

## [ 電子制御工学科 ]

### [区 分 A]

#### 出口 幹雄

Expansion of detectable area by floating electrodes in capacitive three-dimensional proximity sensor

出口幹雄\*

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In the capacitive proximity sensing method, arranging multiple sensing electrodes makes it possible to obtain the three-dimensional position of a nearby object. The author has developed a capacitive proximity sensing method using LC resonance in three reactance elements. In this method, the detectable area can be greatly extended by the floating electrodes, which are capacitively connected to the sensing electrode. By connecting multiple floating electrodes in series, the detectable range can be extended up to the length of the array of floating electrodes. When these electrodes are arranged on a frame, the region surrounded by the frame becomes the detectable area. By applying this frame on any surface, it is possible to make the surface within the opening of the frame a non-contact operating panel, which can be applied as a gesture input device.

#### 出口 幹雄

A Single-Stage Rectifier-Less Boost Converter Circuit for Piezoelectric Energy Harvesting Systems

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IEEE Transactions on Energy Conversion Vol.37 (2022), pp505-514

In this paper, a single-stage rectifier-less boost converter circuit (SSRBC) for piezoelectric energy harvesting from ambient vibration was proposed. The proposed rectifier-less circuit acted as a boost converter to extract energy from a piezoelectric device (PD). It combined the conventional boost, buck-boost methods using two split inductors and single filter capacitor. The proposed integrated circuit topology functioned in both positive and negative half cycles generated by the PD. In the proposed topology, inductors were invigorated by being enveloped with the current, which was produced by the PD through the switches. This facilitated active rectification of ultra-low AC (amplitude < 0.5 VP). Theoretical analysis, control strategies, simulation and experimental study, were presented. The proposed circuit was capable of converting a low amplitude AC voltage of 0.5 VP into 5.1 Vdc. The highest output power extracted by the proposed circuit was 281.1  $\mu\text{W}$ , which outperformed existing circuits. It could potentially facilitate the advancement of vibration-based energy harvesting system for low power demand

applications such as sensors, quartz watches and portable charging devices.

#### 出口 幹雄

### **Design and Application of a Self-Powered Dual-Stage Circuit for Piezoelectric Energy Harvesting Systems**

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IEEE Access (Volume: 9), pp86954 – 86965, (2021.6)

This paper describes the design and practical application of a dual-stage H-Bridge (DSHBR) circuit to reduce the rectification losses and mitigate ripples in piezoelectric energy harvesting. The proposed DSHBR circuit integrates both AC-DC and DC-DC conversion processes using bidirectional switches and a step-up DC-DC converter, which applies to both positive and negative half cycles. One additional feature is that it does not require external power to turn on the bidirectional switches ( $V_{th} < 0.3 \text{ V}$ ). Such feature facilitates active rectification at very low AC voltages ( $V_{ac} < 0.5$ ) generated by the piezoelectric device (PD). To validate the performance of the proposed circuit, a series of experimental tests were conducted. Firstly, the performance of circuit on rectifying the PD output was investigated using a shaker to generate high and low frequency excitations. Next, real-life testing was conducted with human arm motion as the source of excitation. Then, the ability of the entire system to charge solar batteries was investigated. The outcome shows that the DSHBR circuit prominently increased the rectified voltage and the output power while stabilising the DC voltage when compared with the conventional H-Bridge circuit.

#### 出口 幹雄

### **Non-Linear Switching Circuit for Active Voltage Rectification and Ripples Reduction of Piezoelectric Energy Harvesters**

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Energies 2022, 15(3), 709

This paper describes an improved non-linear switching circuit (INLSC) for active rectification of voltage and reduction of ripples in the voltage waveform for the piezoelectric energy harvesting (PEH) system. The proposed converter controls the alternating current (AC) generated by the piezoelectric device (PD) under mechanical vibration. The proposed circuit combines the boost and buck-boost processes through a switching process, which functions in both positive and negative cycles. In addition, it controls the voltage and frequency of the load capacitor. In this process, the passive components in the circuit are energised by being short with the AC voltage using switching signals, which facilitates the active rectification of ultra-low AC voltage. Design considerations, theoretical analysis, simulations and experimental results are presented. It was shown that the circuit was able to control the switching signal and to convert low AC voltage ( $0.44 \text{ V}_i$ ) to high direct current (DC) voltage ( $6.5 \text{ V}_{dc}$ ) while achieving an output power of  $469 \mu\text{W}$  which outperforms the existing similar circuits and synchronous rectifier circuit. The ripples in the rectified voltage were also comparatively less. Application-wise,

the proposed circuit could power a manually connected 7-segments display, commonly used for traffic applications.

