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Energy Harvesting Capability of Air for Measurements Using Self-Powered Wireless Sensor Network

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Abstract
Energy harvesting systems convert ambient energy from environment such as vibration, sunlight, wind, temperature gradient, etc. into electrical energy. Among several ambient energy sources, wind energy can be considered as one of the most promising sources because of its attractive features such as efficiency and economic merit. Air measurements are important parameters in many applications. Normally, battery powered or external power supply is used to drive the wireless sensor network and microcontroller unit. The proposed system basically consists of two macro blocks, respectively: the self-powered wireless sensor and the receiving unit. The self-powered sensor has a section devoted to the energy harvesting, exploiting the movement of an airscrew shaft keyed to a dc motor. The self-powered sensor adopts integrated devices in low-power technology, including a microcontroller, Xbee, an integrated temperature sensor and humidity sensor. The air velocity is measured through the rotor frequency of the electromechanical generator. The receiving unit connected to a personal computer acquires the measured units through Xbee and can be used for civil or industrial applications for the control of the health of the environment.
Keywords – Wind energy, Energy harvesting, Self-powered wireless sensor, and Xbee s2.

I. INTRODUCTION

Generating power is of great importance in today"s world. During the last decade, wind has become a source of energy that is increasingly tapped in many countries. Due to the exhaustion of fossil fuels, it is crucial to develop alternative energy sources. Wind energy, one of the most profitable sources, which is increasing by 30% every year. On a global scale, wind farms supply the equivalent of 40 nuclear reactors (eight times more than in 1995).Airflow measurements contribute to determine the air quality. The commercial airflow measurement system commonly requires a battery, but, recently, in the literature, alternative systems supplied by power-harvesting modules are proposed. However, there are many reasons to eliminate the battery adoption: the size and weight of the devices and the unwanted maintenance burdens of replacement. Moreover, the disposal of the increasing number of batteries is creating an important environmental impact as they contain toxic chemicals. This paper outlines a self-powered sensor that, without any battery, autonomously performs the measurement functions and transmits data to an external receiving unit.

The proposed sensor is powered by a harvesting system that exploits the mechanical energy coming from the velocity of airflow. Since particular power supply is not required, the self-powered sensor can easily be installed at any point of a building. In the literature, airflow harvesters are evaluated for their potential utilization in autonomous measurements. An airflow harvester can be a promising technological solution for producing electricity in different applications.

Wind is a form of solar energy. Winds are caused by the uneven heating of the atmosphere by the sun, the irregularities of the earth's surface, and rotation of the earth. Wind flow patterns are modified by the earth's terrain, bodies of water, and vegetative cover. This wind flow, or motion energy, when "harvested" by modern wind turbines, can be used to generate electricity. The terms "wind energy" or "wind power" describe the process by which the wind is used to generate mechanical power or electricity. Wind turbines convert the kinetic energy in the wind into mechanical power. This mechanical power can be used for specific tasks.

Wind turbines, like aircraft propeller blades, turn in the moving air and power an electric generator that supplies an electric current. Simply stated, a wind turbine is the opposite of a fan. Instead of using electricity to make wind, like a fan, wind turbines use wind to make electricity**.** The wind turns the blades, which spin a shaft, which connects to a generator and makes electricity.

The remaining paper is organized as follows. Existing system is in section II. System

architecture is discussed in section III. This section depicts the hardware architecture. Section III discusses the wireless connectivity. Finally section IV gives the conclusion.

