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Wind Energy Harvesting System powered Wireless sensor Networks for Structural Health Monitoring

R.Raja Sekaran

Electronics and Communication, Sai Ram Engineering College
Sai Leo Nagar, West Tambaram, Chennai – 44.

***Abstract*— Green technology plays a vital role in generating electrical energy and act as power source for various electronic systems. Green technology is defined as harvesting electrical energy from natural power such as wind, solar, vibrations, thermal, tidal waves. Many research and development activities are carrying out by various researchers in this green technology. This paper represents the efficient design and development of ambient wind energy harvesting system based wireless sensor network (WEHS -WSN) for Structural Health Monitoring. In this WEHS WSN system Super capacitor is used as storage device instead of Batteries, which eliminate the complication of replacing the Batteries at regular intervals results in developing a sustainable power Management system for wireless sensor nodes.**

***Keywords*—Energy harvesting, Boost converter, Super capacitor, Wind turbine**

INTRODUCTION

Wireless sensor networks are widely used in various fields such as structural health monitoring, fire fighting, human health care, disaster management, security and surveillance, mobile traffic, modern agriculture, pollution control, forest fire identification, building energy management and many more. Recently many researches are carrying out in various parts of wireless sensor networks, which mainly involve self-energy harvesting at which the wireless sensor networks are deployed, such as solar energy, mechanical energy, thermal energy, sound energy, wind power. This paper presents an innovative micro wind energy harvester suitable for powering low power wireless sensor network system for Structural Health Monitoring. To maximize the wind generator performance over a wide range of operating conditions boost converter is implemented to minimize the power losses of the operating devices and increasing the overall gain.

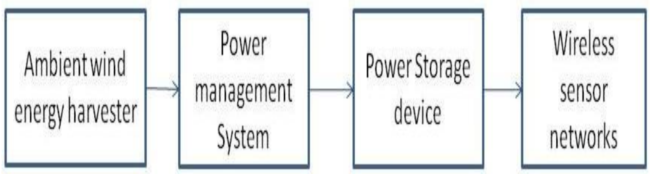

Figure 1 Basic block diagram of wind energy harvester powered WSN

The figure 1 shows the general architecture of WEHS-WSN. The power source of wireless sensor node is harvested from micro wind energy harvester, electrical energy harvested is then rectified using schottky diode bridge rectifier. The boost converter amplifies the rectified harvested electrical signal. In the storage unit a different new approach is carried out by using super capacitor as storage device instead of using Batteries. The wireless structural health monitoring system consists of accelerometer sensor, microcontroller and XBee transceiver module to transmit the measured signal from the Structure to the Base Station.

I. WIND ENERGY HARVESTER

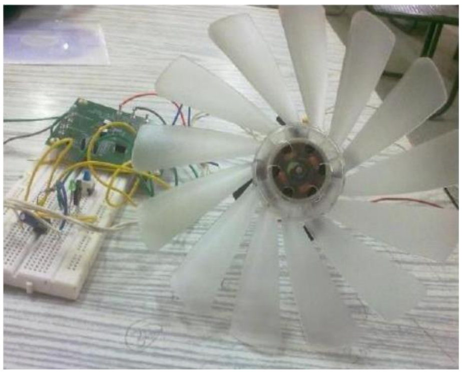

Figure 2 Wind energy harvester

As wind generator, a plastic Thirteen-bladed wind turbine is used with a diameter of 6.7 inches. The high number of windings of the brushless generator attached to its shaft allows harvesting significant power even at low wind speeds, which are also the most frequent ones.

The micro power generator used in the wind turbine is a Single-phase four- pole ac permanent magnet synchronous generator. An electrical equivalent circuit of WTG is shown in the above fig.3. The generated voltage from the generator is given by Vg and its equivalent resistance and inductance are given by Rg and Lg.

