Wireless System for Temperature and Relative Humidity in Oil Palm Tissue Culture Laboratory

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Abstract – **To increase our production of palm oil, the Malaysian Palm Oil Board (MPOB) had adapted the tissue culture technique. This technique was conducted inside the specific laboratory and required frequent monitoring sessions to maintain its crucial parameters in good conditions. To overcome this situation, the wireless monitoring system is developed to reduce the conscripting of manpower monitoring session by using the SHT11 sensor to produce the output data for both temperature and relative humidity parameters with direct utilization of the XBee antennas for transmitting and receiving the data in wireless form. The PIC16F877A microcontroller systems are being used to connect the SHT11 sensor and XBee antenna as the transmitter part and also connect the XBee antenna and LCD module as the receiver part to display the data measured. This system is developed for upgrading the previous wired monitoring system and overcome the manpower consumption for monitoring session to improve the global standard for the oil palm tissue culture technique.**

Keywords – MPOB, Temperature and Relative Humidity Parameters, PIC16F877A Microcontroller systems, SHT11 sensor, XBee antenna, and LCD module.

I. INTRODUCTION

This project was conducted based on recent technology invented, which is Radio Frequency Identification (RFID) technology, as the system can automatically transmit the identity of an object in wireless form using radio waves. As the parameters of the tissue culture technique require frequent observation, the implementation of a wireless monitoring system is made up. The sensor of humidity and temperature, SHT11 is the main component of this project as it is capable to read both temperature and relative humidity data in the form of digital output it can be placed inside the vessel of the oil palm. Hence, the human monitoring session can be minimized as the SHT11 sensor is capable to measure those parameters by itself.

The wireless system has many advantages for this project. As it is capable of transmitting and receiving the data transferred without using wires is the most significant because it can save maintenance costs of internal and external resistance occurred compared with using wired system. Besides, the wireless system makes it convenient to be placed at any place within its range.

As the project is conducted, its main objectives are to develop a hardware product which can be used to collect data using wireless system, develop an algorithm of microcontroller system with direct usage of wireless technology and sensor interferes with existing laboratory equipment, and also to produce the data measured for both temperature and relative humidity parameters on the oil palm in order of ensuring the production with high quality level heredity of the oil palm.

A. *Oil Palm Tissue Culture*

The crucial parameters that are needed to be frequently monitored for the oil palm tissue culture are temperature, relative humidity, liquid phase, and gas composition.

B. *Wireless System*

Previously, the wired monitoring system had been implemented to overcome the frequent manpower monitoring session. Unfortunately, the wired system is no longer popular due to the amount of wires required and maintenances associated with wiring or rewiring as the increasing of resistance occurred as the length of the wires used increases. Today, by implementing automated wireless remote monitoring systems to provide rapid retrieval of higher quality information can reduce operation and maintenance costs [1]. However, the previous wireless system implemented has limited application, which can only monitor one of the crucial parameters of the oil palm tissue culture. The wireless system implemented is capable to read the output data in both conditions of Line of Sight (LOS) and Non Line of Sight (NLOS). This is being done by using two XBee antennas for transmitting and receiving process. The process of transmitting and receiving the data is performed continuously until the connection is removed.

C. *SHT11*

The SHT11 is a single chip relative humidity and temperature multi sensor module comprising of a calibrated digital output [2].The previous wireless monitoring system developed is made use of LM35 sensor. When combined with sensors like LM35, the wireless system can record environmental parameters, such as temperature and specific quality or safety attributes of the product [3]. However, the system implemented can only be applied for temperature monitoring of the oil palm tissue culture. Thus, the SHT11 sensor is being used to improve the previous system, where it can produce output data for both temperature and relative humidity parameters.

D. *PIC16F877A Microcontroller System*

Peripheral Interface Controller (PIC) microcontroller system used in this project is PIC16F877A, which is needed to be programmed using an appropriate command in order to operate it as well as to operate other components attached onto it. It comes with 40-pin connections with five I/O ports and eight A/D input channels on each port, which allows more components to be attached to it. It is needed to be operated at 5V power supply. These PIC16F877A microcontrollers are being used for both transmitter and receiver parts respectively. The proper setting of the register will depend on the application requirements [4]. The PIC16F877A microcontroller is used to perform instruction programmed to complete the process of reading the data from SHT11 sensor to be transmitted via Xbee antenna at the transmitter part and also read the data received from the transmitter part via XBee antenna to display the data collected on the Liquid Crystal Display (LCD) module and personal computer at the receiver part.

II. METHODOLOGY

The development of the project involves both hardware and software part. Fig.1 and Fig. 2 show the overall system block diagram and the flowchart of the methodology for the project respectively.

