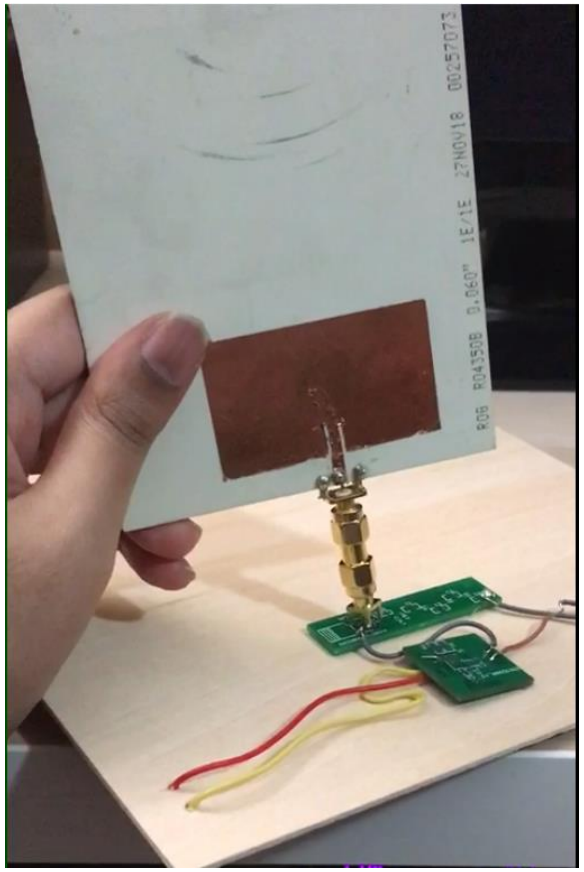
Design and Development of Smart Home Microwave Harvester



ENGR 4941U Capstone Systems Design for ECSE II

Project Supervisor: Dr. Ying Wang

OntarioTech UNIVERSITY

Design Team

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Presentation Outline

- Overview
- Objectives
- Problem
- Project Task: Solution
- Design
- Components
  - Antenna
  - Rectifier
  - Power Management Unit
  - Microcontroller
  - Battery
  - Application
- Budget
- Demo

Objectives

Incorporate smart grid principles by using technology & communication to monitor, regulate, secure, and control the electrical grid

Use home automation system for control lighting, climate, entertainment systems, appliances, home security access control and alarm systems

Harvest Microwaves and RF technology to communicate and power the smart home devices

Problems with Current Technology

Batteries need to be replaced every month or two

IOT devices may need to be hardwired

Out of reach or positioned in obscure place

Time consuming and costly to replace

Project Task: Solution

Autonomous and self-contained system

Powered and charges by RF

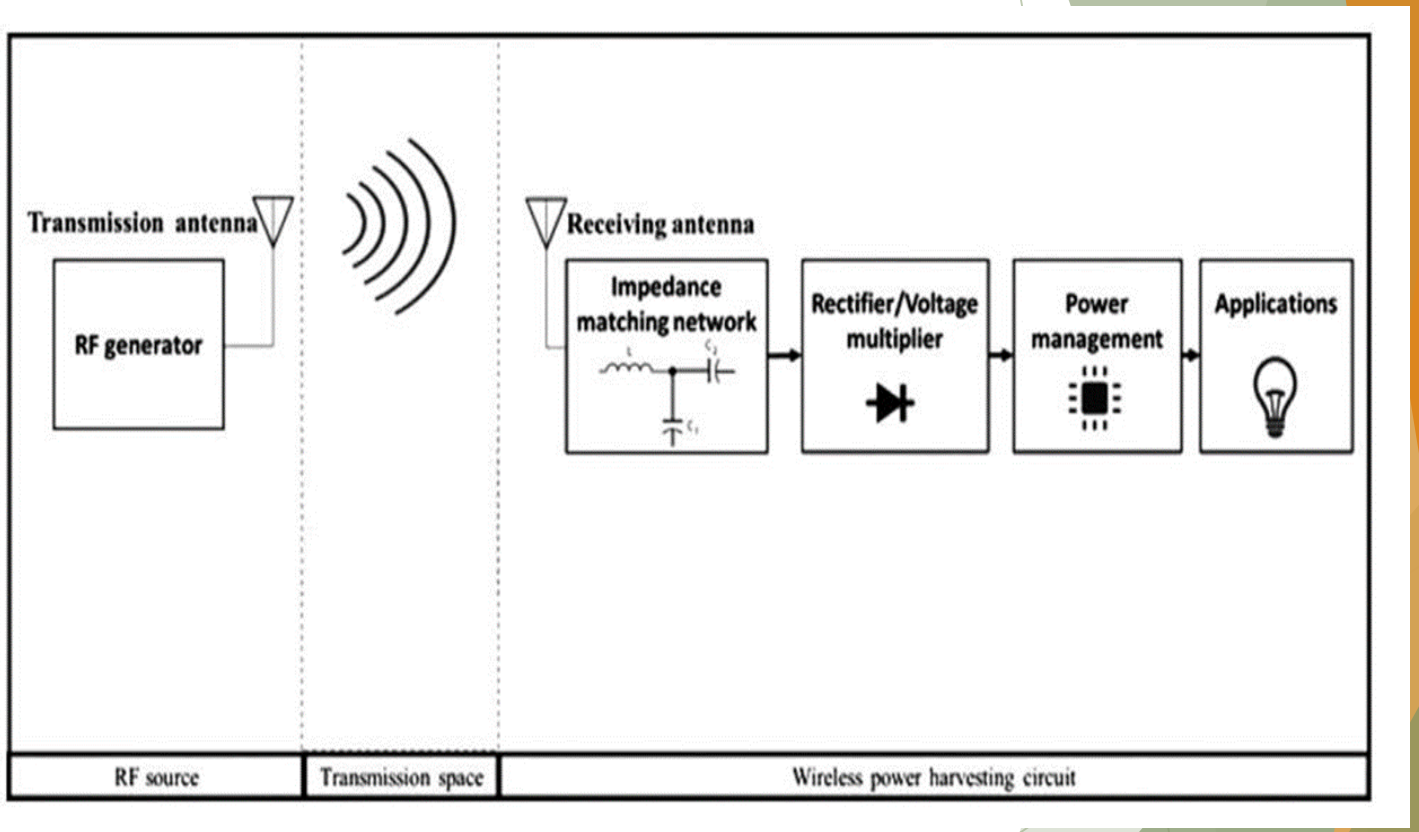
Dual battery solution

Adaptable

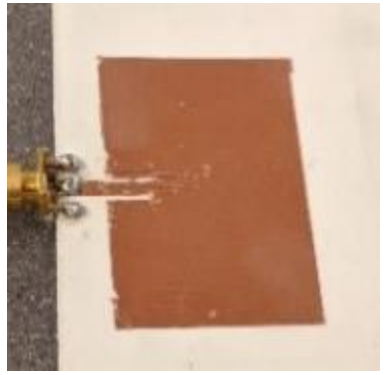
- Various devices
- Locations

Design

- Design choice: To work at 2.4GHz
- We chose to include:
  - Patch antenna
  - Rectifier circuit (RF signal to DC power)
  - Power Management Unit
  - Microcontroller
  - Battery
  - Sensor



