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DESIGN AND IMPLEMENTATION OF PIEZOELECTRIC BASED POWER GENERATION

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Abstract — The main focus of this work is the generation of electric power from people's footstep movement and the pressure produced during walking, which is frittered away. To reduce rectification losses and mitigate ripples in piezoelectric energy harvesting, a dual-stage H-Bridge (DSHBR) circuit is used to generate electric power. Using bidirectional switches and a step-up DC-DC converter, the DSHBR circuit unifies both AC-DC and DC-DC conversion operations. The proposed design is to reduce the switching loss and power loss and increase the efficiency of the system. The design and implementation of a dual-stage H-Bridge circuit in the piezoelectric energy harvesting system to reduce rectification losses and alleviate ripples. Using bidirectional switches and a step-up DC-DC converter that applies both positive and negative half-cycles, both AC-DC and DC-DC conversion processes are included in the proposed DSHBR circuit. Another benefit is that the bidirectional switches do not require any external power to operate. Such features facilitate active rectification at very low AC voltage generated by the piezoelectric device. The outcomes show that the DSHBR circuit prominently increases the rectifier voltage and output power while stabilizing the DC voltage when compared with the conventional H-Bridge circuit. Mechanical vibration is the primary source of piezoelectric energy harvesting, which may be found in daily items such as street lights, refrigerators, washing machines, and industrial machinery vehicles.

Keywords: ***Piezoelectric energy harvesting, self-powered H-Bridge circuit, dual-stage H-Bridge circuit, rectifier, solar battery.***

I. INTRODUCTION

In recent years, human beings are witnessing a rapid increase in the usage of renewable energy sources (RES), such as solar, wind, thermal and mechanical energy (ME). Such a trend is encouraging as it reduces the reliance on non-renewable energy sources, particularly crude oil and fossil fuels. To utilize renewable energy, effective energy harvesting, and conversion mechanisms are crucial.

Lately, the emergence of mechanical vibration-based piezoelectric energy harvesting (PEH) technology as a sustainable, micro-scale energy harvesting and conversion system is found to be a potential alternative to conventional batteries with a limited lifespan for powering electronic devices with low energy demand. Its applications include medical implants and wireless sensors for structural health monitoring.

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II. EASE OF USE

1) PIEZOELECTRIC ENERGY HARVESTING

Mechanical strain is converted to electrical voltage by the piezoelectric effect. This strain might come from a variety of places. A few examples include human motion, low-frequency earthquake tremors, and acoustic noise. Walking can be used to harvest mechanical energy using the piezoelectric effect. This energy can be transformed into usable electrical energy, which can be utilized to power wearable electronic equipment such as sensors and GPS receivers. Some consumer electronic equipment, such as cellular phones and two-way communicators, can be powered directly via piezoelectric energy harvesting.

2) EMBEDDED SYSTEM

An embedded system is one kind of computer system mainly designed to perform several tasks like accessing, processing, storing, and also control the data in various electronics-based systems. Embedded systems are a combination of hardware and software where software is usually known as firmware that is embedded into the hardware. An embedded system is one kind of computer system mainly designed to perform several tasks like accessing, processing, storing, and also control the data in various electronics-based systems. Embedded systems are a combination of hardware and software where software is usually known as firmware that is embedded into the hardware.

3) ABBREVIATIONS AND ACRONYMS

- Renewable Energy Sources (RES)
- Mechanical Energy (ME).
- Global Positioning System (GPS)
- Dual-stage H-Bridge (DSHBR)
- Equations

DUAL-STAGE H-BRIDGE RECTIFIER CIRCUIT

The magnitude of extracted output power is a good measure of the proposed DSHBR circuit's performance. In this study, the rectified voltage and the output power are used to compare the performance of the proposed circuit with other previously proposed circuits in the literature. The input power, Pac can be expressed as:

$$P_{ac} = \frac{V_{Pk}}{\sqrt{2}} \cdot \frac{I_{Pk}}{\sqrt{2}} \cos\varphi$$

Where VPk, IPC is the peak voltage, and current, and ϕ is the phase angle between the voltage and the current of PD.

Considering the rectified DC voltage and the current are generally constant, the product of the voltage across the load capacitor, VCL2, and the current, ICL2, through it can be used to determine the output power of the DSHBR circuit, Pout.