II. EXISTING SYSTEM

Normally, battery powered or external power supply is used to drive the wireless sensor network and microcontroller unit but in the existing system self powered wireless sensor network is used. It periodically measures the temperature and velocity of the airflow and transmits the measured data to the receiving unit using radio-frequency transmitter at 433 MHz.
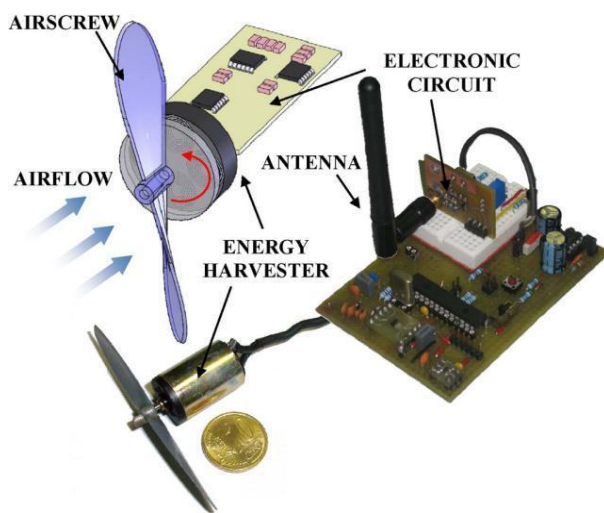

Fig 1 Existing System

III. SYSTEM ARCHITECTURE

A self-powered wireless sensor is proposed for online measurements of air temperature, humidity and velocity. Velocity, humidity and temperatures are important indicators of operational efficiency in the regulation of air conditioning or in industrial implants. The self-powered wireless sensor does not require any battery since it uses the power harvested from the mechanical energy of the air flow. The self-powered wireless sensor sends the measured data to an external receiving unit. A prototype wind mill is used here to give power supply to the Zigbee board in the transmitting section and in the receiver section the air velocity and air temperature is monitored in a PC through Zigbee. The self-powered wireless sensor can be used for civil or industrial applications for the control of the health of the environment.A prototype wind mill is used here to give power supply to the Xbee board in the transmitting section and in the receiver section the air velocity and air temperature is monitored in a PC through Xbee. The self-powered wireless sensor can be used for civil or industrial applications for the control of the health of the environment. The architecture of the proposed
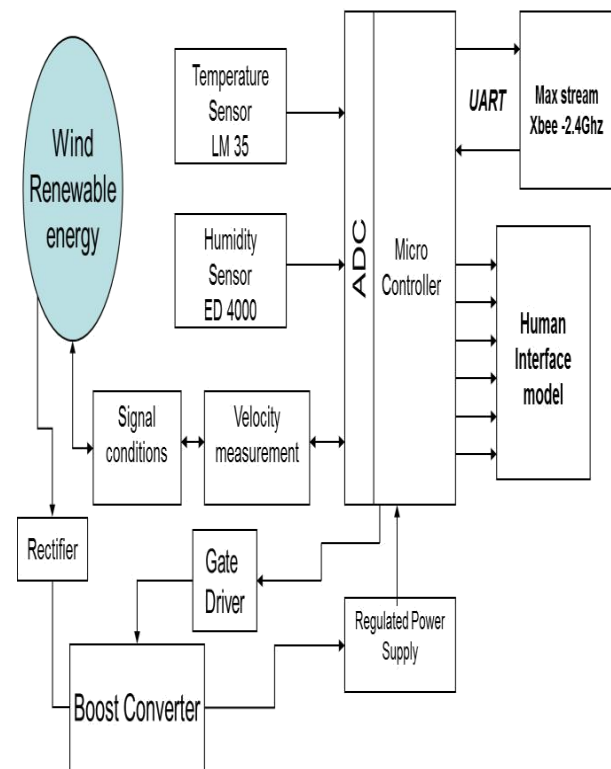
system is shown in figure 2.

FIG 2. Proposed system architecture

A. Temperature Sensor

The LM35 is a precision integrated-circuit temperature sensor that can sense a −40°C to +125°C temperature range using a single positive supply. The LM35"s output voltage is linearly proportional to Celsius (Centigrade) temperature (+10 mV/°C) and has a DC offset of +500 mV. The offset allows reading negative temperatures without the need for a negative supply. The ideal output voltage of the LM35 ranges from +100 mV to +1.75V for a −40°C to +125°C temperature range. The LM35 does not require any external calibration or trimming to provide accuracies of ±3°C at room temperature and ±4°C over the full −40°C to +125°C temperature range. Trimming and calibration of the LM35 at the wafer level assure low cost and high accuracy. The LM35"s linear output, +500 mV offset, and factory calibration simplify circuitry required in a single supply environment where reading negative temperatures is required. Because the LM35"s quiescent current is less than 130 μA, self-heating is limited to a very low 0.2°C in still air. The features of LM 50 are it is suitable for remote applications. Its low cost due to wafer-level trimming. And operate from 4.5V to 10V.
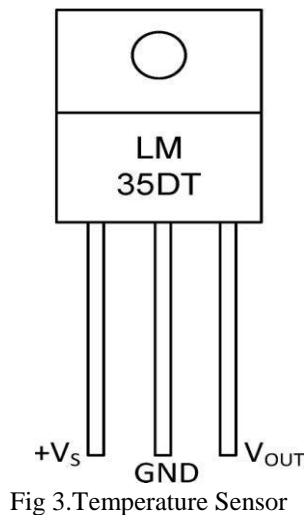
Fig 3.Temperature Sensor