Components



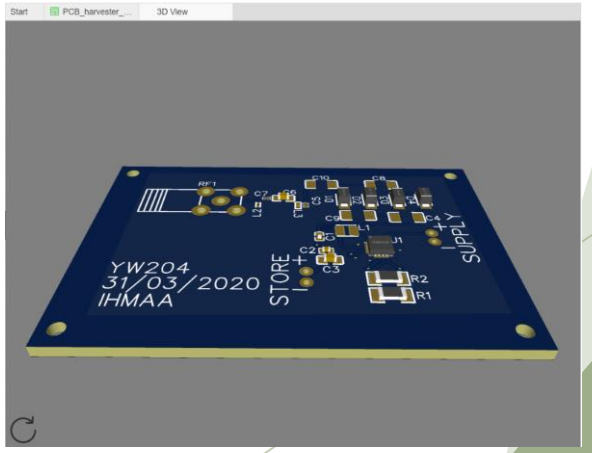
Antenna

Power Management Unit

Microcontroller Development Board

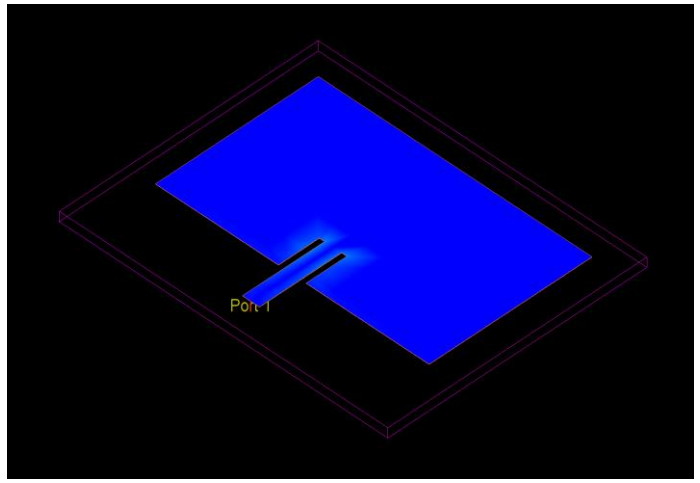
DC Battery

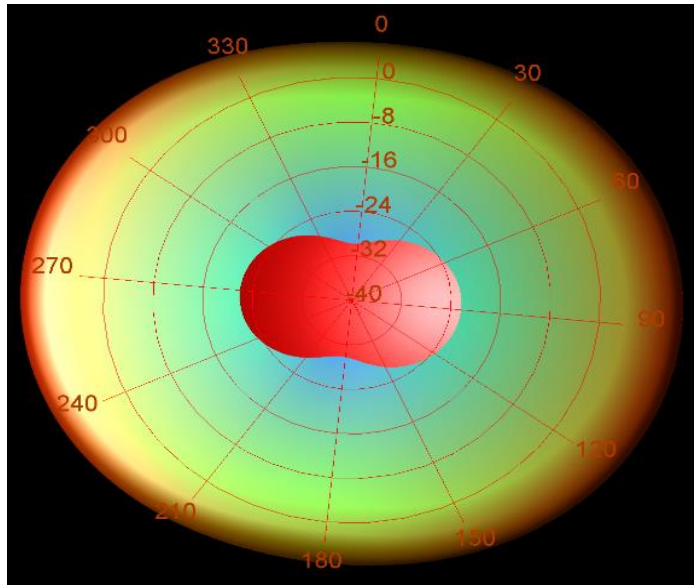
Temperature Sensor



Rectifier

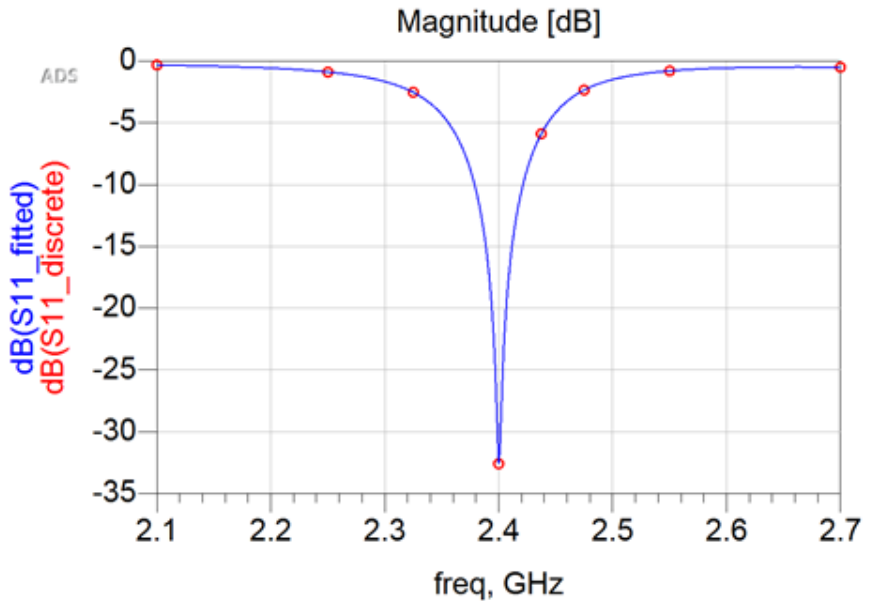
Microstrip Patch Antenna

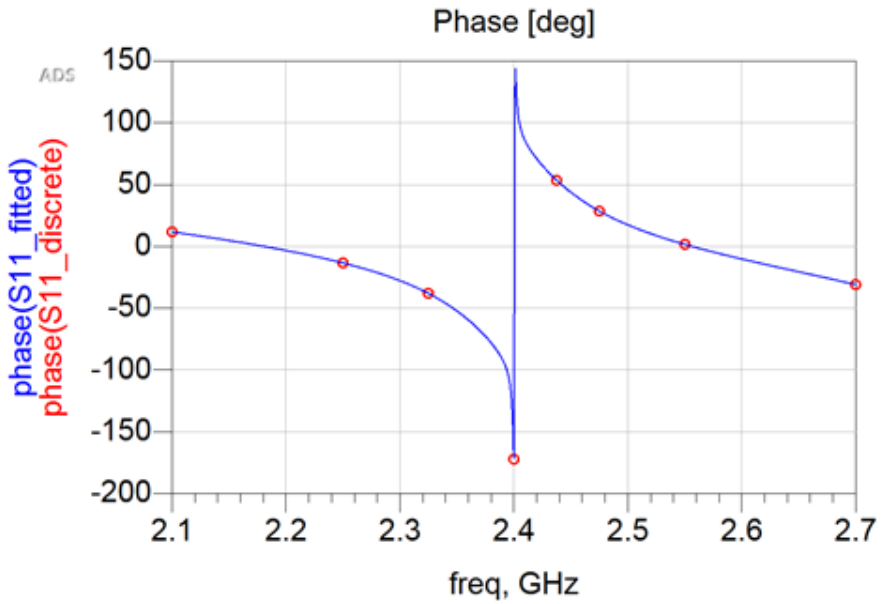


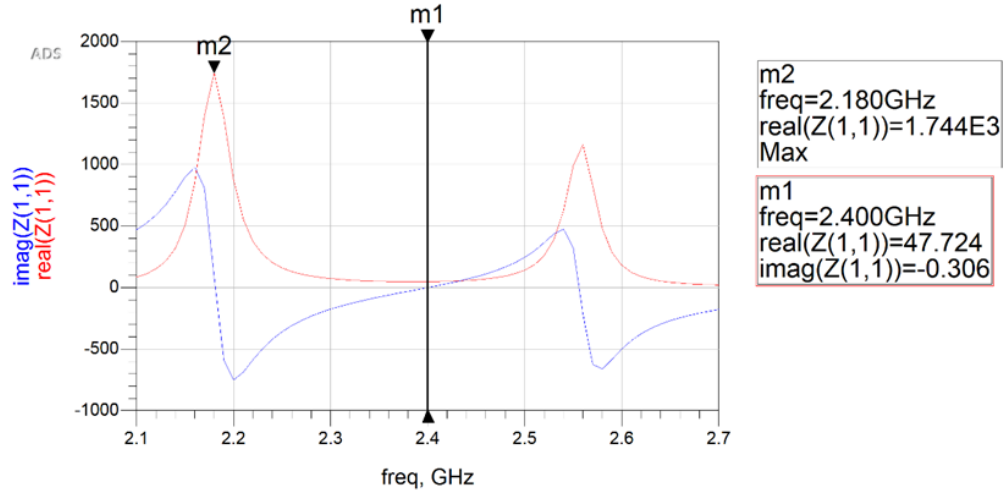


- Microstrip patch antenna
- Frequency 2.4 GHz
- Dimension
  - Length 53.6 mm
  - Width 31.9 mm
- Substrate
  - RO4350B
  - Thickness 1.524 mm
  - Tangential Loss 0.0037
  - dielectric constant (ε) 3.66
- Advantages
  - PCB Boards
  - Small and compact

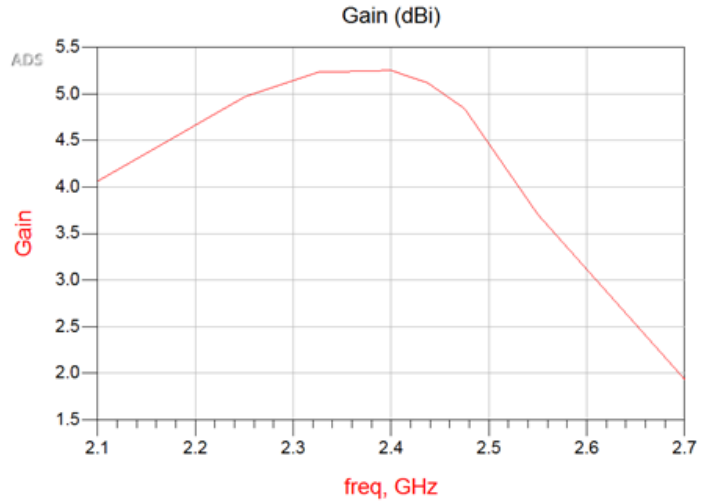
Antenna S and Z Parameters

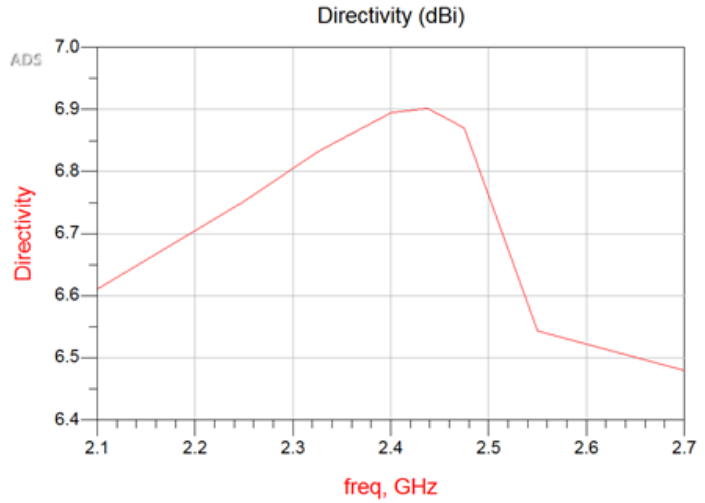


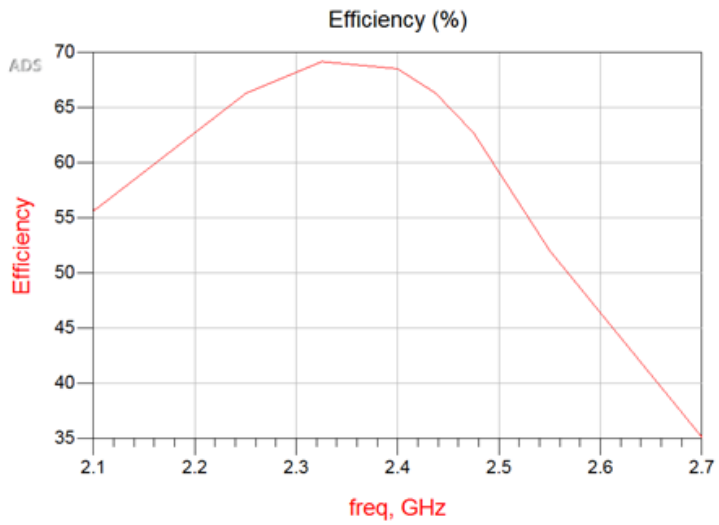


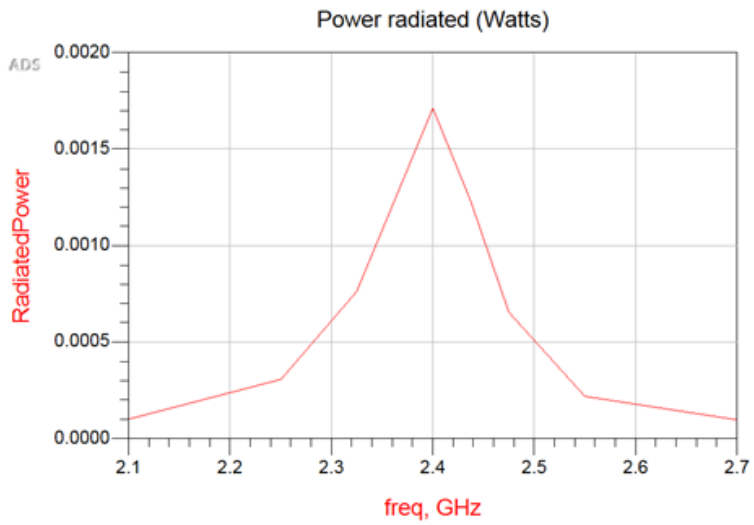


Antenna Cont.