As stated in, the MOSFETs parasitic capacitance between the terminals affects the performance of the Stage – 1 circuit (i.e. H-Bridge), in particular, the power. Power loss, Pswitching loss in the MOSFET occurs during the switching process, known as the switching losses in the H-Bridge circuit, which can be stated as

$$P_{switching\ loss} = \frac{1}{2} V_{DS}\, I_D\, f_s(t_{on} + t_{off})$$

The turn-on and turn-off times of the MOSFETs are denoted by ton and toff, respectively. The proposed circuit's total power loss can be computed as follows:

$$P_{Loss} = P_{ac} - P_{dc}$$

III. RELATED WORKS

A. Authors and Affiliations

[1] *Mohammadreza Sedighi, Ricardo Vasquez Padilla," HIGH TEMPERATURE, POINT PRESSURISED GAS-PHASE SOLAR RECEIVERS", Researchgate Energy Conversion and Management 185(April 2019):678-717*. The heat transfer fluid in gas-phase solar receivers is atmospheric or pressurized gas (HTF). In fact, all four goals are difficult to achieve at the same time since it is difficult to (cost-effectively) overcome the solid absorber's intrinsically low heat transfer performance to the gaseous HTF. This article offers effective prototyping processes for high-temperature receivers based on a review of successful prototyping research. Overall, the authors believe that the current work provides an up-to-date, complete evaluation of progress on gas-phase receivers, as well as some useful, specific advice on the next steps in their development.

[2] *Alok K.Ray Dibakar Rakshit K.Ravikumar, "High-temperature latent thermal storage system for solar power: Materials, concepts, and challenges, Cleaner Engineering and Technology Volume 4, October 2021, 100155",* Solar Dish Micro Gas Turbine (MGT) systems have the potential to be fascinating small-scale power plants for electricity or poly-generation production in off-grid or mini-grid settings. The solar receiver, which must operate at high temperatures with concentrated solar radiations that change dramatically over time, is the most difficult component of such systems. The design and study of a one-of-a-kind solar receiver in combination with a Phase Change Storage system for short-term storage. Materials to prevent rapid changes in the maximum temperature of the MGT working fluid are discussed in this study.

[3] *Iman Izadgoshasba Yee Yan Lima Lihua Tangb Ricardo Vasquez Padilla Zi Sheng Tanga Mohammadreza Sedighia, "Energy Harvesting Techniques for Internet of Things (IoT)", Volume*

184, 15 March 2019, Pages 559-570 in Energy Conversion and Management. The use of piezoelectric energy harvesters (PEH) to collect electrical energy from diverse human motions has gotten a lot of attention in recent years. In this study, a double pendulum system coupled with magnetic force interactions is used to try to improve the efficiency of PEH in harvesting energy from human motions. Three PEH configurations are experimentally explored for comparison: PEH with a cantilever beam (PEHCB), PEH with a single pendulum system (PEHSP), and PEH with a double pendulum system (PEHSD) (PEHDP).

B. *Figures and Tables*

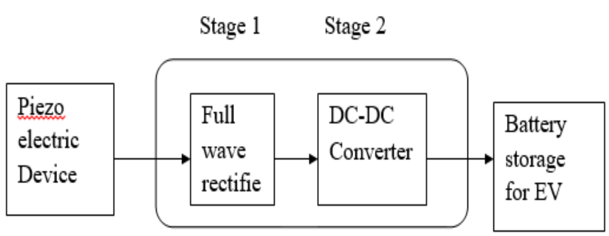


FIGURE 1: DSHBR (DUAL STAGE H-BRIDGE CIRCUIT)

