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Wireless Sensor Networks Based Online Ambient Monitoring

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***Abstract:** Indoor ambient monitoring plays a vital role in air quality management. Monitoring parameters include temperature, pressure, and humidity. The statistical data which is measured is sent using the existent wireless infrastructure which is based on the IEEE 802.15.4 b/g standards. The characteristics and performance of the resulted device are comparable with the ones that are provided by recognized solutions, like ZigBee-based sensor nodes. Further, gathered data can be implemented with data connectivity and ambient sensors As a result of testing, lifetime of the system is for up to three years on a single 3 V small battery.*

***Keywords:** Sensor systems, wireless sensor networks, reconfigurable architecture, Internet.*

I. INTRODUCTION

In today's smart city environment we find that the quality of air has deteriorated both at the outdoor as well as indoor environment. In concern to the indoor air quality (IAQ), it is found that the health of an individual is having an adverse affect. Sick Building Syndrome is the word given to the problems by IAQ. This paper provides a solution to prevent this syndrome by measuring various parameters within the closed area. The measurements can be done within the indoor spaces by a small battery powered. The measured data can be processed by sending the data through wireless network that is based on the IEEE 802.15.4 b/g standard. A combined network topology can also be gathered from various sensing networks. The proposed hardware module is compact with lower power consumption capability and higher end flexibility. The reduced energy profile is achieved by using a low power core microcontroller, and also of a non-dispersive infrared sensor (NDIR) for measuring carbon dioxide, having the lowest power consumption on the market. The power consumption of the temperature and relative humidity sensor is comparable to that of the gas sensor, while the other sensors that are attached which measures the pressure and the intensity of light are less power consuming than these. With advancements in Wifi along with interfacing techniques reduction in power consumption can be achieved along with the preset measurement values. The purpose of such data transmission is for reducing the draining of battery life. The measured data's are projected or displayed on the LCD boards for adequate monitoring. The CO2 and gas sensors used earlier were found to use large power while compared to the recent ones.Hence usage of such sensor minimizes the power consumption of the system. The minimized power consumption by the recent sensors was analyzed based on their specifications.

However, in this paper, small battery powered wireless sensor hardware is presented that allows measurement rates between 1 and 60 samples per hour

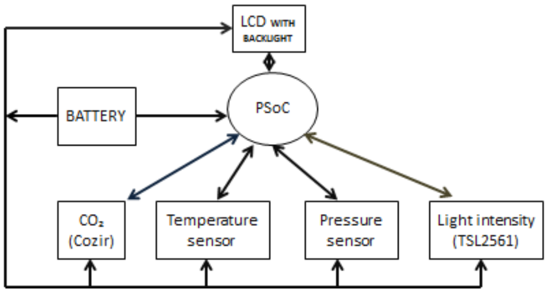

Fig. 1 Existing System

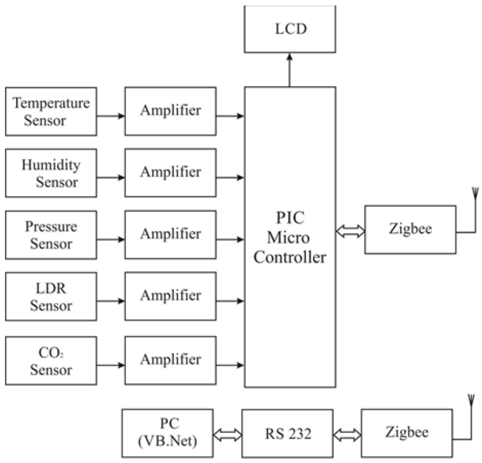

Fig 2 Block Wireless sensor hardware architecture

The data capturing time can be limited to a single measurement per hour that leads to extended battery life for three years.

The developed structure of hardware architecture is explained in the paper along with its relevant features.

II. HARDWARE ARCHITECTURE

A. General Overview

Figure 2 shows the proposed hardware architecture. This system monitors and measures the indoor ambience in terms of CO2 level, pressure, pressure and in the atmosphere the level of CO2 in the air, and also the temperature, level of humidity, absolute pressure and light radiations. The

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measured data is then transferred to a specific IP address using the IEEE 802.15.4 b/g standard. The LCD displays the received data by using standard and specific web application. The data's can also be visualized over certain period of time. The data's obtained can be retrieved at various places. At remote places an alarm is set when the data is received. Gathering of huge data and visualizing it can be done using Internet of Things.