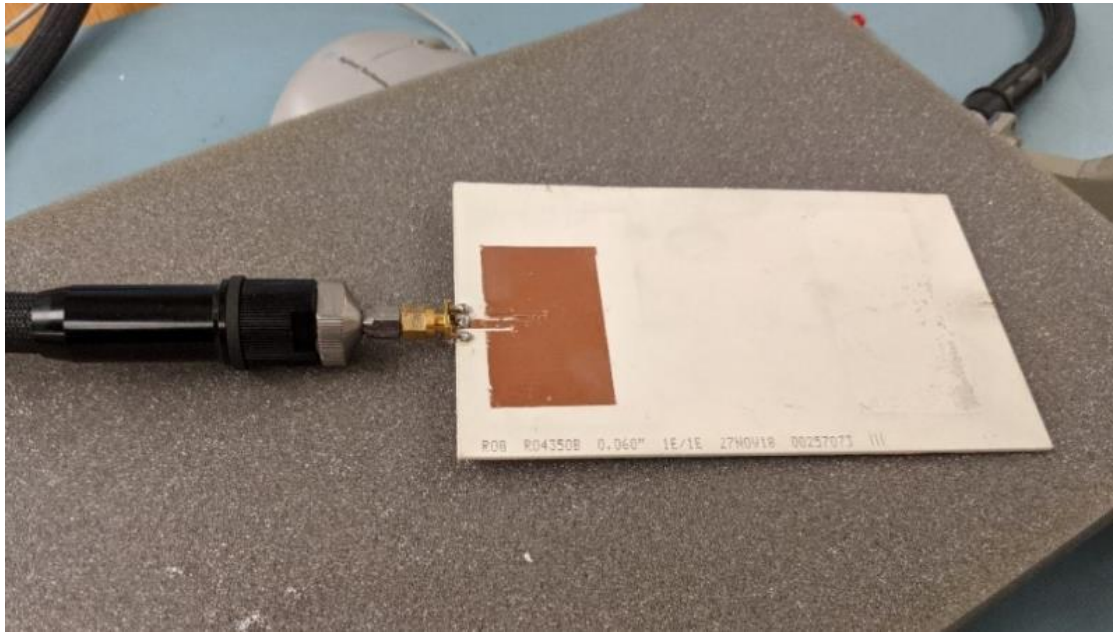


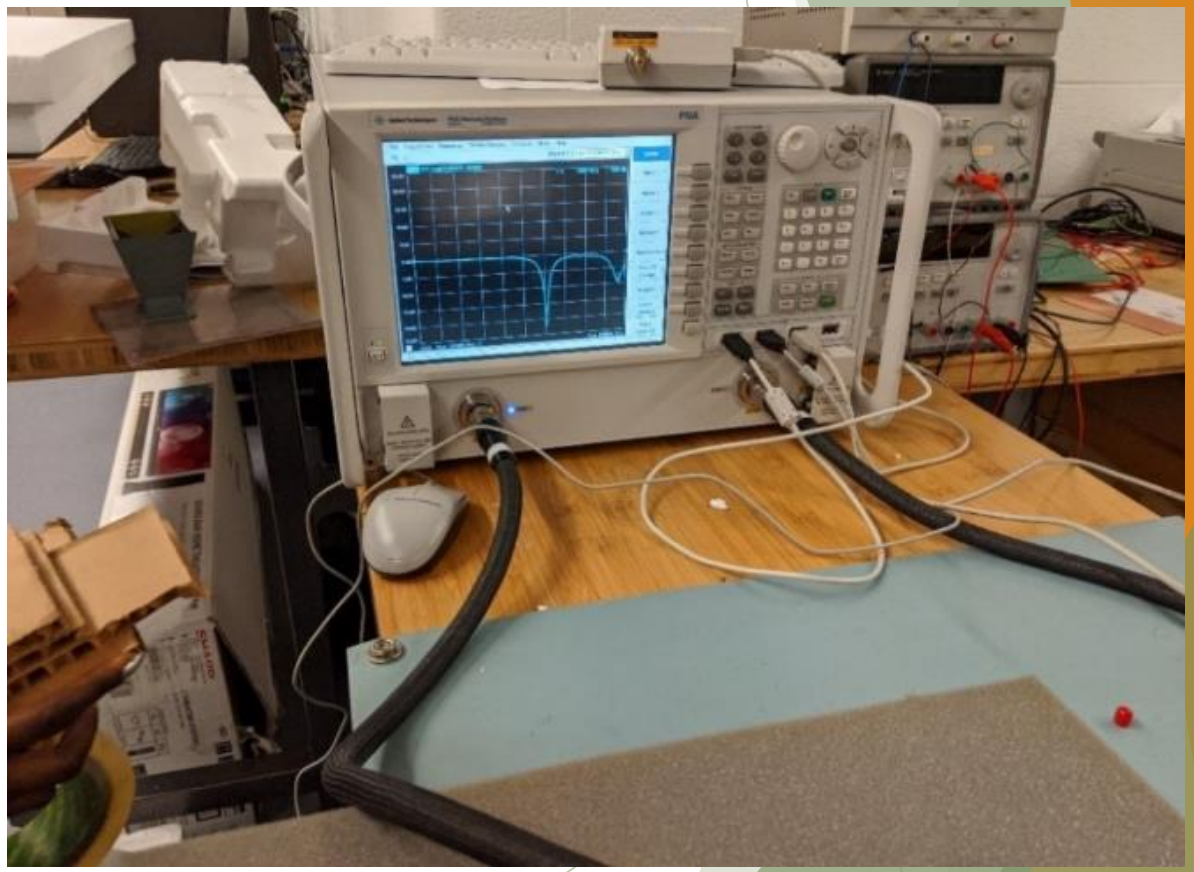




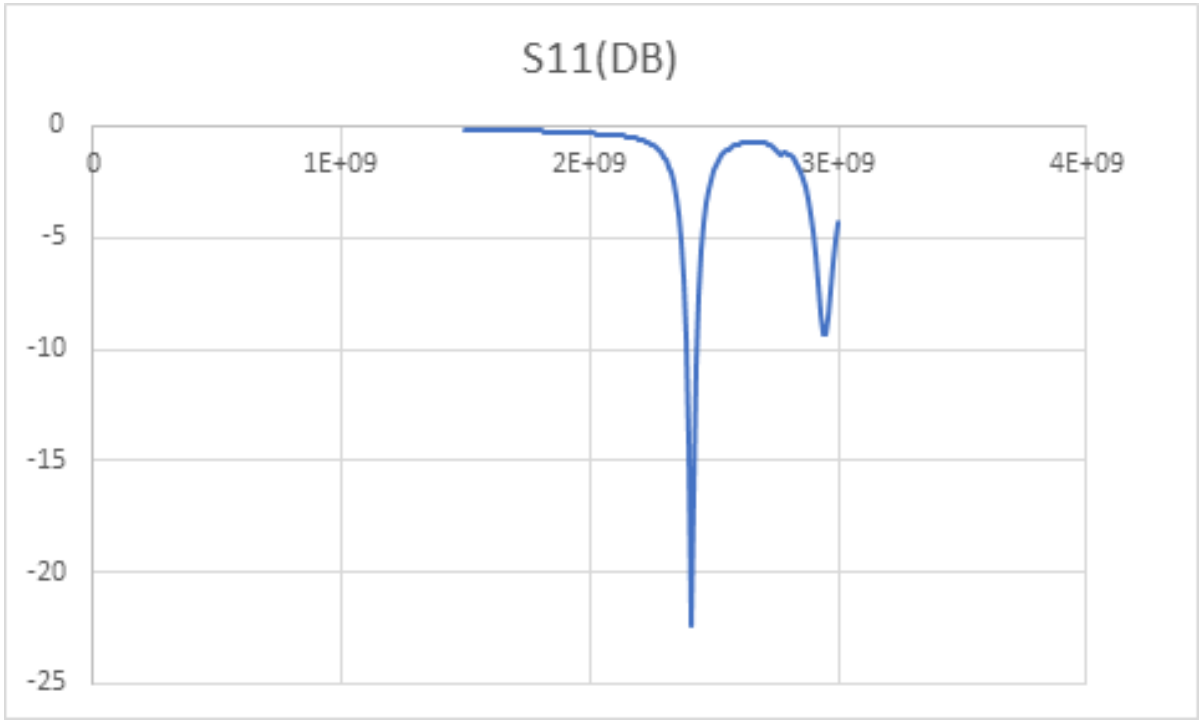


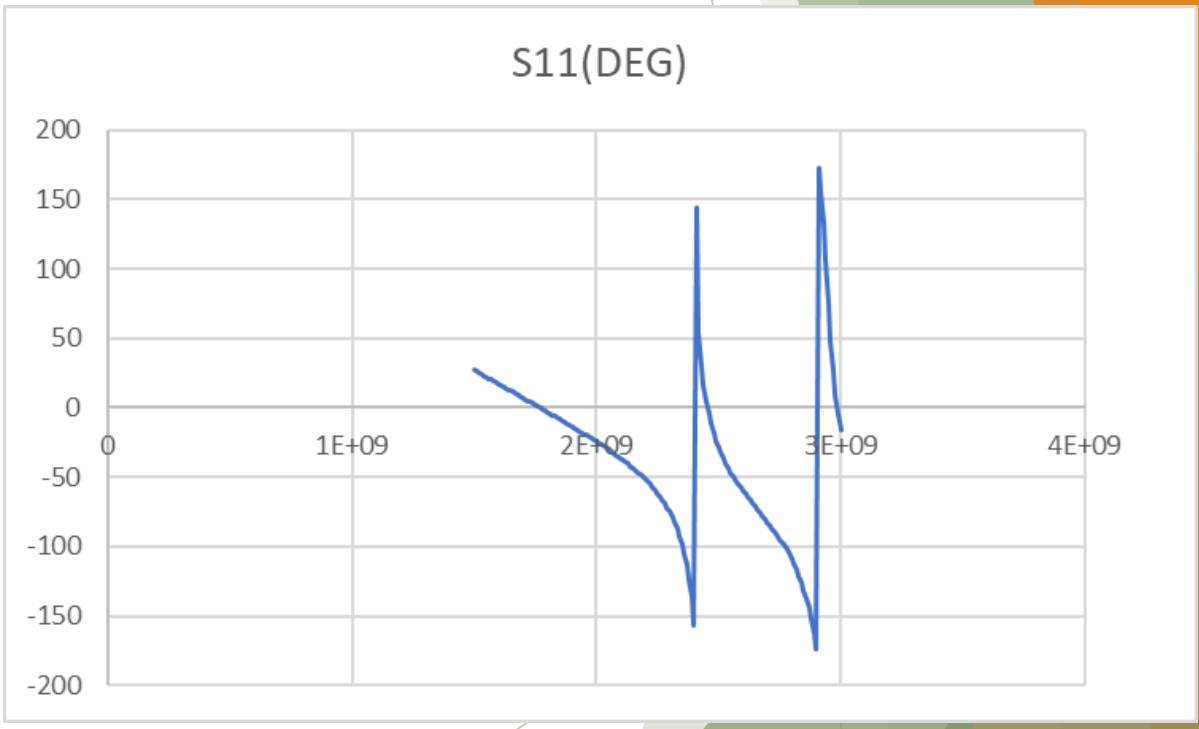
Antenna Results

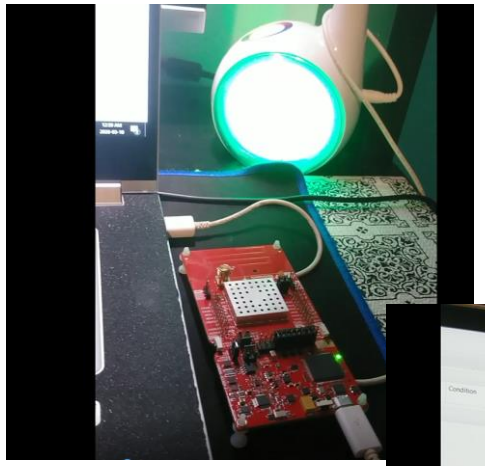


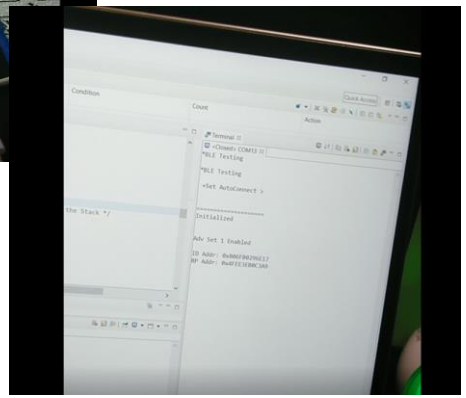


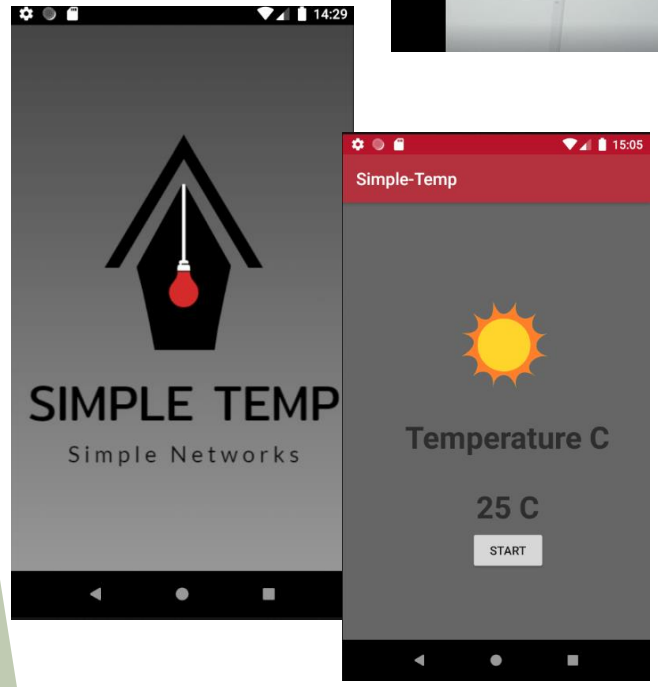
Antenna Simulations











CC1352P wireless MCU and Application

- ‘Ultra-Low-Power Bluetooth Low Energy System’ designed for ioT devices
- Bluetooth module and an integrated temperature sensor
- The function of the MCU is to switch on when its power threshold is met and broadcast a signal.
- Once the phone detects and connects with the MCU using the passcode a connection will be established.
- The Microcontroller will begin reading the voltage entry from register R18, convert it into Celsius.
- This will be set as a characteristic 4 on the profile.
- Once the connection is established, the MCU will begins sending out the temperature value every 10 seconds.
- The application will read it through a Bluetooth adapter
- The MCU is also configure to go got sleep when the power is low, and accommodates for Over the Air Download

