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Wireless Environment Monitoring System using Soil Energy

Nita Arvind Kamble[1], Prof. Dinesh B. Bhoyar[2]
[1,2] *(Department of Electronics and Telecommunication , Yeshwantrao Chavhan College of Engineering,India)*

Abstract : *This paper describes the development of a sustainable power source that can supply sufficient power to wireless sensors in remote locations while requiring less maintenance and low costs. The soil energy is utilized by Microbial Fuel Cell. The soil with microorganisms can produce energy when they are attached with two electrodes, one positive and another negative electrode. This leads to flow of electrons contributing to electricity. The electricity is then utilized to Electronic circuit consisting of microcontroller and the humidity and temperature sensors are attached to it to read out the values of temperature and humidity on PC by using ZigBee Transceiver.*
Keywords: *Humidity sensor, Integrated circuit, Microbial fuel cell, Soil energy, , Temperature sensor,Wireless sensor.*

I. Introduction

Soil contains minerals and many organisms, such as bacteria, fungi, algae, protozoa, nematodes, and earthworms. The organic matter in soil represents a large potential source of energy. Some bacteria in the soil are known to generate electricity (exo-electrogens) without the provision of an exogenous media [3]. The soil energy can be an alternative energy source as the energy is very essential in this energy scarce environment. Through biochemical reactions from the activities of the microorganisms, the energy in the soil can be released as electricity and heat. Recently, the chemical-to-electricity conversion processes from bacteria are utilized to establish microbial fuel cells [5].The electrical properties of the soil are affected by the type of soil, density, operating frequency, water content, and soluble salts and minerals. The equivalent circuit provides insights for optimizing the MFC design and enhancing the output power.

The emerging technology of wireless sensor networks (WSNs) requires reliable energy source for their long-term operations. Wiring a power-source to sensors costs a vast amount of labor and resources. To demonstrate the potential applications of the soil cells, we will design and fabricate a wireless temperature and air moisture sensing system on a printed circuit board (PCB).The capacitive humidity sensor readout IC will be employed to convert the humidity-caused capacitance deviations to frequency deviations.. The data from the wireless sensors is sent to the microcontroller for data processing. There are two circuits utilized one for transmission and another for reception. The transmitter ZigBee is configured with the receiver ZigBee. The final readings will be sent to personal computer as an output.

Thus the overall system will include the MFC, low power microcontroller, air humidity sensor, custom capacitive humidity sensor readout IC, and a ZigBee transceiver with embedded temperature sensor [1].

Micobial Fuel Cell

The Microbial fuel cell is made by connecting two electrodes one anode and one cathode. The microorganisms in the soil are continuously generating biochemical energy in the form of redox reactions. The degradation of organic compounds by the microorganisms leads to oxidation and thus liberating electrons. These electrons are utilized by the electrodes so as to generate electricity.

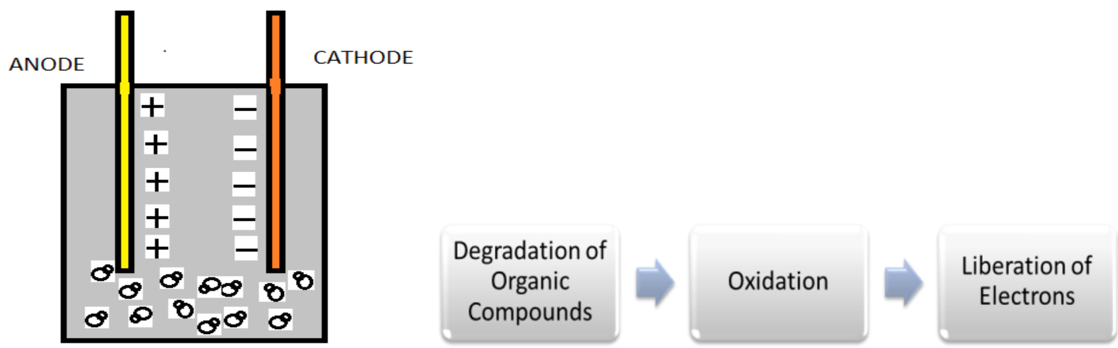

Fig.1. Microbial Fuel Cell

Two Microbial fuel cell has been made by using different soils listed in the table below. The soil is kept inside the vessels along with a lid.

Table 1: Type of Soil

Soil A	Rose plantation Soil with earthworms
Soil B	Farm Soil

The contents added in the two Microbial Fuel Cell has been listed in the following table:

Table 2: Contents of the Soil

Soil	Soil A	Soil B
Soil	950g	1150g
Nitrogen Phosphate Fertilizer	5g	0.5g
Sodium Chloride(NaCl-Common Salt)	2g	1g
$C_{12}H_{22}O_{11}$(Sugar)	5g	6g
$C_6H_{12}O_6$ (Glucose)	1g	---
Citric Acid Solution	7mL	3mL

The soil is provided with the electrodes as to implement two Microbial fuel Cell in each vessel to obtain the cells as:

