Sansevieria Plant: Plant Base Cell (PBC) to power up IoT sensors nodes

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***Abstract*: *First time in this paper we are characterized the sansevieria trifasciata plant to power up IoT sensor nodes. This plant belongs to succulent group and survives at a very high temperature with minimum requirement of water and having higher self-repair ability if any wound in leaf happened. This chosen plant produces larger electrical potential compared to other succulent group plants due to larger oxygen level. The harvested potential varies with the separation between electrodes and with the duration of experimental time. The number of series connected plants and the position of electrodes are the two main factors for controlling the harvested energy. We have harvested 2.80 V when three sansevieria trifasciata plants were connected in series and at least two electrodes were inserted into acidic soil.*

***Keywords*: Green energy, Sansevieria Trifasciata plant, Aloe vera plant, Harvested Energy, Sensor Nodes, Plant base cell**

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I. INTRODUCTION

The modern technologies have been revolutionized due to tremendous progress in Internet-of-Things (IoT) which provides connectivity between billions of smart embedded devices [1-3]. The increased computational capabilities and power efficient communication network makes it possible to deploy the sensors in remote/and inaccessible areas [4-5]. Due to connection of large number of devices through internet, the lifetime of battery is a critical issue [6-7]. It is difficult to recharge as well as replace the battery in remote places [8]. From these reasons, it appears clear that green energy can play an important role in increasing the lifetime of IoT devices [9-10]. Recently, researchers have harvested electrical energy from living plants. The plant-based energy generation is a method that harvests electrical energy from living plants due to chemical reaction between the plant and a pair of electrodes [11-12]. This energy is pollution free, cost effective and green as well as available 24x7 day and night.

The succulent plant are not only water-retaining plants but also produces much higher voltage compared to non-succulent plant because CAM (crassulacean acid metabolism) plants contain more rubisco genes (or chloroplasts) [13-14]. We have focussed our attention on sansevieria trifasciata plants to harvest electrical energy because the leaf of sansevieria trifasciata plant can survive longer and even self-repaired if any wound happens after inserting the electrodes [15].

II. RESULTS AND DISCUSSIONS

All the experiments have been performed in an indoor laboratory unless and until specified with room temperature of 28 to 30 degree Celsius and average humidity of 49% using Aluminium (Al) and Copper (Cu) as an electrode pair. The major disadvantage of harvesting potential from plant is that the leaf damaged once electrode inserted into them, although this damage is very less in sansevieria leaf compared to the aloe vera. To avoid the larger portion to be damage, we have used two other different shape of electrode, surface electrode.

The experimental results (Figure 1) reflects that the harvested potential from the nail electrode pair is almost same as in case of sheet electrode pair whereas harvested potential is very low (of order of 10 mV) when touch/or electrogram electrodes were used (cardiogram electrode) and nail electrodes.

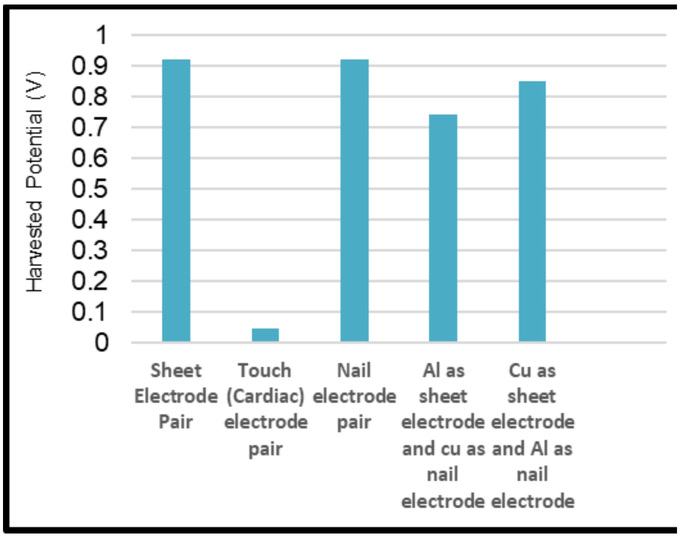

Fig. 1. Harvested potential using different shape of electrode pair

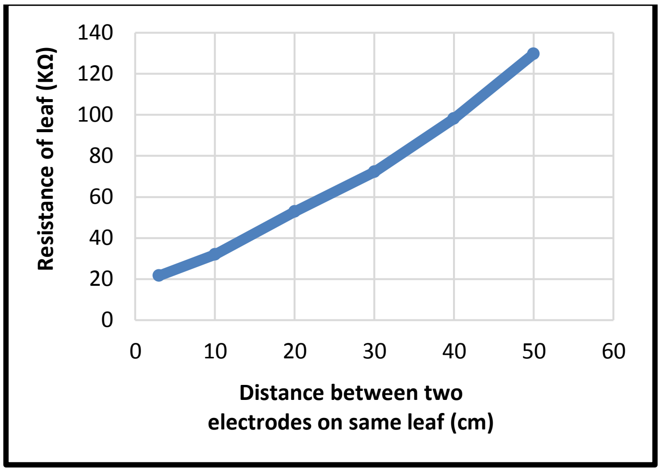

Fig. 2(b). Variation of internal resistance of leaf with separation distance of electrodes.

