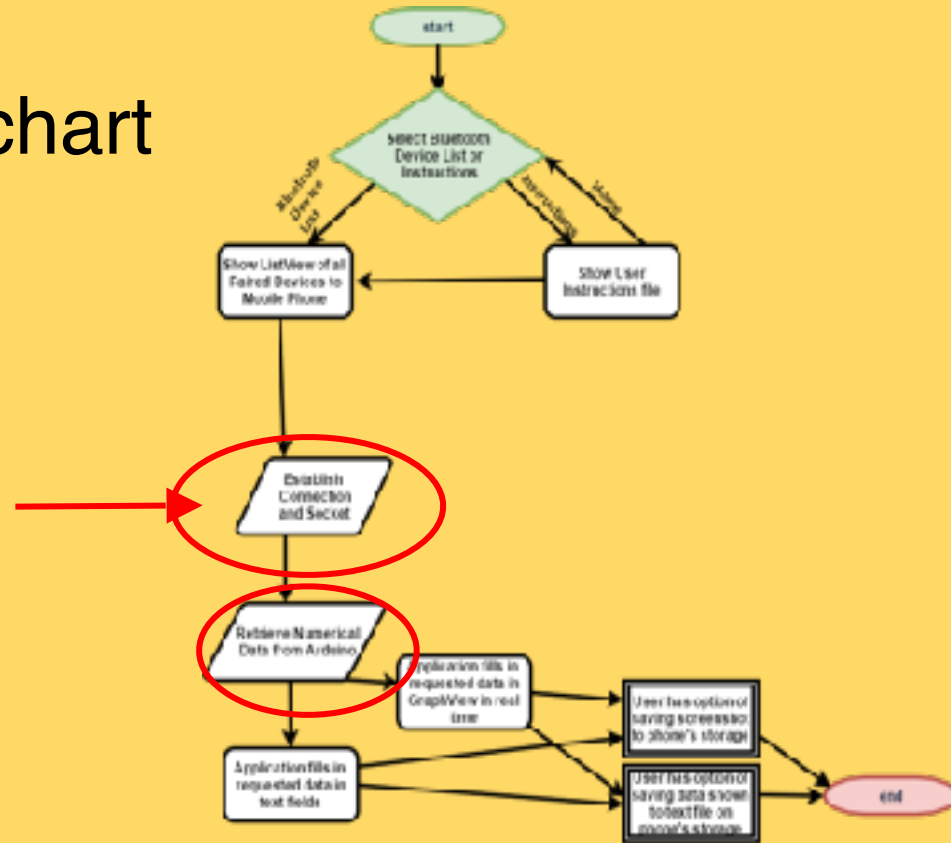
- User initially chooses between Bluetooth Devices and Showing Instructions



Android Software Flowchart

Application Software Structure

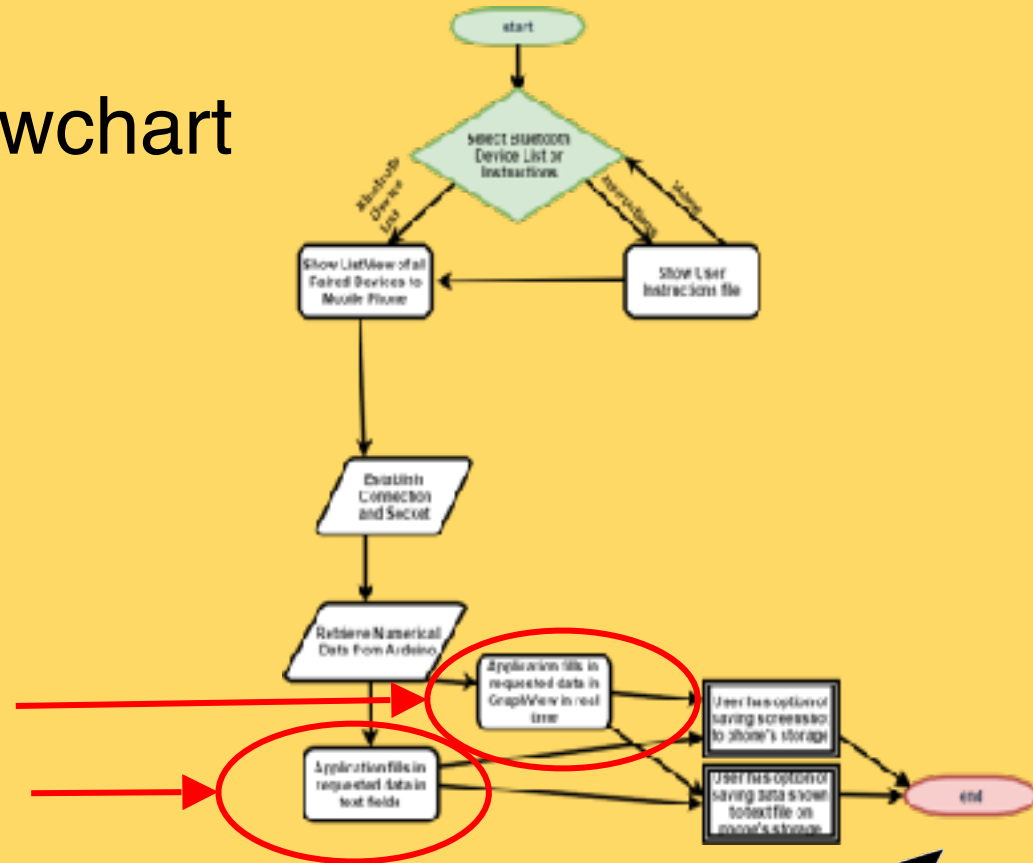
- Connect to socket dictated by the user and data is automatically sent to application



