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Design and Implementation of a Single Stage AC-DC Energy Harvesting Converter for Microgenerator

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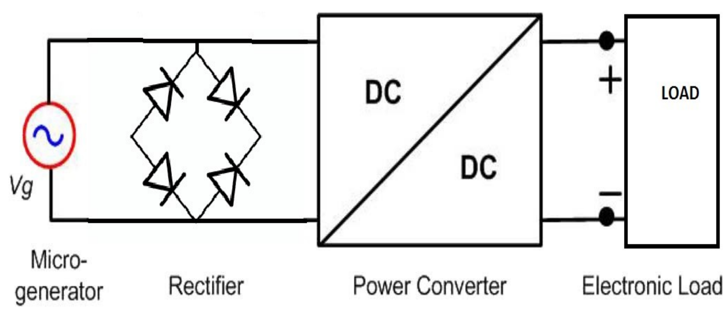
Abstract— In this project, a direct ac-dc power electronic convertor topology is proposed for efficient and optimum energy harvesting from low – voltage micro generators. The convertor utilizes the bidirectional current - conduction capability of MOSFETs to avoid the use of a front – end bridge rectifier. It is operated in the discontinuous conduction mode and offers a resistive load to the micro generator. In this project, a chip has been designed and tested to demonstrate the feasibility of operating a digital system from power generated by vibrations in its environment. Then, two direct ac-dc power electronic convertor topologies are proposed for low voltage micro generators. These two are mainly used in designing the convertor for energy harvesting. The main application of this convertor is used in pacemaker. For this purpose currently we are using lithium battery to give pulse to heart muscles. But this battery is not chargeable. In this we are designing convertor for low voltage energy harvesting especially for pacemaker applications. The future work is that the closed loop of energy harvesting convertor for micro generator can be developed using artificial intelligent technique controllers like fuzzy logic controller, neural network, and genetic algorithms and can be compared with conventional controllers like PI, PID controllers.



I. INTRODUCTION

In paper [1] a chip has been designed and tested to demonstrate the feasibility of operating a digital system from power generated by vibrations in its environment**.**
In this paper[2] two direct ac-to-dc power electronics converter topologies are proposed for efficient and optimum energy harvesting from low voltage microgenerators.
By taking these two papers mainly for my reference and designing converter for energy harvesting.

II. CONVENTIONAL METHOD:

A. Efficiency of Full-wave rectifier

Let $V = V_m \sin\theta$ be the voltage across the secondary winding
$I = Imsin\theta$ be the current flowing in secondary circuit
r_f =diode resistance

R_L = load resistance

B. DC power output

$$Pdc = I_{dc}^2 R_L \text{ ----------------------------(1)}$$

$$I_{dc} = I_{av} = 2\frac{1}{2\pi}\int_0^{\pi} i.d\theta$$

$$I_{av} = 2\frac{1}{2\pi}\int_0^{\pi} \mathrm{Im}\, Sin\theta.d\theta$$

$$I_{av} = \frac{2I_m}{\pi} \text{ ------------------------------------ (2)}$$

$$\therefore P_{dc} = \left(\frac{2I_m}{\pi}\right)^2 R_L \text{ --------------------------- (3)}$$

C. Input Ac Power

$$P_{ac} = I_{rms}^2 (r_f + R_L) \text{ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ (4)}$$

$$I_{rms} = \sqrt{2\frac{1}{2\pi}\int_0^{\pi} i^2 d\theta}$$

Squaring both sides we get

$$I_{rms}^2 = \frac{1}{\pi}\int_0^{\pi} i^2 d\theta$$

$$I_{rms}^2 = \frac{1}{\pi}\int_0^{\pi} (\mathrm{Im}\, Sin\theta)^2 d\theta$$

$$I_{rms}^2 = \frac{I_m^2}{2}$$

$$I_{rms} = \frac{I_m}{\sqrt{2}} \text{ -------------------------------- ----- (5)}$$

$$\therefore P_{ac} = \left(\frac{I_m}{\sqrt{2}}\right)^2 (r_f + R_L) \text{ ----------------------------(6)}$$

$$\therefore \eta = \frac{P_{dc}}{P_{ac}} = \frac{\left(2I_m/\pi\right)^2}{\left(I_m/\sqrt{2}\right)^2} * \frac{R_L}{(r_f + R_L)}$$

$$\eta = \frac{0.812}{1+\frac{r_f}{R_L}} \text{ ---------------------------------(7)}$$