In the present paper, we have calculated the internal resistance of the leaf using voltage divider rule. The voltage across load is given as;

$$V_L = \frac{R_L}{(R_S+R_{Al}+R_{Cu}+R_L)} * V_{NL} \qquad (1)$$

where, R_S is internal resistance which depends upon the distance from root, R_{Al}/and R_{Cu} are internal resistance of the electrodes which are neglected in this calculation because they are of order of µΩ, V_{NL} is open circuit or no-load voltage. Neglecting the electrode resistance, equation (1) reduces to;

$$R_S = R_L * [\frac{V_{NL}-V_L}{V_L}] \qquad (2)$$

The position of electrode pair on a single leaf affects the harvested potential as shown in Figure 2(a). This variation is due to change in internal resistance of the leaf. The harvested potential reduces when two electrodes are separated by equal or less than 30 cm. If separation between Cu and Al electrode on a single leaf is more than 30 cm, the harvested potential takes minimum value and remains constant due to reduced internal resistance of the leaf (Figure 2(b)).

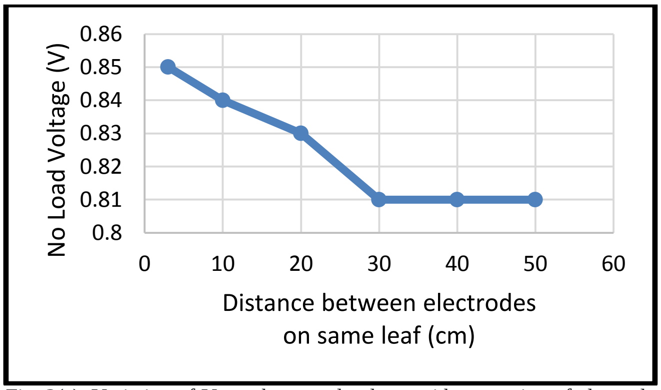

Fig. 2(a). Variation of V_{Noload} harvested voltage with separation of electrode on single leaf.

Figure 3(a) shows the variation the harvested electrical power with no-load voltage. Generally, power increases with increase in harvested potential from a single sansevieria trifasciata leaf.

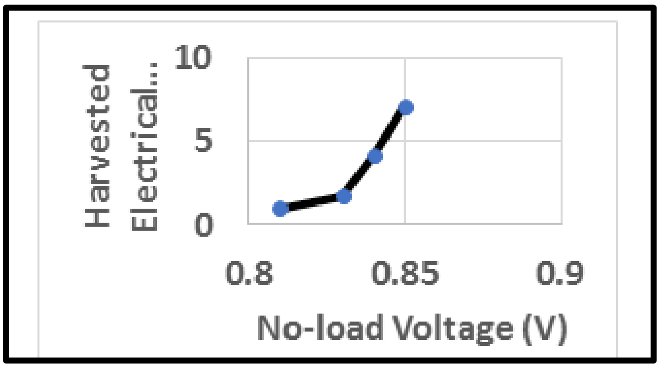

Figure 3(a): Variation of Harvested electrical power with no load voltage

We have connected two sansevieria trifasciata plants in series. The whole experiments have been conducted for cases as shown in Figure 3(b) by choosing soft and matured leaves combination. In case 1, one pair of electrodes is inserted in soft leaf of first plant and second electrode pair is embedded in the matured leaf of other plant. The harvested voltage was 1.40 V which increases to 1.71 V for case II which is like case 1 except electrode pair position. The maximum potential of 1.78 V is observed in case 3

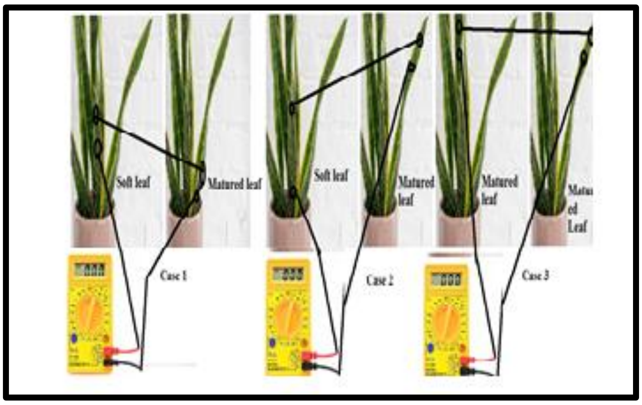

Fig. 3(b). Three different situations for series connections using two sansevieria trifasciata plants.

