GAIN ENHANCEMENT WIRELESS SENSOR TRANSMISSION FOR AGRICULTURE SECTOR USING LINEAR POLARIZATION ANTENNA IN 2.4 GHZ FREQUENCY

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Abstract. Sensors are used to detect changes in the physical or chemical environment whose output is converted into electrical quantities that represent a changing environment. Sensors are widely used in agriculture, especially to detect changes in the physical or chemical environment associated with plant growth. In agricultural applications that have large areas, the problem of location and distance from the sensor to the control center is a problem that must be resolved. To overcome this problem, the sensor system is designed with a wireless connection. In wireless communication system applications, the antenna portion is a very important part that can affect the rate of sensor data transmission. To improve the performance of wireless sensors in sending data, it is necessary to integrate antennas that are compatible with the transceiver sensor system. So this research was conducted to integrate linear polarization antennas with sensors to increase the gain in transmission. From the integration then measurements are taken to get the value of the radiation pattern, gain, bandwidth and delay. From the resulting measurements there is an increase in the strengthening of the wireless sensor transmission and low bit delivery delay by using linear polarization antennas for agricultural sector applications using the 2.4 GHz frequency.

Keywords : antenna, agriculture, sensor, wireless

1. Introduction

Sensors in the electronic world are the parts used to detect changes in the environment. Sensors are widely used in agriculture, especially to detect changes in the physical or chemical environment associated with plant growth, for example: temperature sensors, light sensors, soil moisture sensors, and so on. In agricultural applications that have large areas, the problem of location and distance from the sensor to the control center are separate problems that must be resolved. To overcome this problem, a sensor system is designed, a connection that uses a wireless communication system.

The design of a wireless sensor to monitor temperature and humidity can be done using the nRF24L01 transceiver module [3], where the transmitter section is placed on a farm to send sensor data to monitor temperature and humidity conditions at that location. In wireless communication system applications, there are antenna parts which are very important parts that can affect the rate of sensor data transmission. The design in general still uses a standard antenna from the nRF24L01 transceiver module. To improve the performance of the wireless sensor in sending data, it is necessary to integrate the antenna that matches the sensor transceiver correctly. Many mistakes in choosing the antenna used causes the data communication system to work less than optimal. So from this research it

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is expected to provide a modified analysis of the nRF24L01 standard transceiver module which is integrated with the linear polarization antenna design to improve the strengthening of the wireless sensor.

From the linear polarized antenna that is designed it is expected to get high and efficient reinforcement resulting from the measurement and testing of the antenna including: measurement of radiation patterns, gain, bandwidth and delay.

2. Basic structure

2.1. Linear Polarization Antenna

Linear polarization antenna models are antennas with vertical or horizontal wave propagation. In the concept of an antenna that has wave propagation with linear polarization is the Yagi antenna. Discovered by S. Uda and H. Yagi at Tohoku University in 1926 called the Yagi-Uda antenna. This antenna is a type of unidirectional antenna that is widely used in amateur radio communications, and then as a television receiver antenna, because of its excellent workability and tolerance for variation and construction errors when optimum performance is not a demand. In Figure 1 shows the dimensions and construction of the yagi antenna.

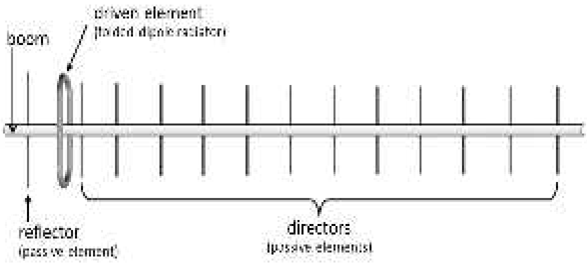

Figure 1. Yagi-Uda antenna dimensions and construction
(Source: http://bcbj.org/antennae/lte_yagi_diy.htm)