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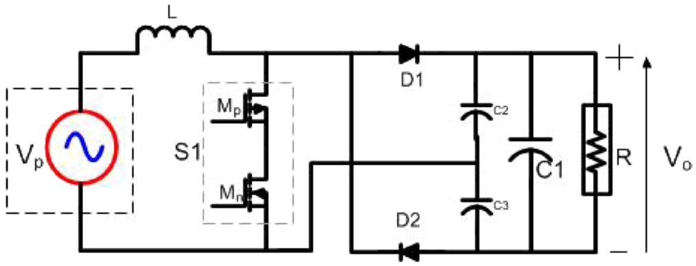
The efficiency will be maximum if r_f is negligible as compared to R_L

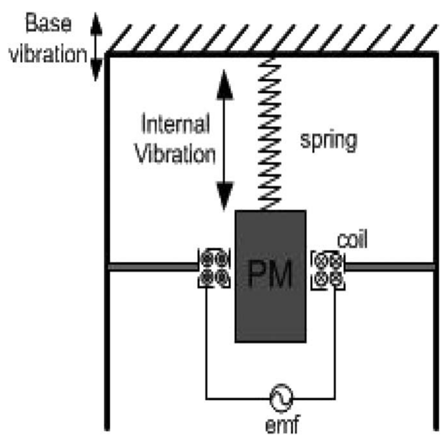
Maximum efficiency = 81.2 %

III. PROPOSED METHOD

To overcome this we are going for dual polarity boost converter.



IV. RESONANCE BASED INERTIAL ELECTROMAGNETIC MICROGENERATOR



A) Operation Of Micro generator

a) It is working under the principle of Faraday’s Induction law.
b) Such micro generators are typically spring–mass systems, in which mechanical energy is converted to electrical energy by electromagnetic damping.
c) The output of an inertial micro generator is typically around a few hundred mill volts of ac.

V. BI DIRECTIONAL SWITCH

TOSHIBA Field Effect Transistor Silicon N·P Channel MOS Type

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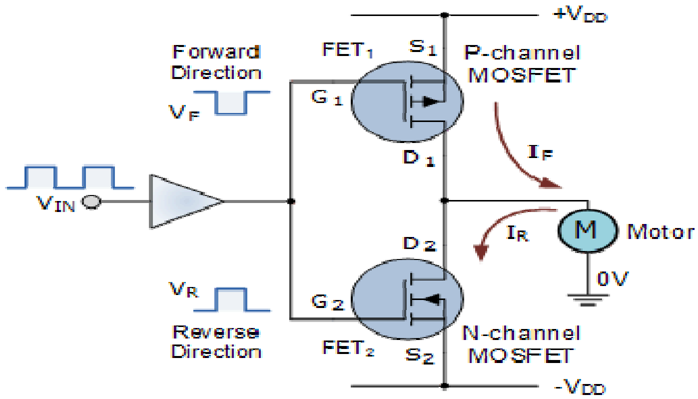
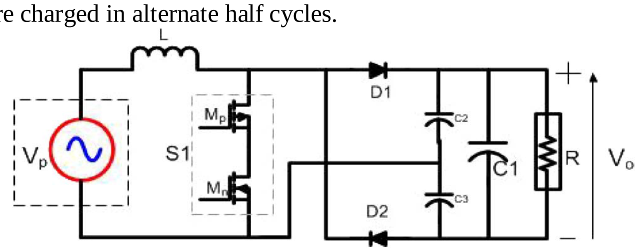


VI. TECHNICAL EXPLANATION:

A) SPLIT CAPACITOR TOPOLOGY

A single inductor l is used for the boost operation in both half cycles. The converter utilizes three capacitors to boost the low ac voltage. Split capacitors c2 and c3 are charged in alternate half cycles.



B) Modes Of Operation

This modes of operation will classified into two categories,

1) *Positive half cycle*

a) S ON

b) S OFF

2) *Negative half cycle*

a) S ON

b) S OFF

3) Positive Half Cycle:

WHEN (S) IS ON:

a) The inductor current increases linearly from zero when switch (S) turns ON. It shown in fig 1

WHEN (S) IS OFF:

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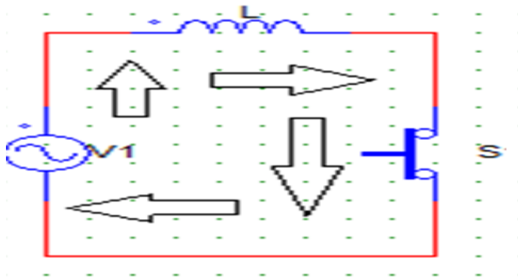
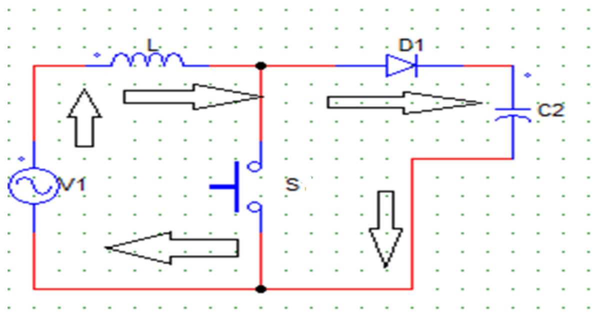
b) When Switch(S) is turned OFF, the body diodes block the circulating current. Diode D1 is forward biased, and the current flows into capacitor C2 to complete the charging process.





