SDDEC19-21
Battery-less IoT Device

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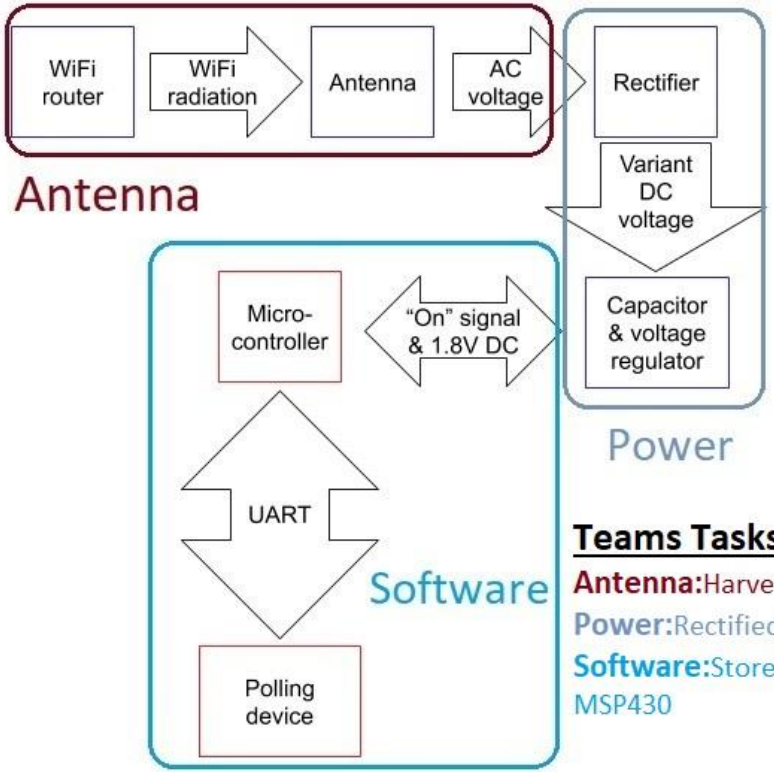
Battery-Less IoT Device

- General Problem statement:
  - Harvest RF energy and convert it into a form useable by a microcontroller to perform a useful task
- General Solution Approach:
  - Harvest and convert ambient RF waves into DC
  - Gradual charge and storage (capacitor bank)
  - Low Power Mode Microcontroller
    - Performs a task (reads temperature)
      - Outputs data (GPIO)

Conceptual Sketch



Teams Tasks:

Antenna: Harvest RF signal from WiFi router

Power: Rectified & Multiplied voltage

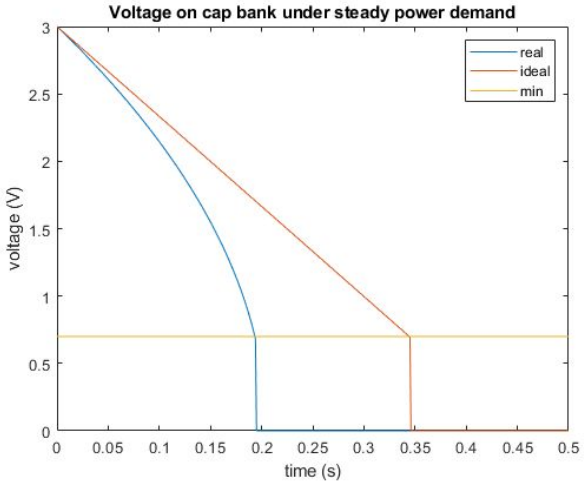
Software: Store and transmit data using MSP430

Semester Goals

- Prototyping our design
- Testing the functionality of our end product
- Design and assembling our final product on a PCB board
- Delivering a device that harvests ambient RF waves and converts the power received into a usable form.