Android Software Flowchart

Application Software Structure

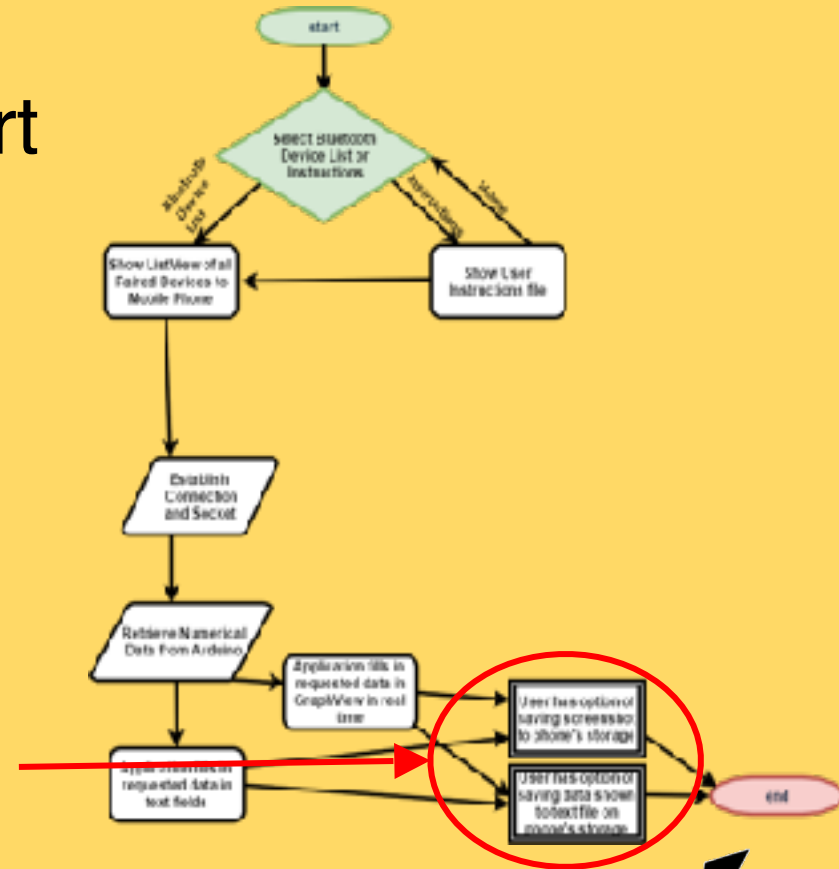
- Application automatically plots data received as well as numerical values and switches between AC and DC based on the selection on the Voltmeter hardware.



