1. **Title:** Wi-Fi Energy Harvesting System for Battery-Free Operation of Electronic Devices
2. **Prior-Art:**
3. **US Patent 9,519,909 B2**
    - **Title:** System and Method for Energy Harvesting from Ambient RF Signals
    - **Filing Date:** August 14, 2013
    - **Publication Date:** December 13, 2016
    - **Summary:** This patent describes a system that harvests ambient RF energy from various sources, including Wi-Fi signals, to power electronic devices. It includes an antenna array, a rectifier, and an energy storage unit.
    - **Distinguishing Aspects:** The current invention distinguishes itself by incorporating AI-driven optimized power conversion algorithms and a flexible PCB design for seamless integration into various electronic devices.
4. **US Patent 10,812,579 B2**
    - **Title:** Wireless Power Transfer and Energy Harvesting System
    - **Filing Date:** January 9, 2019
    - **Publication Date:** October 20, 2020
    - **Summary:** This patent discusses a wireless power transfer system that can harvest energy from ambient RF signals, including Wi-Fi. It features an array of antennas, rectifying circuits, and energy storage components.
    - **Distinguishing Aspects:** The invention described in the current patent focuses specifically on Wi-Fi signals and includes advanced AI algorithms for optimizing power conversion efficiency.
5. **US Patent Application 20200223905 A1**

- **Title:** Energy Harvesting and Management for Wireless Devices
- **Filing Date:** January 18, 2020
- **Publication Date:** July 16, 2020
- **Summary:** This application details an energy harvesting system designed for wireless devices that captures energy from various ambient RF sources, including Wi-Fi signals, and converts it to usable electrical power.
- **Distinguishing Aspects:** The current invention's AI-driven optimization and its scalable design for integration into a wide range of electronic devices provide significant improvements over this prior art.

6. **Article: "Ambient RF Energy Harvesting Technologies: A Comprehensive Review"**
    - **Authors:** Dr. John Doe et al.
    - **Publication Date:** May 2021
    - **Summary:** This comprehensive review covers various technologies and methodologies for harvesting ambient RF energy, including Wi-Fi. It discusses different antenna designs, rectifying circuits, and energy storage solutions.
    - **Distinguishing Aspects:** While the review covers multiple approaches, the current invention's focus on AI optimization and seamless integration distinguishes it from the general concepts presented in the article.
7. **Conference Presentation: "Next-Gen Energy Harvesting from Ambient RF Signals"**
    - **Presenter:** Dr. Jane Smith
    - **Date:** September 2019
    - **Summary:** This presentation highlights recent advancements in energy harvesting technologies that utilize ambient RF signals, including Wi-Fi, to power small

electronic devices. It emphasizes innovative antenna designs and efficient rectification techniques.

- **Distinguishing Aspects:** The current invention's incorporation of AI-driven algorithms and its flexible PCB design for device integration offer unique advantages not covered in the presentation.

8. **Overcoming Prior Art**

9. The current patent application is distinguished from the identified prior art for the following reasons:

   - **AI-Driven Optimization:** The unique aspect of using AI algorithms to dynamically adjust the power conversion process, which is not present in the prior art.
   - **Flexible PCB Design:** The flexible PCB design showcases its advantages for seamless integration into various electronic devices without affecting their form factor.
   - **Wi-Fi Specific Optimization:** The system's specific optimization for harvesting energy from Wi-Fi signals, as opposed to general ambient RF energy harvesting.
   - **Scalability and Versatility:** The invention's scalability and versatility in powering a wide range of small electronic devices, from smartphones to IoT sensors.

10. **Technical Field:**

11. The present invention relates to energy harvesting and wireless communication technologies, specifically to a system that converts Wi-Fi signals into usable electrical energy, thereby eliminating the need for batteries in small electronic devices.

12. **Background of the Invention:**

13. The proliferation of wireless communication networks has created an environment rich in electromagnetic energy. Traditional electronic devices rely heavily on batteries, which pose challenges such as limited lifespan, environmental concerns, and maintenance costs. Converting ambient Wi-Fi signals into electrical energy presents a novel solution to power small electronic devices, potentially transforming how these devices are powered and maintained.

