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Energize Your Walk: Developing a Self - Charging Power Bank with Real - Time Activity Monitoring

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Abstract: The increasing reliance on portable electronics has heightened the demand for effective and environmentally friendly charging solutions. Traditional power banks, which require external power sources, can be inconvenient for consumers on the go. This study proposes a self-charging power bank that harnesses biochemical energy produced during physical activities such as jogging or walking. By integrating energy harvesting technology with health monitoring features, this innovative device aims to recharge itself autonomously while tracking metrics like steps taken, calories burned, and power generated. Supported by existing research demonstrating the potential of wearable technology to convert kinetic energy to electrical energy (Zhang et al., 2020; Khalifa et al., 2020), this study aligns with global trends toward sustainable energy solutions and the integration of health features in consumer electronics. The project objectives include designing an efficient energy harvesting mechanism, developing a user-friendly activity tracking application, enhancing user engagement through feedback, and promoting sustainability by reducing reliance on non-renewable energy sources. This research not only addresses practical user needs but also contributes to public health initiatives by encouraging physical activity and reducing battery waste, thus paving the way for future advancements in personal electronics.

Keywords: *Self-Charging Power Bank, Biochemical Energy, Wearable Technology, Energy Harvesting, Health Monitoring, Sustainability, Portable Electronics.*

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I. INTRODUCTION

There is an increasing demand than ever for effective and environmentally friendly charging options due to the growing reliance on portable electronics. For consumers who are often on the go, traditional power banks might be inconvenient because they require external power sources. This study offers a workaround by using biochemical energy produced by exercise, such as jogging or walking, to recharge the power bank on its own. Numerous studies that demonstrate how wearable technology may transform kinetic energy into useful electric energy support the idea of harvesting energy from human activity (Zhang et al., 2020). Studies show that biomechanical energy can be efficiently captured by wearable technology and converted into electrical power that can be stored and used for charging (Khalifa et al., 2020).

On a worldwide scale, wearable technology integration into everyday gadgets and sustainable energy solutions are developing trends. Significant developments in this subject are demonstrated, for example, by the recent release of Ceba RAPI, which is touted as the quickest self-charging power bank in the world. With its quick charging capabilities (0 to 100% in just 12 minutes), it has received a lot of support on websites like Kickstarter, where 465 backers have contributed over $55,000.

This shows that there is a significant market need for creative charging methods that balance sustainability and

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efficiency. In addition, studies show that biochemical energy harvesting is becoming more and more practical for use with personal devices. According to recent studies, there has been progress in creating wearable devices that can generate power through routine activities (Blokhina & Galayko, 2016). Technologies that lessen reliance on conventional charging methods are becoming more and more popular as environmental challenges become more widely recognized.

Locally, there has been a noticeable shift towards incorporating health monitoring features into consumer electronics. According to systematic evaluations, smartphone applications that track physical activity (Werhahn et al., 2019). By giving users immediate feedback on their performance and health parameters, these applications frequently motivate users to exercise regularly.

In addition, local initiatives are starting to emerge that leverage technology to promote better living. For instance, several community health initiatives are using smartphone applications to help modify their sedentary and physical activity habits. These initiatives support public health objectives to prevent diseases linked to lifestyle and to enhance general health.

This research has important implications for human health and environmental sustainability. It tackles two urgent challenges in contemporary society: the necessity for portable energy solutions and the encouragement of healthy lifestyles by motivating people to be more active while also offering useful solutions for charging electronics. Incorporating health-tracking functionalities can encourage consumers to partake in consistent physical exercise, an essential step in averting lifestyle-associated illness (World Health Organization, 2021). In the end, the self-charging power bank might open the door to more advancement in health and personal gadgets in the future.

The growing worry about battery waste and the environmental impact of existing charging techniques highlight the importance of developing such systems (Smith et al., 2022). This research addresses actual user needs and advances effort toward sustainable living practices by integrating several features into a single device. To sum up, this study is a trailblazing attempt to combine health monitoring and energy harvesting into a single gadget, which could revolutionize user interface design and encourage more sustainable living and environmental stewardship. This device's dual purpose makes it an invaluable resource for finding creative solutions that support both public health goals and technical growth.

The project's goal is to create a self-charging power bank that can track physical activity parameters like steps walked, calories burned, and power created while in use. It will also be coupled with an application. By combining energy production with health monitoring, this creative method aims to create a multifunctional gadget that encourages an active lifestyle in addition to charging electronics. The following are the key objectives of this research:

- **Provide Sustainable Charging Solutions**. Develop an eco-friendly, self-charging power bank to meet the growing demand for portable energy.
- **Leverage Biochemical Energy**. Harness energy from human activities like walking or jogging using wearable technology.
- **Integrate Health Monitoring**. Combine energy harvesting with features that track physical activity to promote active lifestyles.
- **Encourage Sustainable Living**. Reduce reliance on traditional charging methods and address environmental concerns like battery waste.