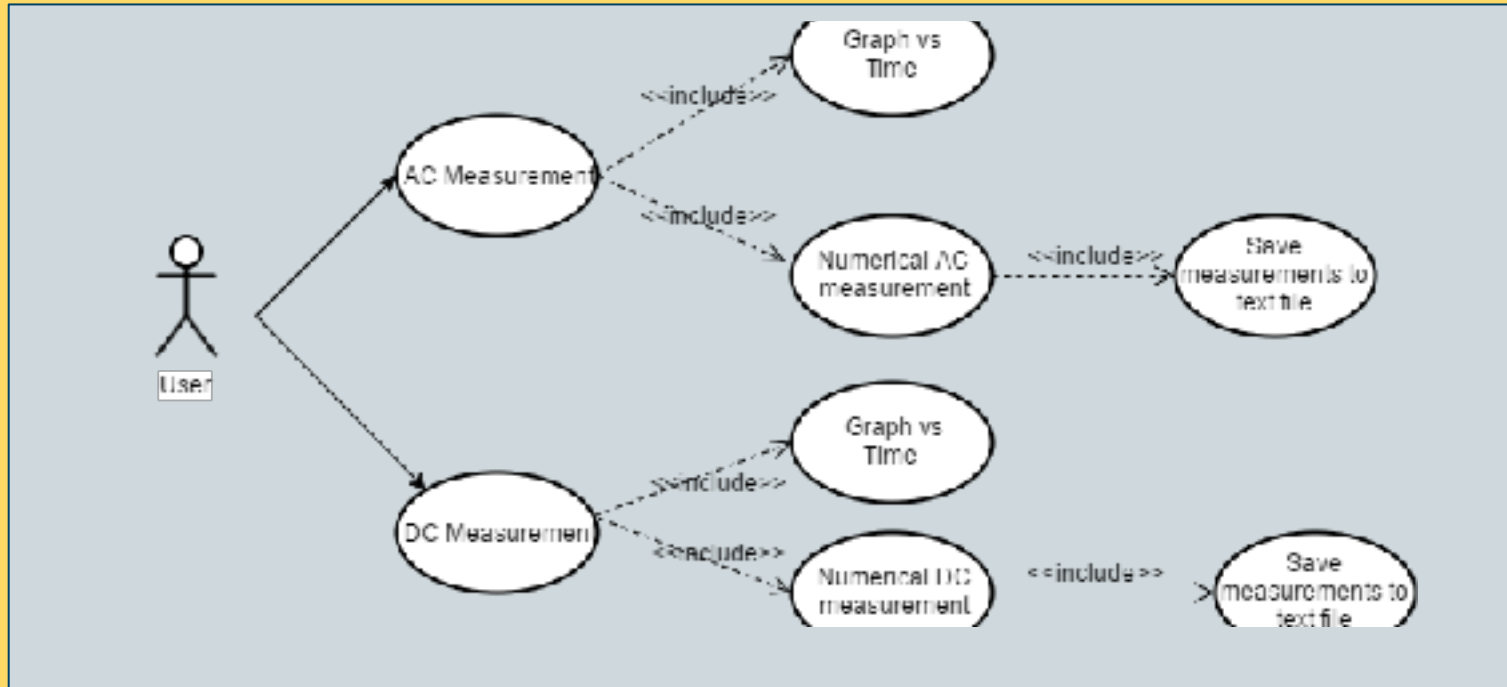
Android Software Flowchart

Application Software Structure

- The User can store this data as either a text file to the phone's storage or the default gallery.