C) Negative Half Cycle

WHEN (S) IS ON:

i) In the negative half cycle, the current rises in the opposite direction when switch(s) is turned on. it shown in fig 3

WHEN (S) IS OFF:

ii) However, this time, when Switch(S) is turned OFF, diode D1 remains OFF and diode D2 is forward biased. The inductor energy is transferred to capacitor C3.It shown in fig 4

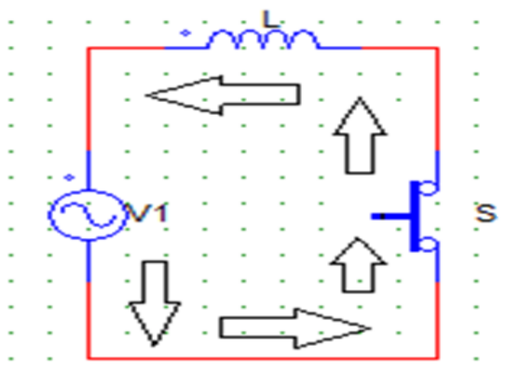


FIG 3

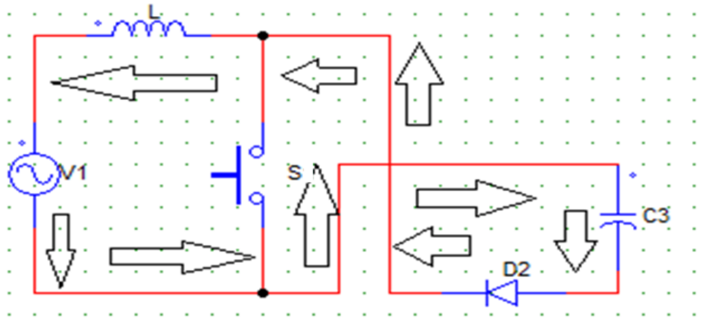


FIG 4

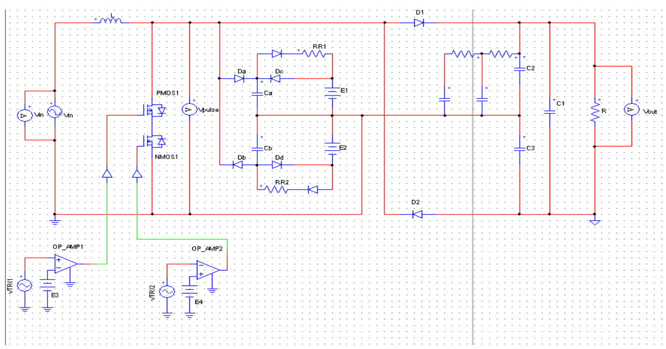
D) SIMULATION PROCESS:

Single stage ac-dc energy harvesting converter open loop and closed loop simulation done it by using P-SIM software.

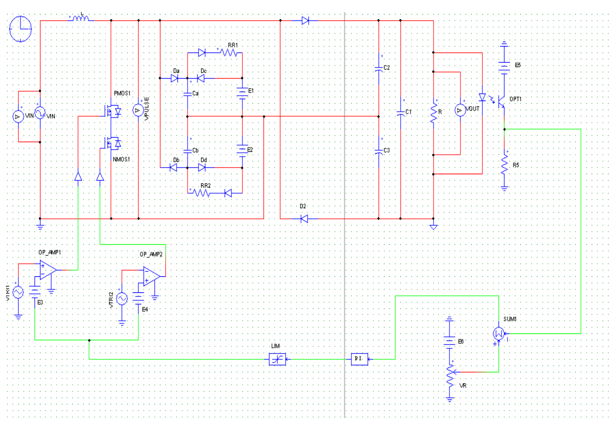
Input Voltage(Microgenerator) - 0.3V -0.8V

Output Voltage(Electronic Load) - 3.5V

i) Open Loop Simulation



ii) Closed Loop Simulation



OP-AMP CIRCUIT :(FEEDBACK CIRCUIT)