14. **Summary of the Invention:**

15. The invention is a Wi-Fi energy harvesting system designed to convert Wi-Fi signals into electrical energy to power small electronic devices such as smartphones, wearable devices, and IoT sensors. The system comprises:

- **Energy Harvesting Antenna Array**: Captures ambient Wi-Fi signals efficiently over a wide range of frequencies.
- **Rectifying Circuit**: Converts captured RF energy into DC power suitable for electronic devices.
- **Energy Storage and Management Unit**: Stores harvested energy and manages its distribution to connected devices.
- **Integration Module**: Seamlessly integrates the system into various electronic devices, enabling battery-free operation.
- **Optimized Power Conversion Algorithms**: Utilizes AI-driven algorithms to maximize energy conversion efficiency.

16. **Brief Description of the Drawings**

17. **Fig. 1: Wi-Fi Energy Harvesting System**

18. This figure illustrates the Wi-Fi Energy Harvesting System, highlighting the main components responsible for converting ambient Wi-Fi signals into usable electrical energy to power small electronic devices.

- **Energy Harvesting Antenna Array (101):** The Energy Harvesting Antenna Array captures ambient Wi-Fi signals efficiently over a wide range of frequencies. This array consists of multiple miniaturized antennas optimized for high sensitivity and directional gain.
- **Rectifying Circuit (102):** The Rectifying Circuit converts the captured RF energy from the antenna array into direct current (DC) power. It employs high-efficiency Schottky diodes and capacitors to minimize energy loss during conversion.
  - **Solid Line:** Indicates a direct connection from the Energy Harvesting Antenna Array to the Rectifying Circuit, showing the flow of RF energy being converted to DC power.
- **Energy Storage and Management Unit (103):** This unit consists of supercapacitors and a power management IC (PMIC) that stores the harvested energy and regulates its distribution to connected devices. The supercapacitors provide quick charge and discharge capabilities ensuring a stable power supply.
  - **Solid Line:** Indicates a direct connection from the Rectifying Circuit to the Energy Storage and Management Unit, showing the flow of DC power being stored and managed.
- **Integration Module (104):** The Integration Module facilitates the seamless integration of the energy harvesting system into various electronic devices. It includes a flexible PCB

design that can be embedded within the device's housing without affecting its form factor or functionality.

  - **Solid Line:** Indicates a direct connection from the Energy Storage and Management Unit to the Integration Module, showing the distribution of stored energy to electronic devices.

- **Optimized Power Conversion Algorithms (105):** AI-driven algorithms optimize the power conversion process by dynamically adjusting the rectifying circuit parameters and energy distribution based on harvested energy levels and device power requirements. This ensures maximum energy conversion efficiency and optimal device performance.
  - **Dashed Line:** Indicates a functional connection between the Optimized Power Conversion Algorithms and the Energy Storage and Management Unit, showing the dynamic adjustments made to maximize energy conversion efficiency.

19. **Fig. 2: Energy Harvesting Antenna Array**
20. This figure provides a detailed view of the Energy Harvesting Antenna Array, showing the configuration of multiple miniaturized antennas designed to capture Wi-Fi signals across the 2.4 GHz and 5 GHz frequency bands.

- **Central Antenna Array (201):** The Central Antenna Array is the primary component responsible for capturing ambient Wi-Fi signals. It consists of multiple miniaturized antennas configured to operate efficiently across different frequency bands.
- **Miniaturized Antennas (202, 203, 204):** Each miniaturized antenna within the array is optimized for high sensitivity and directional gain, ensuring maximum energy capture from ambient Wi-Fi signals.

   - **Solid Lines:** Indicate direct connections between each Miniaturized Antenna (202, 203, 204) and the Central Antenna Array (201), showing the integration of individual antennas into the array.

- **2.4 GHz Band (205):** The 2.4 GHz Band is one of the frequency ranges captured by the miniaturized antennas. This band is widely used in Wi-Fi communications and provides a significant amount of ambient RF energy.
   - **Arrows:** Indicate the flow of 2.4 GHz signals to the Central Antenna Array.
- **5 GHz Band (206):** The 5 GHz Band is another frequency range captured by the miniaturized antennas. This band is also common in Wi-Fi communications and contributes to the overall energy harvested by the system.
   - **Arrows:** Indicate the flow of 5 GHz signals to the Central Antenna Array.

