RF Energy Harvesting Circuit

Juancy Reyes, *REU Participant Student, Wesleyan University*
Ankit Mittal, *PhD Student, Northeastern University*
Ziyue Xu, *PhD Student, Northeastern University*
Aatmesh Shrivastava, *Electrical & Computer Engineering, Northeastern University*

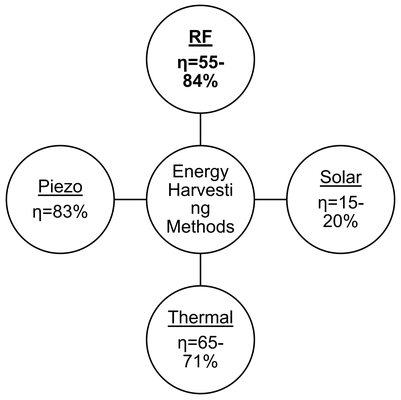
Northeastern University
College *of* Engineering

ABSTRACT

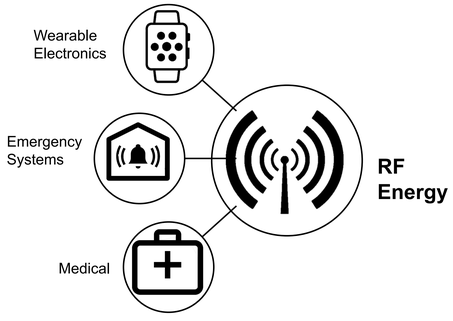
This REU project is part of a larger initiative aimed at designing RF energy harvesting system for broader use in batteryless IoT Applications . The Energy Harvesting circuit will cater to power requirements of the ultra-low power IoT devices. The main challenge is to harvest the energy with maximum possible efficiency and simultaneously use in enabling power to the downstream circuits in the IoT applications.

INTRODUCTION

Energy Harvesting Systems
RF Energy is highly sought after because of its high efficiency. In the figure below four different energy harvesting methods and their efficiencies are noted.



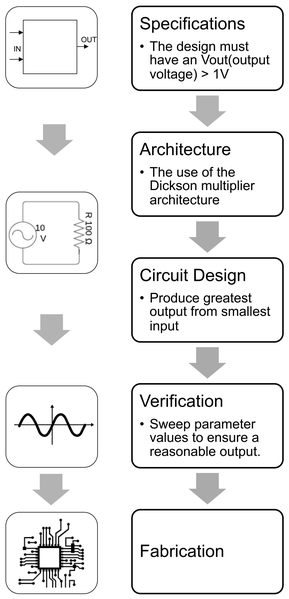
RF Energy Applications
Electromagnetic energy is abundant in space and can be retrieved without limit. The figure below displays fields in which it can be used.



Aim of the Project:
- Develop a modeling circuit for RF Energy Harvesting using passive components(diodes and capacitors) on a CAD tool (OrCAD)
- Contribute to the development of RF Energy Hardware demonstrating the RF Energy Harvesting properties

DESIGN METHODS

Design Methodology
The figure below displays the design methodology steps



Circuit Design Flow
The figure below displays the steps taken to achieve the highest efficiency by optimizing parameter values.