B. Humidity sensor

The EMD-4000 is a bulk resistance-type humidity sensor based on the impedance change of a thin-film polymer due to water vapour absorption. The polymer is deposited on Bismuth alloy terminals, which are set on a ceramic substrate. The sensor is excited by a low voltage alternating current and the impedance measured as a function of relative humidity. The thin-film polymer consists of chemical functional groups that disassociate into ionic species as water vapour is absorbed. This results in increased electrical conductance through the sensor or decrease impedance. The impedance is an inverse exponential function of the surrounding humidity.

The EMD-4000 is capable of withstanding environments where organic vapours are present. It recovers from condensing environments and may be used at temperatures up to 185°F (85°C). The EMD-4000 is also capable of insitu measurement of soluble water in organic liquids such as transformer oil, gasoline, toluene, acetone, and other compounds of varying hydrogen bond strengths. The EMD-4000 is highly repeatable and interchangeable. The sensor is manufactured in high yields to ±5% RH or better tolerances. It is also available in a tighter tolerance band of ±3% RH. This results in a sensor that can be used in many designs without the need for humidity calibration, where the measuring circuit can be calibrated with external reference resistors. The EMD-4000 exhibits a well defined standard response curve as a function of humidity and temperature and has low hysteresis and fast response.

The EMD-4000 Specifications are
* %RH Range at 77°F (25°C) -20% to 95%
* Operating Temperature-41°F to 140°F (5°C to 60°C)
* Storage-0% to 95% RH, -40°F to 185°F (-40°C

to 85°C)
* Accuracy
* Repeatability ±0.5% RH

Fig 4.Humidity Sensor

C. Boost Converter

A boost converter (step-up converter) is a DC-to-DC power converter with an output voltage greater than its input voltage. It is a class of switched-mode power supply (SMPS) containing at least two semiconductor switches (a diode and a transistor) and at least one energy storage element, a capacitor, inductor, or the two in combination. Filters made of capacitors (sometimes in combination with inductors) are normally added to the output of the converter to reduce output voltage ripple.
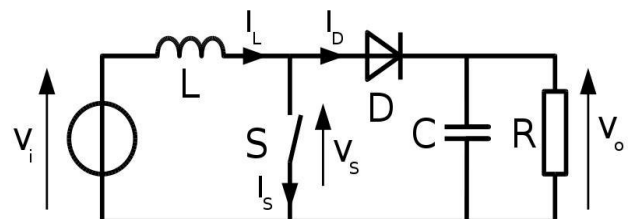
The key principle that drives the boost converter is the tendency of an inductor to resist changes in current by creating and destroying a magnetic field. In a boost converter, the output voltage is always higher than the input voltage. A schematic of a boost power stage is shown in Figure .
(a) When the switch is closed, current flows through the inductor in clockwise direction and the inductor stores some energy by generating a magnetic field. Polarity of the left side of the inductor is positive.
(b) When the switch is opened, current will be reduced as the impedance is higher. The magnetic field previously created will be destroyed to maintain the current flow towards the load. Thus the polarity will be reversed (means left side of inductor will be negative now). As a result two sources will be in series

causing a higher voltage to charge the capacitor through the diode D.

If the switch is cycled fast enough, the inductor will not discharge fully in between charging stages, and the load will always see a voltage greater than that of the input source alone when the switch is opened. Also while the switch is opened, the capacitor in parallel with the load is charged to this combined voltage.