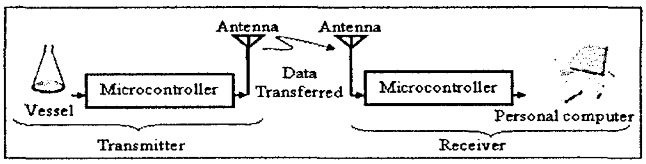

Figure 1. Block diagram for overall data transferred process.

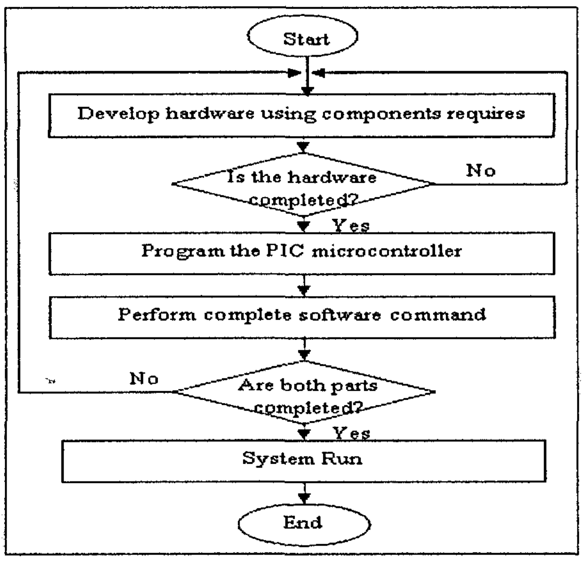

Figure 2. Flowchart of the methodology for the project.

A. *Hardware*

The hardware development consists of two parts which are the transmitter and the receiver. The transmitter part is made up of three main components, while the receiver part is made up of four main components that are essential in order to compose the output data transmitted from the vessel wirelessly.

The transmitter part consists of three main components which are SHT11 sensor, PIC16F877A microcontroller, and XBee module that can transmit the data collected to the receiver part in wireless form. Fig. 3 shows the block diagram of the transmitter part, which the SHT11 sensor read the data for both temperature and relative humidity parameters from the vessel to be sent to the antenna of XBee module through PIC16F877A microcontroller and the data collected are then transferred to the receiver part.

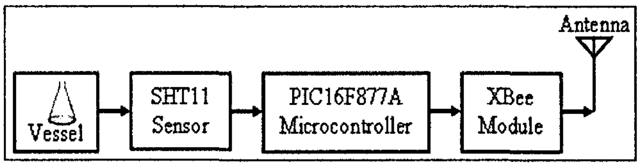

Figure 3. Block diagram of the transmitter part.

Fig. 4 shows the illustration pin configuration to connect between PIC16F877A microcontroller with SHT11 sensor and XBee module. Both SHT11 sensor and XBee module are connected to the Port C from I/O port of the microcontroller, which is SHT11 sensor is connected to RC3 and RC4 pins, and XBee module is connected to the RC6 and RC7 pins. The voltage converter for the voltage dropout from the power supply of the transmitter part is connected to RD4, RD5, and RB1 pins of the microcontroller.

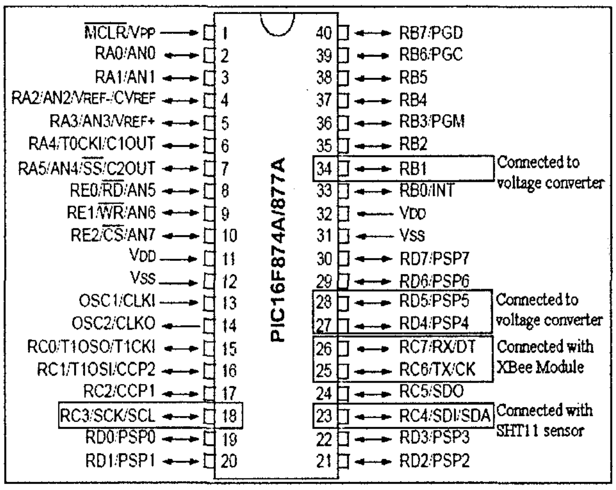

Figure 4. Pin configuration for transmitter part.

The transmitter part is needed to be powered on in order to operate it for continuously reporting temperature and relative humidity parameters changes. The voltage used in this project can be used either using 9V as it is powered by battery source or 12V using AC-DC power supply. The voltage converter and LM1117T voltage regulator are used to provide low dropout of 3.3V to the XBee module and 5V supply for PIC16F877A microcontroller to make the system work as it is the recommended supply voltage for both main components in order to operate the SHT11 sensor wirelessly. Fig. 5 shows the block diagram of the circuit connection for transmitter part with respective components.

