IRJSE International Research Journal of Science & Engineering
Int. Res. J. of Science & Engineering, Special Issue A12, February, 2023 SJIF Impact Factor 6.70
ISSN: 2322-0015 https://doi.org/10.5281/zenodo.7765181
RESEARCH ARTICLE OPEN ACCESS

Development of an Embedded System for Agro-Industrial Applications

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Manuscript Details
Available online on https://www.irjse.in
ISSN: 2322-0015

Editor: Dr. Arvind Chavhan

Cite this article as:
Pawar AM, Deshpande JD and Patil SN. Development of an Embedded System for Agro-Industrial Applications, *Int. Res. Journal of Science & Engineering*, 2023, Special Issue A12: 22-26.
https://doi.org/10.5281/zenodo.7765181

Article published in Special issue of International Conference on "Recent Trends in Materials Science, Synthesis, Characterization and Applications (RTMS-2023)" organized by Department of Physics, Anekant Education Society's, Tuljaram Chaturchand College of Arts, Science and Commerce, Baramati, Dist Pune, Maharashtra, India (Autonomous) date, January 3-4, 2023.

Abstract

Development of an embedded system has ample of applications such as medical, defense, agriculture, industry, vineyard etc. To cater the need of agriculturists and industrialist we have designed smart embedded system for agro-industrial application, wherein ubiquitous wireless sensor network (WSN) technology is deployed. For establishment of wireless sensor network, a wireless sensor node is designed and presented in this paper. Availing promising features of AVR ATmega 8L microcontroller, the wireless sensor node is designed to monitor temperature and humidity in greenhouse and industry respectively. The precision temperature sensor LM35 is employed to read the thermal status and SY-HS 220 for humidity. Moreover, for both signal conditioning circuit is wired about TLC 271, which operates on single power supply only and exhibiting very high input impedance with rail-to-rail input. An analog signal is digitized with on chip analog to digital converter with 10-bit resolution. To ensure wireless communication, DIGI's Zigbee–PRO 802.15.4 transceiver module is deployed as RF module. The sensor nodes are calibrated to the real unit and its performance is confirmed by comparing the results with standard digital thermometer and humidity chamber. The designed embedded system works continuously and precisely for agro-industrial application with great reliability.

Keywords: Wireless Sensor Network, Embedded System, Zigbee, Agro-Industrial, Humidity etc.

Introduction

During recent days, measurement of the humidity and temperature has significant importance, particularly in the industrial and Agricultural sectors [1,2]. Moreover, this exhibits a importance in domestic application as well. To design a smart instrument for detection and measurement of humidity and temperature an ubiquitous embedded system is more reliable, which offers best performance for dedicated application. During the recent days, the use of discrete components to develop electronics system exhibits constraints. The advancement in the integration technology result into advanced microcontroller of promising characteristics by employing which one of can develop smart embedded system for dedicated application using innovative field of wireless sensor network.

Wireless Sensor Network (WSN) is an innovative field for researchers. It is the network of devices, called nodes, which sense the environment and communicate the information collected from the monitored area collaboratively through wireless link [3-5]. Due to its salient features, the WSN is becoming more and more ubiquitous. Wireless Sensor Nodes of WSN consists of an array of sensors, data acquisition system, processor, memory unit, RF module and the power supply. Wireless Sensor Node have salient features such as low power, low cost, high speed, high reliability, large number of configurability, self-configurability etc [6,7]. It exhibits wide spectrum of applications. Wireless sensor Network collects data from the area to be monitored at the base station and it can be deterministically used for controlling of the respective phenomenon.

Presently, there are various fundamental technologies like Zigbee, Bluetooth etc, which are used to build wireless nodes of wireless sensor networks [8-10]. Zigbee technology is mostly reliable and suitable for development wireless sensor network for agri-industrial application. Thus, availing embedded technology a wireless node, called mote, can be designed and implemented for WSN for agro-industrial application.

Development of Wireless Sensor Node: Hardware

Emphasizing embedded philosophy, both hardware as well as firmware is designed for wireless sensor node, which is required for development of Wireless Sensor Network. The present wireless sensor network is designed to recognize the humidity and temperature. Moreover, the co-coordinator node is configured to establish proper communication with the base station.