B. Internal Structure

The microcontroller is the heart of the proposed system . The main function of the on chip controller is to ignite all the specific functions that need to be executed. Apart from the microcontroller the system inculcates various other components. The system components are segregated in such a way that it looks similar to wireless sensor nodes. The segregated sectors include a source, sensing unit, process control unit, transmitter and receiver sector and a storage unit. The sensing unit comprise of various standard and accurate range sensors like CO2 Ambient Sensor, digital temperature sensor and humidity sensor, a pressure sensor and light intensity sensor. These sensors are chosen in a standard that it satisfies the concept of having low power consumption. The sensors are also kept under cost effective mode to minimize the overall system cost. Opting for such components helps in high productivity. Process control unit and the storage system is completely provided by the microcontroller. The Zigbee module helps in transmission of data and provides a room for systematic operation of the system. From the figure 2, we can infer that all the sensors are attached to the core microcontroller and it can be operated at the same time.

C. The Microcontroller

The advanced developments that are made in the semiconductor industry and different process technologies are immense and also in smaller process technologies. In regards to these advancements larger circuits have been reduced to single System-on-Chip that has paved way to large number of applications that use these System-on-Chip solutions. Using such Chips aids in increasing amount of solutions under various sectors. Signal acquisition is integrated by these circuits and conversion functions have also been done the same. The controller is chosen in such a way that the Data storage capability and also processing capability are integrated. The I/O integration provided significant advantages. These advantages also pay way to reduced power consumption, size of the system is compact hence the system can be availed at a lower cost. The controller board has large number of components included on a single chip. The microcontroller used in the proposed system is called Programmable System on Chip. The controller has logic analog that are integrated with the presence of memory and a microcontroller, which is being suitable for designing embedded systems. Hence the proposed system uses this semiconductor controller to satisfy the data processing unit.. The microcontroller has an 8-bit single cycle processor with a frequency of 24 MHz, 64 KB of flash memory, an 8 KB SRAM and an on-chip EEPROM for sorting non-volatile data. This chip was chosen because enough memory is offered by it for the application to be implemented. 62% of flash memory and 3.5% of SRAM is occupied by the program.

D. Wireless Module

The wireless module that is suitable for transmission is Zigbee module. The module is chosen since it involves low cost, low power application. This module mainly focuses on transmitting the data to a specific IP address through an UDP. There also exists a transmission mechanism which provides the format of message during communication. Since the sensors have Wi-Fi communication capability the transfer rates has increased at a higher rate after the encryption process. This may also limit the lifetime of the battery due to increased consumption in power. Several mechanisms were used for countering of this effect only for the purpose of reducing power consumption of the system as a whole.

E. CO2, Temperature and Humidity Sensors

For the special purpose of battery powered applications, the ultra low power CO_2 Ambient Sensor was specially developed. This sensor was opted to get the amount of CO_2 present in the indoor atmosphere. The CO_2 concentrations can be measured between the values 1000 to 2000 ppm. If the concentration increases to 5000 ppm the IAQ system provides continuous alarm. To measure this range of measurements the power consumed by the system is 4mW, provided the maximum value of current is 33mA for a certain period of time. Using digital filter the average of all values are computed and the values can be normalized. Sometimes the values are restricted to reach the final value due to the warm up period. This period contributes to the overall performance of the system including its power consumption. In another concern the filter chosen should be more specific to the sensors. Atmospheric pressure plays a vital role in measuring the CO_2 present in the indoor atmosphere. The altitude at which the sensor is placed also contributes to the precise data measurement. Manual setting or computing can be done for altitude adjustments.

Carbon dioxide sensors are an integral part of the system since it contributes to the demand control ventilation systems. Due to this reason it is very important that the auto calibration is to be done while we consider CO_2 sensors. Hence these sensors play a significant role in the low power consumption unit. When the concentration of CO_2 is over estimated, it may lead to increased usage of outdoor air and hence increased energy costs. Also, underestimation may lead to poor IAQ. The core microcontroller implements fresh air calibration, since the CO_2 sensor gets powered down after each reading. This is performed at regular intervals which are specified by the user in the configuration phase of measurement system and it can also be disabled if required. The environment in which the system operates is of great importance too, because it is found to be revealed that the component which senses carbon dioxide is very sensitive to the dew point, from where the digital output can be decreased down to zero.