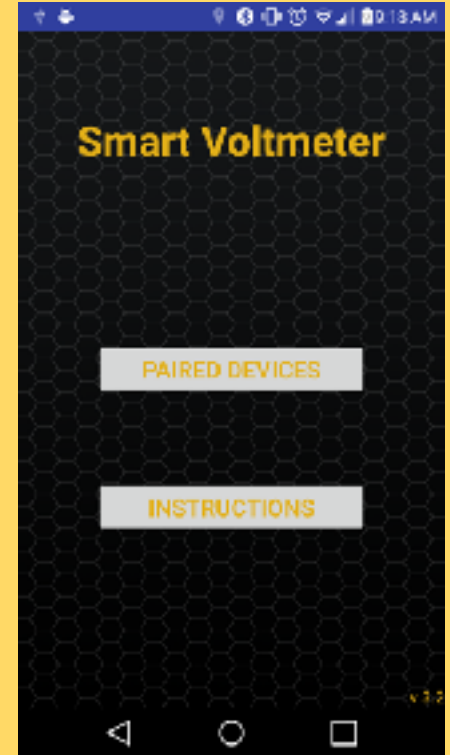


User Case Diagram

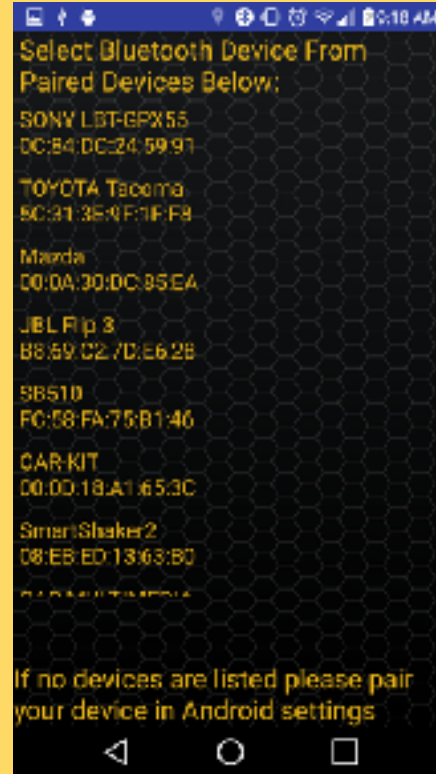
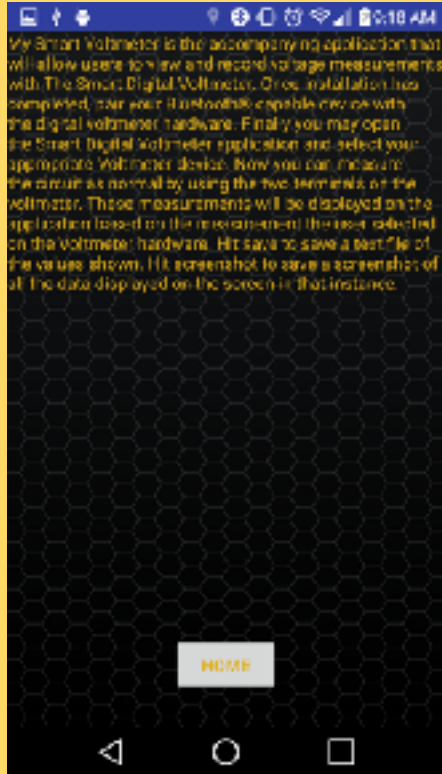


