DESIGN OF WIRELESS SENSOR NODE AND TIME CONTOURED CONTROL SCHEME FOR A COMPOSTING PROCESS

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ABSTRACT

This work presents the design of wireless sensor node and a time contoured control scheme for a composting process. The electronic system is designed using Texas Instruments ultra low powered MSP430 microcontroller chip and Cypress semiconductors CYWM6935, 2.4 GHz wireless module. The software makes appropriate use of low power modes of the processor to keep power consumption minimal. The objective is to control temperature of the composting process at desired level and simultaneously monitor it remotely.

KEYWORDS: *Wireless Sensor Node, Microcontroller, Composting, Ultra Low Power Design.*

1. INTRODUCTION

Composting is a process by which organic material such as yard trimmings, kitchen scraps, wood shavings, cardboard, and paper is biodegraded by micro organisms, resulting in the production of organic and/or inorganic by-products and energy in the form of heat [3]. Micro organisms that are normally present in organic waste materials start the decomposition process when they are exposed to air, and the moisture content of the waste is brought to a suitable level; carbon dioxide, water and heat are given off. As a result the temperature of the heap rises thereby speeding up the basic degradation process, which normally occurs slowly in organic waste. The final product is compost which is of significant value in agriculture. Moreover for the process to give significantly good quality compost the process parameters have to be properly monitored and adjusted .Two such parameters that are important and interdependent to some extent are temperature and oxygen content of the waste material [8]. So a control system is designed to control temperature of the composting process and air flow rate (oxygen supply).

2. WIRELESS SENSOR NODE AND CONTROL SCHEME

System is designed around a Texas Instrument's ultra low powered MSP430F1232 microcontroller, CYWM6935 wireless module for transmitting compost temperature to a remote monitoring station. Fig. 1 shows the control scheme, wireless sensor node along with the compost reactor.

Compost reactor consists of a drum that is insulated within an outer drum to prevent heat loss during the composting process. In the centre of the inner drum, a resistance temperature detector (RTD) ,installed vertically, senses the temperature of the compost. A perforated plate, located approximately 5 inches above the bottom of the reactor, suspends the compost over the air inlet and provides even air distribution to the compost. Air flow to the compost is provided by the blower/fan. The fan offers a very easy means to introduce air (oxygen) in the reactor at regular intervals, and to circulate an air current to cool the process when required. There are basically two conditions for the fan to be switched on; whether the recorded temperature is above 55 degree C, and at regular intervals of 20 minutes. In the first case the fan remains on as long as temperature does not fall below 55 degree C. In the second case the fan is switched on for approximately 30 seconds to allow an influx of oxygen required for the composting process. This amount of time is sufficient to allow enough oxygen in the plant for the process to be sustained [8].The moisture content of the compost mixture is adjusted by adding water to the compost reactors through the top sample ports.

