International Academic Institute for Science and Technology

International Academic Journal of Science and Engineering
Vol. 7, No. 1, 2020, pp. 22-26.

ISSN 2454-3896

International Academic Journal of Science and Engineering

www.iaiest.com

Current Progress of Energy Harvesting Technology Toward Battery - Free IoT

Raghav Kumar [a], Pooja Raghunath [b]

[a] *Department of Electrical Engineering, Omega Engineering College, Pune, India.*
[b] *Department of Electrical Engineering, Omega Engineering College, Pune, India.*

Abstract

Energy harvesting is an affordable way to power sensing nodes that are set up in remote areas. At the same time, keeping an eye on the vibrations of machines or structures is becoming increasingly important. These vibrations are often unpredictable and change over time. To capture these vibrations as a renewable energy source for our sensing nodes, we need energy harvesters that can operate over a wide range or can be tuned. Piezoelectric transducers are a popular choice for harvesting mechanical vibrations. Our goal is to enhance the vibration-based energy harvester by making it auto-tunable, which will give it a broader response range. We examine many wideband energy harvester devices and tuning techniques. The auto-tuning method for cantilever-based energy harvesters could be improved, according to the thesis. Users can select from pre-existing battery settings and even upgrade to new ones from the server thanks to the clever charger's user-friendly design. There are several types of rechargeable batteries, such as lithium-ion, nickel-iron, nickel-cadmium, nickel-manganese, lead-acid, and alkaline. Each type has its own unique characteristics, such as capacity, voltage limits, energy density, power output, charging cycles, and lifespan.

Keywords: Energy Harvesting Technology, Battery Free IoT, Current Progress.

Received: 07 March 2020/Revised: 11 April 2020/Accepted: 22 May 2020/Published: 30 June 2020

Introduction

Energy harvesting (EH) is all about capturing energy from our surroundings and turning it into usable direct current (DC). Remarkably, high power transfer over several kilometers has been achieved, boasting efficiencies of around 70% for powering ultra-high frequency (UHF) RFID devices at distances of up to 10 meters. There are many RF energy sources in the environment as a result of the growing use of wireless technologies like WLAN (which runs at 2.4GHz and 5.8GHz), RFID (2.45GHz, 5.8GHz, and 24.125GHz), mobile phones (3G, 4G, and digital TV), radios, GSM, and even microwave ovens. Wireless Sensor Networks (WSNs) are a well-known area of research that provides a basic framework for the Internet of Things (IoT) (Sun et al., 2018). The core components of WSNs are sensors, actuators, embedded controllers, and networking devices that provide data and information transmission. One of the biggest concerns is keeping a consistent power source for all of these smart, connected devices, most of which are battery-operated. RF energy harvesting, which generates a low-power DC supply from harvested RF energy—such as that from radar, Wi-Fi, GSM, and radio/TV transmitting stations—is an environmentally benign and potential substitute. Engineers are in charge of updating modern technologies, including wearables, 5G, IoT, and artificial intelligence (AI). The majority of these technologies use sensors that are positioned in remote locations; however, these sensors need batteries to function. Regretfully, replacing the batteries in so many sensors on a regular basis can be challenging and hazardous to the environment. Energy Harvesting (EH) or Green Energy (GE) provides a workable answer to this environmental issue by utilizing energy from readily available renewable sources. Apart from specific radio frequency energy sources such as Wi-Fi, WLAN, and Bluetooth, ambient energy can be converted into electrical energy from a range of sources, such as the sun, wind, heat, and even vibrations. Choosing the most effective energy harvesting method can facilitate the construction of end devices, including WSN/IoT nodes.

Literature Review

Technological advancements continue to transform our workspaces with innovative portable electronic devices, including wearables, emerging every day. Rechargeable batteries, such as NiMH/NiCd, Li-Ion, and Lead-Acid, serve as the primary power source for these portable devices. In these key research areas, scientists are primarily focused on enhancing charge density, reducing charging times, minimizing size, and lowering the costs of rechargeable batteries. This focus has led to the creation of new rechargeable batteries with various chemical compositions (Tang et al., 2018). Every battery comes with its own unique charging algorithm, especially when you compare Lithium-ion batteries to Lead-acid ones. This is where universal chargers step in as a practical solution, allowing us to avoid the hassle of using different chargers for each type of rechargeable battery. Plus, they help save money by utilizing the charging profiles and algorithms of the chargers we already have. However, there's a catch: when a new type of battery hits the market with its own charging algorithm, those universal chargers often can't keep up. To tackle this issue, we can leverage IoT technology, which offers a smart solution through embedded devices and the existing internet infrastructure. As IoT applications continue to grow across various sectors, they enable real-time monitoring, remote database access, and seamless interaction between devices and systems. That's why we're proposing a cutting-edge IoT-based smart universal charging system that can handle both current batteries and any new ones that come along (Ku et al., 2015).

Methodology

The proposed design integrates both hardware and software and is separated into two main sections: the charging part and the IoT section. Buck converters are one type of DC-DC converter that reduces input voltage or current to the necessary output levels. Because constant monitoring of the voltage and current levels is necessary for best performance, it is imperative that the inductor (L) and capacitor (C) in this converter configuration be precisely designed (Elahi et al., 2020).

