A Low Switching Frequency AC-DC Boost Converter for Powering Miniaturized Implants Wirelessly

National Aeronautics and Space Administration

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I. Background:

- Providing power to an implantable medical device (IMD) wirelessly is critical to an implant's efficacy.
- A switching regulator has been demonstrated to convert a low-voltage AC power to a high-voltage DC power.

Goal:

Lower the switching frequency of the AC-DC boost converter to reduce the power dissipation associated with the switching and increase the converter's efficiency.

II. Operating Principles:

1. The switching edge lines up with the zero crossing of the input AC.
2. Fig 1 (a). The switch is ON and the inductor charges itself by shorting it to the ground.
3. Fig 1 (b). The switch is OFF and the inductor starts behaving like a voltage source when it is connected to the load.
4. Fig 1 (c). On Positive half cycle, diode D_2 is OFF and C_{S1} charges. On negative half cycle, D_1 is OFF and C_{S2} charges.

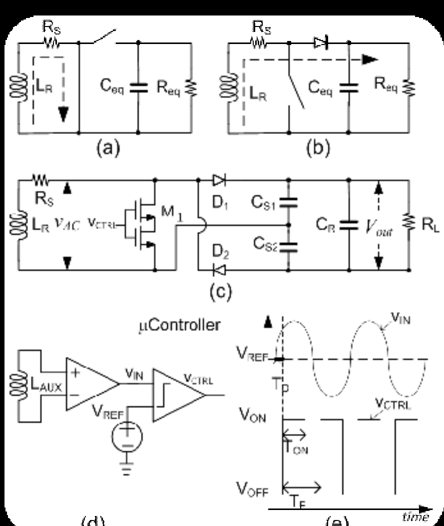

Fig. 1. A simplified circuit diagram of the low switching frequency AC-DC boost converter and its operating principles.

III. Implementation:

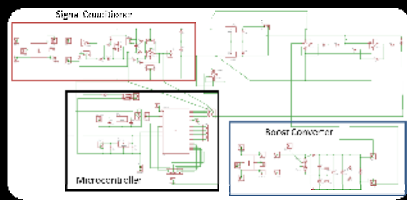

Fig. 2. Schematic of the AC-DC boost converter

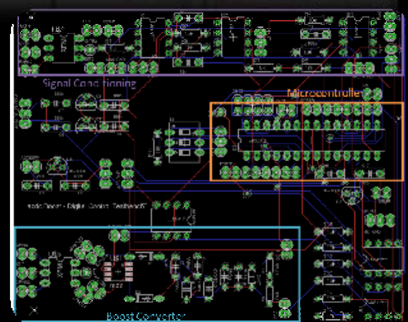

Fig. 3. Layout of the AC-DC boost converter

IV. Experiments:

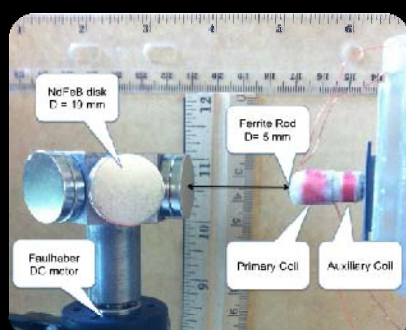

Fig. 4. A photograph of the wireless power transfer using rotating magnets.

Duty Cycle

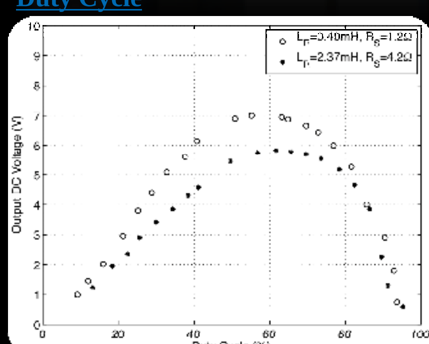

Fig. 5. Graph of DC output versus the duty cycle.

- The DC output of coil B peaks at 5.83 V with a duty cycle of 62%, coil A peaks at 6.95 V when the duty cycle is 57%.
- Coil B has a DC output peak at a larger duty cycle and has a larger time constant (L_r/R_s) than coil A.

Delay Time

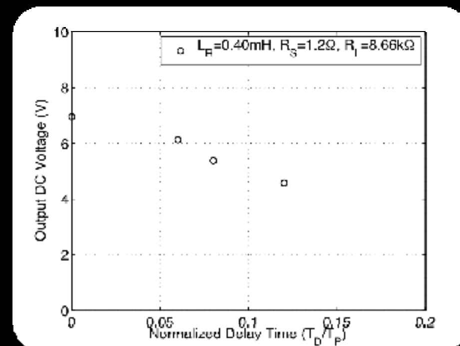

Fig. 6 Graph of DC output versus the delay time that is inserted before the rising edge of the pulse .

- The measurement results indicates that DC output voltage drops 12% (from 6.95 V to 6.13 V) when the rising edge of the switching pulse is ~5% behind the zero crossing of the input AC.
- The data points from the graph indicates that accurate timing between the switching pulse and input AC is important to the performance.

V. Conclusion:

In this project a low frequency AC to DC boost converter is used to amplify a 500 mV AC input voltage to a desired output DC voltage of 5 Volts or greater. The high voltage is achieved when very fast switching causes a discontinuity that creates a spike of the voltage. Because the switching frequency is twice the input AC frequency, the boost converter is able to convert the input voltage to about 6.9 volts with pulses at 400 Hz and a 57 % duty cycle.

VI. Future Plans:

- Implement with closed-loop control
- Integrated Circuit implementation

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