Power Storage Specifications

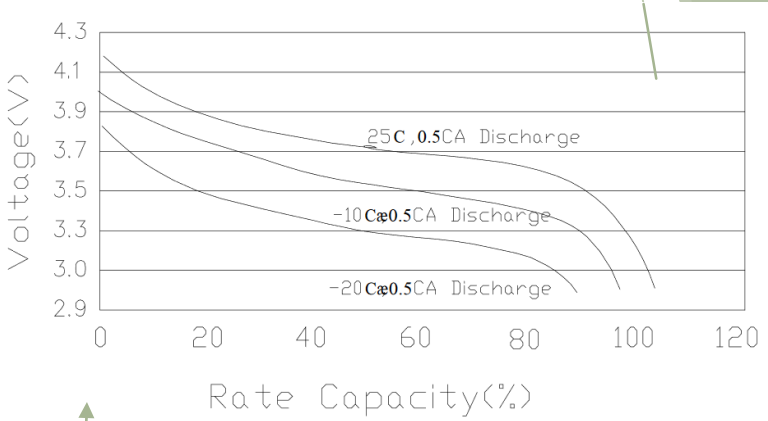
- We need to have an energy storage component to satisfy the Smart Grid Requirement
- Supplying voltage of battery needs to be within 1.8 to 3.8 V
- This constant voltage is needed so the microcontroller isn't damaged
- Current consumption for when all components are running: ~150mA
- Able to power device for RF energy storage and possible sensors
- Rechargeable even after voltage fluctuations
- Small size

Battery

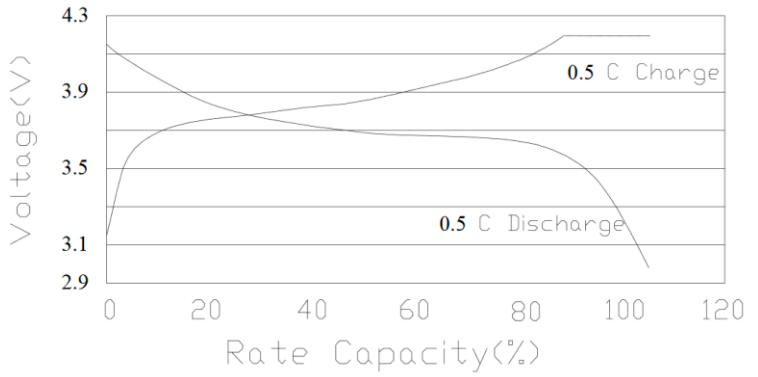
- BT1XXX… Batteries (which was picked from last semester)
  - Rechargeable NiMH battery
  - Capacity Typical: 400mAh
  - Nominal Capacity: 300mAh
  - Charging Voltage: 2.4 V
  - Supply Voltage: 2 to 2.8 V
  - Charging constant current 15mA at constant voltage of 2.4V

Battery: Why it was chosen

- This kind of battery is rechargeable and provides the best charge rate even for fluctuating voltage levels.
- It provides steady output voltages which won't damage the microcontroller.
- The discharge rate is suitable for our tasks and to provide power needed temporarily
- It has the smallest size while still meeting the other specifications