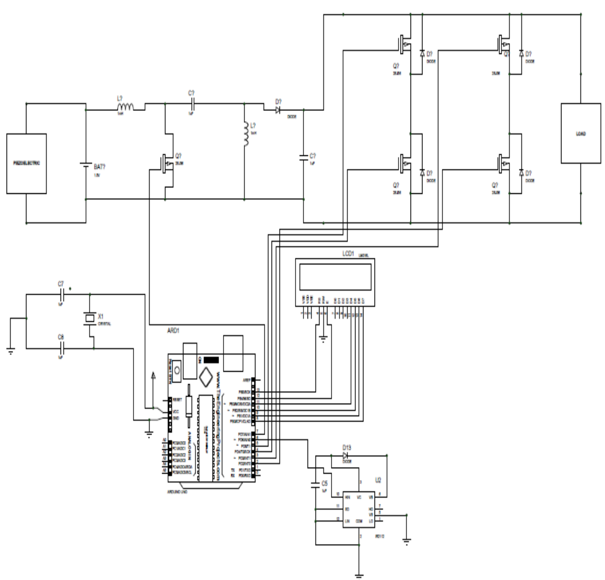


FIGURE 2: PROPOSED CIRCUIT DIAGRAM

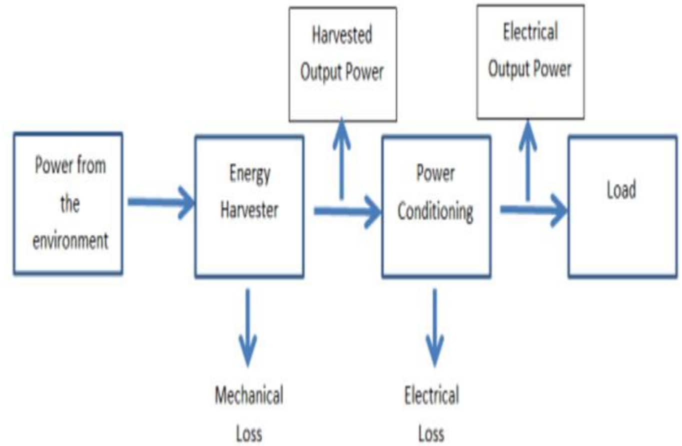


FIGURE 3: STAGES OF PROPOSED SYSTEM

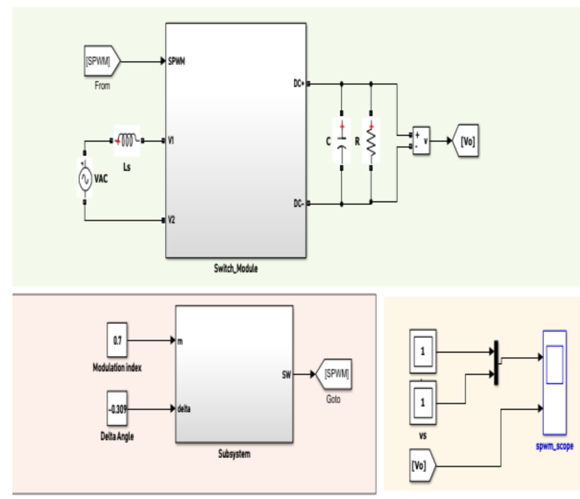


***FIGURE 4 :* SIMULATION BLOCK DIAGRAM OF DSHBR**

C. *Methodology*

The proposed system rectifier circuit-based power generation system is implemented in this project. A dual active bridge-based electronic circuit is implemented in this project. A DSHBR circuit is proposed to reduce rectification losses, operate at low AC voltages, and mitigate the ripples in output voltage. A self-powered H-Bridge circuit for rectifying AC voltage to DC voltage, while Stage – 2 involves the DC-DC converter for stabilizing the rectified voltage. It's worth noting that the suggested DSHBR circuit doesn't require an external power supply to turn on the bidirectional switches at any point.

A full-wave bridge rectifier (FBR) circuit is the easiest way to convert AC to DC. in this system high level of harmonics is present design incorporated bidirectional transistors to attenuate the forward voltage losses in the rectification process. However, the study did not present the output power extracted from the circuit. The suggested controller changed the switching frequency and fs of the step-down converter circuit to maximize the output power flow into the battery and proposed a dual-stage rectifier circuit. However, due to its switching frequency

D. Proposed Algorithm

Maximum Power Transfer Theorem explains what the criteria are to deliver the source power to the electrical load with maximum transfer efficiency. When the source impedance of an AC source is the complex conjugate of the load impedance, the maximum power transfer occurs.