When the switch is then closed and the right hand side is shorted out from the left hand side, the capacitor is therefore able to provide the voltage and energy to the load. During this time, the blocking diode prevents the capacitor from discharging through the switch. The switch must of course be opened again fast enough to prevent the capacitor from discharging too much.

D. Microcontroller

The microcontroller used here is PIC 16F877A.The program on the microcontroller, reads the value of body temperature, heart rate and sweat rate. Then the processed output in digital form is sent to the medical server through GSM/GPRS transmission and also display on LCD screen. The microcontroller programming is done using Embedded C, a middle level language for controller units. The PIC microcontroller is high performance RISC CPU and peripheral features. It has 5 ports for internal and external usage. It has three on chip Timers and in built 8 bit and 10 bit Analog to Digital Converter. It has serial as well as Parallel Communication facilities.

E.RECTIFIER

Arectifier is an electrical device that converts alternating current (AC), which periodically reverses direction, to direct current (DC), which flows in only one direction. The process is known as rectification. Physically, rectifiers take a number of forms, including vacuum tube diodes, mercury-arc valves, copper and selenium oxide rectifiers, semiconductor diodes, silicon-controlled rectifiers and other silicon-based semiconductor switches. Historically, even synchronous electro mechanical switches and motors have been used. Early radio receivers, called crystal radios, used a "cat's whisker" of fine wire pressing on a crystal of galena (lead sulfide) to serve as a point-contact rectifier or "crystal detector".

Rectifiers have many uses, but are often found serving as components of DC power supplies and high-voltage direct current power transmission systems. Rectification may serve in roles other than to generate direct current for use as a source of power. As noted, detectors of radio signals serve as rectifiers. In gas heating systems flame rectification is used to detect presence of flame.

Because of the alternating nature of the input AC sine wave, the process of rectification alone produces a DC current which, although unidirectional, consists of pulses of current. Many applications of rectifiers, such as power supplies for radio, television and computer equipment, require a steady constant DC current (as would be produced by a battery). In these applications the output of the rectifier is smoothed by an electronic filter to produce a steady current.

IV. WIRELESS CONNECTIVITY

The XBee family of ZigBee/802.15.4 RF modules is the premiere choice for OEMs looking for excellent wireless performance in a cost-effective, small form factor solution. Each XBee module comes in either a regular or long-range "–PRO" version. All XBee modules are pin-for-pin compatible with the exception of a few varying I/O features, which provides a standard footprint for OEMs with multiple applications.

Xbee Series 1 is based on ZigBee/802.15.4 silicon from free scale. Its 802.15.4 firmware feature set makes it ideal for point-to-point, peer-to-peer, and point-to-multipoint (star) topologies. TheXBee Series 1 gives the user maximum control over network nodes and minimum latency.

XBee Series 2 is based on ZigBee/802.15.4 silicon from Ember. It features ZigBee firmware for creating ad-hoc mesh networks. The XBee Series 2 performs automatic route discoveries to create a self-healing network of full-function routers and low-power end devices. XBee Series 1and Series 2 modules do not communicate with one another. Known for ease of use, the XBee modules are ready to operate out of the box and offer simple AT commands or an API for advanced, user-settable configurations. XBee modules are recognized worldwide for reliable wireless data communication in the license-free 2.4 GHz ISM band.

FIGURE 4.4 XBEE S2

V. CONCLUSION

During the last decade, wind has become a source of energy that is increasingly tapped in many countries. Self-powered wireless sensor for air temperature, humidity and velocity measurements

with energy harvesting capability has been proposed. The system has been designed for measuring the air temperature, humidity and velocity of an airflow and transmits the measured data, through Xbee operating at 2.4 Ghz. A commercial airscrew is connected to an electromagnetic generator. The harvested power, using the air motion energy, supplies an electronic circuit for the measurements of air temperature and velocity. The microcontroller, which coordinates the operation of the self-powered wireless sensor, switches on the sensor modules to execute temperature, humidity and velocity measurements. Subsequently, the microcontroller turns on the transmitter module and sends the data to the receiving unit. The receiving unit is connected to personal computer, through which we can view the measured units and can be used for the industrial applications.

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