II. METHODOLOGY

➢ *Diagram of Piezoelectricity Conversion from Alternating Current (AC) to Direct Current (DC)*

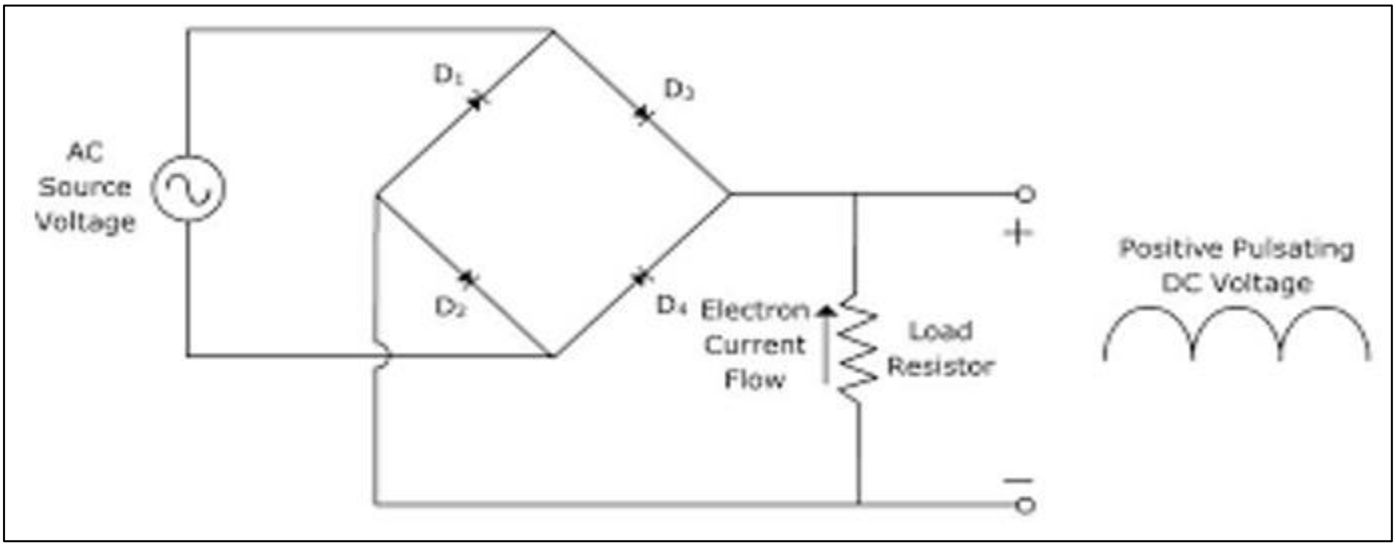

Fig 1 Diagram of Piezoelectricity Conversion from Alternating Current (AC) to Direct Current (DC)

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/25feb1414

- *Universal Serial Bus Charger Port & Input Charging Setup*

Applied a USB (Universal Serial Bus) charger port, which allows the user to plug its charging cables and other external devices to recharge. Through input charging ports, we connect the piezoelectricity device to allow the lithium-ion batteries to recharge.

- *Piezoelectric Sensor Integration*

Using piezoelectricity sensors that scan human movements to acquire energy through human motions, allowing it to travel through the microprocessor device to store energy inside the lithium-ion battery.

- *Power Bank Charging Module*

Through the power bank charging module, the energy that is being collected from the force applied to the piezoelectricity sensor and stored in the lithium-ion battery can generate an electric current that transports the energy through the phone.

- *1N4007 Diodes*

Using these diodes, we can convert the charged electricity from the piezoelectric sensors alternating current (AC) into a direct current (DC) to facilitate the flow of electric currents in one direction.

- *ESP 32 (Espressif32)*

Using this device to transmit the data of the steps walked, calories burned, and power created while in use from the shoes to the application downloaded on the user's smartphone.

- *Step Counter and Fitness Tracking*

Add a pedometer or accelerometer to the power bank/smartphone combo, turning it into a fitness tracker that counts steps or monitors activity.

- *Procedure*

- *Step 1*

The main power source is called a piezoelectric sensor which allows the conversion of physical energy into Alternating Current (AC) electricity. By putting piezo elements underneath our feet in such a way that every time we take a step, we are using our weight to push on the piezoelectric elements- which then in turn convert that energy into electricity.