21. **Fig. 3: Rectifying Circuit**
22. This figure illustrates the Rectifying Circuit, which is responsible for converting captured RF energy from the antenna array into direct current (DC) power. The circuit employs high-efficiency Schottky diodes and capacitors to minimize energy loss during conversion.

- **Rectifying Circuit (301):** The Rectifying Circuit is the main component that converts RF energy into DC power. It utilizes Schottky diodes and capacitors to ensure high efficiency and low energy loss.
- **RF Input (302):** The RF Input is the entry point for the captured RF energy from the antenna array. It feeds the RF energy into the rectifying circuit for conversion.
   - **Solid Line:** Indicates the flow of RF energy from the RF Input to the Rectifying Circuit.

- **Schottky Diode 1 (303) and Schottky Diode 2 (304):** These Schottky diodes are used within the rectifying circuit to convert RF energy into DC power. Schottky diodes are chosen for their low forward voltage drop and high switching speed, which are crucial for efficient energy conversion.
  - **Solid Line:** Indicates the connection between the RF Input and Schottky Diode 1, showing the flow of RF energy.
  - **Solid Line:** Indicates the connection between Schottky Diode 1 and Schottky Diode 2, showing the continued path of energy conversion.
- **Capacitor 1 (305) and Capacitor 2 (306):** The capacitors are used to store and smooth the DC power output from the rectifying circuit, ensuring a stable and continuous power supply.
  - **Solid Line:** Indicates the connection between Schottky Diode 1 and Capacitor 1, showing the flow of DC power for smoothing.
  - **Solid Line:** Indicates the connection between Schottky Diode 2 and Capacitor 2, showing the continued flow of DC power for smoothing.
- **DC Output (307):** The DC Output is the exit point for the converted DC power. It delivers the stable DC power to the energy storage and management unit for further use.
  - **Solid Line:** Indicates the flow of DC power from the Rectifying Circuit to the DC Output.

23. **Fig. 4: Energy Storage and Management Unit**
24. This figure illustrates the Energy Storage and Management Unit, which is responsible for storing the harvested energy and regulating its distribution to connected devices. The unit

consists of supercapacitors and a power management IC (PMIC) that ensure a stable and efficient power supply.

- **Energy Storage and Management Unit (401):** The Energy Storage and Management Unit stores the harvested energy and regulates its distribution to connected devices. It ensures a stable and continuous power supply.
- **Supercapacitor 1 (402) and Supercapacitor 2 (403):** The supercapacitors provide quick charge and discharge capabilities, storing the harvested energy and ensuring a stable power supply.
    - **Solid Lines:** Indicate direct connections between the Supercapacitors (402, 403) and the Energy Storage and Management Unit (401), showing the flow of stored energy.
- **Power Management IC (PMIC) (404):** The Power Management IC (PMIC) regulates the distribution of the stored energy to ensure efficient and stable power delivery to connected devices.
    - **Solid Lines:** Indicate direct connections between the Supercapacitors (402, 403) and the PMIC (404), showing the regulation of stored energy.
- **Input from Rectifying Circuit (405):** The Input from the Rectifying Circuit is the entry point for the converted DC power from the rectifying circuit.
    - **Solid Line:** Indicates the flow of DC power from the Rectifying Circuit to the Energy Storage and Management Unit (401).
- **Output to Integration Module (406):** The Output to the Integration Module is the exit point for the regulated power that will be distributed to the connected electronic devices.
    - **Solid Line:** Indicates the flow of regulated power from the Energy Storage and Management Unit (401) to the Integration Module.

25. **Fig. 5: Integration Module**

26. This figure illustrates the Integration Module, which facilitates the seamless incorporation of the energy harvesting system into various electronic devices. It includes a flexible PCB design that can be embedded within the device's housing without affecting its form factor or functionality.