Driven element is an element that provides power from a transmitter, usually through a transmission line. The parasitic element is an element that obtains power by itself through coupling with other elements in the array due to the distance between adjacent elements between elements. The driven element has a length of 1/2 λ. So the formula for calculating the total length of a Yagi driven element is shown in Equation 1 as follows:

$$L = 0.5 \times K \times \lambda \ (2.5) \qquad (1)$$

Where:

L = Length of Driven Element
K = Velocity Factor (on metals 0.95)
λ = wavelength (m)

2.2. Wireless Sensor Transceiver

Wireless sensor or also called wireless sensor is a system based on wireless networks that forms digital data in the computer world. In general Wireles Sensor or wireless sensor is an embedded system equipment in which there are one or more sensors and is equipped with communication system equipment or can be called a sensor that works without using cables. The sensor in this equipment is used to capture or collect information that is appropriate to the characteristics of the sensor. Information that has been collected in the form of analog signals is converted into digital signals and then transmitted to a node via wireless or wireless media such as Wifi, Bluetooth, Inftrared, and others. Each point in the wireless sensor is equipped with a radio transceiver as a receiving or sending node or also other supporting devices.

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Figure 2. Transceiver NRF24L01
(Source: https://randomnerdtutorials.com/nrf24l01-2-4ghz-rf-transceiver-module-with-arduino)

2.3. Sensor

The sensor is a device that serves to detect symptoms or signals originating from changes in an energy such as electrical energy, physical energy, chemical energy, biological energy, mechanical energy and so on. An example is DHT11 which is a digital sensor that can measure the temperature and humidity of the surrounding air.

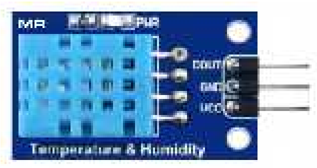

Figure.3. DHT11 Sensor
(Source: https://www.robotics.org.za)

2.4. Arduino Uno

Arduino is a microcontroller board based on ATmega328. Arduino has 14 input / output pins of which 6 pins can be used as PWM outputs, 6 analog inputs, 16 MHz crystal oscillators, USB connections, power jacks, ICSP heads, and reset buttons. Arduino is able to support a microcontroller; can be connected to a computer using a USB cable or supplied with an AC to DC adapter or using a battery to get started.

Figure 4. Arduino Uno
(Source: https://www.robotistan.com)

3. Design and Experiment

3.1. Design Yagi antenna

The first thing is to be able to realize the yagi antenna which is to determine the specifications of the antenna working frequency and the material used for the yagi antenna. Calculate the size and make the desired design to get maximum results. Then start assembling the antenna that has been calculated mathematically.

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Yagi antenna design can be explained: determine the frequency of work, calculate the size of the driver element, the reflector element, the directional element, the size of the boom., antenna realization in accordance with specifications, and antenna testing and measurement.

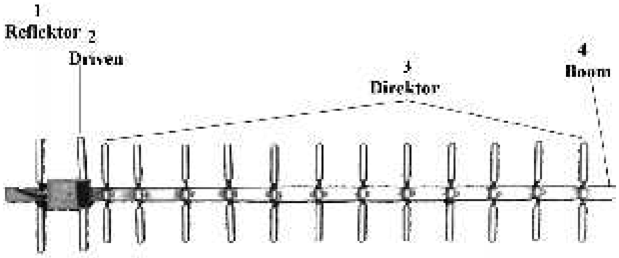

Figure 5. Construction of the yagi antenna

3.2. Design Sensor Transceiver System

In planning the sensor transceiver system the system parts include: the control system using Arduino, the sensor system uses DHT11, the transceiver consisting of the transmitter system (TX) and the receiver (RX) uses the NRF24L01 Transceiver module with SMA connector and finally the Yagi antenna system which is a Yagi antenna system antenna with linear polarization which is the design result that is integrated with the sensor transceiver system. The overall system block diagram can be shown in Figure 6.