Technical Challenges - Solved

- Power Circuit Design
  - Mitigating leakage current
    - Solution: smaller capacitor bank
    - .01*C*V = leakage of good capacitor
    - 1/100th the size = 1/100th the leakage
  - Efficient voltage regulation and current (graph)
    - Found better regulator (TLV61224)
      - Output 3V instead of 3.3V
      - Quiescent current 5uA instead of 65uA
  - Fabricating compact circuits
    - Heat guns, solder paste, flux pens, better solder tips



Technical Challenges - Unsolved

- Power Circuit Design
  - Need a voltage supervisor in front of the regulator
    - Required under discontinuous-power model
    - Enables voltage regulator at 0.8V; disables it at 0.7V

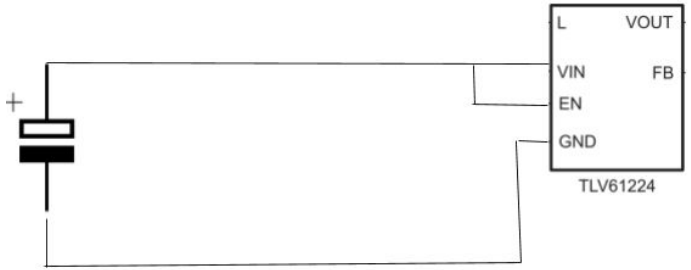


Fig: Original Design

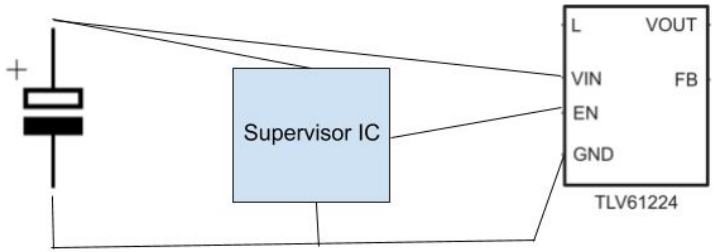


Fig: New Design

Technical Challenges - Solved

- Antenna
  - Found an antenna that gave similar gain to what we wanted commercially.

- Impedance Matching
  - Test boards have arrived for testing parasitics. We now have a way to measure them.

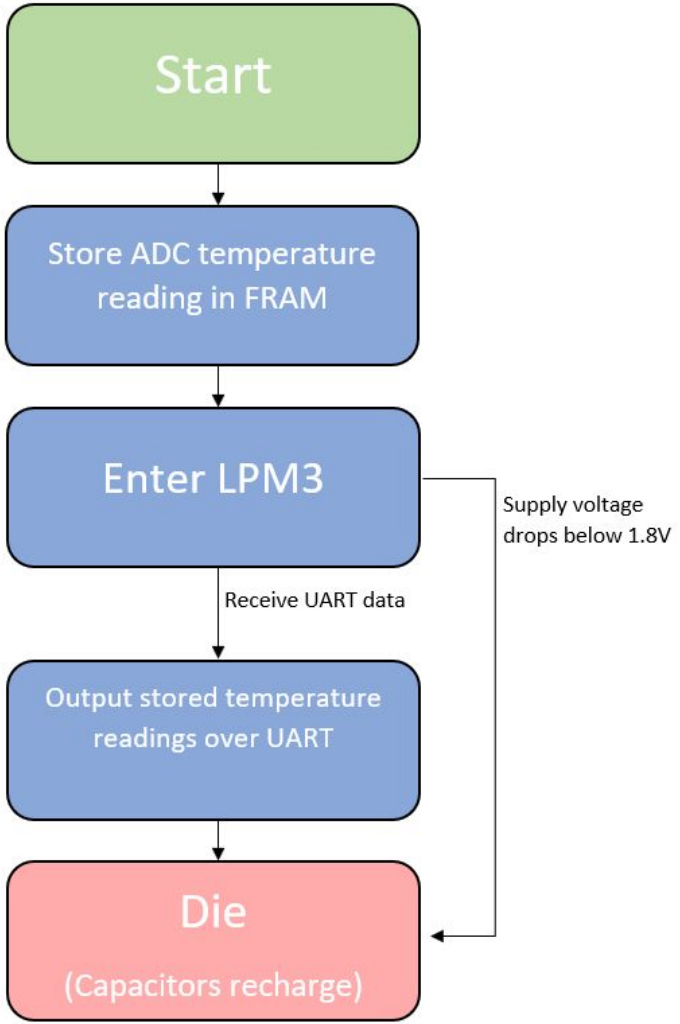
Technical Challenges - Unsolved

- Antenna
  - Whether the WiFi Router broadcasts enough to charge our capacitor.

- Impedance Matching
  - What will be the loss of efficiency from simulation to real world?
  - Will impedance matching add large amounts of components to the board?

