Design of timing series connection technique to collecting power from microbial fuel cell using capacitor

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Abstract

Research Centre for Chemistry, Indonesian Institute of Sciences has developed microbial fuel cell power source. Voltage produced maximum one volt per batch. In order to get higher voltage from power source mostly done by connected power source in series but voltages produced by microbial fuel cells cannot be sustainably increased by linking them in series due to voltage reversal which substantially reduces stack voltages. This paper will purpose how to design the collecting maximum power point from Microbial fuel cells trough timing series connection using capacitor, the fluctuate voltage from 25% decrease become only become 7.7 %.

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Keywords: Microbial fuel cell; power collecting; series connecting.

1. Introduction

Microbial fuel cells (MFCs) convert chemical energy stored in biodegradable substrates into direct electricity, which can be used to power remote sensors or offset the energy used during domestic wastewater treatment [1]. Studies mostly used acetate, glucose, or other simple substrates to characterize the performance of materials, reactor configurations, or microbial activities [2]. Research Centre for Chemistry, Indonesian Institute of Sciences has developed microbial fuel cell power source from household wastewater (wasted water from rice rinsing).

One of the main challenges facing MFC technology is how to make collecting power more efficient because the output power of an MFC still low and difficult to use directly. Advanced power conversion techniques need to be developed to maximize power collecting. The power collectors have been studied in recent years.

Jae-Do Park [3] said that a synchronous boost converter was developed for more efficient power collector from MFCs. Compared to the conventional diode based boost converter, the synchronous boost converter based collector increased collecting efficiency. Implementation of a diode based boost converter is straight forward because the diode automatically opens when it is reverse biased and does not allow a reverse flow except a small reverse recovery current. The effect of reverse recovery can be negligible if a fast recovery Schottky diode is used. However, due to high power loss, the diode was replaced with a metal oxide semiconductor field effect transistor (MOSFET).

Youngy Kim says in [4] voltages produced by MFCs cannot be sustainably increased by linking them in series due to voltage reversal, which substantially reduces stack voltages. Voltage reversal was eliminated here by using arrangements of multiple capacitors in the circuit. This circuit is also capable of producing higher power densities over shorter time intervals by controlling the time interval for charging and discharging the capacitors. Even with this substantial power oscillation to
produce a high peak in power, average power was stationary, confirming that there were negligible energy losses in the circuit over longer time intervals. This finding shows that the capacitor circuit design will enable MFCs to power electronic devices that require higher electrical power over non-continuous time intervals.

Muhammad Alaraj say in [5] to collect more power from an MFC, power electronic converters have recently been used to replace resistors or charge pumps, because they have superior controllability on MFC’s operating. Efficiency in collecting scheme synchronous fly back converter was showed an improved performance with a simpler configuration and charged the output capacitor faster than the boost converter.

Consequently, it enhances the main advantage of using the DC-DC converters, which is the ability to control the operating point of the MFC to maximize the collecting efficiency and store the power for practical use. Topics such as self-sustainable collector without using external power supply for control circuitry and maximum power point tracking (MPPT) scheme for even better harvesting efficiency will discuss in this paper.

2. Method and material

Three MFC reactors consist of 1 liter-glass tube, which anode chamber filled with 900 mL wastewater and 100 mL isolate microbes suspension and using air cathode. The wastewater had COD concentration 3,000 – 4,600 mg/L (pH 5.7 and conductivity 1.39 – 1.57 mS). Batch reactors operated aerobically on temperature 25+0.1°C. Electrodes connected to multimeter SANWA and data collected every 4 hours.

Carbon plate 5mm of 4 cm x 7 cm was placed as the anode and cathode, as their good performance and inexpensive material electrode for MFC [7]. Salt-bridge, as cation exchange, was clamped to separate between anode and cathode chamber. The MFCs were inoculated with the effluent of an operating with domestic wastewater (wasted water from rice rinsing), and the inoculated MFCs were operated in fed-batch mode.

To avoid voltage reversal in connecting MFCs serial capacitor is being used. Capacitor is an ideal charge storage device and has been intensively used in MFC circuit designs, for its high capacitance and the feature that can be charged and discharge rapidly [6,7]. Capacitors were charged in parallel by the MFCs, but linked in series while discharging to the circuit load. Figure 1 show the circuit connection between MFCs and capacitor.

To get more efficiency power collecting the MPPT has investigated in every cylindrical chamber MFCs reactors, figure 2 and table 1 show the result of experiment voltage per cylindrical chamber MFCs reactor. In experiment result show that maximum voltage is 0.872 volt, minimum voltage is 0.517 volt and average voltage is 0.710737 volt. The fluctuating voltage is 24.97408 %, to get voltage at least 1.5 volt three MFCs reactors should combined (in serial manner), because the minimum value is 0.517. In order to obtain the maximum value/higher efficiency serial connected should combined not in the same time cycle, but try to fine right timing, so the sum of the three MFCs reactors are always constant Figure 3 show the method in timing serial connected MFCs reactor.

![Fig. 1. The circuit connection between MFCs and capacitor.](image)

Table 1. Experiment result voltage single MFCs reactor

<table>
<thead>
<tr>
<th>Time (hours)</th>
<th>Voltage (Volt)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.517</td>
</tr>
<tr>
<td>4</td>
<td>0.779</td>
</tr>
<tr>
<td>8</td>
<td>0.789</td>
</tr>
<tr>
<td>12</td>
<td>0.809</td>
</tr>
<tr>
<td>16</td>
<td>0.78</td>
</tr>
<tr>
<td>20</td>
<td>0.828</td>
</tr>
<tr>
<td>64</td>
<td>0.608</td>
</tr>
</tbody>
</table>
3. Result and discussion

After determining the timing and connected as serial manner, next cycle will be continued and the accumulation voltage will remaining constant or at low fluctuate value. Figure 4 show the result of experiment accumulation voltage MFCs reactor in series connection. The sequential timing combined determined the fluctuate accumulation voltage. In experiment result show that accumulation maximum voltage is 2.339 volt, minimum accumulation voltage is 2.01 volt and average voltage is 2.132211 volt. The fluctuating voltage is 7.7%.
4. Conclusion

MFCs reactors were connected in serial manner can produce the maximum voltage value but every MFCs reactor connected parallel with capacitor. To obtain higher efficiency serial connected should combined not in the same time cycle, but must at right timing so the sum of the three MFCs reactors are always constant. The sequential timing combined determined the fluctuate accumulation voltage. In experiment result show that accumulation maximum voltage is 2.339 volt, minimum accumulation voltage is 2.01 volt and average voltage is 2.132211 volt. The fluctuating voltage is 7.7 %.

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References