Android Application

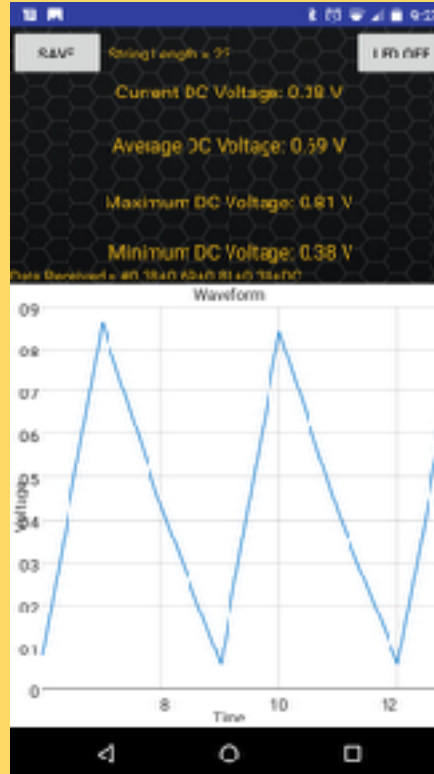
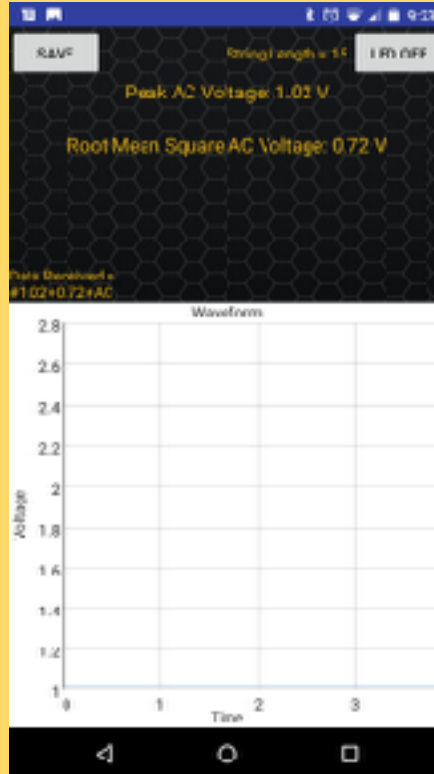
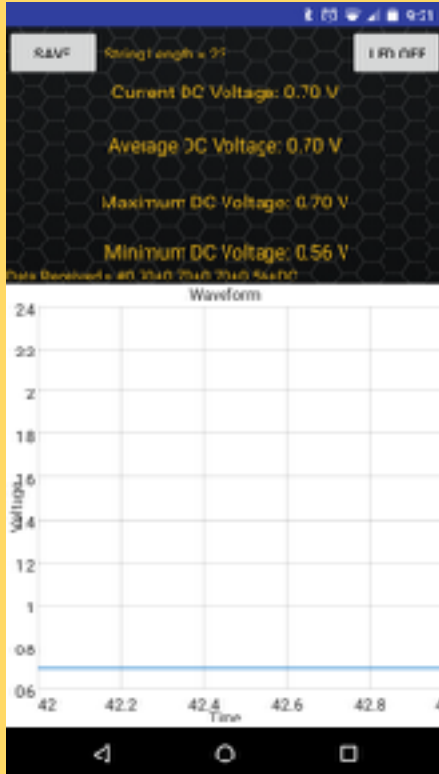
- Simple User Interface:
- AC or DC is displayed depending on the hardware's selection measurement style
- Both AC and DC display both the numerical as well as the graphical representations of data.
- AC voltage will measure Peak and RMS Voltage, while DC will measure Current, Average, Maximum, and Minimum voltages.
- Users will have the option to push a button and have the numerical data stored.