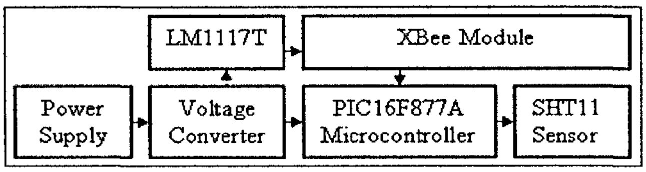

Figure 5. Block diagram of circuit connection for transmitter part.

The receiver part consists of four main components, which are XBee module, PIC16F877A microcontroller, LCD module, and RS232-USB cable in order to receive and display the output data transmitted from the transmitter part. Fig. 6 shows the block diagram of the receiver part.

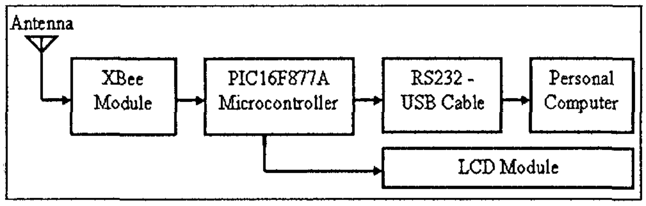

Figure 6. Block diagram of the receiver part.

The receiver part responds to each transmitted data and reports the readings of the SHT11 sensor from the transmitter part. The data collected by the receiver part are displayed both on the LCD module itself and also on the personal computer via RS232-USB cable.

Fig. 7 shows the illustration pin configuration to connect the PIC16F877A microcontroller with LCD module and XBee module. The LCD module and XBee module are connected to the Port D and Port C from I/O port of on the microcontroller respectively, where the LCD module is connected to RD0 until RD7 pins and the XBee module is connected to RC6 and RC7 pins. The voltage converter for the voltage dropout from the power supply to the microcontroller of the receiver part is connected to RC1, RC2, and RB1 pins.

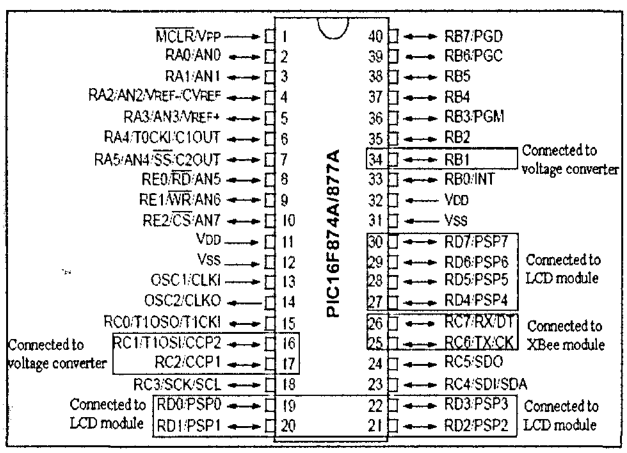

Figure 7. Pin configuration for receiver part.

The receiving part is powered by either using 9V as it is powered by battery source or 12V using AC-DC power supply in order to operate it for continuously receiving data of temperature and relative humidity parameters. The voltage converter and LM1117T voltage regulator are used to provide low dropout of 3.3V for XBee module and 5V supply for PIC16F877A microcontroller to make the system work and operate the LCD module to keep displaying the data transferred. Fig. 8 shows the block diagram of the circuit connection for the receiver part with respective components.

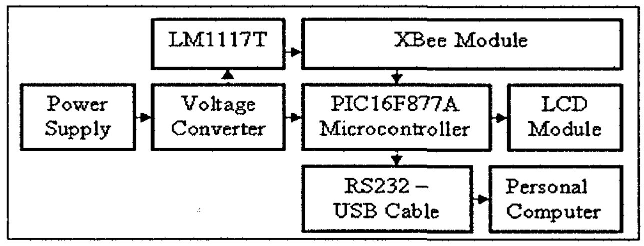

Figure 8. Block diagram of circuit connection for receiver part.

The XBee modules that are being used for both the transmitter part and receiver part have an operating frequency of 2.4GHz and can be used in indoor communication ranging up to 30m and outdoor Line of Sight up to 100m [5].

B. Software

The software part deals in programming the microcontroller so that it can control the operation of the IC's used in the implementation [6]. The PIC16F877A microcontrollers are used for both the transmitter part and receiver part of the project. It is chosen because it can be reprogrammed to write and erase the command loaded. The programming language that is being loaded to the PIC16F877A microcontroller is C Language by using CCS C Compiler as it supports the Microchip PIC16x devices. The output obtained is being loaded via RS232-USB cable to the personal computer to read the respective data of temperature and relative humidity parameters from the SHT11 sensor. Fig. 9 and Fig. 10 show the flow chart for the software programming of the PIC16F877A microcontroller for both transmitter part and receiver part respectively. Before starting the program, the initialization or set the registers and ports used in PIC need to be done [7]. The functions of the program are to monitor temperature and relative humidity parameters as indicated by the system sensors [8].

