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Alternative Renewable Resources for Powering a Wireless Sensor Node

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Abstract - Wireless sensor network are tremendously increasing their applications. Wireless sensor nodes are building blocks of wireless sensor nodes. The powering of wireless sensor node can be done by batteries which have very short lifetime. The battery should be replaced after its life time because power provided by batteries would not last long. In this paper, a wireless sensor node is powered using renewable resources. Different types of renewable resources are identified and the wireless sensor node is powered using one of the renewable resources so that it can operate in any environment. The obtained voltage is given to wireless sensor node according to the proposed model.The thermocouple in this model is designed in intellisuit software in 3D module. The obtained voltage at the output is again passed through the remaining blocks in the proposed model and finally it can be viewed in LCD display.

Keywords— Wireless sensor node, Batteries, Renewable energy sources, thermal energy, thermocouple, Intellisuite software.

I. INTRODUCTION

There is an increase in need for monitoring and transfer of information even from remote areas and the wireless sensor networks are used for this purpose. They are having many applications in many fields like health and habitant monitoring, environment observation and forecasting systems. Most importantly they are used in places where communication should be set up instantly without any infrastructure like cyclone hit areas. These wireless sensor network consists of many number of wireless sensor nodes which are powered using batteries. These batteries have short lifetime and are inefficient for continuous operating of wireless sensor node and the batteries also contain many harmful chemicals like lead, cadmium and mercury. These materials become waste after battery life time and when they penetrate into soil they contaminate the soil and even water and also air if they are burnt. These wireless sensor nodes are placed in remote areas where batteries after its life time cannot be replaced with another. To provide a wireless sensor node with uninterrupted energy resources, we will use renewable energy resources to power a node. These renewable energy resources are ever lasting and they are eco friendly. Normally an ideal sensor node will be consuming power in milliwatt range so here we will generate power in watts so that a node is powered with enough power to operate continuously.

Different types of renewable resources which can be used to power a sensor node are identified. The Different types of renewable resources can power a wireless sensor node in different regions as tabulated in table 1. How much power they generate is also tabulated in table 1[1].The wireless sensor nodes are mainly operated in ground, underwater and floating regions. So a renewable energy should be identified to power it in all these regions.

After a detail study about these renewable resources, their advantages, disadvantages and mainly the places they can be employed, can use thermal energy to power a wireless sensor node. This wireless sensor node can operate under water, floating water and on ground. Which means that a node powered by a thermal energy can be used in any or almost all environment.

TABLE I
DIFFERENT TYPES OF RENEWABLE RESOURCES AND POWER GENERATED

Type of renewable resource	Operational areas	Power generation range
Thermo electric energy	Ground, Floating and under water	1.57-31.4mW
Piezo electric	Ground, Floating and under water	0.02-3.5mW
Hydro Energy	Floating	500-1000mW
Sediment Energy	Under water, Floating	3.4mW-2.5W
Sea water energy	Under water, Floating	6W
Solar energy	Ground, Floating	0.4mW-85W
Ambient radio frequency	Ground (only in urban areas)	0.014-2.75mW

This paper proceeds by discussing proposed model in second section. Furthermore, third section comprises designing thermocouple and then discussing about the result obtained from the designed prospect.

II. PROPOSED MODEL

In this model a wireless sensor node is powered using a thermo couple which generates voltage from temperature difference. This model consists of thermocouple, thermistor, signal conditioning module, and display to view the power supplied to wireless sensor node. The block diagram for this model is as shown in fig 1.

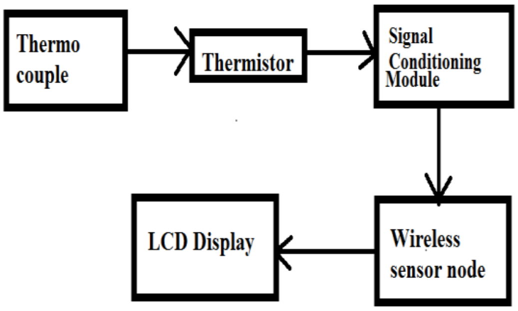

Fig.1 The block diagram for powering a wireless sensor node using thermal energy.

The designed thermocouple consists of two junction, two different temperatures are applied at the junction and is made up of two different type of materials [2]. The potential difference obtained is collected at the right leg of the thermocouple. Thermistors are temperature dependent or temperature sensitive resistors in which resistance value changes when there is change in temperature. The Resistances of the thermistor changes as temperature changes which can be explained by the Steinhart-Hart equation shown in equation.1

$$1/T = A + B*\ln(R) + C*(\ln(R))^3 \ R \qquad (1)$$

Where A,B,C are constants and T is temperature in ^{o}K., R is resistance.