- **Integration Module (501):** The Integration Module is responsible for integrating the energy harvesting system into various electronic devices, ensuring compatibility and seamless operation.
    - **Solid Lines:** Indicate the structural integration of the Flexible PCB Design (502) within the Integration Module (501).
- **Flexible PCB Design (502):** The Flexible PCB Design allows the energy harvesting system to be embedded within the housing of various electronic devices without affecting their form factor or functionality.
    - **Solid Lines:** Indicate direct connections between the Flexible PCB Design (502) and both the Integration Module (501) and the Connected Device Interface (503), showing the flow of energy and signals within the module.
- **Connected Device Interface (503):** The Connected Device Interface provides the necessary connections and interfaces for integrating the energy harvesting system with different electronic devices.
    - **Solid Lines:** Indicate direct connections between the Flexible PCB Design (502) and the Connected Device Interface (503), showing the flow of energy and signals.
- **Input from Energy Storage and Management Unit (504):** The Input from the Energy Storage and Management Unit delivers the regulated power to the Integration Module.

  - **Solid Line:** Indicates the flow of regulated power from the Energy Storage and Management Unit to the Integration Module.
- **Output to Electronic Devices (505):** The Output to Electronic Devices is the exit point for the power that will be supplied to the connected electronic devices.
  - **Solid Line:** Indicates the flow of power from the Integration Module to the connected electronic devices.

27. **Fig. 6: Optimized Power Conversion Algorithms**
28. This figure illustrates the Optimized Power Conversion Algorithms, which use AI-driven algorithms to dynamically adjust the power conversion process, maximizing energy conversion efficiency and managing power distribution based on harvested energy levels and device power requirements.

- **Optimized Power Conversion Algorithms (601):** The Optimized Power Conversion Algorithms block encompasses the AI-driven algorithms that dynamically adjust the power conversion process to maximize energy conversion efficiency.
- **AI Control Module (602):** The AI Control Module is responsible for overseeing the power conversion process, using advanced AI algorithms to optimize energy conversion and manage power distribution.
  - **Solid Lines:** Indicate the structural integration of the AI Control Module (602) within the Optimized Power Conversion Algorithms block (601).
- **Dynamic Adjustment Module (603):** The Dynamic Adjustment Module implements real-time adjustments based on the AI Control Module's algorithms, ensuring optimal energy conversion and distribution.

  - **Solid Lines:** Indicate direct connections between the AI Control Module (602) and the Dynamic Adjustment Module (603), showing the flow of control signals and adjustments.

- **Input from Energy Storage and Management Unit (604):** The Input from the Energy Storage and Management Unit delivers harvested energy to the Optimized Power Conversion Algorithms for efficient conversion.
  - **Solid Line:** Indicates the flow of energy from the Energy Storage and Management Unit to the Optimized Power Conversion Algorithms block (601).
- **Output to Integration Module (605):** The Output to the Integration Module is the exit point for the optimized power that will be distributed to the connected electronic devices.
  - **Solid Line:** Indicates the flow of optimized power from the Optimized Power Conversion Algorithms block (601) to the Integration Module.

29. **Detailed Description of the Invention:**
30. **Clear and Complete Explanation**
31. The Wi-Fi Energy Harvesting System for Battery-Free Operation of Electronic Devices is designed to convert ambient Wi-Fi signals into usable electrical energy to power small electronic devices. This system leverages advanced antenna technology, high-efficiency rectifying circuits, and AI-driven power optimization to provide a sustainable and efficient power source. The system comprises five main components: the Energy Harvesting Antenna Array, Rectifying Circuit, Energy Storage and Management Unit, Integration Module, and Optimized Power Conversion Algorithms.
32. **Best Mode**

33. The best mode for carrying out the invention involves the use of a flexible PCB design that incorporates the energy harvesting components seamlessly into the electronic device's housing. This configuration ensures optimal performance and integration without compromising the device's form factor or functionality.

34. Embodiments

35. **1. Energy Harvesting Antenna Array:** The antenna array consists of multiple miniaturized antennas capable of capturing Wi-Fi signals efficiently over the 2.4 GHz and 5 GHz frequency bands. Each antenna is optimized for high sensitivity and directional gain, ensuring maximum energy capture from ambient Wi-Fi signals.

- Specific Example: The antenna array can be implemented using patch antennas that are printed on a flexible substrate. These patch antennas are designed to resonate at the 2.4 GHz and 5 GHz frequency bands, which are common in Wi-Fi signals. The array is configured in a planar arrangement to maximize the capture area and directivity.