### 出口 幹雄

#### **An Improved Rectifier Circuit for Piezoelectric Energy Harvesting from Human Motion**

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Applied Sciences Vol.11 (2021) pp2008-2029

Harvesting energy from human motion for powering small scale electronic devices is attracting research interest in recent years. A piezoelectric device (PD) is capable of harvesting energy from mechanical motions, in the form of alternating current (AC) voltage. The AC voltage generated is of low frequency and is often unstable due to the nature of human motion, which renders it unsuitable for charging storage device. Thus, an electronic circuit such as a full bridge rectifier (FBR) is required for direct current (DC) conversion. However, due to forward voltage loss across the diodes, the rectified voltage and output power are low and unstable. In addition, the suitability of existing rectifier circuits in converting AC voltage generated by PD as a result of low frequency human motion induced non-sinusoidal vibration is unknown. In this paper, an improved H-Bridge rectifier circuit is proposed to increase and to stabilize the output voltage. To study the effectiveness of the proposed circuit for human motion application, a series of experimental tests were conducted. Firstly, the performance of the H-Bridge rectifier circuit was studied using a PD attached to a cantilever beam subject to low frequency excitations using a mechanical shaker. Real-life testing was then conducted with the source of excitation changed to a human performing continuous cycling and walking motions at a different speed. Results show that the H-Bridge circuit prominently increases the rectified voltage and output power, while stabilizes the voltage when compared to the conventional FBR circuit. This study shows that the proposed circuit is potentially suitable for PEH from human motion.

### 松友 真哉

#### **Interactive Motor Design System using 2D Finite Element Analysis with Fast Mesh Modification Method**

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IEEE Transactions on Magnetics, doi: 10.1109/TMAG.2022.3159993. (2022.3)

In this paper, we propose an interactive visualization method for motor design. In the proposed design system, the user can immediately observe the analysis result of the design change. Furthermore, if the proposed system is executed in cooperation with the projector, designers can change the design of the motor with their fingers and discuss it on the board. Furthermore, since this system can be executed on a Web browser, it can also be executed on a smartphone or tablet PC.

### 松友 真哉

#### **Interactive Motor Design System using 2D Finite Element Analysis with Fast Mesh**

## Modification Method

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COMPUMAG 2021 (The 23rd Conference on the Computation of Electromagnetic Fields) 、CMP375、(2022.1)

We propose Interactive Motor Design System for educational and industrial use. There were two problems. How to create a mesh and view the results quickly. We took a lattice mesh in polar coordinate and the way to visualize at certain interval despite of calculation speed. In the proposed design system, the user can immediately observe the analysis result of the design change. Furthermore, if the proposed system is executed in cooperation with the projector, designers can change the design of the motor with their fingers and discuss it on the whiteboard.

## 眞鍋 知久

Interactive Motor Design System using 2D Finite Element Analysis with Fast Mesh

## Modification Method

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IEEE Transactions on Magnetics, doi: 10.1109/TMAG.2022.3159993. (2022.3)

[概要は前掲]

## 眞鍋 知久

Interactive Motor Design System using 2D Finite Element Analysis with Fast Mesh

## Modification Method

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COMPUMAG 2021 (The 23rd Conference on the Computation of Electromagnetic Fields) 、CMP375、(2022.1)

[概要は前掲]

## [区 分 E]

## 出口 幹雄

3D Proximity Sensing Frame for Non-Contact Operation Panel

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The IEEJ International Workshop on Sensing, Actuation, Motion Control, and Optimization, (2022.3)

Capacitive proximity sensing method using LC resonance in the circuit containing three reactance elements has been developed, which can detect slight change in stray capacitance of the sensing electrode. The electronic circuit in this method is composed only of general-purpose

electronic components. Arranging multiple sensing electrodes on a frame, it is possible to estimate the three-dimensional position of an object existing in the region surrounded by the frame. Attaching this frame on a panel surface, any operation panel can be made non-contact operatable.

## 出口 幹雄

### 柔らかい線路の特性を利用した生体センシング

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\*新居浜工業高等専門学校電子制御工学科

令和3年度電気・電子・情報関係学会四国支部連合大会、(2021.9)

伝送線路の伝播特性は線路形状に依存する。柔らかい材質からなる導体を線路として、これを衣服等に敷設しておけば、体の動きに応じて線路が変形し、それに伴い伝播特性が変化する。これによる伝播遅延時間の変化を検出すれば、これから呼吸や心拍等に伴う体の動きを検知することができ、生体センシングに応用することができる。そのための基礎検討として、形状の変形が規則的で予測可能なものとして、コイルばねと金属メッシュを用いて、長さに対する伝播特性の変化を調べた。

## 出口 幹雄

### CONSIDERATION OF THE SPECIAL COURSE FOR ASSISTIVE TECHNOLOGY ENGINEER DEVELOPMENT IN COLLABORATION WITH MEDICAL INSTITUTIONS

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International Symposium on Advances in Technology Education Conference, (2021.8)

