Wireless Sensor Node for Farm Monitoring

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***Abstract* — This paper discusses the design of a wireless sensor node for a farm monitoring system. The system allows farmers to monitor the surrounding environment as well as the animal movement. This system consists of sensors, a wireless transceiver and a main control system. It monitors the surrounding temperature, humidity and animal motion before transmitting the data to a base station. With the wireless device, farmers are able to monitor the animal activity within the range of 1.5 km. To ensure the device can perform properly, this paper discusses the verification method to determine the accuracy of the measured data against commercial devices. From the results, the wireless sensor node is able to perform measurement with 95% to 99% accuracy as compared to benchmark devices.**

Keywords: Temperature, Humidity, Motion, Wireless Sensors

I. INTRODUCTION

Farming plays an important role in any country's economy. It ensures enough food supply for domestic use and export. In Malaysia, the main activities include planting rice, rubber and palm oil. The need to supply livestock for domestic use has also increased due to local demand. However, most farming activities still use traditional methods. Thus, to increase farming productivity, the latest technology should be adopted.

A wireless sensor node can be one solution to increase farming productivity. The system allows users to collect important data remotely and use the data to help make important decisions. For example, keeping a clean environment is important to ensure good growth and the health of the livestock. Environmental factors, such as temperature and humidity, could greatly affect the animals' health, comfort and stress levels. In addition, it is also important to monitor the movement of the animals since it can give important signs in relation to their health. This can provide an early warning system to the farmer and act as a guide when taking any preventive action.

One of the challenges in designing the wireless sensor node is to ensure the accuracy of the measured data. In this paper, the design of a wireless sensor node that can monitor motion, temperature and humidity for farm monitoring is discussed. To ensure the accuracy of our design, we verify our design against existing commercial devices.

This rest of the paper is organized as follows. Section II reviews the existing work on wireless sensor nodes. The design methodology is discussed in Section III. Section IV discusses the results obtained from the experiments. Finally, Section V concludes the paper.

II. LITERATURE REVIEW

The paper in [1] discusses the design of a temperature and humidity control for greenhouses that grow various flowers. It uses a 16-bit single chip microcomputer as the main control, a wireless transceiver chip, and a temperature and humidity sensor. The system consists of a central station and several base stations. The temperature and humidity data are collected and transmitted from the base stations that monitor the environment to the central station.

In [2], a wireless sensor to monitor soil humidity and temperature is discussed. The system consists of a ZigBee system-on-chip device, a temperature and humidity sensor, and the use of solar energy to power the device. The device is able to measure the temperature with a range of -40°C ~123.8°C.

Paper [3] discusses the design of a wireless sensor to monitor air temperature and its velocity. This data is used to determine indoor air quality and provide a healthy environment for the home occupants. While typical air flow measurement is powered using batteries, this design is self-powered. It utilizes the air flow to produce the electric to power the wireless sensor node. The system is designed to transmit data using 433 MHz point-to-point communication. The results show that the device can operate with air velocities as low as 3m/s.

Paper [4] discusses the usage of a wireless sensor network for the early detection of avian influenza in large chicken farms. In this work, the authors study a health monitoring system for 0.1 billion chickens. Instead of applying the wireless sensor node to all chickens, this method only applies to 5% of the chickens. The sensor detects an unusual state of the chicken such as fever and weakness. The results show that this method can detect the avian influenza two days earlier when 5% of the chickens are attached with the sensors.

In [5], a wireless sensor network to monitor tea plants and their environment is discussed. In order to prevent the tea plant suffering damage from frost, a temperature auto monitoring system is developed. The wireless sensor nodes monitor the temperature at specific locations in the farm and send the data through wireless communication. The data can be used to control the fan to blow air at the thermal inversion layer of the tea plant to prevent frost damage.