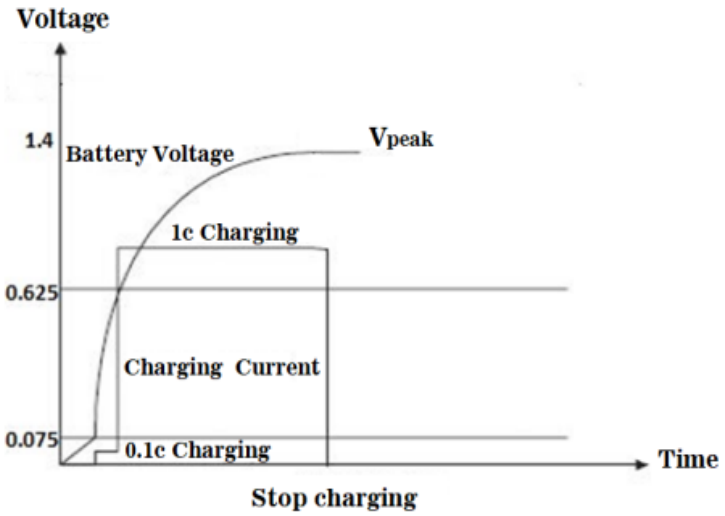


Fig. 1: Charging curve of single cell NiMH/NiCd batteries

Thus, the microcontroller receives these values back. The analog voltage generated by the ACS712 current sensor is equivalent to the current it measures. To control the battery charging process, the PID controller continuously monitors this voltage and current data. Based on the preset set points, the PID controller puts in endless effort to maintain a constant voltage and current While the voltage maintains constant during the charging process in the CV mode, the current stays constant in the CC mode. To charge a certain type of battery, the user inputs the CC and CV values (Zeadally et al., 2020). Before charging begins, the microcontroller checks the battery voltage. If the voltage is below the full discharge level, the battery is labeled as faulty. If the voltage exceeds the full discharge level, the controller switches to the constant current technique and sets the current according to the CC value. The PID control is then employed to ensure that the current remains constant during the CC phase. When the battery voltage exceeds 80% of its nominal voltage or full charge, the microcontroller enters CV mode. The voltage is then adjusted to match the CV value using a constant voltage algorithm. In this case, PID control is also employed to keep the voltage steady during the CV phase (Shirvanimoghaddam et al., 2019).

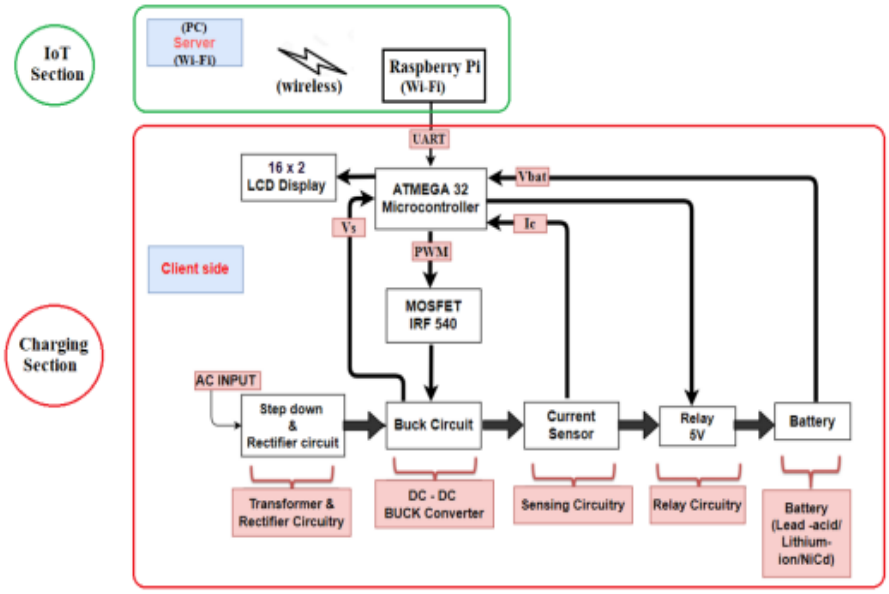


Fig. 2: Block diagram of the proposed system

The LCD display informs you by continuously updating the voltage (V) and current (I). When the battery reaches its maximum voltage and the current falls below 4% of the rated current, the charging cycle is over; the LCD display indicates this (Ma et al., 2019).

Results and Discussion

The two main parts of the proposed design for an IoT-based intelligent charging system are the charging section and the IoT section. In the Internet of Things space, a PC is the server and a Raspberry Pi is the client. These two components are remotely connected and maintain databases for various battery charging profiles. The microcontroller-based buck converter in the charging section uses a Proportional Integral Differential (PID) technique to monitor the battery's voltage, current, and temperature. It then provides the proper DC output voltage and current to charge any chosen battery, whether it's an old or new model. The rapid advancement of technology has made instant access to everything increasingly vital (Adila et al., 2018).