Manufacturing education in collaboration with medical institutions is very important and useful. National Institute of Technology, Niihama College (NIT, Niihama College) is offers a two-year systematic curriculum as the "Special Course for Assistive Technology Engineer Development (AT course)". This is the process of learning the basic knowledge of Medical welfare engineering, and manufacturing based on the needs of clinical field. In the AT course, problems in clinical environment are given as themes, and students take the initiative in working toward solving the issues while receiving advice on fluids, controls, sensors, programming, etc. from teaching staffs. However, it is difficult to imagine the problems in clinical environment, and multifaceted viewpoints, ideas, and knowledge are required to solve the problems. Also, in clinical environment, it doesn't matter who made it. Furthermore, in order to create products that can be used in clinical environment, it is necessary to have "technology" and "strategy" that enable high-quality manufacturing as well as the functions required by users. It is not possible to nurture engineers who can make practical things only by school education, and social implementation education in collaboration with the local community is necessary. Therefore, as the AT course, we built an education system in collaboration with medical institutions. In addition, this system is designed to nurture engineers who can "manufacture with care" and to create an environment where they can learn manufacturing from various perspectives. This report provides an overview of the AT course and examples of actual efforts. Also summarize student efforts and feedback from clinical institutions, consider changes in student awareness before and after taking the course, and describe the benefits of collaborating with medical

institutions. As an example of our efforts, we will introduce a proposal for an efficient ventilation method in a rehabilitation room using CFD (Computational Fluid Dynamics).

### **福田 京也**

#### **身近な原子時計のはなし**

福田京也\*

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令和3年度新居浜高専市民講座（新居浜生涯学習大学）第7回、(2021.10)

測位システムであるGPSの衛星には、正確な時計である「原子時計」が搭載されている。カーナビゲーションシステムは、複数のGPS衛星からの電波を受信し、受信位置と地図情報とを組み合わせ、現在地をリアルタイムに表示するシステムである。また、時刻合わせが不要な電波時計は、日本標準時と連動した「原子時計」の時刻情報を載せた電波を定期的に受信し、正確な時刻を表示する装置である。我々の身近なカーナビや電波時計の基礎技術である「原子時計」の原理について説明し、2021年10月に打ち上げ予定の準天頂衛星による日本版測位ナビゲーションシステム（QZSS）についても解説する。

### **栗原 義武**

#### **正規乱数を利用したデジタル系の誤り率シミュレーションに関する一検討**

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2021年度映像情報メディア学会冬季大会、21D-2、(2021.12)

本稿では、デジタル技術における誤り率特性を求めるプログラミングによるシミュレーション結果において、加法性白色ガウス雑音を仮定する際、一般的に利用されるボックスミュラー法により検討を行った。デジタル系プログラミング環境として、15bit整数による乱数値と31bit整数による乱数値の違いによって同一プログラムであっても実行結果が異なる場合原因を検討した。

その結果、15bit整数による乱数値では通常のシミュレーション手法では誤り率の理論値から大きく外れてしまうが、本稿による工夫によって、15bit整数による乱数値においても31bit乱数と同程度まで理論値に近づけることが可能であることが明らかとなった。

### **松友 真哉**

#### **モータ設計のためのインタラクティブ可視化システムの開発**

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令和4年電気学会全国大会 (2022.3)

モータ設計の基礎検討や動作原理の学習にも活用できるインタラクティブ可視化システムの開発を行っている。モータ設計時に有限要素法による磁界シミュレーションを活用することは一般的である。しかし、有限要素法でのシミュレーションは、モデル作成、メッシュ生成、結果の可視化、などのステップを経て実行するため、モータの設計変更や検討をその場でリアルタイムに行うことは難しい。そこで我々は、これをシームレスに実行できるモータ設計のためのインタラクティブ可視化システムを開発している。

### **松友 真哉**

#### **有限要素磁界解析とGAを利用したリフティングマグネットの形状最適化**

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電気・電子・情報関係学会四国支部連合大会 (2021.9)

有限要素法による磁界解析と遺伝的アルゴリズムを利用してリフティングマネットの形状最適化設計を試みたことについて報告した。電磁力の最大化と鉄心質量の最小化を両立するパレート解が得られることを検証した。

### 松友 真哉

#### 2次元有限要素法を高速化したインタラクティブなモータ設計システムの開発

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電気・電子・情報関係学会四国支部連合大会(2021. 9)

磁界解析をモータ設計に利用する際、設計変更に伴ってモデル変更が必要であるが、それに手間がかかると設計アイデアの議論が滞る恐れがある。本発表では、2次元有限要素法を高速化し、モータ設計のためのインタラクティブな磁界可視化システムを開発していることについて報告した。

### 眞鍋 知久

#### モータ設計のためのインタラクティブ可視化システムの開発

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令和4年電気学会全国大会(2022. 3)

[概要は前掲]

### 眞鍋 知久

#### 2次元有限要素法を高速化したインタラクティブなモータ設計システムの開発

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電気・電子・情報関係学会四国支部連合大会(2021. 9)

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