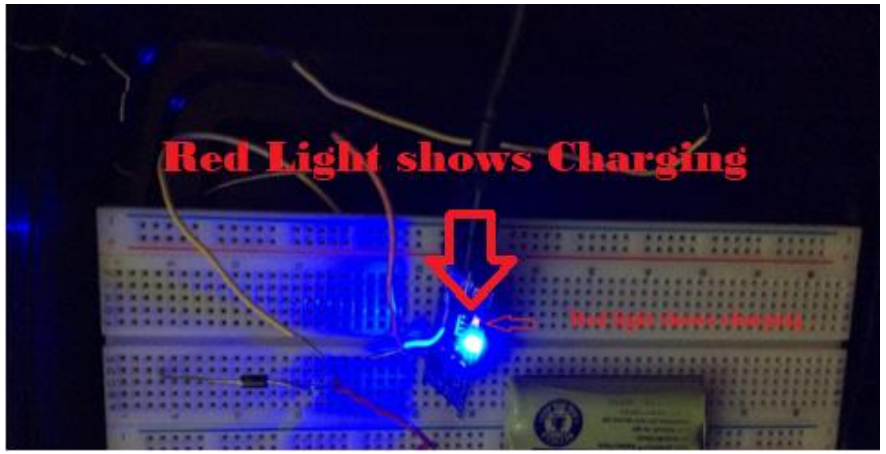


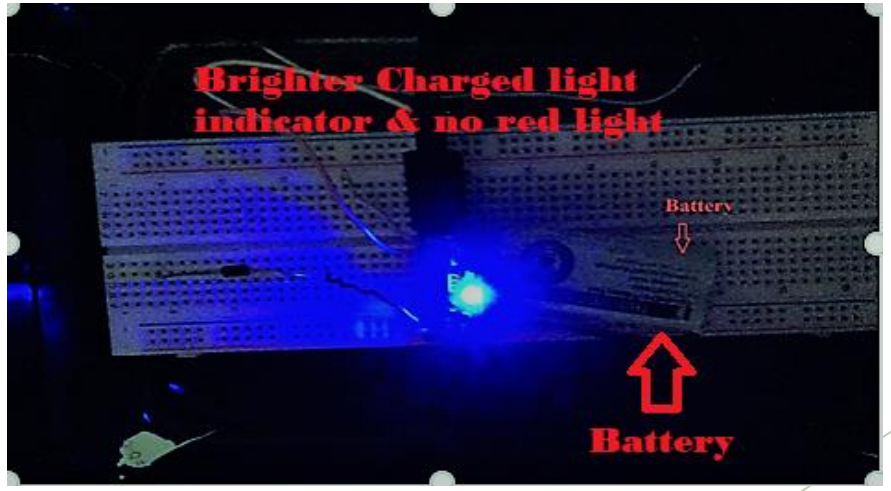
Output graph from datasheets



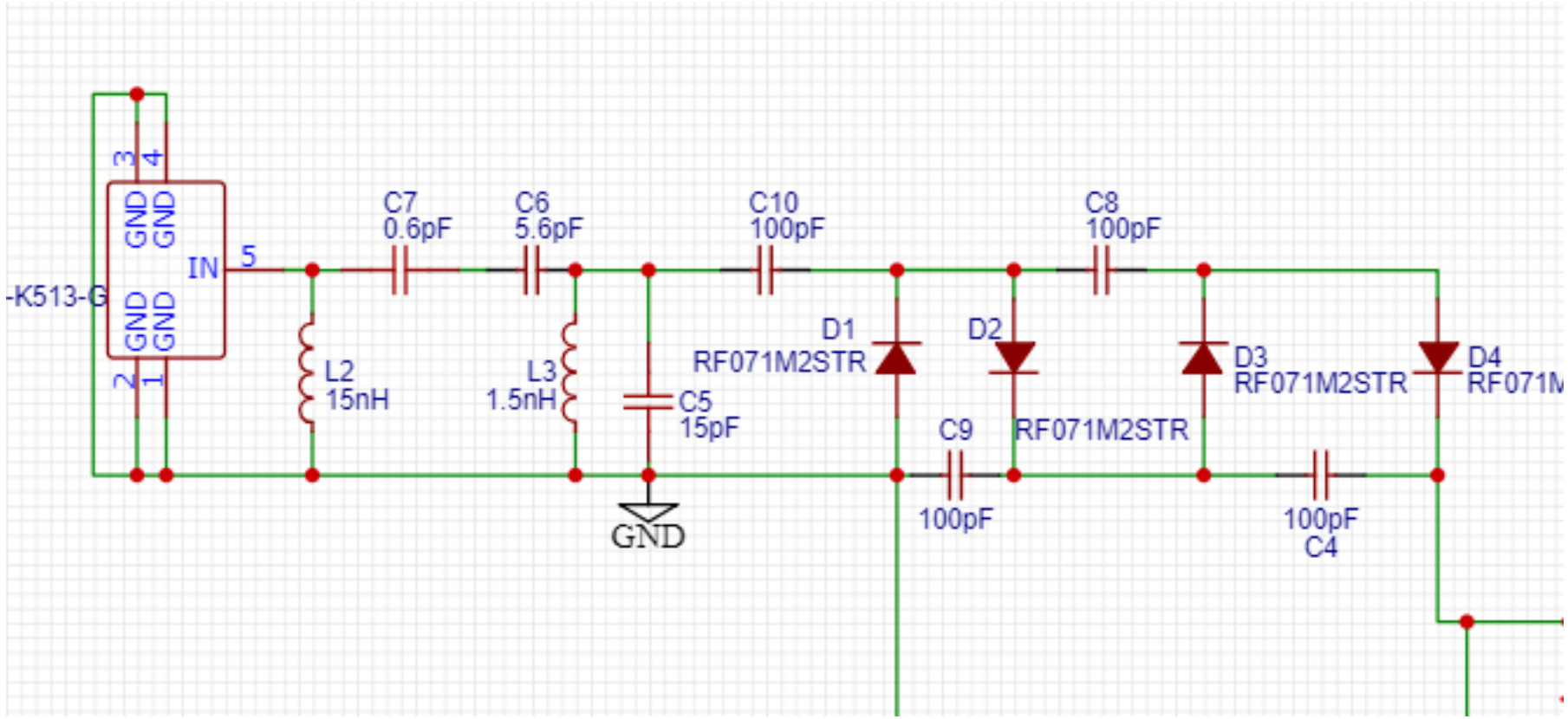
Battery (Updates from this semester)

- Due to this pandemic, it's been hard to amalgamate all our components together
- Isolated, I've worked on showing the battery's able to charge.
- **Values were use that may not exactly reflect what we'll see from the air, but it's the best we could do