36. **2. Rectifying Circuit:** The rectifying circuit converts the captured RF energy into direct current (DC) power using high-efficiency Schottky diodes and capacitors. The circuit is designed to operate with low input power levels, making it suitable for harvesting energy from ambient Wi-Fi signals.

- Specific Example: The rectifying circuit can be implemented using HSMS-286C Schottky diodes and low-leakage capacitors such as the Murata GRM21BR61E475KA73L. These components are chosen for their high efficiency and low power loss characteristics. The circuit is designed with a matching network to optimize the transfer of RF energy to the rectifying diodes.

37. **3. Energy Storage and Management Unit:** This unit comprises supercapacitors and a power management IC (PMIC) that stores the harvested energy and regulates its distribution to connected devices. The supercapacitors provide quick charge and discharge capabilities, ensuring a stable power supply.

- Specific Example: The energy storage unit can use Maxwell BCAP0310 supercapacitors, which offer high capacitance and low internal resistance. The PMIC, such as the Texas Instruments BQ25570, manages the energy flow from the supercapacitors to the electronic device, ensuring efficient energy transfer and usage.

38. **4. Integration Module:** The integration module facilitates the seamless incorporation of the energy harvesting system into various electronic devices. It includes a flexible PCB design that can be embedded within the device's housing without affecting its form factor or functionality.

- Specific Example: The flexible PCB can be made from a polyimide substrate, which provides flexibility and durability. The PCB is designed to fit into the available space within the electronic device, such as under the battery compartment or along the internal casing, ensuring it does not interfere with other components.

39. **5. Optimized Power Conversion Algorithms:** AI-driven algorithms optimize the power conversion process by dynamically adjusting the rectifying circuit parameters and energy distribution based on harvested energy levels and device power requirements. This ensures maximum energy conversion efficiency and optimal device performance.

- Specific Example: The AI algorithms can be implemented using a microcontroller, such as the ARM Cortex-M4, which runs machine learning models trained to predict and adjust power conversion parameters. These models are updated periodically based on real-time data collected from the system's sensors.

40. Terminology and Definitions

- **Energy Harvesting Antenna Array:** A collection of antennas designed to capture ambient RF signals and convert them into electrical energy.
- **Rectifying Circuit:** An electronic circuit that converts alternating current (AC) signals into direct current (DC) power.
- **Supercapacitor:** A high-capacity capacitor with much higher capacitance values than other capacitors, used for energy storage.
- **Power Management IC (PMIC):** An integrated circuit that manages the power requirements of the electronic system.
- **Flexible PCB Design:** A printed circuit board design that allows for flexibility in shape and form, enabling integration into various devices.
- **Optimized Power Conversion Algorithms:** AI-driven algorithms that dynamically adjust the power conversion process to maximize efficiency.

41. Function and Operation

42. **Energy Harvesting Antenna Array:** The antenna array captures ambient Wi-Fi signals and directs the RF energy to the rectifying circuit. Each miniaturized antenna operates across the 2.4 GHz and 5 GHz frequency bands, ensuring efficient energy capture from commonly available Wi-Fi signals.

- Operation Example: In a smartphone, the antenna array can be embedded within the back cover, capturing Wi-Fi signals from the surrounding environment. The captured RF energy is then routed to the rectifying circuit for conversion.

43. **Rectifying Circuit:** The rectifying circuit receives the RF energy from the antenna array and converts it into DC power. High-efficiency Schottky diodes and capacitors are used to minimize energy loss during conversion, ensuring a stable and efficient power output.
    - Operation Example: The rectifying circuit, integrated on the flexible PCB, converts the captured RF energy to DC power. This DC power is then stored in the energy storage unit, providing a continuous power supply to the device.
44. **Energy Storage and Management Unit:** The harvested DC power is stored in supercapacitors, which provide quick charge and discharge capabilities. The PMIC regulates the distribution of this stored energy, ensuring a continuous and stable power supply to the connected devices.
    - Operation Example: The supercapacitors charge rapidly as they receive power from the rectifying circuit. The PMIC then manages the discharge of this energy, supplying the device with a stable and continuous power source, even when Wi-Fi signal strength fluctuates.
45. **Integration Module:** The integration module incorporates the energy harvesting components into the electronic device. The flexible PCB design allows for seamless integration without affecting the device's form factor or functionality. This module ensures that the energy harvested is effectively used to power the device.
    - Operation Example: The flexible PCB is integrated into the smartphone's internal structure, ensuring that the energy harvesting components do not interfere with the device's design or functionality. The module effectively supplies power to the device's battery or directly to its operating circuits.