Android Application

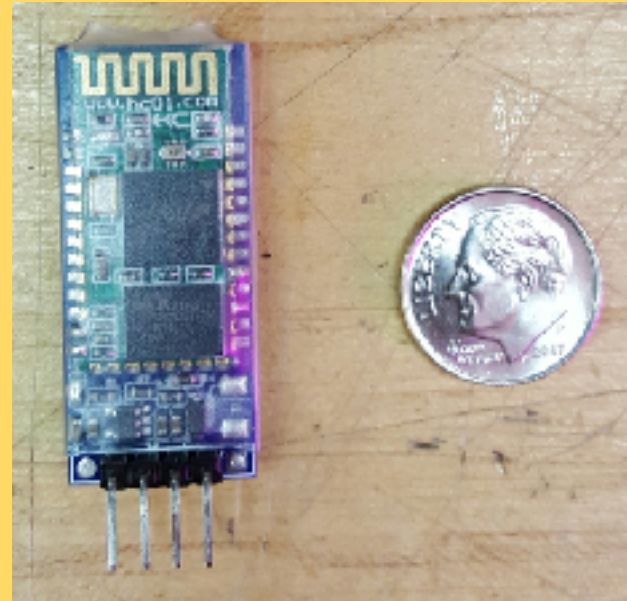


Android Application

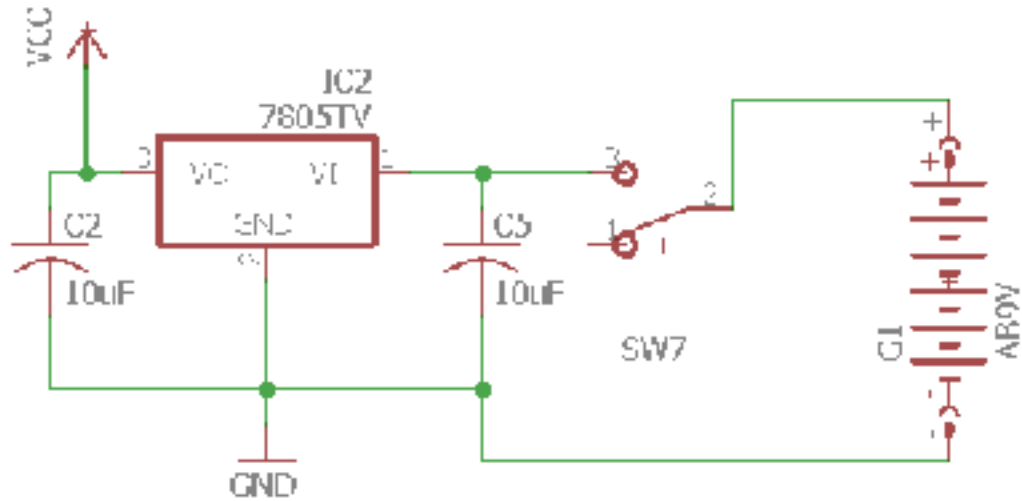


Bluetooth® Module

- HC-06 Bluetooth Module
- Compatible with ATmega328P and Arduino IDE
- Can transmit and receive signals
- Will be used to send measured data to smartphone application
- Compatible with Android phone
- Adaptive Frequency-Hopping (AFH)
- 79 channels between 2402 - 2480 MHz
- Occurs 1600 /sec
- Quick connectivity
- Low power
- Portability



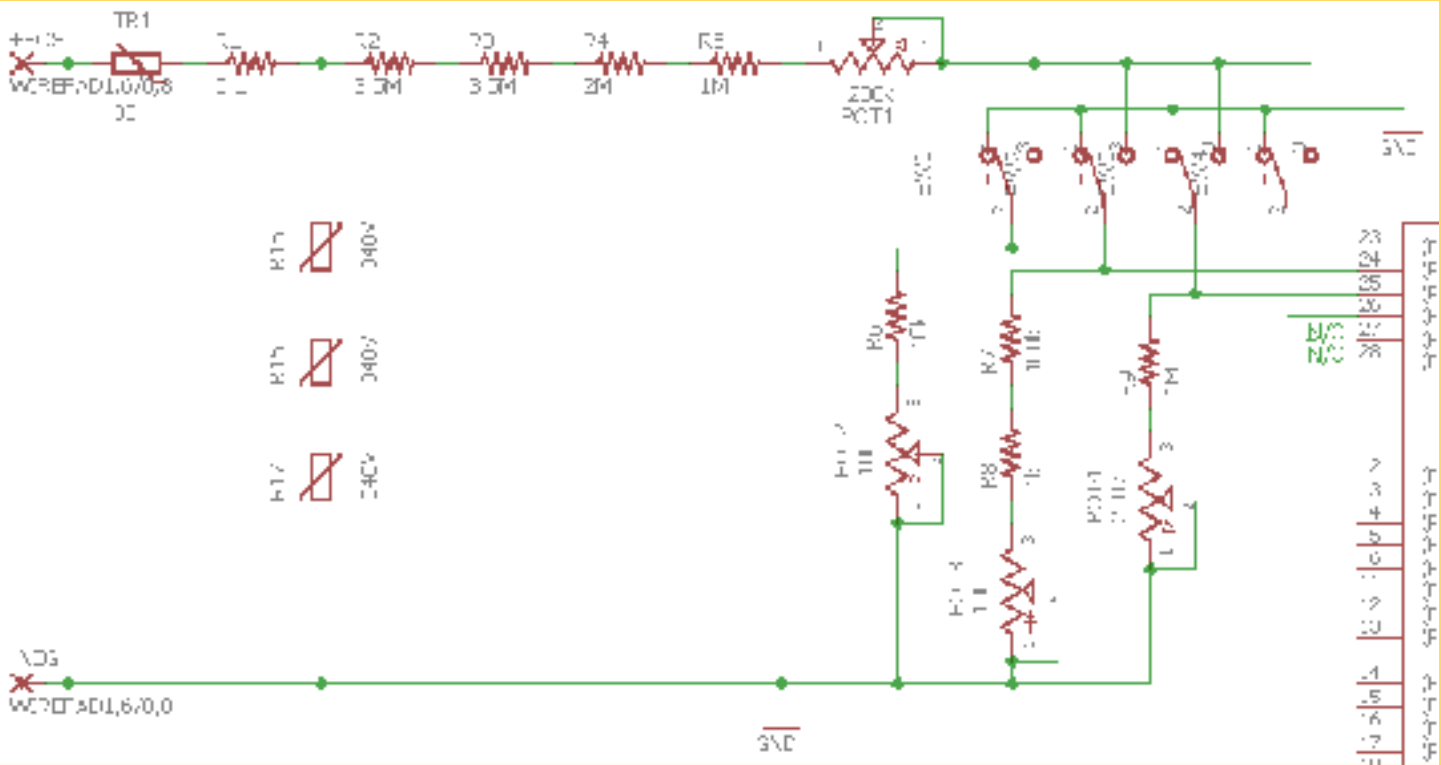
Power Supply



- 9V battery
- SPST On/Off switch
- Voltage regulator (LM7805)
- 5V
- Capacitors for steady voltage