The values of temperature and relative humidity values can be measured with the help of a very low cost digital temperature and a humidity sensor. The components that are embedded on a small PCB are a capacitive humidity sensor, thermistor which acts as a temperature transducer and a small package microcontroller that are used for processing the signal. The accuracy of the sensor is acceptable in numerous applications with values of ±2 % (with a maximum of ±5 %) for humidity and of ±0.5°C for temperature. The value of power consumption is 1 mA which is in active mode and is 40 μA in the sleep mode. Since this value seems to high during sleep mode, it has become one of the reasons for implementing a separate power supply for sensors. This can be switched off by the Central Processing Unit. The CO2sensor's specification provides temperature and humidity ranges. The operation conditions allow temperatures between0°C and 50°C and that of relative humilities between 0% and 95% which are non-condensing.

F. Absolute Pressure and Light Sensors

For the simple measurement of atmospheric pressure a pressure sensor with an I2C interface is opted. The compensation of CO2 deviation can also be done, if required. The accuracy is of ±1 kPa initially, which can also be translated to an error of approximately 100 m in altitude. This sensor has an absolute pressure range which is between 50 kPa and 110 kPa. The consumption of power is 5 µA in active mode and only 1 µA of the power is consumed in shutdown mode.

G. Sensors Power Supply and Reverse Battery Protection

The power consumed in sleep mode for all the sensors does not allow the battery to be utilized for a longer period. For this purpose, a separate power supply was developed and included in the design. The chip which is used here, offers an output that is disconnected from the input, also provides higher efficiency when using small amount of power ranging upto 140 mA at +3.3 V, from an 1.8 V input, and also consumption of current in shutdown mode, which is very lower (i.e.,) lower than 1 µA. All these characteristics help in maximizing the lifetime of the battery in mobile applications. The CR123A 3 V lithium battery represents the main power supply. For the accomplishment of safer operation, implementation of reverse protection is done even when the battery is changed. The capacity of this type of battery is 1500 mAh which is influenced by temperature variations only in a slight manner and also by loads.

H. PCB

The PCB of the device is usually double sided, with all components assembled on the top layer. The bottom layer of the PCB is used only for traces and also for ground plane. There are certain components which make up the user interface and which can be accessed by the users. Such components are namely, the buttons, LCD and also the LED. These are the components which are accessible from outside. Whenever a PCB is to be created, special attention is to be paid for creating it as compact as possible by ensuring whether all the sensors are exposed correctly. Thereby ease of access is provided for the connection of cables which are used for programming and configuring.

III. HARDWARE SETUP AND EXPERIMENTAL RESULTS

Fig 3 Communication through ZigBee

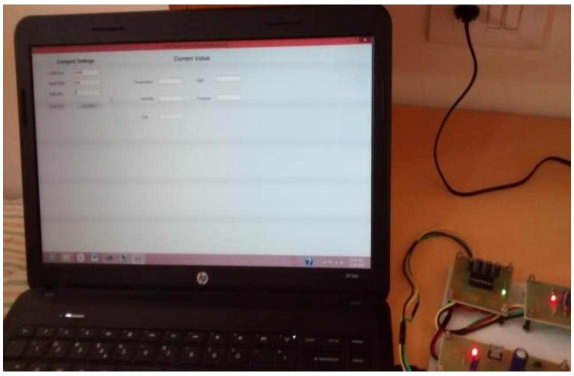

Fig 4 Display of Values from sensors on PC

IV. CONCLUSION

A compact battery-powered system was developed, which monitors and measures the various parameters such as the absolute pressure, relative humidity, temperature, the level of carbon dioxide in indoor spaces, which sends the data of measurement by using the existent wireless infrastructure that is based on the IEEE 802.15.4b/g standards, was presented. Testing of power consumption is done in a real environment, at the rate of a single transmission per minute, thereby indicating the lifetime of battery close to four months. Further investigation revealed that, the system can operate continuously for upto three years without the necessity for replacing the battery. The feature to be noted in the device is that the attached CO2 sensor is self-calibrated and hence the low power consumption mode is satisfied. It finds application in a wide range of monitoring as a component in WSN, in IoT or else in a cyber-physical system. The future work can be carried out by implementing solar based power source with a charging circuit. The developed system is of a reasonable that was achieved by carefully selecting the board components and sensors.

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