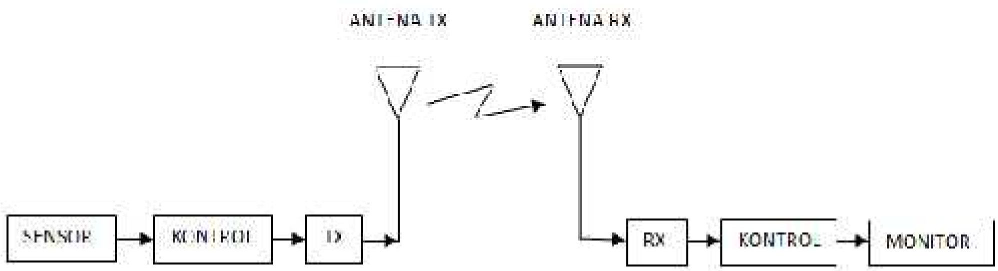

Figure 6. Wireless Sensor System Block Diagram

4. Design results

4.1. Antenna Design

Antenna design results can be shown in the figure 7.

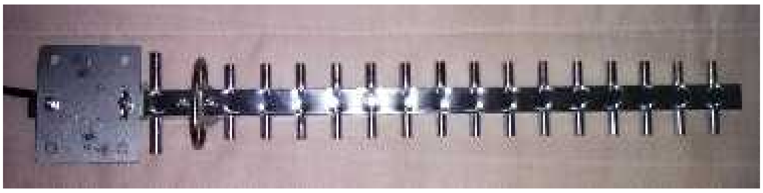

Figure 7. Antenna design results

4.2. Sensor Transceiver System

The overall system with integration of linear polarization antennas and sensor systems can be shown in Figure 8.

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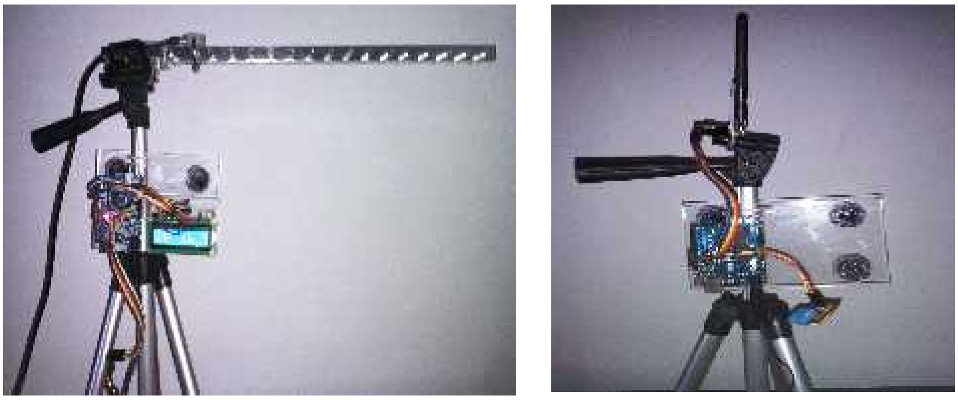

(a) (b)

Figure 8. Sensor Transceiver System (a) Receiver, (b) Transmitter

5. Measurement Results

5.1. Resonance Frequency

This resonance frequency is used to see the working frequency of the antenna that is designed, as shown figure 9.