Table 3: Current and Voltage obtained in the soil

Type of Soil	Electrodes 1 Current (mA)	Electrodes 2 Current(mA)	Electrodes 1 Voltage(V)	Electrodes 2 Voltage(V)
Soil A	0.39(Zn-Cu)	6.1(Fe-Cu)	0.35V(Zn-Cu)	0.40(Fe-Cu)
Soil B	0.07(Fe-Cu)	0.06(Fe-Cu)	0.03V(Fe-Cu)	0.04(Fe-Cu)
Type of Soil	Electrodes 1 Current (mA)	Electrodes 2 Current(mA)	Electrodes 1 Voltage(V)	Electrodes 2 Voltage(V)
Soil A	0.39(Zn-Cu)	6.1(Fe-Cu)	0.35V(Zn-Cu)	0.40(Fe-Cu)
Soil B	0.07(Fe-Cu)	0.06(Fe-Cu)	0.03V(Fe-Cu)	0.04(Fe-Cu)

As voltage for Fe-Cu pair for soil A is highest it is used for further experiment.1mL Hydrogen Sulphide and 1mL Ammonium Sulphide is added so as to obtain 1.02 V.
MFC using ice tray is created by using ice tray with 12 cups
-10 iron nuts
-12 copper wire
-1 screw

- This cell is implemented by using a series cell method
- The voltage is increased by using citric acid solution , sodium chloride each 1g in each cell and sugar 0.5g in each cell
- The result obtained is about 2.83V
- The LED glows

Fig.2.Reading of Voltage

The Microbial Fuel Cell is implemented by using a
-soil
-ice tray
-galvanized iron nuts
-copper wires

-a screw
- This cell is implemented by using a series cell method
- The result obtained is about 1.68V
- The LED glows

Fig.3.Reading of Voltage

Electronic Circuit

The second part of the project is to make the electronic circuit. There are two circuits one for the transmitter section and another for the receiver section.
1.**PCB layout**: The PCB layout of the electronic circuit is put on the board.
2.**PCB design**: The PCB layout is then designed on the board by using Ferric Chloride solution with the water.
3.**Component mounting:** The components such as capacitors rectifiers, Fixed Voltage regulator IC 7805 and Variable Voltage Regulator IC LM317, also Atmegha 16 microcontroller, ZigBee are mounted on the PCB board.
4.**Component testing**: The components whether working are then tested by using multimeter.
5.**ZigBee Interface**: The ZigBee is interfaced with the microcontroller and the COM port
6.**Connection**: The connections are made between the components as per the PCB layout.

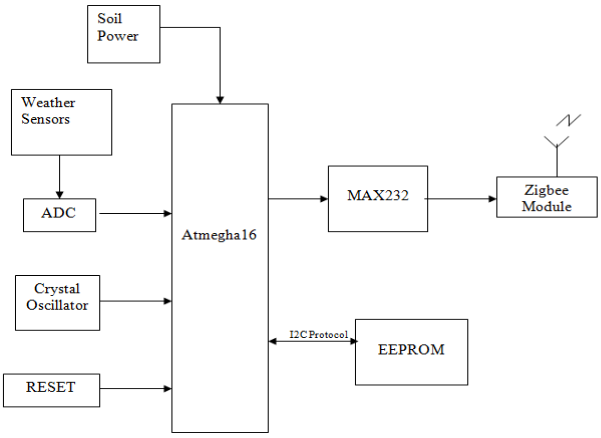

Fig.4.Block Diagram of Transmitter section

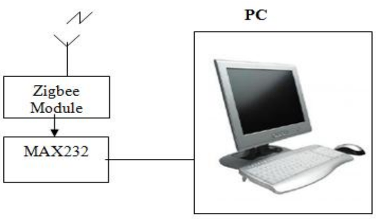

Fig.5.Block Diagram of Receiver Section

Electronic circuit for Transmitter section

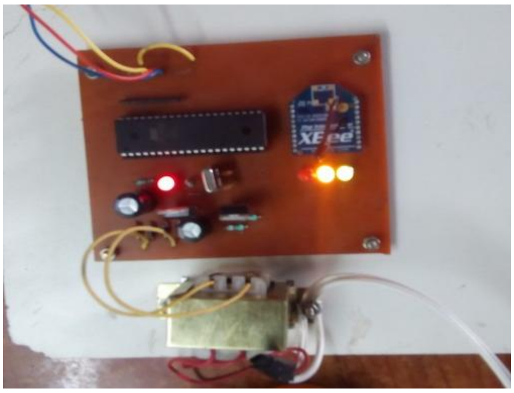

Fig.6. Electronic circuit for Transmitter section

Electronic circuit for Receiver section

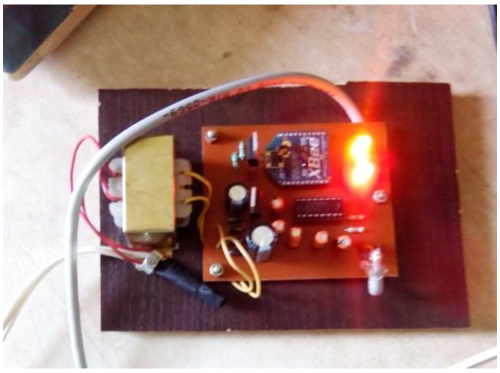

Fig .7:Electronic Circuit for Receiver Section

II. Conclusion

Compared to other renewable energies, such as solar and tidal energy, soil energy is easily accessible, insensitive to environment changes, and does not require expensive infrastructure. The system can be further utilized for remote field experiments and environment monitoring in energy-constrained areas to avoid frequent battery replacement. To improve the output power of a soil cell, cultured bacteria and prepared soil substrate can be used. The new technology can enable promising applications in environmental monitoring and green electronics.

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