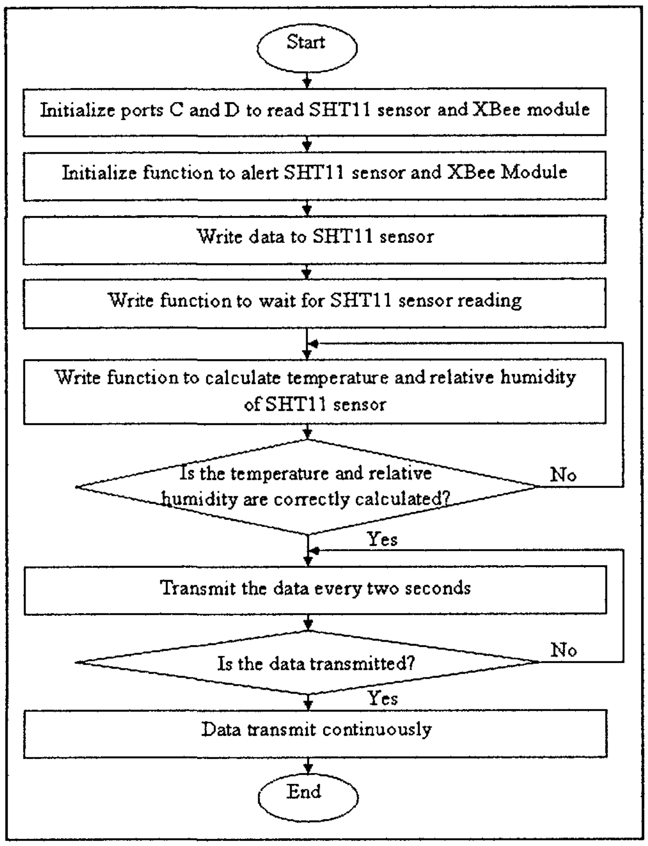

Figure 9. Flow chart of the microcontroller' program for transmitter part.

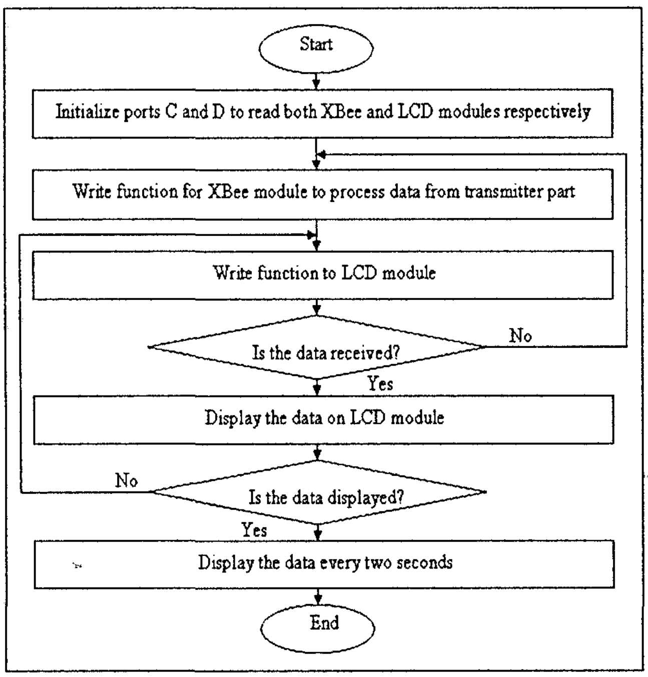

Figure 10. Flow chart of the microcontroller' program for receiver part.

III. Results And Discussion

The results for both temperature and relative humidity parameters are captured to be displayed on the LCD module and Visual Basic software. Fig. 11 and Fig. 12 show the hardware developed for both the transmitter and receiver parts respectively with proper labeling of the components used. Both parts consisted of the Light Emitting Diode (LED) component to indicate that XBee modules are functioning. Fig. 13 shows the results obtained for both temperature and relative humidity on LCD module at the receiver part.