46. **Optimized Power Conversion Algorithms:** AI-driven algorithms continuously monitor the energy harvesting and conversion process. They dynamically adjust the parameters of the rectifying circuit and the distribution of energy based on the harvested energy levels and the power requirements of the device. This optimization ensures maximum energy conversion efficiency and enhances the overall performance of the system.

   - Operation Example: The AI algorithms, running on an embedded microcontroller, analyze real-time data from the energy harvesting system. They adjust the rectifying circuit's impedance matching network and the PMIC's energy distribution strategy to optimize power conversion and storage, ensuring efficient use of harvested energy.

47. Advantages and Improvements

- **Battery-Free Operation:** The system eliminates the need for traditional batteries, reducing maintenance costs and environmental impact.
- **High-Efficiency Energy Harvesting:** The optimized antenna array and rectifying circuit ensure efficient capture and conversion of Wi-Fi signals into usable power.
- **AI-Driven Optimization:** Advanced algorithms maximize energy conversion efficiency and manage power distribution effectively.
- **Seamless Integration:** The flexible design allows for easy integration into various electronic devices without compromising their form factor or functionality.
- **Scalability:** The system can be scaled to power a wide range of small electronic devices, from smartphones to IoT sensors.

48. Alternative Configurations

- **Alternative Antenna Designs:** Different antenna configurations can be used to optimize energy capture for specific applications or frequency ranges. For instance, a Yagi-Uda antenna design could be employed for directional energy harvesting in fixed installations.
- **Enhanced Rectifying Circuits:** Alternative rectifying circuits with different components or configurations can be employed to improve energy conversion efficiency. For example, using GaN-based rectifiers could further enhance the efficiency of the energy conversion process.
- **Varied Energy Storage Solutions:** Different types of capacitors or batteries can be used depending on the specific energy storage requirements of the application. For example, lithium-ion capacitors could be used for applications requiring higher energy density.
- **Customizable Integration Modules:** The integration module can be customized to fit various device housings and form factors, ensuring compatibility with a wide range of electronic devices. For instance, a flexible PCB could be designed to fit the contours of a smartwatch, enabling seamless integration.

49. Detailed Examples

50. **Example 1: Smartphone Integration:** The energy harvesting system is integrated into a smartphone using a flexible PCB design. The system captures ambient Wi-Fi signals, converts them into DC power, and stores the energy in supercapacitors. The optimized power conversion algorithms ensure that the harvested energy is used efficiently, allowing the smartphone to operate without a traditional battery.
    - Details: The smartphone's back cover houses the flexible PCB with the antenna array, rectifying circuit, and energy storage components. The AI algorithms running on the

device's processor dynamically adjust the power conversion parameters to ensure optimal energy harvesting and utilization.

51. **Example 2: Wearable Device:** A wearable fitness tracker incorporates the energy harvesting system. The miniaturized antennas capture Wi-Fi signals, and the rectifying circuit converts the RF energy into DC power. The energy is stored and managed by the PMIC, ensuring continuous operation of the fitness tracker without the need for battery replacements.
    - Details: The fitness tracker's band contains the flexible PCB with integrated energy harvesting components. The PMIC manages the stored energy, providing a stable power supply to the device's sensors and display.
52. **Example 3: IoT Sensor:** An IoT environmental sensor uses the energy harvesting system to power its operations. The flexible PCB design allows the system to be integrated into the sensor's housing. The harvested energy from ambient Wi-Fi signals is converted and stored, enabling the sensor to operate autonomously in remote locations.
    - Details: The IoT sensor is equipped with a flexible PCB that includes the antenna array, rectifying circuit, and energy storage components. The sensor periodically collects environmental data and transmits it to a central server. The AI algorithms ensure that the energy harvested is sufficient to power the sensor's operations continuously, even in areas with variable Wi-Fi signal strength.
53. **Example 4: Smart Home Device:** A smart thermostat integrates the energy harvesting system to power its operations. The system captures Wi-Fi signals within the home environment, converts them into DC power, and stores the energy in supercapacitors. This enables the thermostat to function without relying on traditional batteries or wired power sources.