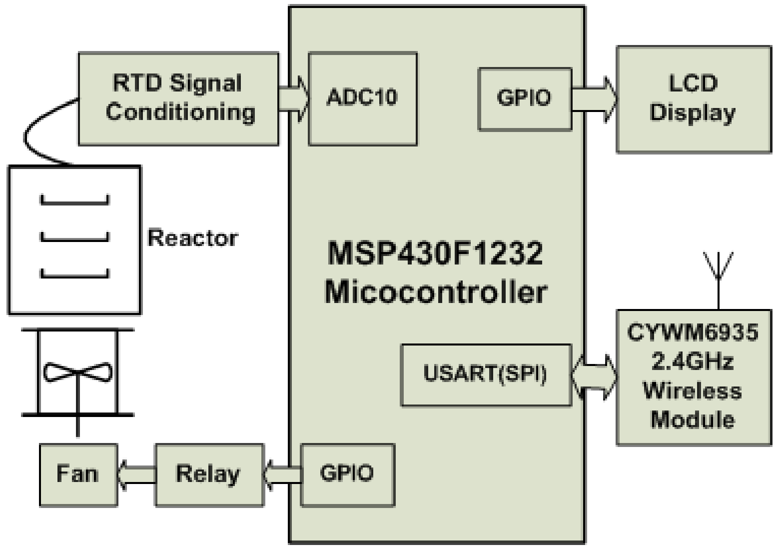

Figure 1. Wireless Sensor Node and Control System

2.1. Signal Conditioning and Wireless Transmitter

This application uses PT100 RTD for temperature sensing. The RTD signal conditioning circuit converts the resistance changes on account of temperature variations into a proportional voltage that is applied to analog to digital converter. The MSP430F1232 device integrate, 10-bit 200 kbps ADC with internal reference, sample and hold and data transfer controller. Also the USART configured in SPI mode is used to communicate with the CYWM6935 (2.4GHz ISM band) wireless module. The MSP430F1232 microcontroller acts as a SPI master while CYWM6935 wireless module acts as SPI slave. The acquired temperature information is processed according to the control logic, displayed locally on the LCD screen and simultaneously transmitted over the air using CYWM6935 module. Depending upon the time elapsed and temperature value the fan is switched on and off according to the logic depicted in the flowcharts.

The fan aerates and cools the compost in a reactor. The bacteria in the material require a minimum level of oxygen for their metabolic processes; they generate significant amounts of heat as they digest the compost. If left uncontrolled, they might use up all the oxygen or the temperature might rise to a level that would kill the bacteria [5].

2.2. Remote Monitoring Station(Wireless Receiver)

The remote monitoring station as shown in Fig. 2 consists of MSP430F1232 microcontroller at its heart, CYWM6935 wireless module and LCD display for remote monitoring of the compost temperature. The remote monitoring station can be placed at a centralized location to monitor the progress of the composting process. The CYWM6935 provides a complete SPI-to-antenna radio modem. The CYWM6935 is designed to implement wireless devices operating in the worldwide 2.4-GHz Industrial, Scientific, and Medical (ISM) frequency band (2.4 GHz *to* 2.4835 GHz)supporting a range of 50 meters or more. This restricts us to place remote monitoring station within 50 meters of the transmitter.

A Texas Instruments MSP430 Family microcontroller (MSP430F1232) has been chosen to use for the application because it is readily available, well supported with documentation and applications information, and has relatively inexpensive evaluation tools. The family of microcontrollers is designed specifically for industrial control, instrumentation, and measurement tasks with low-power, extended battery-life applications as prime design objectives [2][4]. Rather, the easy-to-understand architecture, instruction set, and family structure contributed significantly to the selection.

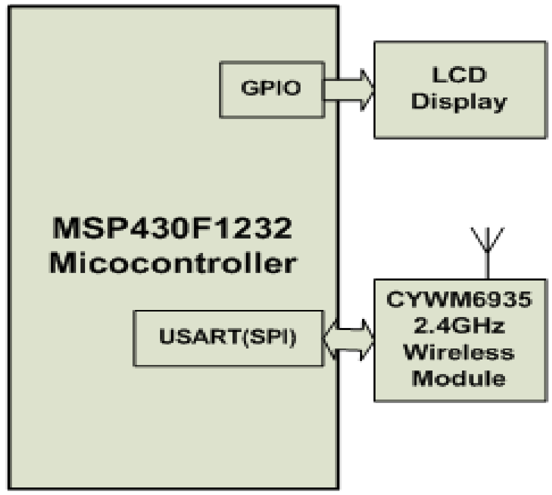

Figure 2. Remote Monitoring Station

3. FLOWCHARTS

As shown in Fig. 3 the system needs periodic processing and hence low power modes are used and timer interrupts are used for periodic processing.