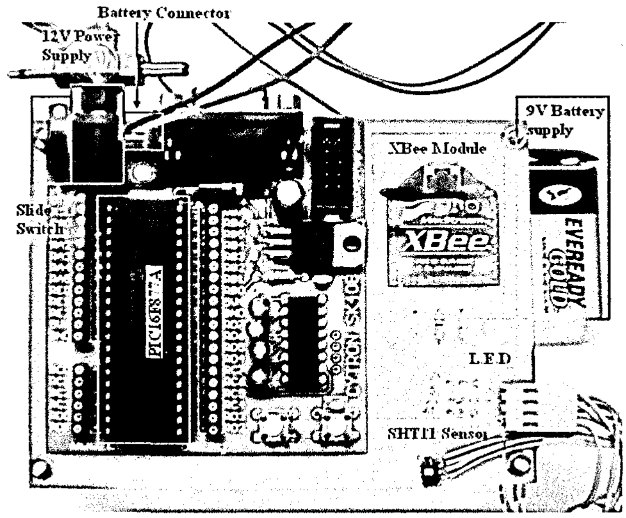

Figure 11. Hardware developed for the transmitter part.

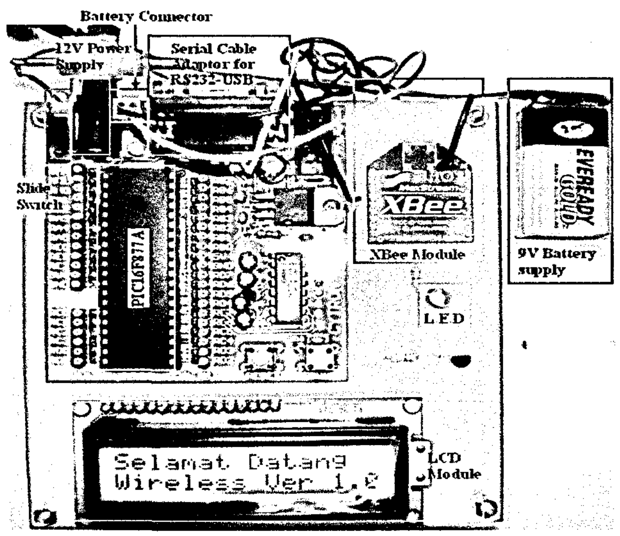

Figure 12. Hardware developed for the receiver part.

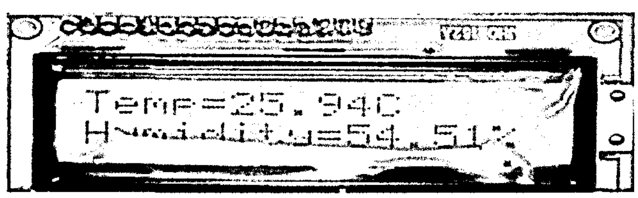

Figure 13. Results obtained on LCD module of the receiver part.

The hardware part is being tested at the MPOB tissue culture laboratory in order to monitor the crucial parameters of temperature and relative humidity. The hardware is placed at various conditions for data collection process.

Fig. 14 and Fig. 15 show the data collected for both temperature and relative humidity parameters are displayed on the personal computer by using Visual Basic software. Shortly, these data are stored on the database system in a real-time condition.

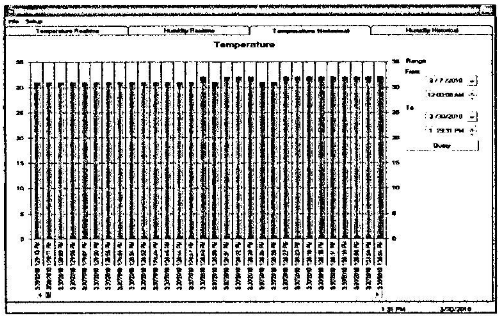

Figure 14. Results of the temperature parameter shown on Visual Basic.

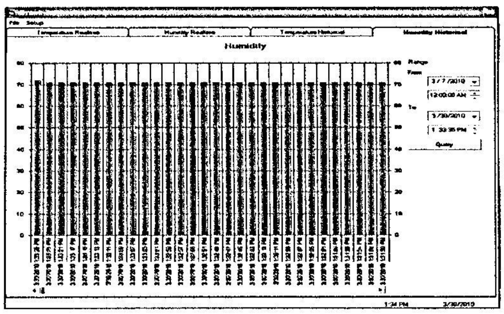

Figure 15. Results of the relative humidity parameter shown on Visual Basic.

The data collected for both temperature and relative humidity parameters using the hardware developed are also measured using the thermometer and hygrometer to compare between both these data to make sure whether the data measured are correct or vice versa. The range of the results obtained for temperature parameter is in between 25°C until 29°C, while the relative humidity is in between 46% until 89%.

The data for both temperature and relative humidity parameters are collected from two different places, which are inside and outside the laboratory room. The SHT11 sensor is also attached at two different conditions, which are inside and outside the tissue culture vessel in order to measure the parameters. Fig. 16 shows the SHT11 sensor is attached inside the tissue culture vessel in laboratory.