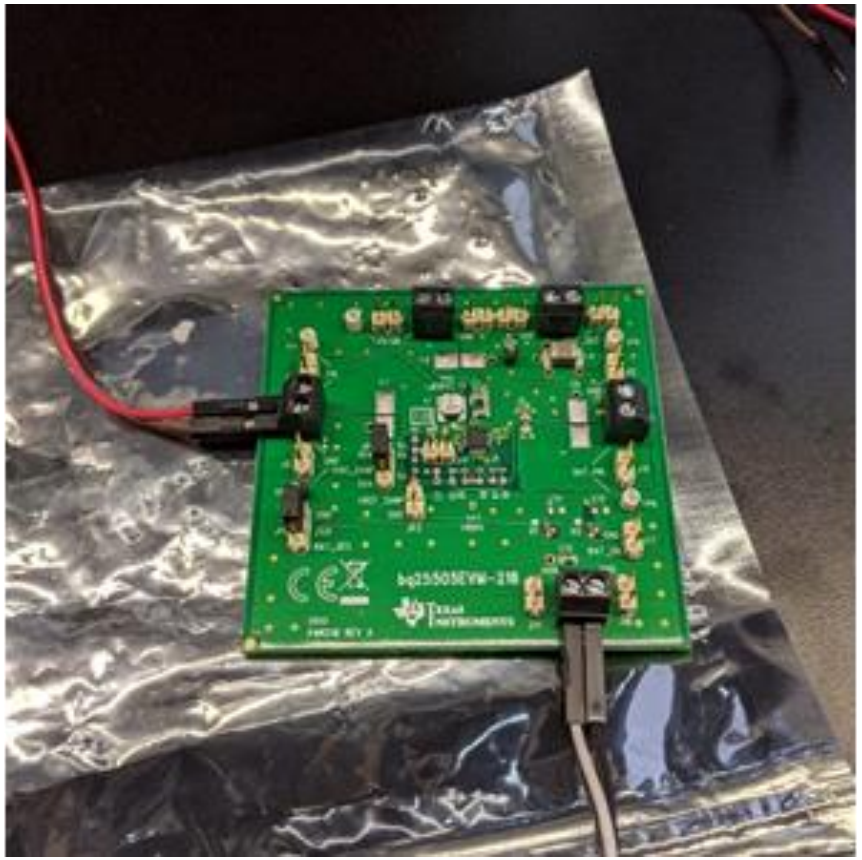


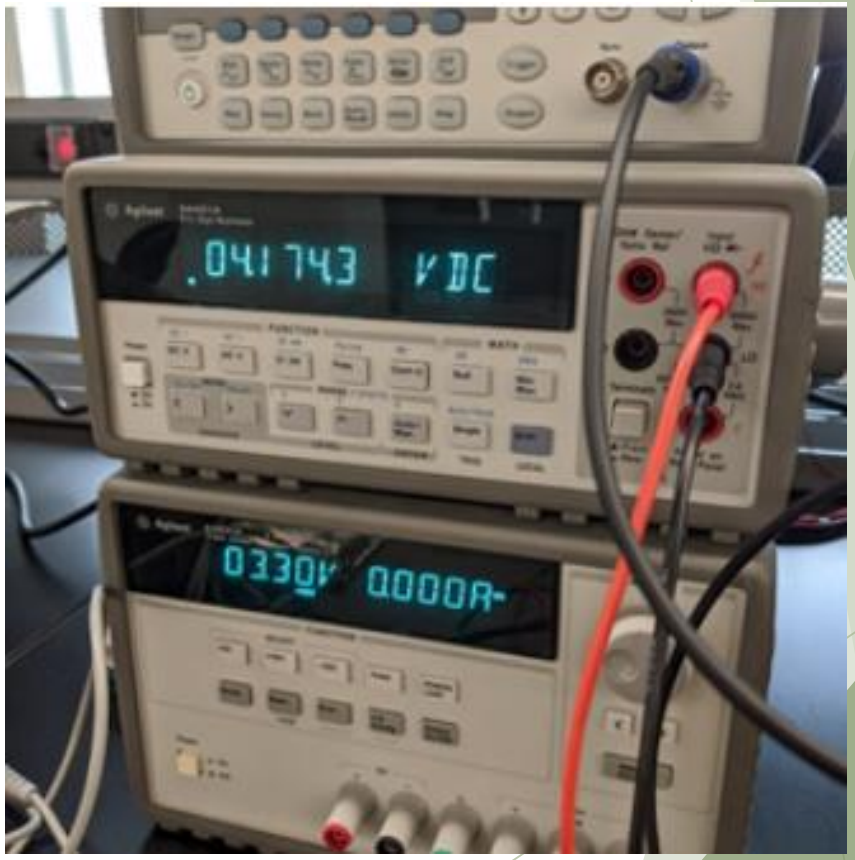
Rectifier Schematic



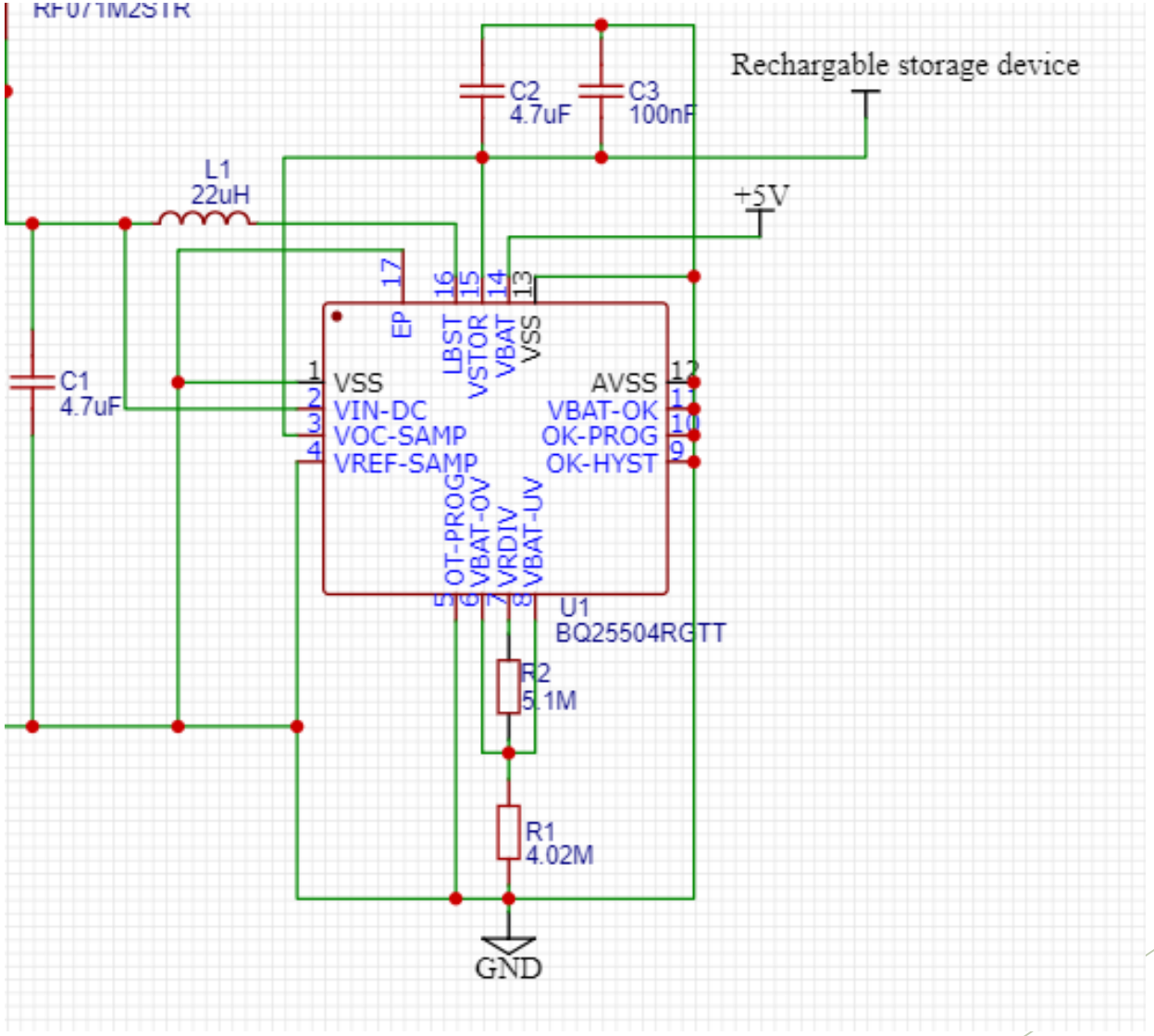
- *Cockcroft-Walton voltage multiplier for RF-DC conversion*

PMU Testing (development board)

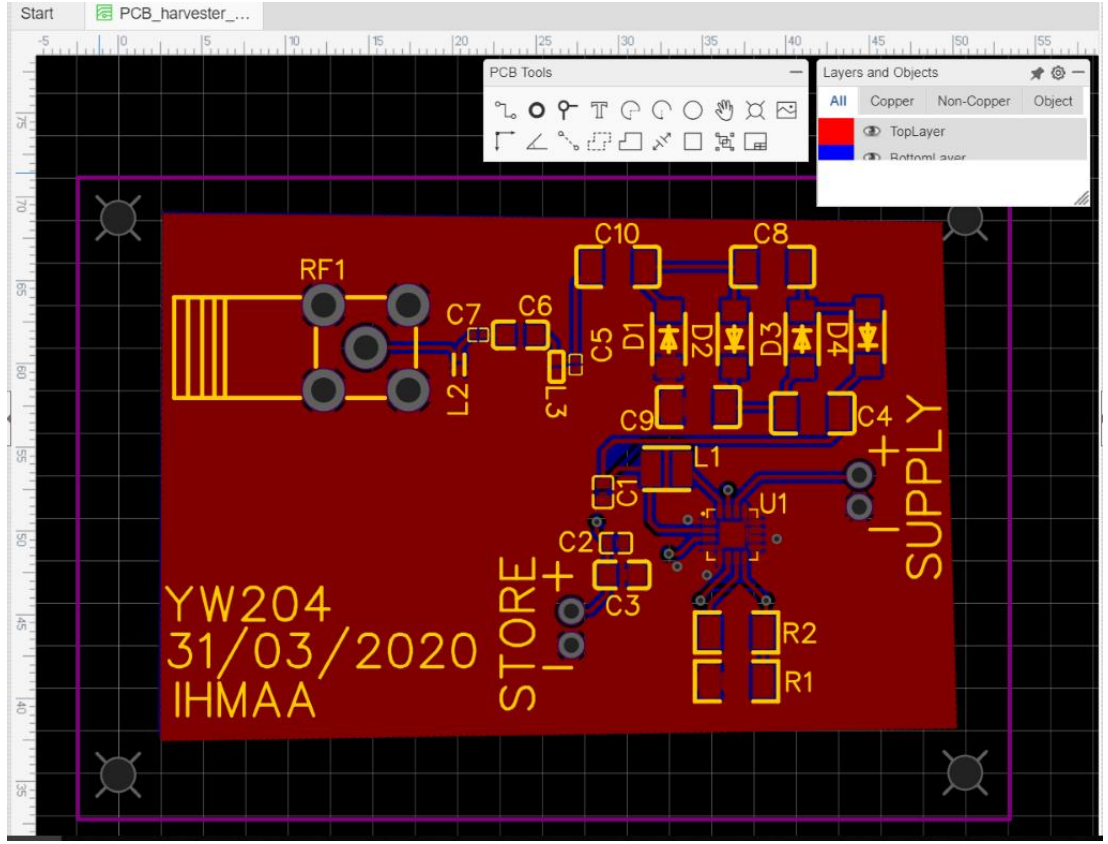




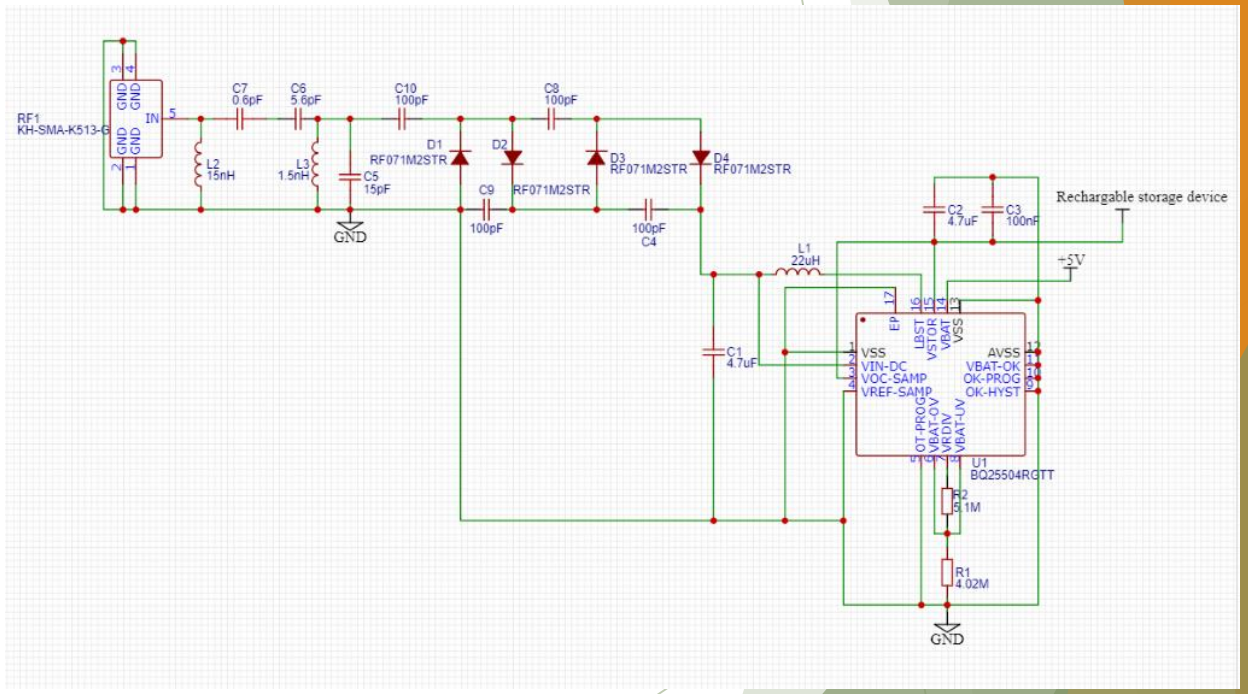
PMU circuit


Rechargable storage device
C2
4.7uF
C3
100nF
L1
22uH
+5V
C1
4.7uF
EP
LBST
VSTOR
VBAT
VSS
VSS
VIN-DC
VOC-SAMP
VREF-SAMP
AVSS
VBAT-OK
OK-PROG
OK-HYST
OT-PROG
VBAT-OV
VRDIV
VBAT-UV
U1
BQ25504RGTT
R2
5.1M
R1
4.02M
GND