We have charged the capacitor of 100 µF after harvesting electrical potential from a single leaf of sansevieria plant in various soil conditions as shown in Figure 4(a). Here, capacitor is connected directly to the plant. We have observed that the maximum stored voltage in the capacitor was about 900 mV when soil having lower pH (pH<7) as seen in Figure 4(b).

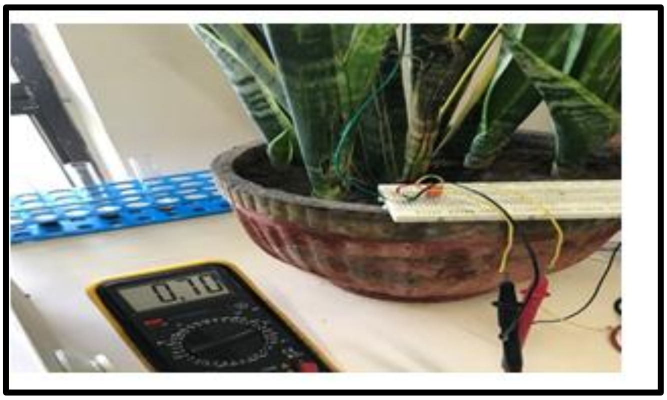

Fig. 4(a). Experimental setup to charge a capacitor of 100 µF

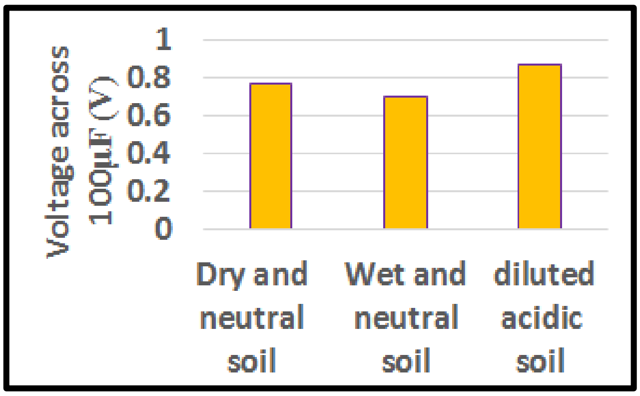

Fig. 4(b). Experimental results of stored voltage in capacitor of 100 µF connected directly to plant.

Figure 4 (c) shows the percentage variation in voltage across the capacitor when it is connected directly to the plant through a resistor of 1 KΩ. The capacitor stores larger energy when it is connected directly to the plant. The capacitor charges for first two hours in case when it is connected in series with resistor and after that stored voltage almost remains constant whereas it charges up to 3 hours and reaches to its peak value when it is directly connected to plant and then falls slightly.

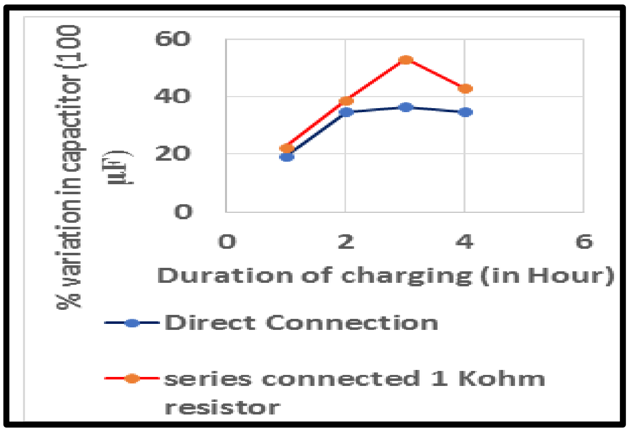

Fig. 4 (c). Percentage variation in capacitor voltage with time.

III. CONCLUSION

Sansevieria plant is a favorable candidate to replace the aloe vera plant for harvesting electrical potential due to its self-repairing capability and higher photosynthesis rate compared to aloe vera plants. This plant harvest larger potential than other succulent plants due to higher conductance of CO_2 for photosynthesis. The harvested potential is more than 1 V from single leaf of sansevieria plant in presence of dilute acidic soil. The harvested electrical potential falls with time as well as the separation between two electrodes on single leaf due to associated parasitic capacitance and resistance. The harvested electrical power increases with increase in no-load voltage.

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Dr Ajay Kumar Singh is at present working as Professor in Electronics and Communication Engineering, NIIT university since 2020. After PhD in 1994, he has joined the Electronics and Electrical Department of BITS Pilani as lecturer and then promoted to Assistant Professor in 2003. In 2005, Dr Singh has joined Multimedia University-Malaysia. Dr Singh has supervised 4 PhDs and 7 master by research. He has published about 100 research papers in various International/National journals and conferences. He has served as member in various technical programme committee of international conferences. He has authored two textbooks, contributed two chapters in book and one research book.