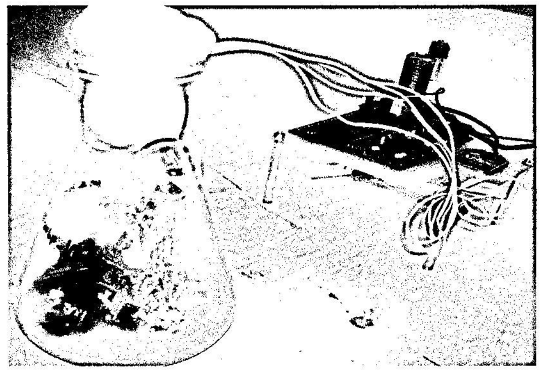

Figure 16. SHT11 sensor attached inside the tissue culture vessel.

The data collected is measured from three different laboratory rooms with two conditions of each, which are Line of Sight (LOS) for direct data collected and Non Line Of Sight (NLOS) with presence of obstacles such as wall. The data collected for temperature parameter is shown in Table I. The table indicates results obtained from various conditions, which is SHT11 sensor was placed inside and outside of the laboratory room, with condition of either SHT11 sensor was placed inside the tissue culture vessel or vice versa using thermometer and hardware developed.

TABLE I. TABLE DATA FOR TEMPERATURE PARAMETER.

Condition		Distance, (m)	Thermometer, (°C)	Hardware, (°C)
Inside the laboratory room.	Sensor was placed outside the tissue culture vessel.	1m	26.00°C	25.94°C
		5m	25.83°C	25.88°C
		10m	26.30°C	26.30°C
		15m	27.30°C	27.33°C
		20m	27.50°C	27.57°C
		25m	28.10°C	28.07°C
		30m	28.30°C	28.31°C
	Sensor was placed inside the tissue culture vessel.	1m	26.20°C	25.66°C
		5m	26.25°C	25.61°C
		10m	26.25°C	26.23°C
		15m	27.35°C	27.38°C
		20m	28.70°C	28.78°C
		25m	28.00°C	28.08°C
		30m	28.10°C	28.11°C
Outside the laboratory room.	Sensor was placed outside the tissue culture vessel.	1m	NIL	NIL
		5m	NIL	NIL
		10m	26.00°C	25.94°C
		15m	26.98°C	26.98°C
		25m	27.00°C	27.09°C
		30m	27.49°C	27.51°C
	Sensor was placed inside the tissue culture vessel.	1m	NIL	NIL
		5m	NIL	NIL
		10m	25.55°C	25.63°C
		15m	27.35°C	27.35°C
		25m	27.38°C	27.41°C
		30m	27.98°C	28.01°C

The tabulated data collected for temperature parameter using thermometer and hardware developed are visualized in the form of graph shown in Fig. 17 and Fig. 18 respectively.

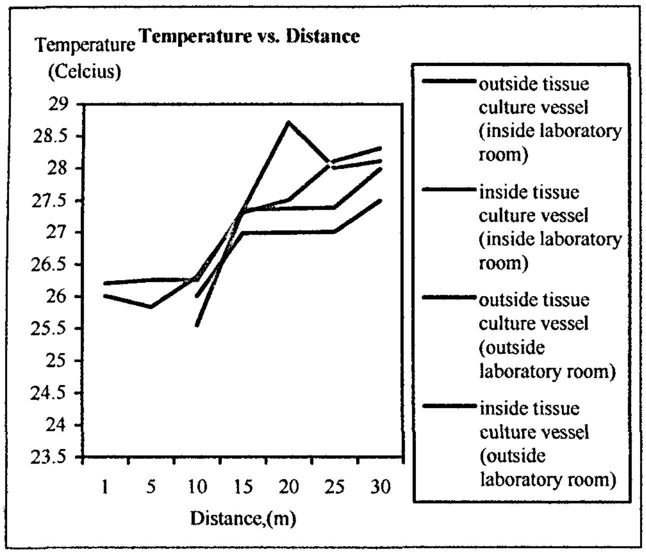

Figure 17. Graph of "Temperature versus Distance" for thermometer measurement.