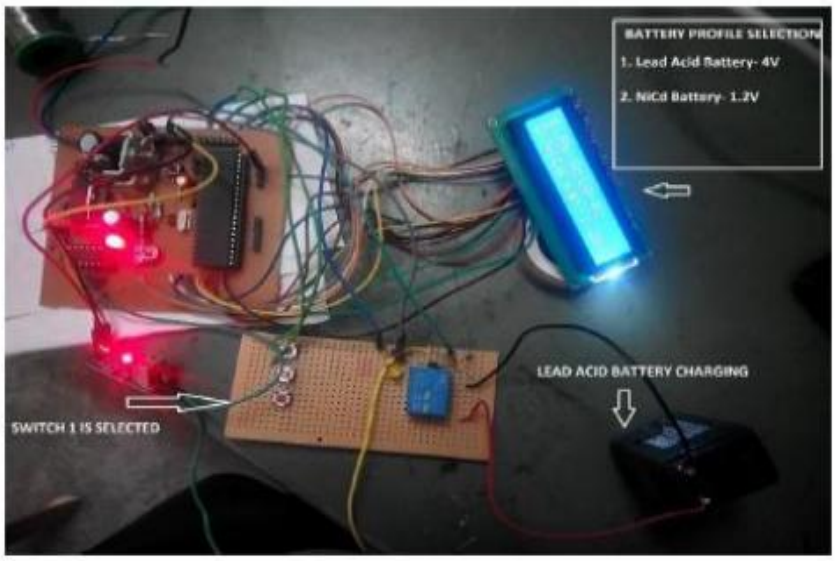


Fig. 3: Charging Lead acid battery

To save costs and boost productivity, we steer clear of the power circuits. A Wireless Sensor Network (WSN) typically consists of a storage device, a power management unit, and an energy harvesting device. The energy gathering device converts ambient energy from various sources, such as solar, wind, heat, vibration, and radio frequency wireless energy, into DC voltage. The power management unit (PMU) is essential because it regulates the power supplied to the WSN Node (End Device) or stores the energy that is captured. Meanwhile, the storage device stores the electricity that has been collected for later use.

Conclusion

One promising method to lessen the reliance of IoT devices on batteries is ambient energy harvesting, which is all about drawing energy from our surroundings. The battery life of IoT sensors may be significantly extended using "ambient IoT" technology, and it may even be possible to develop sensors that are completely battery-free. We presented a novel IoT-based universal charger in this study. The IoT section and the charging section are the two primary components of this charger. In the IoT segment, a PC acts as the server and a Raspberry Pi as the client. The server connects to the controller over the Internet and stores a database of battery profiles. In contrast, the charging section includes a microcontroller-based buck converter that keeps an eye on the battery's temperature, voltage, and current. It uses the Proportional Integral Derivative (PID) algorithm through the PWM technique to ensure the correct output voltage for battery charging. Our suggested charger is adaptable enough to charge a range of multi-chemistry batteries, in contrast to conventional chargers that are limited to using a single battery type. What sets this charger apart is its ability to update existing battery profiles and incorporate new ones from the server as they become available.

References

Sun, H., Yin, M., Wei, W., Li, J., Wang, H., & Jin, X. (2018). MEMS based energy harvesting for the Internet of Things: a survey. *Microsystem Technologies*, *24*, 2853-2869.

Tang, X., Wang, X., Cattley, R., Gu, F., & Ball, A. D. (2018). Energy harvesting technologies for achieving self-powered wireless sensor networks in machine condition monitoring: A review. *Sensors*, *18*(12), 4113. https://doi.org/10.3390/s18124113

Ku, M. L., Li, W., Chen, Y., & Liu, K. R. (2015). Advances in energy harvesting communications: Past, present, and future challenges. *IEEE Communications Surveys & Tutorials*, *18*(2), 1384-1412.

Elahi, H., Munir, K., Eugeni, M., Atek, S., & Gaudenzi, P. (2020). Energy harvesting towards self-powered IoT devices. *Energies*, *13*(21), 5528. https://doi.org/10.3390/en13215528

Zeadally, S., Shaikh, F. K., Talpur, A., & Sheng, Q. Z. (2020). Design architectures for energy harvesting in the Internet of Things. *Renewable and Sustainable Energy Reviews*, *128*, 109901. https://doi.org/10.1016/j.rser.2020.109901

Shirvanimoghaddam, M., Shirvanimoghaddam, K., Abolhasani, M. M., Farhangi, M., Barsari, V. Z., Liu, H., ... & Naebe, M. (2019). Towards a green and self-powered Internet of Things using piezoelectric energy harvesting. *Ieee Access*, *7*, 94533-94556.

Ma, D., Lan, G., Hassan, M., Hu, W., & Das, S. K. (2019). Sensing, computing, and communications for energy harvesting IoTs: A survey. *IEEE Communications Surveys & Tutorials*, *22*(2), 1222-1250.

Adila, A. S., Husam, A., & Husi, G. (2018, April). Towards the self-powered Internet of Things (IoT) by energy harvesting: Trends and technologies for green IoT. In *2018 2nd international symposium on small-scale intelligent manufacturing systems (SIMS)* (pp. 1-5). IEEE.