Integrated Rectifier and PMU

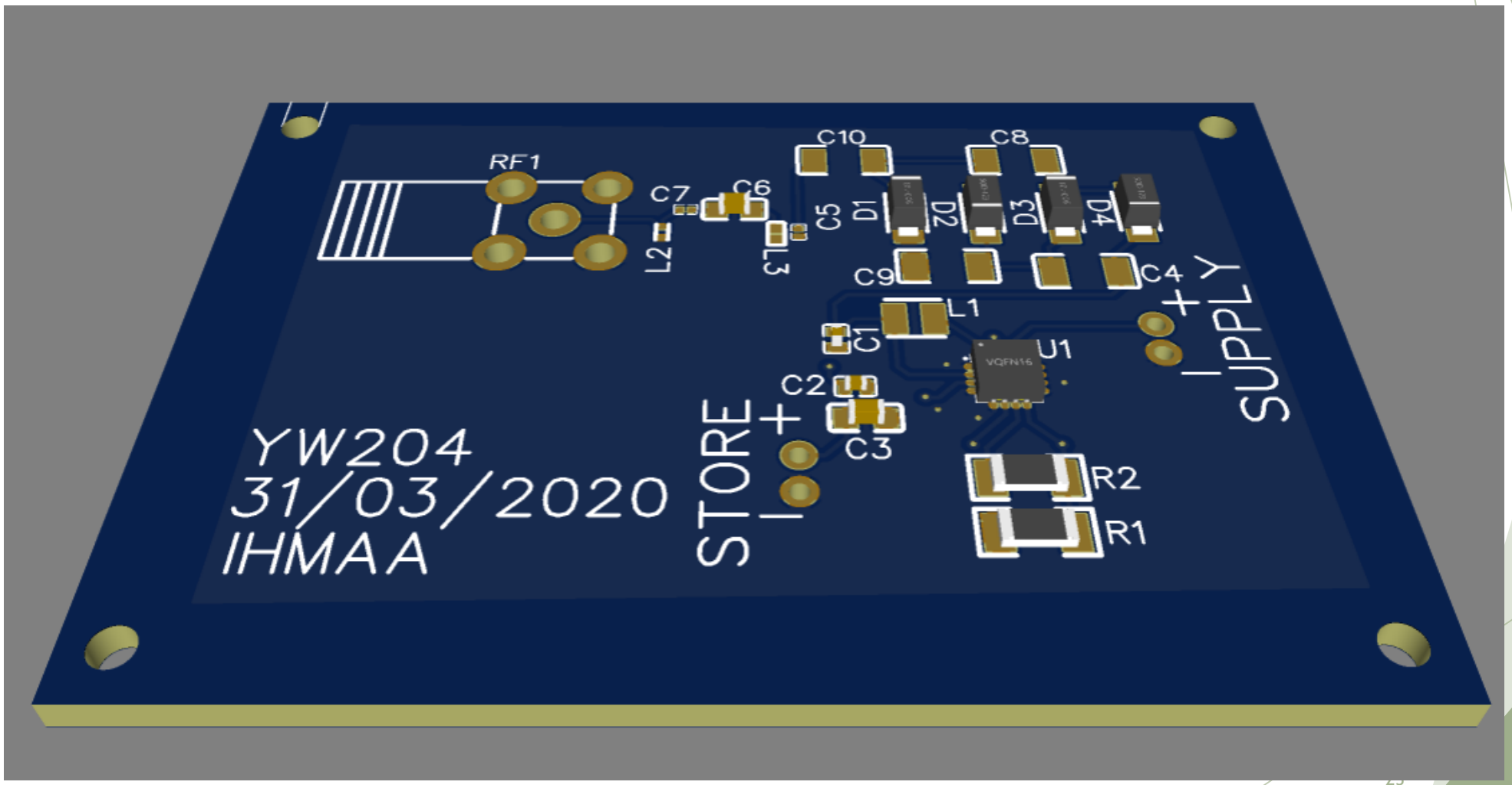


Layout view of PCB board

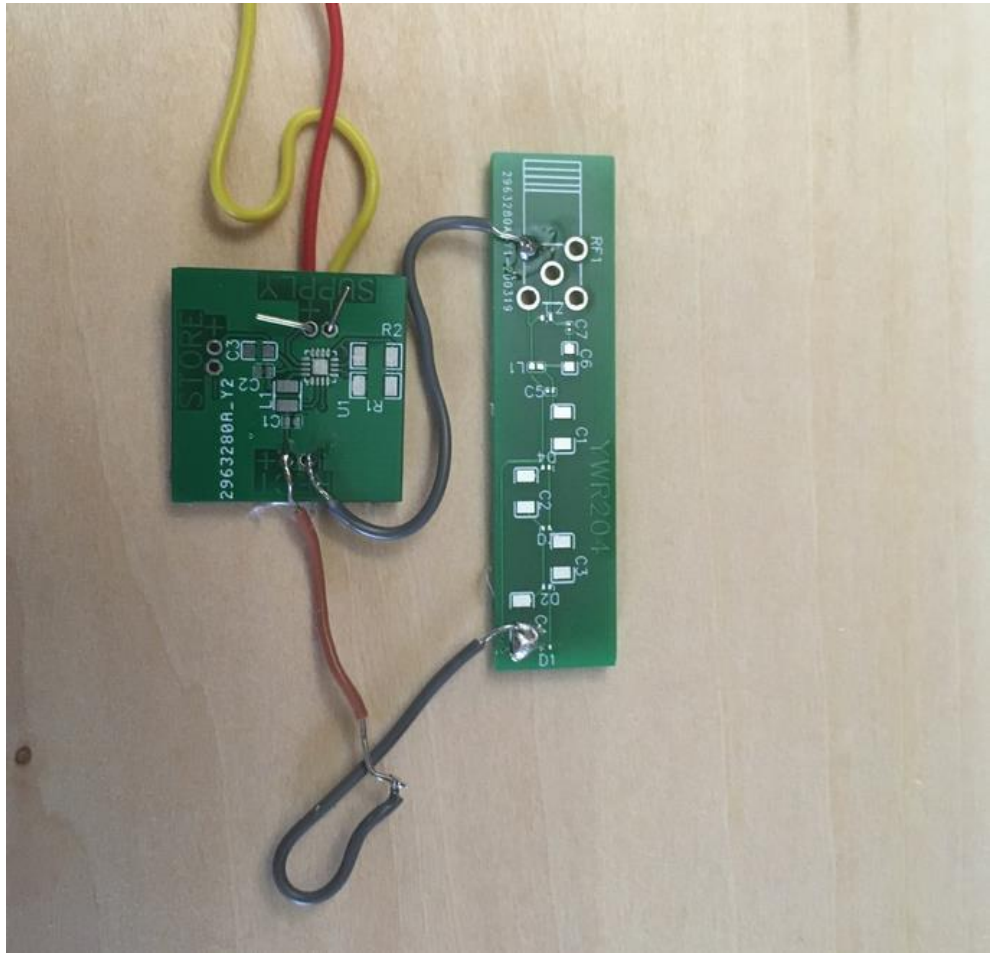


Final Schematic of integrated rectifier and PMU

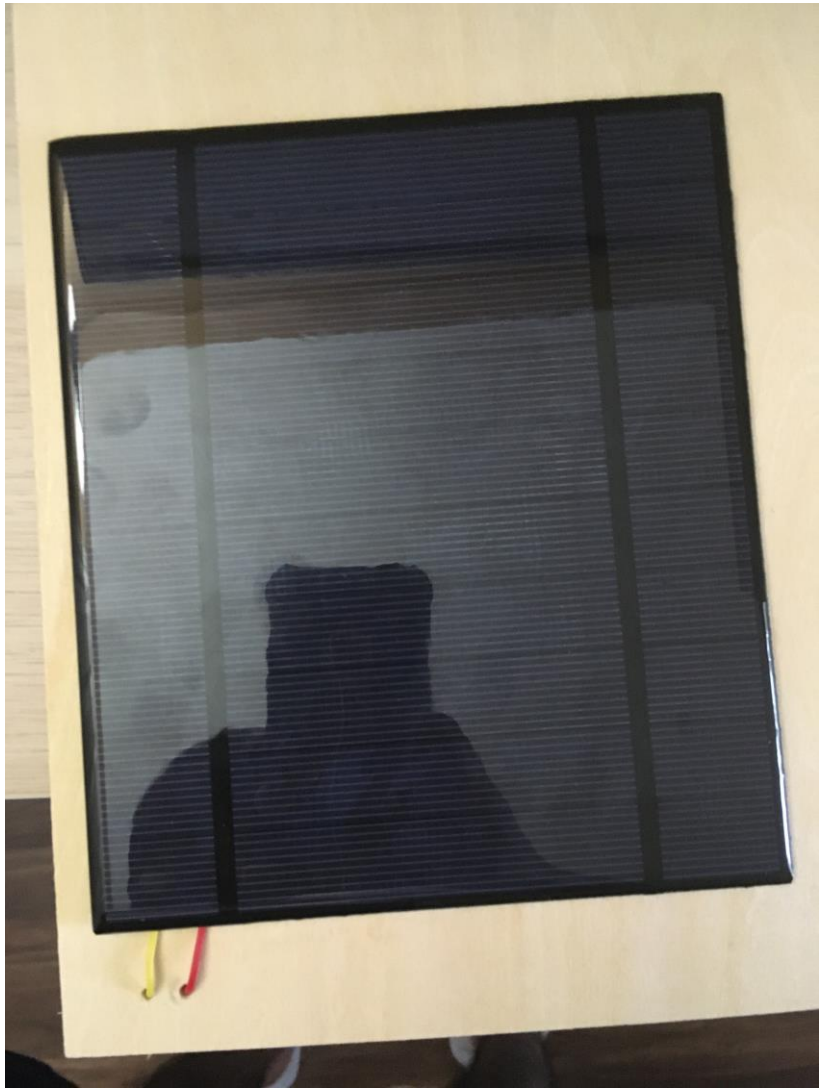
Integrated rectifier + PMU 3D view



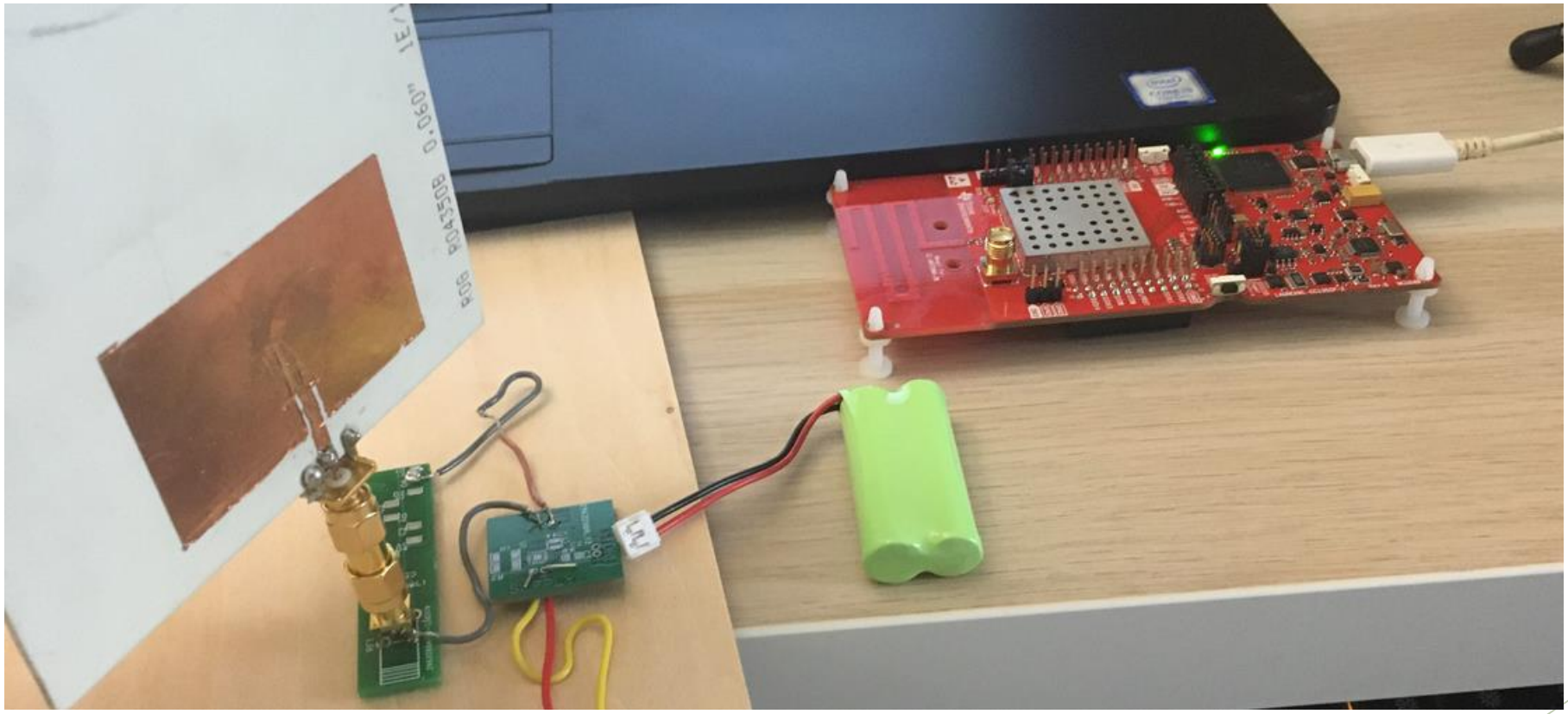
Integrated rectifier + PMU 3D view



PMU power solution: renewable energy!



PMU power solution: renewable energy!



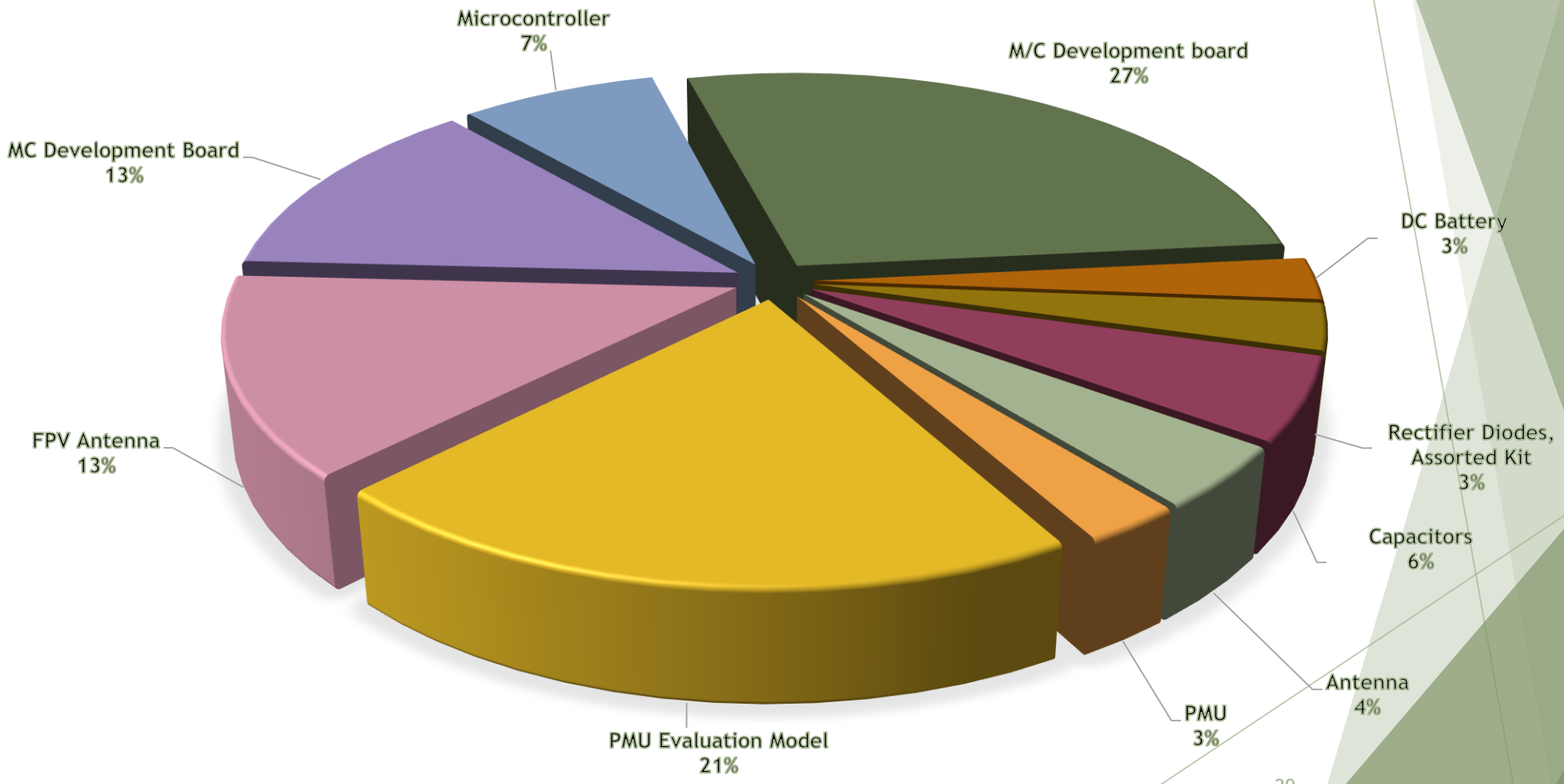
Relation to the Smart Grid

- Smart Grid is a concept firmly rooted in energy production and efficiency
- Enables both utilities, distributors, and consumers to make better decisions based on the availability of power
- Can save time and money
- Our system can be transformed into a much smarter version of itself in due time, functioning similarly to a "smart" appliance

Budget

Total Budget			$1,000.00	
Item	Component	Quantity	Price	Total