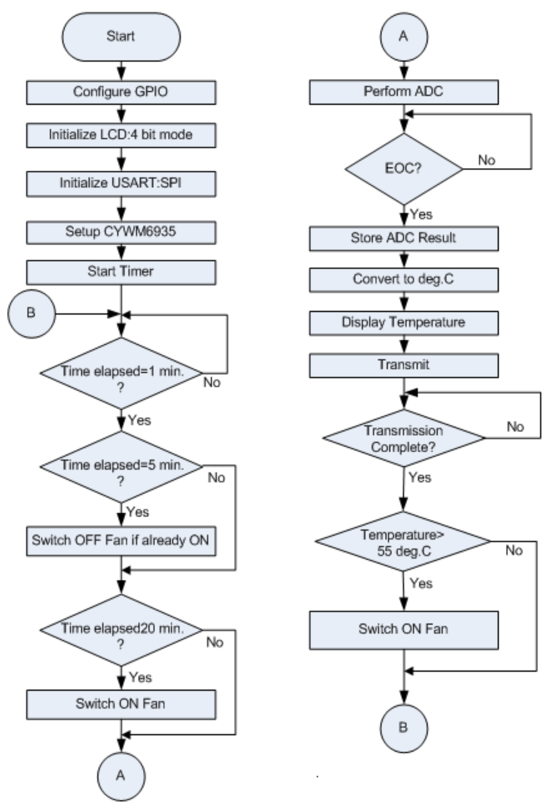

Figure 3. Transmitter Flowchart

The main loop is written so that the start up housekeeping is performed, then the selected low power mode is entered. Processing is then performed within interrupt service routine (ISR), at the end of ISR the processor is restored to low power mode. This is a great way to save power consumption when the application is required to make periodic decisions. In the design of prototype sensor node, the wireless interface consumes the largest fraction of the power and size budget of the node. While the demands of the sensing and digital processing components cannot be ignored, their duty cycle is typically very low. A combination of advanced sleep, power down, and leakage reduction techniques makes it possible to make their average power dissipation virtually negligible [10].

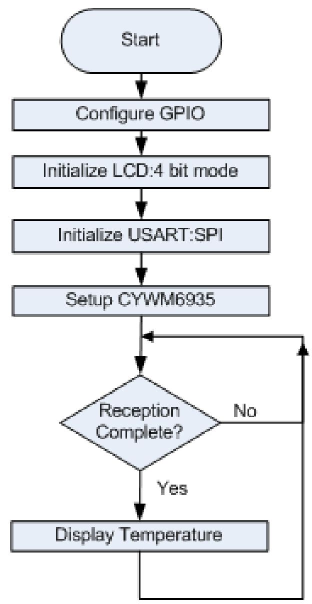

Figure 4. Receiver Flowchart

4. SOFTWARE DEVELOPMENT

The software for this application is developed in C language using the IAR Embedded Workbench IDE which contains MSP430 IAR C Compiler, MSP430 IAR assembler, a powerful editor, project manager and Flash Emulation Tool (FET) debugger. The complete development system comprising a PC with the IAR Embedded Workbench installed, Olimex FET connected to the PC parallel port, JTAG and target board are shown in Fig. 5.

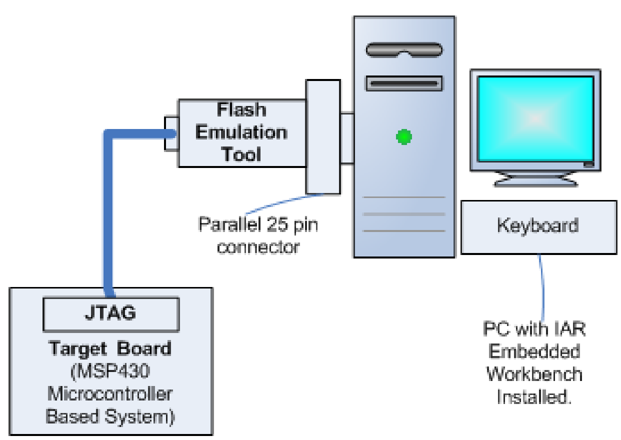

Figure 5. Software Development System

5. SOLAR POWERED BATTERY OPERATED SYSTEM

The entire electronics for this system is battery operated and solar powered. Solar panels charge the batteries. Power supply for the electronics uses low dropout regulators (LDOs) while the fan is driven by an inverter. So a solar powered control system for a environment friendly composting process makes this a truly green technology.

6. RESULTS

The experiment was conducted for almost 96 hrs (4 days) on a laboratory scale compost reactor. During the initial 15 hrs composting process was allowed to happen naturally without temperature control. Temperature feedback control was initiated after 15 hrs. After 20 hrs, temperature of compost pile was successfully maintained at around set point value of 55 degree C. At the end of the experiment, moisture content of the material was found to be 60 % and a pH of 8.0 was recorded. These values of moisture content and pH after maintaining compost temperature at 55 degree C for several hours signifies production of a good quality compost.

7. CONCLUSION

A wireless sensor node and a control system for turning organic waste into a valuable product is presented in this paper. Usage of advanced microcontroller like Texas Instruments MSP430 makes the electronics reliable and ultra low powered. During design, we have given full consideration to energy-saving principles. We have adopted low power consumption devices in each module. Temperature sensor, microcontroller, wireless transceiver are all low power consumption ones. Composting reduces difficulty in treating organic waste and creates economic revenue stream from the sale of compost. It is a good source of fertilizer to the agricultural community for crop application.

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