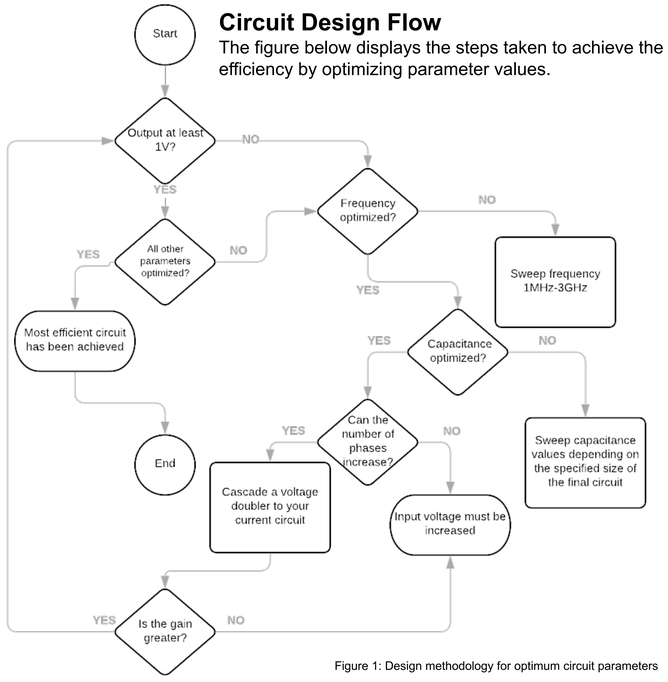


Figure 1: Design methodology for optimum circuit parameters

Dickson Multiplier
The Dickson Multiplier is the chosen Energy Harvesting System design architecture.

Vout = NVp-Vd

Vout :output voltage
Vp : input voltage amplitude and
Vd :diode cut-in voltage of the

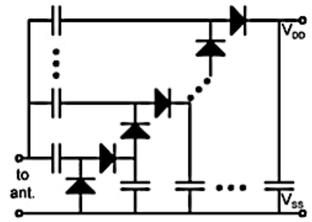


Figure 2: Dickson multiplier topology

RF Energy Harvester Circuit Design
The final RF Energy Harvesting circuit design consists of an 11 phase rectifier.

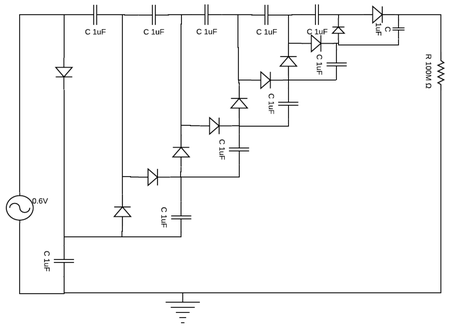


Figure 3: Rectifying circuit with 11 phases.

RESULTS

Gain vs. VAMPL (V)

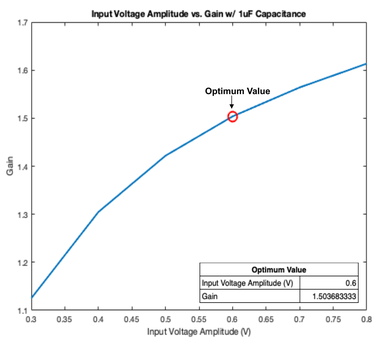


Figure 4: Input Voltage Amplitude vs. Gain

Gain vs. N (number of stages)

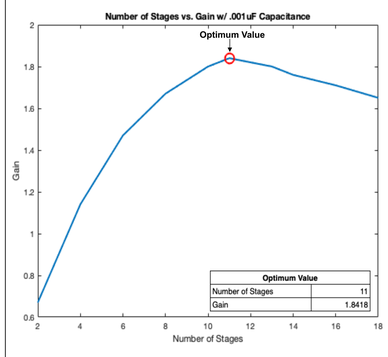


Figure 5: Number of Stages vs. Gain

Gain vs FREQ (Hz)

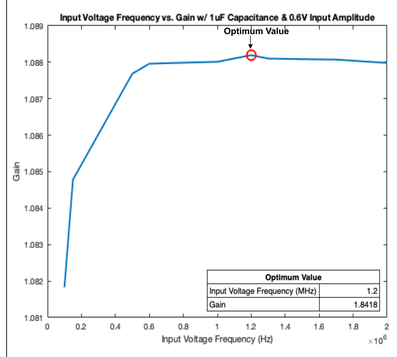


Figure 6: Input Voltage Frequency vs. Gain

The optimum parameter values are:
- VAMPL= 0.6V
- CAP= 1uF
- N= 11 stages
- FREQ= 1.2 MHz

Resulting in a gain of 7.433

CONCLUSIONS

The energy system was designed with a frequency of 1.2MHz and produces an output of 4.4602V from a 0.6V input.
Future work includes:
- Continue PCB Design in collaboration with the Energy Circuits and Systems Group , Northeastern University
- Deploy the system for real time applications

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