In thermocouple if the temperature at thermocouple junctions increase then voltage generated increases, so to maintain constant voltage thermistor is used These thermistors are of two types. They are positive temperature coefficient, negative temperature coefficient. In positive temperature coefficients as temperature increases there is increase in resistance, where as in negative temperature coefficients as temperature increases resistance decreases. The thermistor used in the proposed model is positive temperature coefficient thermocouple [8].

This constant voltage obtained at the output of the thermistor is given to signal conditioning module. The signal conditioning module consists of Filtering, Amplifying and isolation. The filtering is done to remove the noise. The amplification is done on signal so that it is not mistaken for noise .The signal conditioning module is mainly used to condition the signal i.e. to maintain constant signal. The signal generated is of low power so can be mistaken for noise and the signal can be efficiently used by wireless sensor node and signal can be viewed in LCD as it gives sharpened signal with zero geometric distortion.

III. DESIGN OF THERMOCOUPLE

A thermocouple is designed to power a wireless sensor node. The main phenomenon involved in thermocouples is seebeck effect. All the materials in the universe have unique coefficient of thermal expansion which means no two elements have same coefficient of thermal expansion [3].So two different materials joined at two junctions are subjected to heat at one junction and comparatively less heat at other junction then as they have different coefficient of thermal expansion there will be flow of electrons from hot junction to cold junction and this produces voltage [9].

The thermocouple consists of left leg and right leg and the two legs are connected by a connector. The temperature is applied on top of connector and due to this temperature the electrons present in the metal start moving and this result, in uniform concentration distribution in thermocouple and produce the voltage i.e, Potential difference.

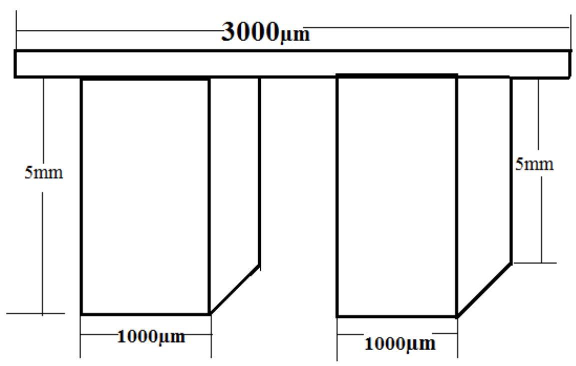

Fig. 2 Thermocouple model with dimensions of left leg, right leg and connector.

The thermocouple can be designed in intellisuit software which uses MEMS technology and it provides a tightly integrated design environment which is used to link entire MEMS organization. It has many modules like intellimask, intellifab, 3D builder and thermoelectric mechanical etc.We can fabricate thermocouple in intellifab and mask it in intellimask.We can even build it in 3D builder and analyse it in thermoelectric mechanical module.

For the fabrication of the thermocouple first create a mask in intellimask and then in intellifab fabricate the thermocouple the thermocouple here can be fabricated in 14 stages. Which are shown in fig 3.Two masks layers should be created in intellimask module. In mask 0 layer a rectangle is made in 2D .The rectangle is drawn from 0 to 3000units on x-axis and 0 to 1000 units on y-axis as shown in fig 4. In the mask 1 layer two rectangles are drawn of length and breadth 1000 units as shown in fig 5.These masks layers are used in fabrication to cover the specific regions when the entire substrate is exposed to UV rays.

#	Type	Material	Process	Process ID	Process Option
1	Definition	Si	Czochralski	100	
2	Deposition	SiO2	Bulk	Standard	Conformal Deposition
3	Deposition	PolySi	LPCVD	Standard	Conformal Deposition
4	Exposure	UV	Contact	Kerf	
5	Etch	PolySi	Clean	Piranha	Partial Etching
6	Deposition	Al	Bulk	Standard	Conformal Deposition
7	Exposure	UV	Contact	Kerf	
8	Etch	Al	RIE	Cl2_BCl3	Partial Etching
9	Exposure	UV	Contact	Kerf	
10	Etch	Si	Clean	Piranha	Partial Etching
11	Exposure	UV	Contact	Kerf	
12	Etch	SiO2	Clean	RCA	Partial Etching
13	Exposure	UV	Contact	Kerf	
14	Etch	Al	RIE	Cl2_BCl3	Partial Etching