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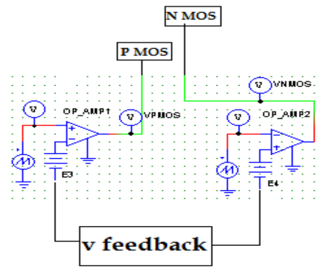
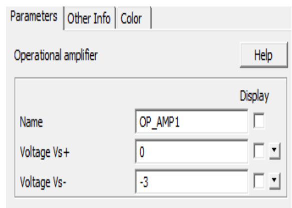
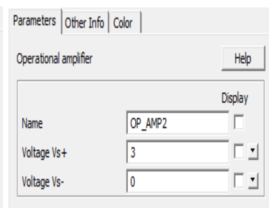
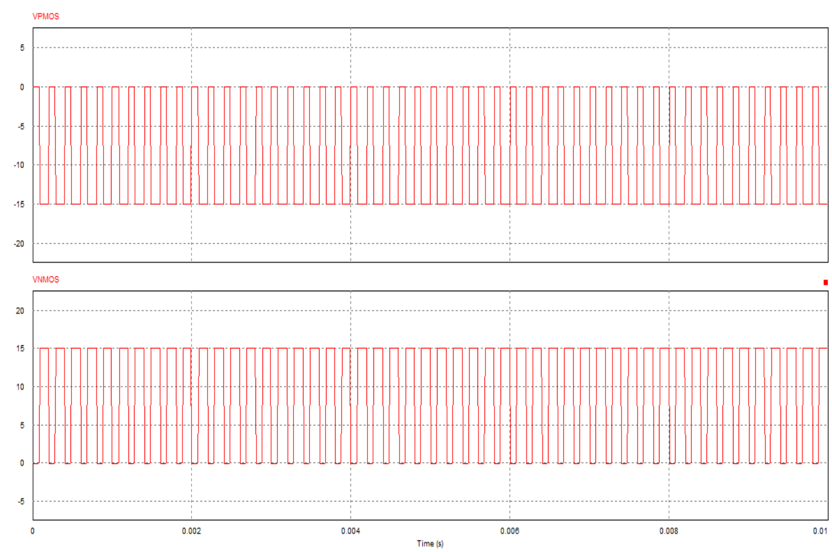


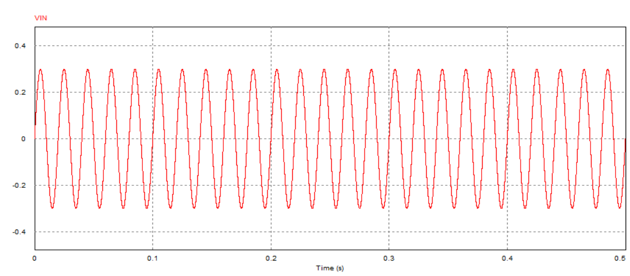




OP AMP 1 OP AMP 2

VOLTAGE PULSE TO P MOS & N MOS:





INPUT VOLTAGE:

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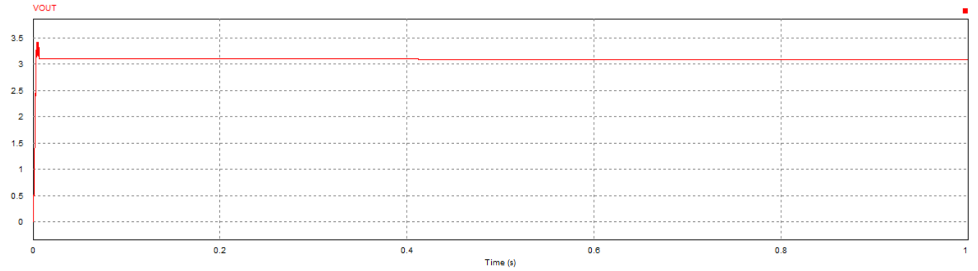
OUTPUT VOLTAGE**:**



VII. APPLICATION & INFERENCE

A) Currently we are using Lithium(Li) battery to give pulses to heart mussels. This battery The main applications of this converter is used in PACEMAKER.
B) For this purpose is not chargeable.
C) In this project we are designing converter for low voltage energy harvesting especially for pacemaker applications.
D) But this is not implantable device.

VIII.FUTURE WORK

The closed loop of energy harvesting converter for micro generator can be developed using artificial intelligent technique controllers like fuzzy logic controller, neural network, genetic algorithms and can be compared with conventional controllers like PI, PID controller

IX. CONCLUSION

A) The closed loop of energy harvesting converter for micro generator can be developed using artificial intelligent technique controllers like fuzzy logic controller, neural network, genetic algorithms and can be compared with conventional controllers like PI, PID controller.
B) This paper has presented a split-capacitor-based ac–dc boost converter for low-power low-voltage energy harvesting.
C) The converter utilizes this bidirectional switch to boost the low ac microgenerator voltage to a steady dc voltage in both the input half cycles.
D) A suitable startup circuit, an auxiliary dc supply, and a feedback circuit are proposed for the implementation of the converter.
E) The Designed Auxiliary Circuits Draw Minimal Power And Are Able To Operate The Converter At A High Efficiency

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