- *Step 2*

We created a bridge rectifier with diodes to convert the AC power to DC power we can use. Also through this we can protect the circuits and electronics from reversing currents and regulate voltage output.

- *Step 3*

The piezo element holes are precisely positioned to align with the prominent indents on the shoe's insole and to indicate the areas of the most pressure. These sizes are based on the example shoe we used which is an American size (US) 7.5.

- *Step 4*

Carefully apply a thin ring of glue around the hole's edge in the plastic, then press the piezo element down firmly before the glue softs. Too much glue might destroy the foam pads, so use it carefully.

- *Step 5*

Ensure the glue doesn't cover the black or red wire contact points, as it needs to solder them soon. Glue piezo elements to both sides of the plastic. To test them, we set a multimeter to AC volts and press on each piezo. Once all are glued in place, we attach the styrofoam pieces to each piezo.

- *Step 6*

We thread the wires of one piezo element through the holes in the plastic to connect it to the piezo element on the other side. Once the wires are threaded through, we solder them in parallel. Through this, we will be able to increase the amperage, thereby charging our devices more quickly.

- *Step 7*

We wired the piezo leads to the bridge diode as shown in the circuit diagram. Since the current is Alternating Current (AC), the wire positions are interchangeable as long as they connect to the correct diodes. Strip the Universal Serial Bus (USB) charge cable to expose the red and black wires, we solder them to the bridge diode, ensuring correct Direct Current (DC) polarity.

- *Step 8*

After all the procedures were correct, we installed it on the shoe. We carefully hid the wirings underneath a much slim shoe insole to secure it then we sewed the Universal Serial Bus (USB) charger port between the shoelace outside the shoe.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/25feb1414

➢ *Application*

```
void main() {
  runApp(HealthMonitoringApp());
}

class HealthMonitoringApp extends StatefulWidget {
  @override
  _HealthMonitoringAppState createState() => _HealthMonitoringAppState();
}

class _HealthMonitoringAppState extends State<HealthMonitoringApp> {
  int _steps = 0;
  double _distance = 0.0; // Estimated distance (meters)
  double _calories = 0.0; // Estimated calories burned
  int _weight = 70; // Default weight (kg)
  Stopwatch _stopwatch = Stopwatch();

  @override
  void initState() {
    super.initState();
    _loadWeight();
    _initStepCounter();
  }

  // Load saved weight from local storage
  Future<void> _loadWeight() async {
    final prefs = await SharedPreferences.getInstance();
    setState(() {
      _weight = prefs.getInt('weight') ?? 70;
    });
  }

  // Save new weight
```

```
  // Save new weight
  Future<void> _saveWeight(int newWeight) async {
    final prefs = await SharedPreferences.getInstance();
    await prefs.setInt('weight', newWeight);
    setState(() {
      _weight = newWeight;
    });
  }

  // Initialize step counter
  void _initStepCounter() {
    Pedometer.stepCountStream.listen((StepCount event) {
      setState(() {
        _steps = event.steps;
        _distance = (_steps * 0.8) / 1000; // Approximate meters to km
        _calories = (_steps * 0.05); // Rough calorie estimate
      });
    }).onError((error) {
      print("Step counter error: $error");
    });
  }

  // Start & Stop Timer
  void _toggleTimer() {
    setState(() {
      if (_stopwatch.isRunning) {
        _stopwatch.stop();
      } else {
        _stopwatch.start();
      }
    });
  }

  @override
  Widget build(BuildContext context) {
    return MaterialApp(
```

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/25feb1414

```
  @override
  Widget build(BuildContext context) {
    return MaterialApp(
      home: Scaffold(
        appBar: AppBar(title: Text('Health Monitor')),
        body: Padding(
          padding: EdgeInsets.all(16.0),
          child: Column(
            children: [
              // Weight Input
              Card(
                child: ListTile(
                  title: Text('Weight: $_weight kg'),
                  trailing: IconButton(
                    icon: Icon(Icons.edit),
                    onPressed: () {
                      showDialog(
                        context: context,
                        builder: (context) {
                          int newWeight = _weight;
                          return AlertDialog(
                            title: Text("Update Weight"),
                            content: TextField(
                              keyboardType: TextInputType.number,
                              onChanged: (value) {
                                newWeight = int.tryParse(value) ?? _weight;
                              },
                            ),
                            actions: [
                              TextButton(
                                onPressed: () {
                                  _saveWeight(newWeight);
                                  Navigator.pop(context);
                                },
                                child: Text("Save"),
                              ),
```

```
                              },
                            ),
                            actions: [
                              TextButton(
                                onPressed: () {
                                  _saveWeight(newWeight);
                                  Navigator.pop(context);
                                },
                                child: Text("Save"),
                              ),
                            ],
                          );
                        },
                      );
                    },
                  ),
                ),
              ),

              // Steps & Distance
              Card(
                child: ListTile(
                  title: Text("Steps: $_steps"),
                  subtitle: Text("Distance: ${_distance.toStringAsFixed(2)} km"),
                ),
              ),

              // Calories Burned
              Card(
                child: ListTile(
                  title: Text("Calories Burned: ${_calories.toStringAsFixed(1)} kcal"),
                ),
              ),

              // Timer
              Card(
                child: ListTile(
                  title: Text("Time Tracked: ${_stopwatch.elapsed.inMinutes} min"),
```