The sensors of sensor node sense humidity and temperature and convert it in to electrical signal either in the form of voltage. To amplify this low level signal, the signal conditioning stage is introduced, which follows data acquisition stage. After conditioning, the signal is fed to the analog channel of controller for digitization and further processing. After successful processing the same data is transmitted towards the base station through smart RF module.

The details regarding electronic part of the design are presented through block diagram, shown in figure 1. The hardware of the system encompasses following sections.

a. Sensor Unit
b. Signal Conditioning Circuit
c. The Microcontroller AVR ATmega 8L
d. Trans-receiver module(zigbee)

a. Sensor Unit:

The sensor modules of humidity sensor (SY-HS 220) and temperature sensor (LM-35) availed for agro-industrial application. The details regarding these sensors are highlighted through following sub sections.

i) Humidity Sensor (SY-Hs 220):

Humidity is one of the important parameters requires to be measured. To measure humidity a smart humidity sensor module SY-HS-220 is opted for the system under design shown in the figure 2. The board consists of humidity sensor along with signal conditioning stages.

This humidity sensor is of capacitive type [11,12]. It provides DC voltage depending upon humidity of the

surrounding in RH%. This work with +5-volt power supply. The operating humidity range is 30 to 90 RH%. For the interfacing purpose, the three pins named as B, W and Rare provided. The assignment to these three pins is as, pin W DC output voltage, pin B ground and pin R- power supply (+5V). The humidity dependent dc voltage (V_0) is extracted from this sensor module and then applied to analog part of the circuit for further processing.

ii) Temperature Sensor (LM 35):

The temperature sensor LM 35 exhibit good linearity over wide temperature range. The temperature sensor LM 35 provides the temperature dependent emf with temperature coefficient 10 mV/^{0}C. The LM 35 does not require any external trimming for calibration. It provides, typically, the accuracy of ±1⁄4 ^{0}C at room temperature and ±3⁄4 ^{0}C over full, -55 to +155 ^{0}C, temperature range. It draws only 60 µA current [13-15]. Figure 3 depicts the temperature sensor LM 35. As presented in figure 3, the LM 35 has three terminals, middle of which is output terminal and remaining two are employed to power the sensor.

c) The Microcontroller AVR ATmega 8L:

The salient features of microcontroller decide the reliability of the Wireless Sensor Node [11]. Therefore, deploying the microcontroller AVR ATmega 8L the computational part of the Wireless Sensor Node is developed. This microcontroller is small in size and exhibit low power consumption. It depicts, smart on chip resources by availing which an embedded design can be realized. Figure 9 depicts the pin description of AVR ATmega 8L [16]. The salient features of microcontroller AVR

ATmega 8L, who helps to develop very smart embedded system is as below

- It has RISC instruction set with 32 general purpose working registers
- 8 Kbytes of In-system programmable flash with read while write capabilities
- 512 bytes of EEPROM
- 1K byte of SRAM
- 23 general purpose I/O lines
- a 6-channel ADC with 10-bit resolution
- a byte oriented Two-wire Serial Interface
- a programmable Watchdog Timer with Internal Oscillator
- a serial programmable UART

d) Trans-receiver module (Zigbee):

Wireless communication is the prime need of Wireless Sensor Network. For present node, the RF section is designed about Zigbee series 2 devices launched by Digi Corporation and operates within ISM band and supports IEEE standard 802.15.4 [17,18] shown in figure 4. To ensure wireless communication, the Zigbee is interfaced to microcontroller in UART mode.

The salient features of this zigbee device are as mentioned below [19,20]

- RF data rate: 250 Kbps
- Operating frequency: 2.4 GHz
- 63 mW (+18 dBm) North American version
- Indoor/Urban range: Up to 300 ft (90 m)
- Outdoor/RF line-of-sight range: Up to 1 mile (1.6 km) [21]

Thus, by this embedded system, Wireless Sensor Node, the humidity and temperature dependent signal is produced and transmitted towards the receiver installed at the base station.