The AC current source, with an internal impedance ZS = RS + jXS and a load impedance of ZL = RL + XX. To deliver a maximum of 17 Chapter 2 Power Management in Energy Harvesters power from the mechanical side to the electrical load, the load impedance should be the complex conjugate of ZS, ZL = RL − jXS. Maximum power is then derived by Pmax = R2 S + X2 S 4RS I

Power transfer from an energy harvester is highly affected by the load impedance which is connected to the harvester. In order to minimize power loss due to mismatching of impedances between harvester and interface circuitry, there is the impedance matching technique. Impedance matching is also the technique able to deliver maximum power from the harvester to the electrical side there have been various impedance matching techniques in the literature.

IV. RESULTS AND DISCUSSION

A. SIMULATION RESULT

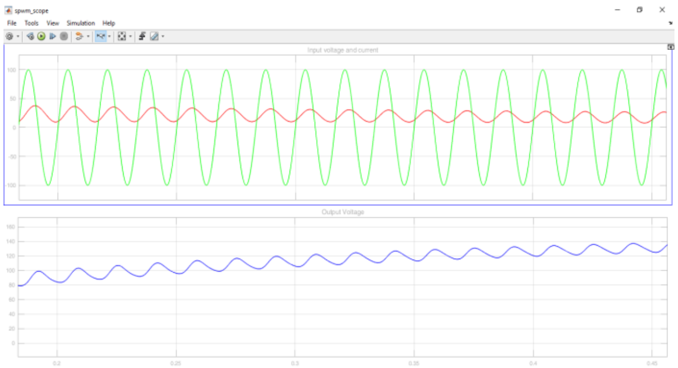


FIGURE 5: INPUT VOLTAGE AND CAPACITOR VOLTAGE

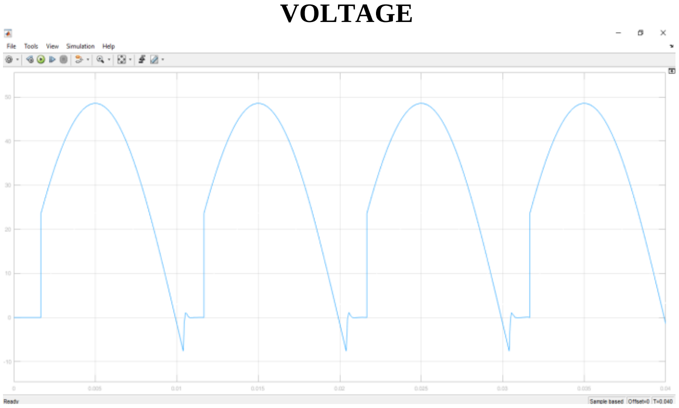
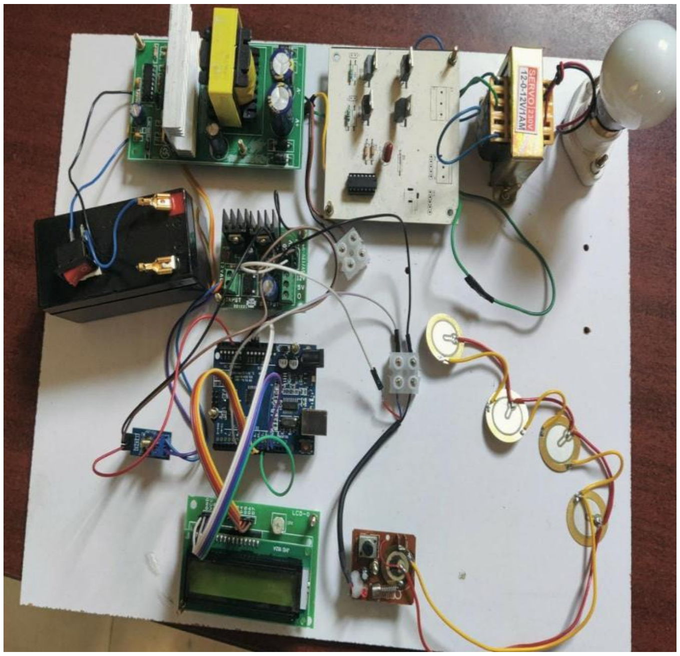