Technical Challenges - Solved

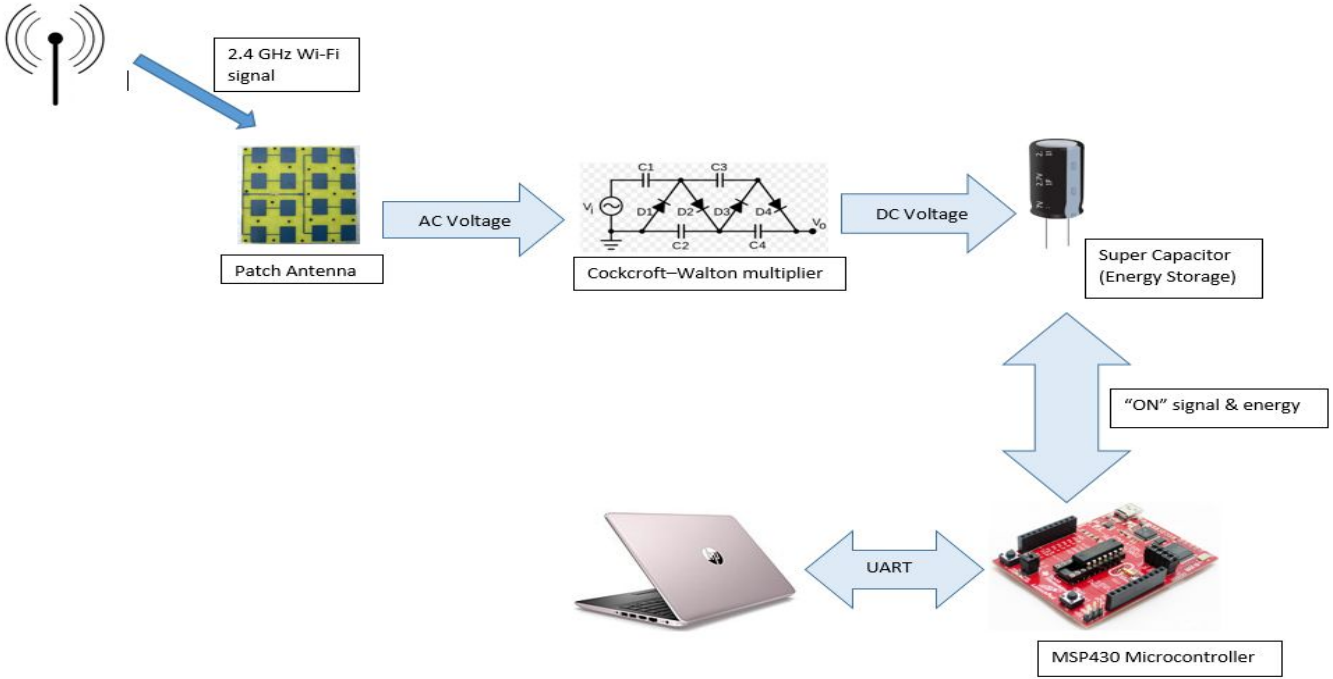
- Embedded Systems
  - Efficiency
    - Interrupt-based data delivery
    - 0.4 µJ per temperature read
  - Data retention and delivery
    - FRAM verified
    - UART-to-serial connectors readily available
      - RealTerm, PuTTY, etc.



Technical Challenges - Unsolved

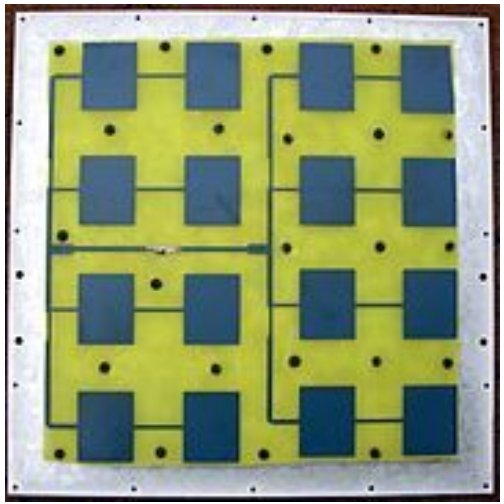
- Embedded Systems
  - Further optimizations
  - Circuit integration
    - Working with Power Circuit team
    - Simple UART connection for user (Serial? USB?)

Questions?