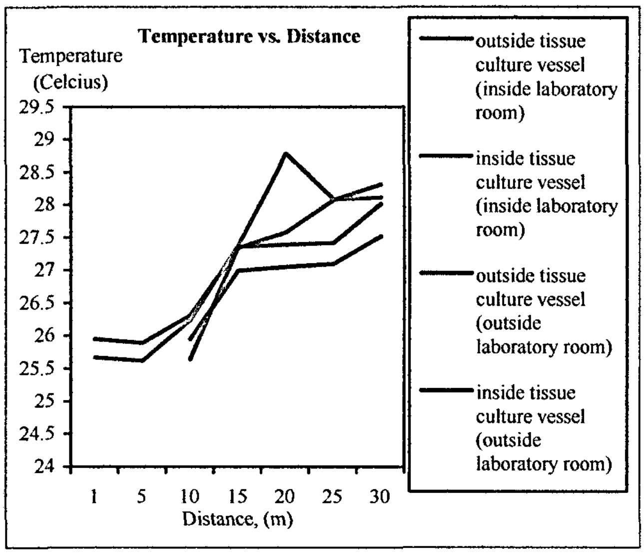

Figure 18. Graph of "Temperature versus Distance" for hardware developed measurement.

Based on the data collected for the temperature parameter, the graph of "Temperature versus Distance" for both thermometer and hardware developed are yielded a slightly the same curves. It shows that as the distance increases, the temperature measurement increases too as the sensor is placed to the three different laboratory rooms which have specific temperature range according to the suitability of the oil palm tissue culture growth. The temperature should be constant throughout the entire tissue culture room [9].

The data collected for relative humidity parameter is shown in Table II by using both hygrometer and hardware developed. The table indicates results obtained from various conditions, as same as the temperature measurement.

TABLE II. TABLE DATA FOR RELATIVE HUMIDITY PARAMETER.

Condition		Distance, (m)	Hygrometer, (%)	Hardware, (%)
Inside the laboratory room.	Sensor was placed outside the tissue culture vessel.	1m	NIL	54.51%
		5m	NIL	55.17%
		10m	NIL	48.98%
		15m	48.00%	48.10%
		20m	49.00%	49.78%
		25m	48.50%	48.80%
		30m	48.45%	48.77%
	Sensor was placed inside the tissue culture vessel.	1m	NIL	85.19%
		5m	NIL	85.29%
		10m	NIL	88.63%
		15m	NIL	87.90%
		20m	NIL	87.02%
		25m	NIL	86.83%
		30m	NIL	85.92%
Outside the laboratory room.	Sensor was placed outside the tissue culture vessel.	1m	NIL	NIL
		5m	NIL	NIL
		10m	NIL	48.97%
		15m	47.00%	46.53%
		25m	46.00%	46.99%
		30m	46.00%	46.91%
	Sensor was placed inside the tissue culture vessel.	1m	NIL	NIL
		5m	NIL	NIL
		10m	NIL	88.87%
		15m	NIL	87.32%
		25m	NIL	86.78%
		30m	NIL	85.31%

The tabulated data collected for relative humidity parameter using hydrometer and hardware developed are visualized in the form of graph shown in Fig. 19 and Fig. 20 respectively.

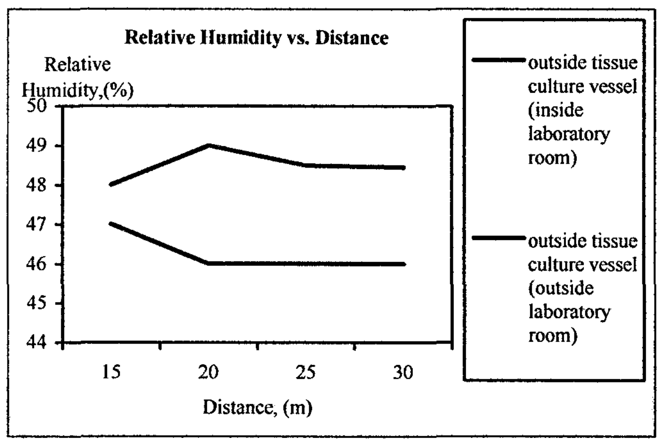

Figure 19. Graph of "Relative Humidity versus Distance" using hygrometer.

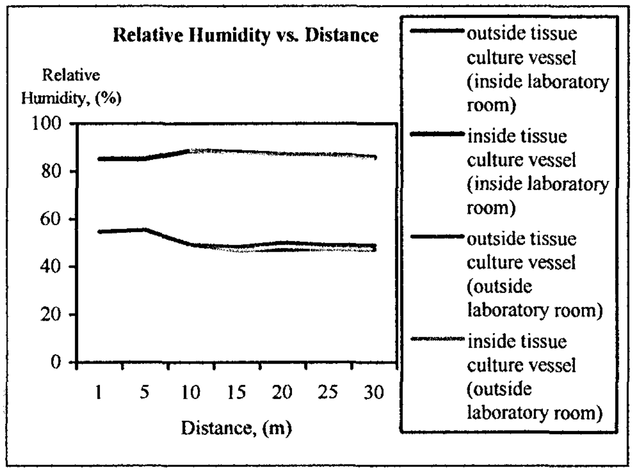

Figure 20. Graph of "Relative Humidity vs. Distance" using hardware developed.

