RF Energy Harvesting for LED Lighting

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Project No.: HW-05
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The Backgrounds
Ready Applications: Lighting and remote sensing for forests, countryside, parks, smart buildings and smart old buildings.

Future Applications: Wearable & implanted electronic devices powering

The Design and Results
Target Frequency: 2.4GHz
RF power = -30dBm to -10dBm
Bandwidth = 100MHz
Antenna Gain =

The Objectives & The Difficulties
- Input Power ↓ charging time ↑
- Charging Time ↑ Stored Power ↑
- Light-up Time & Brightness ↑

RF Energy Harvesting
Without a specific source
Dedicated RF source generator
Wide frequency range
Specific frequency
Unknown distance and yet direction
Known direction and distance
Non-stop
Source is turned-on on demand
Extremely low power
High/Sufficient power
Need to be developed. It is challenging as signals are too weak
Some products are available already

RF source
Transmission space
RF generator
Transmission antenna
Receiving antenna
Impedance matching network
Rectifying/ voltage multiplier
Power management
Applications
AC/DC Conversion
Gain, RF-to-DC power conversion efficiency, Number of rectifying stage
Storage Voltage Regulation
Loading 1.6V LED

Isolate loading and storage capacitor by switch
• promote charge up efficiency

Theoretical Gain = 11 vs Actual Gain = 6
• Switching loss in circuit elements
• Voltage drop across diodes
• Resistive loss for hand soldered components and long copper traces

Conclusions:
• A complete RF energy harvesting system was designed, simulated, fabricated, and tested.
• Successful to turn on an LED with proper regulating circuit can be used to power some low-power circuits also.
• Further development for smaller, wider bandwidth, all direction antenna system design, lowering the switching losses based on low-voltage CMOS technology; incorporating of regulating circuits.

Cross dipole antenna
- S11 @2.4GHz = -8.36dB
- Bandwidth (>-10dB) = 200MHz
- Gain = 2.46dBi

Radiation pattern
Future work: Trimming on fabricated antenna

Impedance Matching Network
New voltage gain for lighting-up the LED
Gain, bandwidth and center frequency are suitable for regulating with signal for energy harvesting

The required time for the LED to lighten-up under different Input Power (dBm)

Output Voltage (V)

Input Power (dBm)

LED Light-up Time & Brightness ↑

The Output Voltage to the storage capacitor as the complete RF electrical parameters are modified

RF : available everywhere & non-stop

Future work: Add regulator to regulate the output voltage to be close to the turn on voltage of the LED
Allows system to work at lower dBm environment