Antenna	ANT-DB1-RAF-RPS	1	$18.66	$18.66
PMU	BQ25505RGRR	2	$5.94	$11.88
PMU Evaluation Model	BQ25505 EVM	1	$92.04	$92.04
FPV Antenna	JMT	1	$59.65	$59.65
MC Development Board	TI CC1352P	1	$56.98	$56.98
Microcontroller	QN9083DUKZ	5	$6.60	$33.00
M/C Development board	QN9080-DK	1	$122.30	$122.30
DC Battery	BT-18433/28433	2	$6.39	$12.78
Rectifier Diodes, Assorted Kit	1N4001-4007; 1N5817, 1N5818, 1N5819	100	$0.14	$14.00
Capacitors	Electrolytic: 0.1 uF to 1000 uF	500	$0.05	$25.00
Inductors	10 uH to 10 mH range	145	$0.17	$24.65
Rectifier V1	Capacitor, Diodes, and connectors	1	$15.77	$15.77
Rectifier V2	Capacitor, Diodes, and connectors	1	$30.68	$30.68
Rectifier V3	Capacitor, Diodes, and connectors	1	$42.44	$42.44
Extra Components		1	$8.93	$8.93
Resonator	Capacitor, Diodes, and connectors	1	$40.62	$40.62
Router	TP-Link AC1200	1	$56.48	$56.48
Shipping		1	$20.00	$20.00
Total	Units	766	Cost	$665.86

Budget Breakdown




LIVE DEMO

Thank You

Questions?