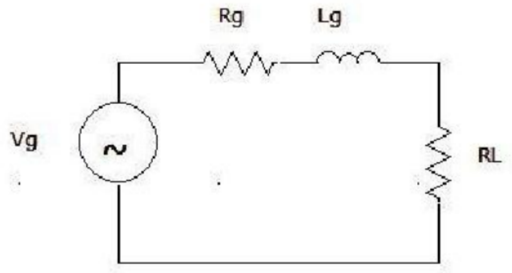

Figure 3 Equivalent circuit diagram of wind turbine generator

II. POWER MANAGEMENT SYSTEM

A. Bridge Rectifier

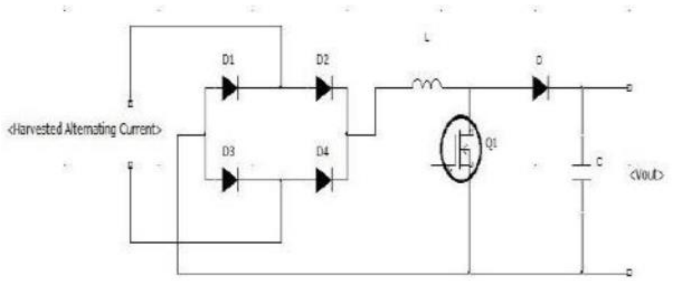

Figure 4 Bridge Rectifier with boost converter

The electrical signal harvested from micro wind turbine generator is in the form of alternating current (AC). In order to convert the harvested alternating current to direct current (DC) bridge rectifier is used. The bridge rectifier consists of four low power schottky diodes; if normal PN junction diode is used then the voltage drop across each diode is 0.7 volts, results in more power consumption. The schottky diode operates in 0.3 volts, so it is more suitable for rectification process in energy harvesting applications.

B. Boost Converter

The boost converter converts an input voltage to a higher output voltage. The boost Converter is also called a step-up converter. Boost converters are used in battery powered devices, where the electronic circuit requires a higher operating voltage than the battery can supply, In autonomous energy harvesting wireless sensor networks boost converter helps to increase the scavenged minimum voltage to a maximum designed voltage. The Boost Converter Circuit Diagram is shown in Fig. 5.

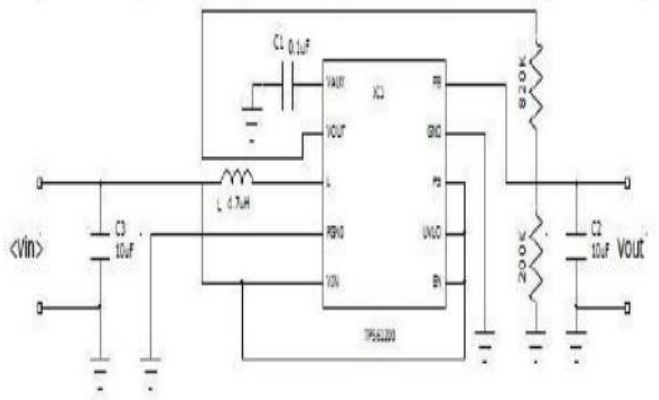

Figure 5 Boost converter circuit diagram

The Circuit Diagram Consists of Boost Converter TPS61200, Which has the Input Range from 0.3v to5.5v. The Output Voltage is adjustable from 1.8v to 5.5v. The Under Voltage Threshold Lockout Threshold is adjusted to Minimum by Connecting UVLO to Vin. The Boosted Voltage from the Converter is stored by using Super Capacitors. The figure 6 shows the generated power to the corresponding wind speed.