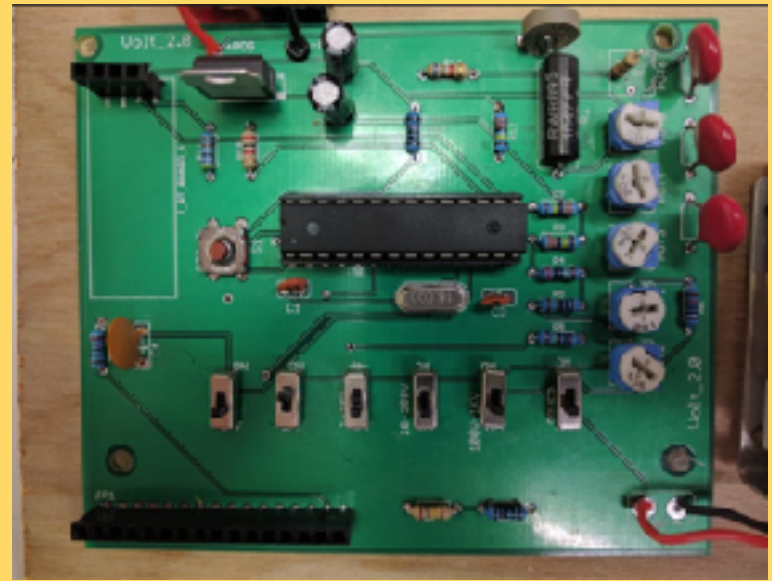


Input Measurement and Safety Components



Input Measurement

- Range vs Resolution
 - Resolution inversely proportional to range, i.e. better resolution = smaller range of measurement
 - Voltage divider
- Input Impedance
 - No current draw
 - High input impedance $\sim 10\text{M}\Omega$
- Range Switching
 - User selects range
 - Ranges not in use must be grounded



Vin Range (Volts)	R1 (Ohms)	R2 (Ohms)	Vout (Volts)
1.00 - 9.99	10000000	1111111	0.099999991
10.0 - 99.9	10000000	101010	0.099999901
100 - 1000	10000000	10010	0.0999999001



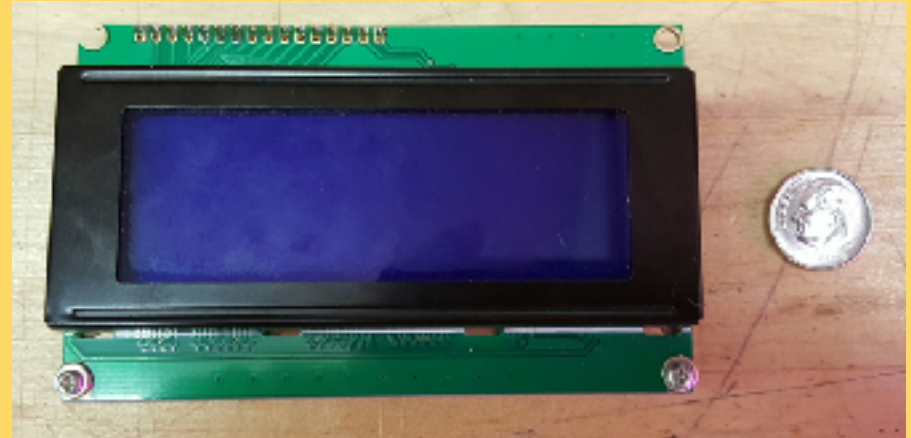
Safety Components

- Fuse
 - Thin wire
 - Melts from high current
- Varistor or Zener Diode
 - Trap extra voltage
 - Zener diode = higher maintenance
- Thermistor
 - “Thermal” and “Resistor”
 - Overcurrent protection
- Wire wound resistor
 - Limits current
 - Has natural capacitance and inductance
 - Not ideal for AC circuits
- PCB safety
 - Isolation slots to separate nodes
 - Arc-overs