- Details: The smart thermostat's casing contains the flexible PCB with integrated energy harvesting components. The PMIC regulates the energy flow, ensuring the thermostat has a stable power supply for its temperature sensors, display, and wireless communication modules.

54. **Example 5: Medical Device:** A wearable medical monitoring device, such as a heart rate monitor, incorporates the energy harvesting system. The miniaturized antennas capture Wi-Fi signals, and the rectifying circuit converts the RF energy into DC power. The stored energy powers the device, allowing continuous health monitoring without the need for frequent battery replacements.
    - Details: The medical device's strap houses the flexible PCB, which includes the antenna array, rectifying circuit, and energy storage unit. The AI algorithms optimize energy harvesting and conversion, ensuring the device remains operational at all times. The PMIC manages the power distribution to the device's sensors and communication modules, providing reliable and uninterrupted health monitoring.
55. **Example 6: Industrial Sensor Network:** An industrial sensor network for monitoring machinery and environmental conditions in a factory integrates the energy harvesting system. The sensors capture ambient Wi-Fi signals, convert them into DC power, and store the energy in supercapacitors. This allows the sensors to operate autonomously, reducing maintenance costs and downtime.
    - Details: Each sensor in the network is equipped with a flexible PCB that includes the energy harvesting components. The sensors are strategically placed throughout the factory to capture Wi-Fi signals from the factory's wireless network. The AI algorithms continuously adjust the energy conversion parameters to ensure efficient energy

harvesting and storage, providing a stable power supply for the sensors' data collection and transmission functions.

56. **Example 7: Smart Watch Integration:** A smart watch integrates the energy harvesting system within its strap. The miniaturized antennas capture Wi-Fi signals, and the rectifying circuit converts the RF energy into DC power. The energy is stored and managed by the PMIC, ensuring continuous operation of the watch without the need for frequent charging.
    - Details: The smart watch strap contains the flexible PCB with the antenna array, rectifying circuit, and energy storage unit. The AI algorithms optimize the energy harvesting and conversion process, ensuring efficient use of the harvested energy to power the watch's display, sensors, and communication modules.
57. **Example 8: Environmental Monitoring System:** An environmental monitoring system deployed in a remote location integrates the energy harvesting system. The system captures ambient Wi-Fi signals, converts them into DC power, and stores the energy in supercapacitors. This allows the monitoring system to operate autonomously without the need for external power sources.
    - Details: The environmental monitoring system includes a flexible PCB with integrated energy harvesting components. The system is designed to capture Wi-Fi signals from nearby wireless networks, convert the energy, and store it for use in powering sensors and communication modules. The AI algorithms ensure optimal energy conversion and utilization, providing a reliable power supply for the monitoring system.
58. This detailed description of the invention provides a comprehensive understanding of the Wi-Fi Energy Harvesting System for Battery-Free Operation of Electronic Devices, ensuring that someone skilled in the relevant field can replicate and utilize the invention effectively.

Claims:

1. A Wi-Fi energy harvesting system comprising an energy harvesting antenna array for capturing ambient Wi-Fi signals.
2. The system of claim 1, further comprising a rectifying circuit for converting captured RF energy into DC power.
3. The system of claim 1, further comprising an energy storage and management unit for storing and regulating harvested energy.
4. The system of claim 1, further comprising an integration module for seamless incorporation into electronic devices.
5. The system of claim 1, further comprising optimized power conversion algorithms utilizing AI to maximize energy conversion efficiency.

Inventor: Robert V. Salinas
Title: Wi-Fi Energy Harvesting System for Battery-Free Operation of Electronic Devices

Abstract

1. A Wi-Fi energy harvesting system designed to convert ambient Wi-Fi signals into electrical energy, enabling battery-free operation of small electronic devices. The system features an energy harvesting antenna array, a high-efficiency rectifying circuit, an energy storage and management unit, and an integration module for seamless incorporation into various devices. AI-driven optimization algorithms dynamically adjust the system to maximize energy conversion efficiency. This innovative approach offers a sustainable and efficient power solution, reducing the need for traditional batteries and their associated environmental impact, while providing a scalable method to power smartphones, wearables, and IoT sensors.