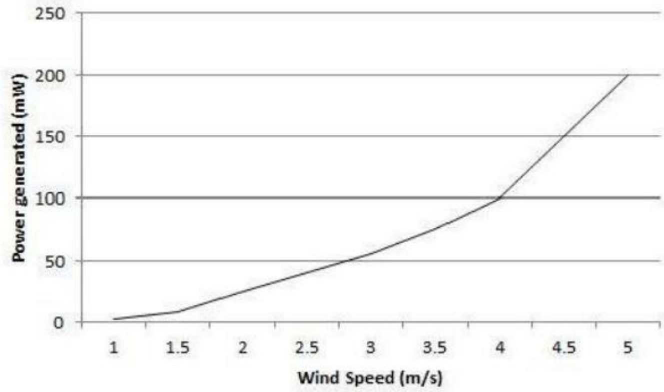

Figure 6 Wind speed vs. Power generation

C. Energy Storage Devices

Many energy harvesting wireless sensor networks need energy storage due to continuous sensing operation even though there is no energy to harvest. Commonly used energy storage devices for energy harvesting include Super capacitor and rechargeable batteries such as nickel-metal hydride (NiMH), Lithium-Ion (Li-Ion), and thin film batteries. Rechargeable batteries are most widely used for long storage application but Batteries have the problem of non-ideal effects including aging and rate capacity effects. The main disadvantage of NiMH batteries for energy harvesting is the relatively high self-discharge rate. NiMH batteries lose about 4 percentage of their capacity every day due to self discharge. If Li-ion batteries are used for energy harvesting applications, it should have dedicated circuits to monitor the battery voltage for overvoltage, under voltage, overcurrent, and over temperature conditions.

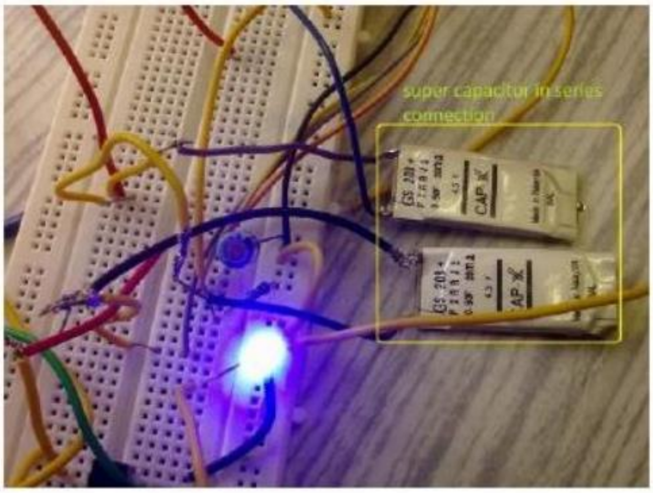

Figure 7 Super capacitor storage

In recent years alternative storage technologies become emerged, including Super capacitor, thin film batteries and fuel cells. Super capacitors are also called as ultra capacitors ranging from Mf to hundreds of farads, portable sized capacitors. The main advantages of super capacitors are the high-power density, virtually unlimited number of charge discharge cycles, improved performance at high and low temperatures, and low equivalent series resistance (ESR). Super capacitors do not have the aging and rate-capacity problems.

In WEH-WSN 3farad, 5.4v and 0.9 farad, 4.5v super capacitors are tested and used to power the system. The accelerometer ADXL202 is used to measure the dynamic behaviour of the Structure. The ADXL202 consists of two channels, one channel is parallel to gravity and other is vertical to gravity. The measurement range of the accelerometer is from -2G to +2G. The analog signal from the accelerometer Sensor ADXL202 is converted in to digital by using A/D converter. AT mega 8 microcontroller is used to process and control the measured data from the accelerometer. During processing microcontroller consumes in the range of tens of mill watts to hundreds of mill watts and it consumes few microwatts in sleep mode. The Microcontroller remains in sleep mode when no event occurs and enters in to active mode if event occurs, this energy efficient programming algorithm saves more harvested Energy in the storage device. The measured value is then transmitted using series 1 XBee-Pro module to the base Station. The data transfer rate of the XBee- pro transceiver module is 250kbps.The Transceiver module has the indoor coverage range of 90metres and in outdoor line of sight range is about 1mile. The amount of current consumes during Transmission is 250mA, and in Sleep mode it consumes 6uA.

III. CONCLUSION

This paper presented the implementation of low cost ambient wind energy harvesting System based wireless sensor network (WEHS-WSN) for structural health monitoring application. The system is powered by micro wind energy harvester with super capacitors as energy storage elements. The dynamic behaviour of the structure is measured by using accelerometer sensor and transmitted to the base station, where the measured data will be received. The received data is then processed and displayed as a graph in the GUI.

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