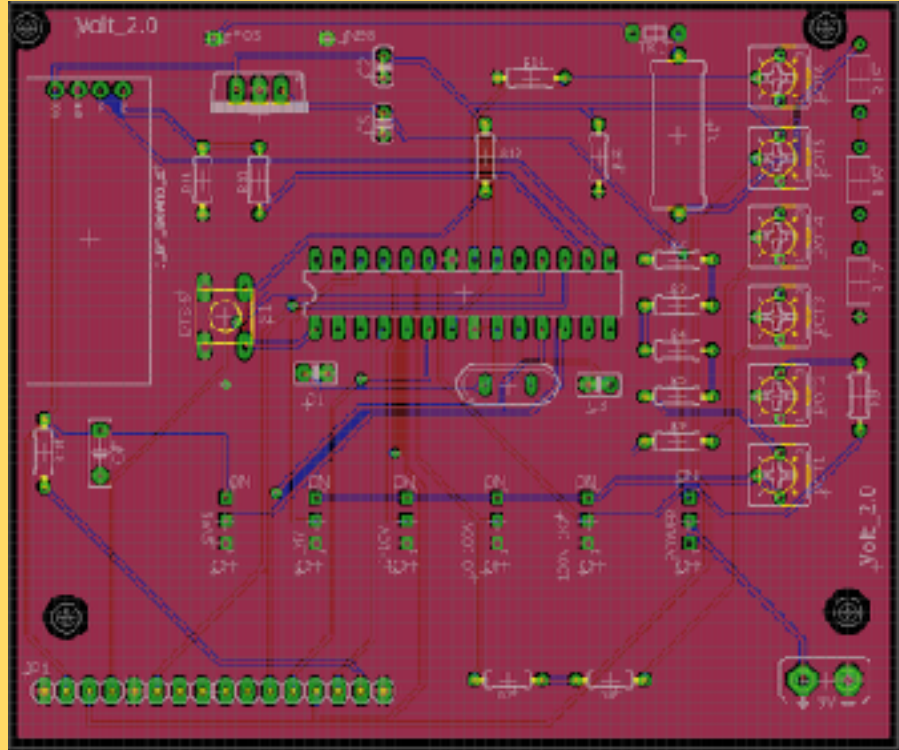
LCD

- Four lines
- Displays multiple voltages measurement parameters
 - Maximum, minimum, mean, etc.
- Displays user warnings
 - Multiple ranges selected!
 - Maximum voltage reached for that range!



PCB Design

- Eagle Software
- 2 layer board
- 10 cm by 8.4 cm
- EleCrow - supplier
- Top and bottom layers
 - Grounded
 - Helps dissipate heat



Final Product



Administrative Content



Budget

Component	Quantity	Cost per Unit
9V Battery	2	\$0.49
Microcontroller	1	\$10.99
PCB	5	\$5.51
Tablet/Phone	1	N/A
Wireless Adaptor	1	N/A
Bluetooth Module	1	\$7.39
PTC Thermistor	1	\$1.24
LCD	1	\$1.99
Resistors	20	\$0.08
Probes	2	\$7.99

Varistors	3	\$1.10
WW Resistor	1	\$1.25
Trim potentiometers	1	\$0.35
Range Switches	4	\$0.47
Pushbuttons	2	\$0.20
Power Switch	1	\$0.47
LEDs	4	\$0.10
Crystal Oscillator	1	\$1.24
Capacitors	4	\$0.10
Battery Connector	1	\$2.99
Estimated Total		\$72.77

Sponsored by: Commercial Lighting Enterprises



Smart Digital Voltmeter
Group 19

Project Conclusion

Accomplishments

- Accurate DC measurement
 - All ranges
- Bluetooth connectivity
- Application Development
- Meter/Application integration
- PCB design
- Waveform display

Challenges

- Only Android compatible
- Pairing to earlier Android versions
- PCB safety isolation design
- Accurate AC limited to 100 Hz
 - ADC sampling rate
- Smooth waveform display
 - Bluetooth transmission rate
 - Application frame skip
- Frequency Measurement



Thank you