III. METHODOLOGY

In this section, the design of a wireless sensor node for a farm monitoring system is discussed. Fig.1 shows the overall block diagram of the design to monitor temperature, humidity and motion. This project consists of three sensors, a microcontroller and a wireless transmitter. The sensor measures the temperature, humidity and motion of the animals before inputting the data into a microcontroller. The microcontroller will process the measured results and transmit the data using the wireless transmitter. At the receiver, the data will be processed and the results displayed on a LCD panel.

In this work, to measure the temperature and humidity, the sensor from [6] is used. It consists of temperature and the humidity measuring devices in a compact size of 30mm x 22mm. The humidity device consists of a special plastic material whose electrical characteristics change according to the amount of water vapour in the air. The device produces two analogue signals for temperature and humidity which will be converted into a digital signal using the analogue-to-digital converter (ADC) build-in microcontroller. Table 1 summarizes the device characteristic.

An inertial measurement unit from [7] is used to detect the object motion. The sensors consist of a gyroscope, an accelerometer and a magnetometer to measure orientation, velocity and gravitational force. The devices are stored compactly along with an on-board controller that outputs the object motion using a serial interface with a power supply of 3.3V to ensure that it operates properly. It outputs three main data, namely roll, yaw and pitch that measure the rotation around X-axis, Y-axis and Z-axis, respectively.

To communicate between the sensors and the base station, a wireless ZigBee device [8] is used. With an operating voltage of 3.3V, the device transmits the measured data from the microcontroller to the receiver with the maximum range of 1.5 km, low power consumption and the ability to operate within the ISM 2.4 GHz frequency band.

The overall system is controlled by a microcontroller from Microchip [9]. The PIC24F16KA102 device is selected due to its low power operation which is important for wireless devices. Furthermore, the device has a built-in ADC that is useful to convert the analogue signal from the sensor before being processed by the microcontroller. Table 2 summarizes the characteristics of the device.

The overall wireless sensor node schematic is shown in Fig.2. The humidity and temperature sensor is connected to pin 2 and 3 of the microcontroller. The microcontroller reads the analogue signals from the device one by one before converting them into digital signals using the built-in ADC. The motion sensor is connected to pin 5 where it sends the data serially to the microcontroller. The overall operation of the system is shown in the flow chart in Fig.3.

IV. RESULTS AND DISCUSSION

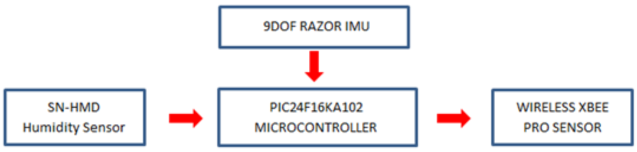
In this section, the experimental results are discussed in detail. To verify the operation of the designed wireless sensor node, the measured value is compared against a commercial device. Table 3 represents the measurement results for the body temperature. From the table, our device gives an average reading of 36.8°C, which is close to the one recorded by the commercial device which is 36.7°C. This is equivalent to a more than 99.7% accuracy achieved by our system when measuring body temperature compared to commercial devices.

TABLE 1: TEMPERATURE AND HUMIDITY SENSORS' CHARACTERISTICS.

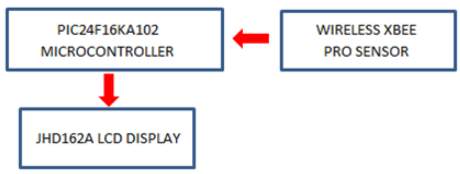
Item	Specification
Output voltage range	DC 1.0—3.0 V
Operating RH Range	20 to 95% (100% RH intermittent)
Temperature Range:	0°C to 50°C
Time Response (63% step change)	1 min

TABLE 2: SUMMARY OF KEY FEATURES FOR THE PIC24F16KA102 MICROCONTROLLER [10].