FIGURE 6 : OUTPUT VOLTAGE

B. HARDWARE RESULT



V. CONCLUSION

A DSHBR circuit for rectifying voltage and power from the PEH system under high and low frequencies of vibrations and human motion-induced excitation was designed and investigated. By assimilating the advantage of MOSFETs, which has low threshold voltage in Stage – 1, and DC-DC converter, which stabilizes the rectified voltage in Stage – 2, the DSHBR circuit successfully produced higher rectified voltage with fewer ripples and higher output power when compared with the regular H-Bridge circuit. Furthermore, the suggested circuit's voltage rectified as a result of low-frequency PEH was found to be capable of charging a solar battery, demonstrating the circuit's practical application. The proposed circuit delivered 3.4 Vdc of rectified voltage and 115.6 W of output power from PVDF in the HMIV test involving arm movement, while 8.8 Vdc and 84.2 W of rectified voltage and output power were accomplished in the SIV tests. Modification of the DSHBR circuit to integrate the non-linear process is recommended for future development. Under high and low frequencies of vibrations, as well as human motion-induced stimulation, a DSHBR circuit for rectifying voltage and the PEH system's power was constructed and investigated. By assimilating the advantage of MOSFETs, which has low threshold voltage in Stage – 1, and DC-DC converter, which stabilizes the rectified voltage in Stage – 2, the DSHBR circuit successfully produced higher rectified voltage with fewer ripples and higher output power when compared with the regular H-Bridge circuit. Furthermore, the suggested circuit's voltage rectified as a result of low-frequency PEH was found to be capable of charging a solar battery, demonstrating the circuit's practical application. The proposed circuit delivered 3.4 Vdc of rectified voltage and 115.6 W of output power from PVDF in the HMIV test involving arm movement, while 8.8 Vdc and 84.2 W of rectified voltage and output power were accomplished in the SIV tests. Future development should include modifying the DSHBR circuit to incorporate the non-linear process.

REFERENCES

1. M. Sedighi, R. V. Padilla, R. A. Taylor, M. Lake, I. Izadgoshasb, and A. Rose, ``High-temperature, point-focus, pressurized gas-phase solar receivers: A comprehensive," Energy Convers. Management, vol. 185, pp. 678717, Apr. 2019.
2. S. Roundy, P. K. Wright, and J. Rabaey, ``A study of low-level vibrations as a power source for wireless sensor nodes," Comput. Commun., vol. 26, no. 11, pp. 11311144, Jul. 2003.
3. M. Sedighi, R. V. Padilla, P. Alamdari, M. Lake, A. Rose, I. Izadgoshasb, and R. A. Taylor, ``A novel high-temperature (>700 C), volumetric receiver with a packed bed of transparent and absorbing spheres," Appl. Energy, vol. 264, Apr. 2020, Art. no. 114705.
4. I. Izadgoshasb, Y. Y. Lim, L. Tang, R. V. Padilla, Z. S. Tang, and M. Sedighi, ``Improving the efficiency of piezoelectric-based energy harvesting from human motions using double pendulum system," Energy Convers. Manage., vol. 184, pp. 559570, Mar. 2019.
5. Y. Y. Lim, S. T. Smith, R. V. Padilla, and C. K. Soh, ``Monitoring of concrete curing using the electromechanical impedance technique: Review and path forward," Struct. Health Monitor., vol. 20, no. 2, pp. 604636, Mar. 2021.
6. Y. Y. Lim, S. T. Smith, and C. K. Soh, ``Wave propagation-based monitoring of concrete curing using piezoelectric materials: Review and path forward," NDT E Int., vol. 99, pp. 5063, Oct. 2018.
7. N. A. A. Nawir, A. A. Basari, M. S. M. Saat, N. X. Yan, and S. Hashimoto, ``A review on piezoelectric energy harvester and its power conditioning circuit," ARPN J., 2018.
8. A. Rahman, O. Farook, M. R. Islam, and W. Xu, ``Recent progress in electrical generators for oceanic wave energy conversion," IEEE Access, vol. 8, pp. 138595138615, 2020.
9. A. S. Sarangi, S. K. Sahu, and K. Patra, ``Comparison of circuits for dielectric elastomer-based energy harvesting," in Proc. 2nd Int. Conf. Inventive Syst. Control (ICISC), Jan. 2018, pp. 413417.
10. A. M. Eltamaly and K. E. Addoweesh, ``A novel self-power SSHI circuit for piezoelectric energy harvester," IEEE Trans. Power Electron., vol. 32, no. 10, pp. 76637673, Oct. 2017.