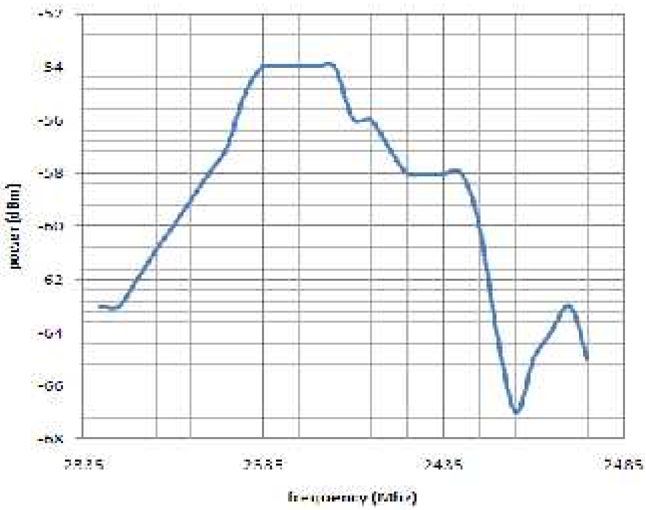

Figure 9. Resonance Frequency Yagi antenna

The antenna bandwidth can be determined by the equation 2.

BW = Bandwidth (Hz)

$$BW = f2 - f1 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

Where:

f1 = Lower Frequency = f_{lsb} (Hz)

f2 = Upper Frequency = f_{usb} (Hz)

Band Width Yagi antena:

Band Width $_{yagi}$ = 2450 MHz – 2365 MHz

Band Width $_{yagi}$ = 85 MHz

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5.2. Radiation Pattern

The antenna radiation pattern is a graphical statement that describes the radiation properties of an antenna in a far field as a function of direction [2], as shown figure 10.

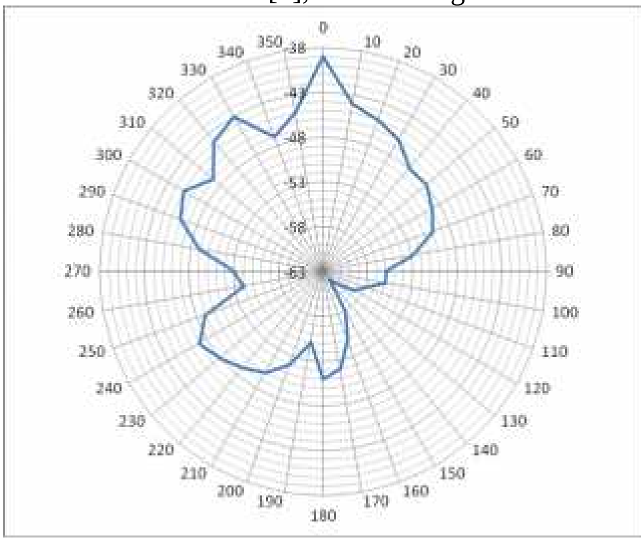

Figure 10. Radiation Pattern Yagi antenna

5.3. Antenna Gain

At 2.4 GHz frequency measurement, the received Monopole antenna power level is -48 dBm. The received Yagi antenna power level is -39 dBm. For the ½ Dipole antenna power as the comparator antenna, the gain power is -41 dBm.

The measurement results can be calculated the antenna gain (P1) to the λ ½ dipole antenna (P2), follow the equation 3.

$$G = P1 - P2 \text{(dBm)} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.. \quad (3)$$

Gain (G) Monopole antenna = -48 – (-41) = -7 dBm
Gain (G) Yagi antenna = -39 – (- 41) = 2 dBm

5.4. Data Streaming Testing

Referring to the data rate test, the streaming data test uses the same method which is sending data continuously (streaming) of 1000 bytes. Tests are carried out at 9600 bitrates and distances from 1 to 10 meters. This test is carried out 2 times each time the distance is increased. The test results are shown in Table 1.

Table 1. Measurement Delay of byte

Distance (m)	**Monopole (byte)**	**Dipole (byte)**	**Yagi (byte)**
1	20	0	0
2	8	21	20
3	8	15	12
4	50	1	24
5	10	20	1
6	36	18	34
7	6	0	8
8	0	0	5
9	0	10	2
10	20	40	2
Total	158	125	108

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6. Conclusion

From the results of measurements made, the conclusion is: for linear polarization antennas have a greater gain than monopole antennas, the radiation pattern of linear polarization antennas is uni directional and the measurement of the number of bits that experience delay using linear polarization antennas is less than other antennas.

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