Key Features	PIC24F16KA102
Program Memory Type	Flash
Program Memory (kB)	16
CPU Speed (MIPS)	16
SRAM Bytes (kB)	1.5
Data EEPROM (bytes)	512
Digital Communication Peripherals	SPI, I2C™ and two UART modules
Pin Count	20
Timers 16-bit	3
Capture/Compare/PWM modules	2 CCP
ADC	9 ch, 10-bit
Operating Voltage Range (V)	1.8 to 3.6
Comparators	2



(a)



(b)

Fig.1: Wireless senor node block diagram (a) transmitter (b) receiver.

Table 4 shows the results for room temperature measurement. From the benchmark thermometer, the temperature value of 33°C is recorded. For the measured room temperature value, the reading has slight variation during the measurement time as opposed to the mercury thermometer. This slight variation could be the result of the sensitivity of the temperature sensor in response to small temperature variations in the room. On average, the room temperature measurement gives only 4.3% error as compared to the benchmark thermometer.

Fig.3 shows the measurement results for the humidity measurement value from 10% to 90%. From the graph, the measured value is closely matched with the commercial humidity sensor. On average, the sensor node gives 96% accuracy as compared to the benchmark sensor.

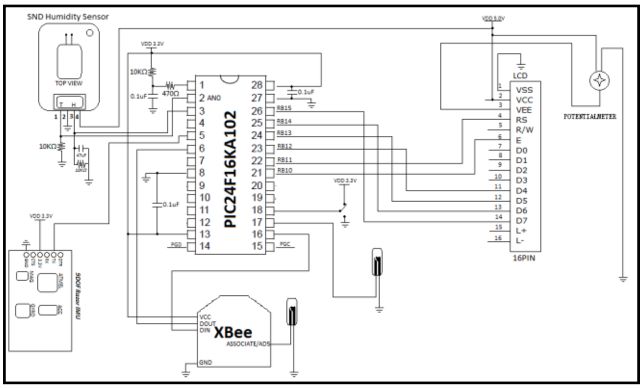


Fig.2: Overall schematic diagram for the wireless sensor node.

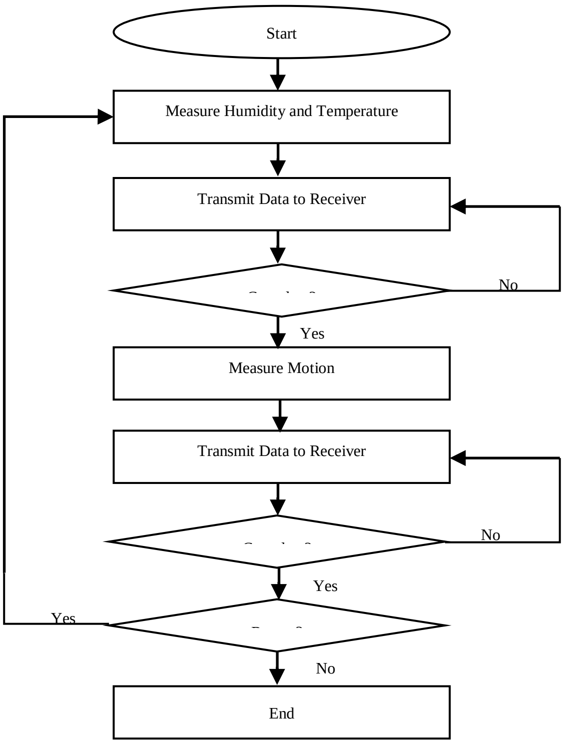


Fig.3: Flow chart of the project.

For the motion sensor, the device outputs three sets of motion information - yaw, pitch and roll - as shown in Table 5,6 and 7. The results are compared against the readings when the device is connected directly to the PC. The results are obtained when the sensor is moved in a random fashion. From the table, our device gives accurate results as compared to the reading measured using the PC. From the table, the measurement error for yaw, pitch and roll is 0.1%, 0.2% and 0.7%, respectively. From the results, the device can achieve very accurate results (>99%) as compared to the benchmark data.