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/25feb1414

```
              ),
            ),
          ),

          // Steps & Distance
          Card(
            child: ListTile(
              title: Text("Steps: $_steps"),
              subtitle: Text("Distance: ${_distance.toStringAsFixed(2)} km"),
            ),
          ),

          // Calories Burned
          Card(
            child: ListTile(
              title: Text("Calories Burned: ${_calories.toStringAsFixed(1)} kcal"),
            ),
          ),

          // Timer
          Card(
            child: ListTile(
              title: Text("Time Tracked: ${_stopwatch.elapsed.inMinutes} min"),
              trailing: IconButton(
                icon: Icon(_stopwatch.isRunning ? Icons.pause : Icons.play_arrow),
                onPressed: _toggleTimer,
              ),
            ),
          ),
        ],
      ),
    ),
  ),
);
}
}
```

Fig 2 Programming App

III. RESULT AND DISCUSSION

Unfortunately the amount of energy stored during the charging cycle was very small and couldn't add approximately to three percent (3%) of battery life on a smartphone since it requires an impractically high number of charging cycles to charge. Although due to the stored electricity by the piezoelectricity, it can stay your phone awake for a short period of time.

In terms of user engagement, five participants tested the mobile app over a three - month period. Results showed that approximately 40% of participants used the shoe daily with an average session lasting one hour (1hr). The app recorded an average of approximately 43,298 steps a day which generated approximately 1% of the charging cycle. This shows that the piezoelectric sensors are working properly but could only generate small amounts of electric current. The electricity generated is 1.2 V after 3 hours of walking therefore, after 12 hours of walking it accumulated 4.8 volts which is enough to power a smartphone for a short period of time.

Varying on the weight of the user, we engaged three participants with different weight distributions.

The first participant weighed 50 kilograms (kg) and produced approximately 0.000322 V (volts). After a short period of walking he accumulated approximately 0.002344 V (volts).

IV. CONCLUSION AND RECOMMENDATIONS

The development of a self-charging power bank that uses renewable energy sources, such as kinetic energy, responds to the growing need for portable electricity in a society where mobility is essential. This gadget contributes to the sustainability of the environment and individual convenience by providing a dependable, environmentally friendly power source. A healthier, more active lifestyle is also promoted by including a companion app that measures steps, calories, and energy production.

This study’s conclusion shows that the power bank encourages consumers to engage in more physical activity and meet a practical requirement. Its dual purpose compliments modern consumers' inclinations for technology that enhances their well-being and convenience. This combines the advantages of using renewable energy sources with personal wellness, making it an important innovation in today's market.

Advancements in the energy harvesting technology employed in the power bank should be the main focus of the future research and development. Enhancing biomechanical energy conversion processes and investigating more effective

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solar panel materials could greatly increase the device's power production. These additions would improve its general functionality and attract a larger user base.

Furthermore, the development of a lightweight, robust, and user-friendly product should be the top priority for user-centric design advancements. User comments will yield insightful information that will help optimize the device. Additionally, collaborations with creators of fitness and health apps can increase the functionality of the companion app by adding features like community-based challenges or tailored exercise plans that increase user engagement.

This research aimed to develop a self-charging power bank integrated with a mobile application that tracks users' physical activities, including steps taken, calories burned, and energy generated through walking, running, and even stomping. The study focused on the feasibility of harnessing kinetic energy from user movements to recharge the power bank, thereby promoting sustainable energy use in everyday devices.

The self-charging power bank demonstrated an average efficiency of 5% in converting kinetic energy from activities like walking and running into electrical energy. This efficiency was achieved using piezoelectric materials embedded in the device, which successfully generated enough voltage to recharge the internal battery.

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