Development of Wireless Sensor Node: Firmware

The WSNode realizes the embedded technology, wherein entire hardware is designed about microcontroller AVR ATmega 8L. Therefore, for the synchronization of operations, the firmware is required. Employing CodeVision AVR, an IDE, the firmware is developed in embedded C environment. The flash of the microcontrollers are programmed by using SinaProg 1.3.5.6, which supports USB based programmer. The software developed for measurement of humidity and temperature consists of various functions. Along with the main program the firmware comprises various

modules developed for specific tasks. Following are the modules developed and used in the program with proper sequence.

a. Initialization of LCD [lcd_init( )]
b. Character display [lcd_display]
c. Analog to digital conversion [ADC (channel)]
d. Calibration to humidity [data_from_Channel_0]
e. Calibration to temperature [data_from_Channel_1]
f. Decimal to BCD and ASCII conversion [(dec-bcd)]
g. Parameter value display [LCD ()]
h. Configuration of LCD [LCD cmd ()]
i. Sending data to LCD [LCD data ()]
j. Serial communication [UART ()]
k. Delay Function [Msdelay ()]

The encryption to avoid network attack is also realized in the firmware.

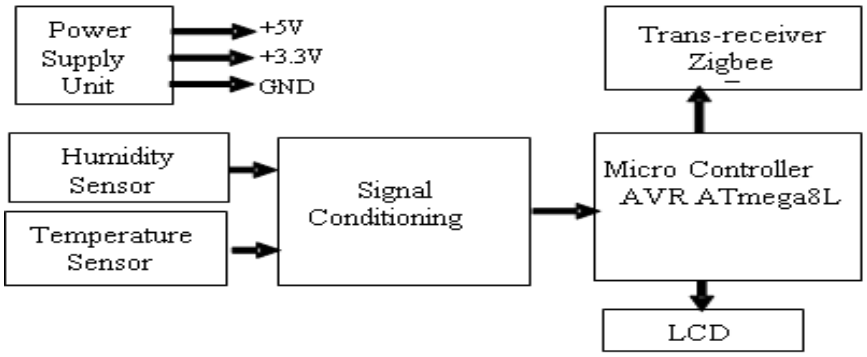

Figure 1: Block diagram of Wireless Sensor Node (WSNode)

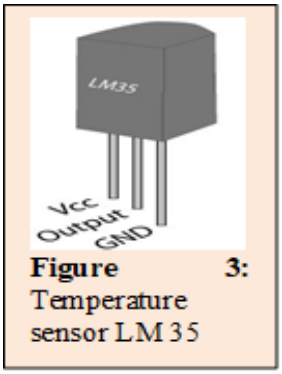

Figure 3: Temperature sensor LM 35

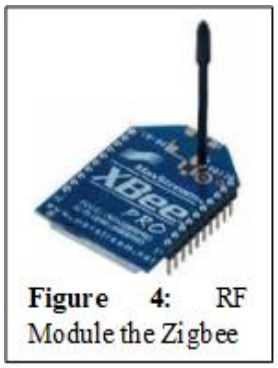

Figure 4: RF Module the Zigbee

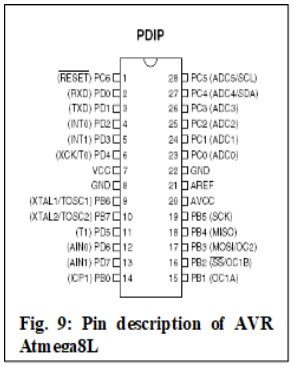

Fig. 9: Pin description of AVR Atmega8L

Result and Discussion

The Present paper describes monitoring of two parameters, temperature and humidity as well for agro-industrial application. The analog part of the hardware provides the emf, in millvolt, in proportion with value of actual variables, the temperature and humidity and thus it is essential to convert these emfs in to degree centigrade for temperature and relative humidity in %. Emphasizing measurement of humidity and temperature sensor node is successfully designed and implemented for the practical purpose for agro-industrial application. On inspection of the performance, it can be concluded that the present system is reliable and precise.

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