Based on the comparison, the device can perform very accurate measurements as compared to the benchmark device and has good potential to be used as a wireless sensor node. In the next work, further rigorous tests will be done using actual animals in order to measure the effectiveness of the design.

TABLE 3: BODY TEMPERATURE MEASUREMENT

Body Temperature			
Times(minutes)	Benchmark	Measured	Error (%)
1	36	36.4	1.1
2	36	36.7	1.9
3	36.5	36.9	1.1
4	37	36.7	-0.8
5	37	37	0
6	37	37	0
7	37	36.7	-0.8
8	37	36.9	-0.3
Average	**36.7**	**36.8**	**0.3**

TABLE 4: ROOM TEMPERATURE MEASUREMENT

Room Temperature			
Times(minutes)	Benchmark	Measured	Error (%)
1	33.0	34.7	4.9
2	33.0	34.4	4.1
3	33.0	34.4	4.1
4	33.0	33.2	0.6
5	33.0	35.0	5.7
6	33.0	34.7	4.9
7	33.0	34.4	4.1
8	33.0	35.0	5.7
Average	**33.0**	**34.5**	**4.3**

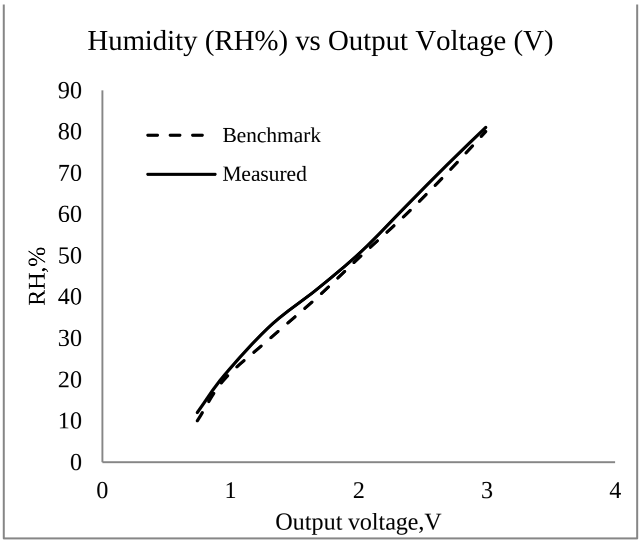


Fig.4: Graph of relative humidity (RH%) versus output voltage.

TABLE 5: GRAPH DEGREE VERSUS TIME IN YAW

	Y(H)	Y(P)	Error
1	28.20	28.24	0.14
2	28.22	28.23	0.04
3	28.22	28.23	0.04
4	28.20	28.24	0.14
5	28.22	28.24	0.07
6	28.20	28.24	0.14
7	28.23	28.24	0.04
8	28.20	28.24	0.14
Average			**0.09**

TABLE 6: GRAPH DEGREE VERSUS TIME IN PITCH

	P(H)	P(P)	Error
1	-12.50	-12.53	0.24
2	-12.52	-12.52	0.00
3	-12.52	-12.53	0.08
4	-12.50	-12.53	0.24
5	-12.51	-12.52	0.08
6	-12.50	-12.53	0.24
7	-12.52	-12.53	0.08
8	-12.50	-12.53	0.24
Average			**0.15**

TABLE 7: GRAPH DEGREE VERSUS TIME IN ROW

	R(H)	R(P)	Error
1	10.21	10.28	0.68
2	10.20	10.29	0.87
3	10.23	10.30	0.68
4	10.23	10.27	0.39
5	10.20	10.29	0.87
6	10.21	10.30	0.87
7	10.20	10.29	0.87
8	10.23	10.29	0.58
Average			**0.73**

V.

VI. CONCLUSION

This paper discusses the design of a wireless sensor node that can be used to monitor animals in farms. The device monitors motion, surrounding temperature and humidity for the targeted object. From the experiments, the device shows more than 95% to 99% accuracy as compared to the commercial devices. Based on these results, this device has good potential to be used as a wireless sensor node.

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