2.4 GHz Wi-Fi signal
Patch Antenna
AC Voltage
C1
C3
D1
D2
D3
D4
C2
C4
Cockcroft–Walton multiplier
DC Voltage
Super Capacitor (Energy Storage)
"ON" signal & energy
UART
MSP430 Microcontroller

Thank you

Antenna Circuit



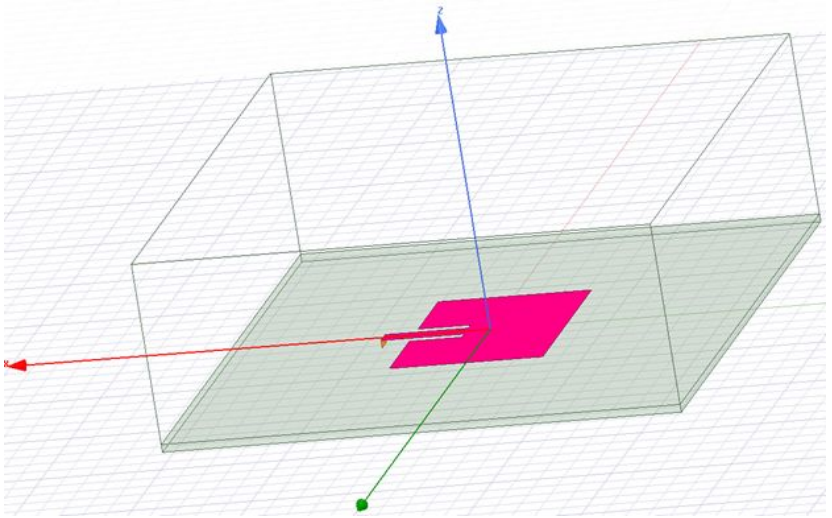
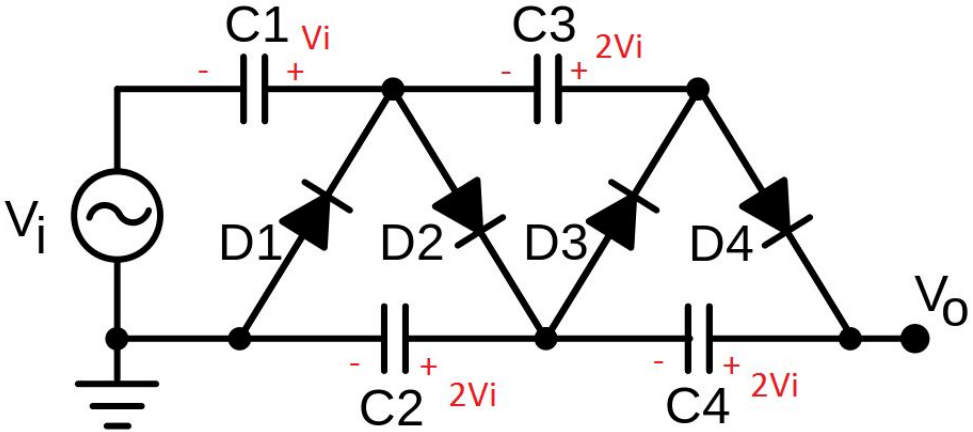
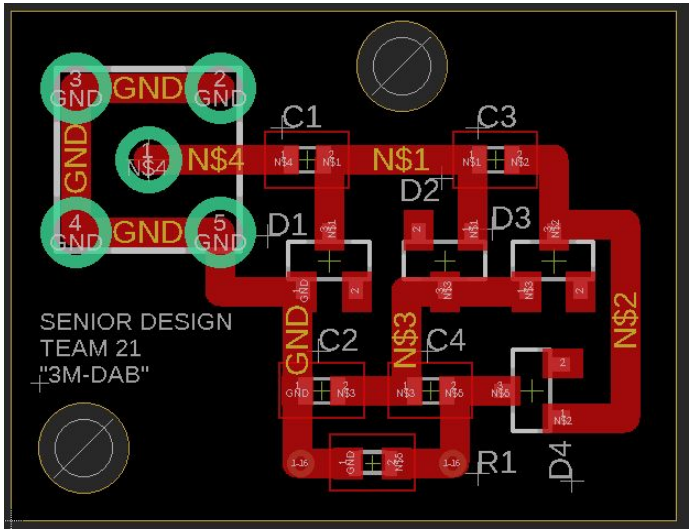


Figure 01: 2.4 GHz Patch Antenna

Rectifier Circuit





Schematic and board of Cockroft-Walton voltage multiplier

Software Control Flow