Based on the data collected for the relative humidity parameter, the graph of "Relative Humidity versus Distance" for both hygrometer and hardware developed are yielded different curves. It shows that the measurement for relative humidity parameter is higher inside the laboratory room compared to the outside of it. As the sensor is placed inside the tissue culture vessel, the measurement recorded is increases almost doubled due to the air conditioning equipped. The air conditioning equipment indirectly controls the relative humidity parameter [10].

The data collected for both temperature and relative humidity parameters shows that the value measured yield slightly different value compared between the value obtained from thermometer and hygrometer with the SHT11 sensor from hardware development. This happen due to the precision of the SHT11 sensor is more accurate as it is build to produce digital output compared with the precision of both thermometer and hygrometer.

The conditions of inside and outside the laboratory rooms can affect the temperature readings for both measurement methods used. Measurement taken from inside the laboratory room is higher compared to the measurement taken from its outside. As the condition inside the laboratory room is always closed, both temperature and relative humidity parameters' measurement are slightly higher compared to the outside because it contains less ventilation of air flow inside it.

IV. CONCLUSION

As a conclusion, both the hardware and software parts of the project conducted were successfully developed by using the respective components required and had been tested at MPOB. The algorithm used to operate the microcontroller system can measure signal from SHT11 sensor and transmit the data in wireless form effectively. The data measured for both temperature and relative humidity had been successfully displayed on LCD module and thus minimized the conscripting of manpower monitoring to collect both data frequently in order to ensure the growth of the oil palm seedlings by using tissue culture technique in a good manner. Thus, the wireless monitoring system developed is benefiting the economic growth of MPOB as it is capable to monitor both crucial parameters of temperature and relative humidity without conscripting human monitoring session.

V. FUTURE WORK

Since the hardware developed is designed to measure parameters of temperature and relative humidity, it is recommended that the hardware be tested in various weather conditions, such as during daytime and night and also throughout rainy and drought seasons in order to prove its reliability towards monitoring system.

As the SHT11 sensor has the subsequent command of three address bits, only '000' is supported and cannot be changed. Thus, it can be used for future applications such as sensor networks which is a type of sensor that can be utilized in automation and control technologies in future development.

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REFERENCES

[1] "Wireless Remote Monitoring Systems," Weston Solutions Inc, 1400 Weston Way, P.O. Box 2653, West Chester, PA 19380, May 2005.

[2] "Application Note Sample Code SHT11 Humidity & Temperature Sensmitter," Sensirion The Sensor Company, SENSIRION Inc, Westlake Pl. Ctr. 1, suite 240. 2801 Townsgate Road, Westlake Village, CA 91361 USA, October 2006.

[3] Yuhaini Idayu Binti Mohd Ali, "Wireless System for Temperature Monitoring in Oil Palm Bio-Laboratory, B. Eng. Thesis," Faculty of Electrical Engineering, Universiti Teknologi MARA, Malaysia,pp. 1-42, December 2009.

[4] R. Demeter & R. Campeanu, "Microcontroller Based Ethernet Embedded Systems," Dept. of Automatics, Transilvania University of Braşov, 2009.

[5] Assist. Prof. Grisha Spasov, "Measurement of Temperature and Humidity Using SHT11/71 Intelligent Sensor," Department of Computer Systems, Technical University - branch Plovdiv, 25, Tzanko Djustabanov Str., 4000 Plovdiv, Bulgaria, September 2004.

[6] M. Raghuvanshi, "Implementation of Wireless Sensor Mote," Department of Nuclear Engineering and Technology, Indian Institute of Technology, Kanpur, pp. 2-70, June 2006.

[7] Ida Laila Binti Ahmad, "Development Of A PC Interfaced Blood Pressure Meter," Faculty of Electrical Engineering, Universiti Teknologi Malaysia, pp. 1-79, May 2006.

[8] R. López, S. Galindo, E.Gaytán, R.Juárez, "Temperature And Humidity Laboratory Remote Controller," Journal of the Mexican Society of Instrumentation, pp. 1-7, February 1996.

[9] ":Setting Up a Tissue Culture Lab," Department of Biotechnology Applications for Plant Breeding and Genetics, Michigan State University, East Lansing, MI 48824, pp.1-13, 2004.

[10] "Tissue Culture CIP Training Manual," International Potato Center, Av. La Molina 1895, La Molina, Lima 12, Peru, pp. 2-14, 2008.