Fig. 3 Fabrication steps for thermocouple in intellifab

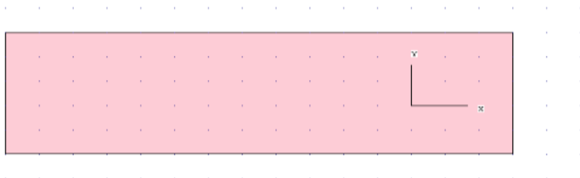

Fig.4 Formation of mask layer 0 for thermocouple in intellimask

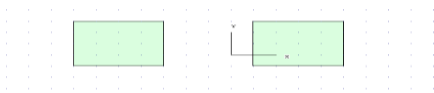

Fig.5 Formation of mask layer 1 for thermocouple in intellimask

The thermocouple can also be directly built in 3D builder by using the dimensions mentioned in fig 2. After building it the thermocouple is meshed with suitable co-ordinates values. This can be shown in fig 6 in 3D builder.

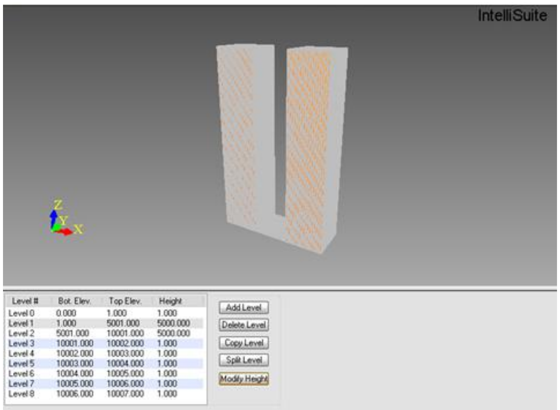

Fig.6 Building of thermocouple in 3D builder and meshing it

Now the thermocouple built in 3D builder is analysed in thermo electro mechanical module as shown in fig 7. The material to the entities and temperature which is the input is given in thermo electro mechanical module. The temperature of 60 degrees is given on top of the connector and temperature of 20 degrees is given at bottom face of the connector. The boundaries of all the faces of the thermocouple are fixed. While building the thermocouple first the connector is build by selecting the dimensions as 0 to 3000 on x-axis and 0 to 1000 on y-axis. The legs of thermocouple are then built. One from 0 to 1000 on x- axis and other from 2000 to 3000 from x- axis. Here the material used for left leg is aluminium, right leg is copper and connector is aluminium.

Fig 7 Analysing of thermocouple in TEM module in intellisuit software

After the giving the temperature at both sides of the connector, the temperature is distributed throughout the thermocouple.

IV. RESULT

After giving all the materials to thermocouple structure and after applying temperature to the both sides of the connectors a potential difference is created which is distributed throughout the thermocouple. The potential difference produced is distributed as shown in fig 8.

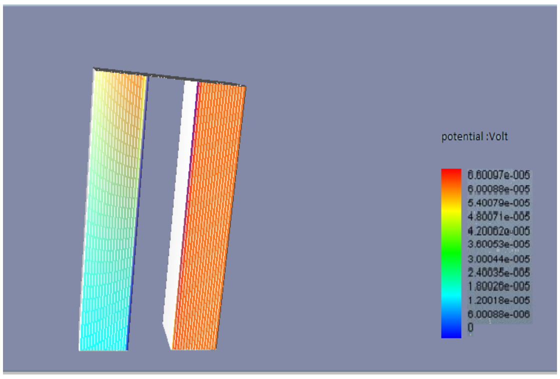

Fig 7 Potential distribution of thermocouple obtained in Thermo electric module in intellisuit software.

The red regions indicate the regions where high potential difference is created and the blue regions indicate the regions where comparatively less potential difference is created. It is inferred that as distance from the junctions increases the potential difference created increases. The height of the thermocouple designed is 5mm. If the height of the thermocouple is further increased then the potential difference obtained increases but if the size of the thermocouple increases then it becomes difficult to power a wireless sensor node which is very small. So the optimal height of 5mm is taken as the height of the thermocouple. Further the designed thermocouple has two junctions which can be maintained at two different temperatures and generates a potential difference. So this design is optimal for fabricating thermocouple. The fabrication is achieved by the use of material copper because of its high resistivity. As the resistivity increases the potential difference obtained increases. So we use materials with high resistivity.

V. CONCLUSIONS

The Batteries which results in hazardous wastes are replaced by renewable energy resources to power a wireless sensor node so that the node can operate continuously. The proposed model powers a wireless sensor node using Thermal energy obtained from the thermocouple which is fabricated in intellisuit software and generates the voltage needed to power a wireless sensor node. The obtained voltage is again passed through thermistor, signal conditioning circuit before giving to wireless sensor node and the consumed power can be even viewed by LCD display.

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