Introduction

The main components in the design of WSN consists of a sensor unit, and communication unit.

Accelerometer sensor units composed used to measure the displacement of the soil material. Communication unit is composed by XBee module that transfers data between nodes can be done wirelessly. In addition to the sensor unit and the communication unit are also units of the Real Time Clock (RTC) as the unit that regulates the timing of data delivery.

Displacement of soil material position can be detected using H48C accelerometer sensor by means of double integration on acceleration data obtained from accelerometers.

Data obtained from the accelerometer containing noise so that the necessary filtering of data. The filter used is a digital filter Low Pass Filter (LPF) and using Bessel filter prototype.

WSN is designed using a star topology (Figure 1) by using 2 units and 1 unit gateway router.

Router malakukan duty for land acquisition movement data periodically and then sends it to the gateway. While serving gateway receives the data sent by the router and sends it back to-server.

Method of Acceleration Data Acquisition

H48C membaca data percepatan dengan menggunakan ADC 12 bit. Untuk mengkonversi data dari ADC 12 bit percepatan setiap sumbu(g) dapat dihitung dengan persamaan berikut.

RESULTS AND DISCUSSION.

Characteristics H48C.

Pada akselerometer H48C pengukuran statik dilakukan ketika sensor tidak mendapat gaya dari luar melainkan hanya gaya gravitasi.

Pada pengukuran statik ini akan menghasilkan data yang merepresentasikan posisi sensor relatif terhadap permukaan bumi. Sehingga dapat diperoleh sudut roll (φ), pitch(ρ), dan theta(θ).

In the static measurements will generate data that represent the position of the sensor relative to the earth's surface. To obtain the roll angle (φ), pitch (ρ), and theta (θ).

Formation of each - each angle φ, ρ, θ shown by figure 2, while the readings each - each angle is shown by Figure 3.

In the dynamic measurement data obtained acceleration sensor movement. This dynamic acceleration represents the influence of outside force that causes the sensor to switch positions. To test the dynamic acceleration is done by shifting the position of the sensor on each axis.

Direction of movement is shown by the graph acceleration sensor is formed. The movement begins with the positive direction of a hill and ends with the valley while the negative direction of movement begins and ends with a valley with a hill. Figure 4 shows the difference in graphics acceleration that is formed on the movement towards the positive and negative directions.

Figure 4. Difference in acceleration graphs formed at the direction of the positive (left) and negative direction of movement (right)

Figure 5 shows the results obtained from the accelerometer on the movement in the x-axis as far as 10 cm, 20 cm, 30 cm, 40 cm and 50 cm.

Figure 5. Acceleration data on the x-axis movement

B. Displacement Measurement Module

To get the position shift multiple integration process is carried out on the data obtained from the accelerometer acceleration. The first integration will produce velocity data. Equation (2) is an integration equation to obtain data on the speed of the n-th sample. While the transfer of data to obtain a position after the sample to - n used equation (3).

Figure 6 shows the graphs obtained from the data of acceleration, velocity and displacement.

Figure 6. (A) graphics acceleration, (b) the speed chart and (c) displacement graph

C. Bessel Low Pass Filter

Data from the accelerometer, there are still a lot of noise so that the necessary filters.

Acceleration data from the accelerometer signal information is represented in a discrete time series. So the selected filter IIR (Infinite Impulse Response) and analog prototype filter is selected Bessel filter LPF.

Accelerometer data capture as many as 125 within 1 second of data so that the sampling frequency is 125 Hz, while the frequency of 5 Hz cutt off is made.

The frequency response of the digital filter is in [0,1] while 1 represents π which is the Nyquist frequency so that π = 62.5 Hz. Cutt off frequency of the digital filter is ωc = fc / fs = 0:04 rad / s.

 To find the recursion coefficients of the transfer function filter that will be made on these tests were performed using the filters available on the website helper http://www-users.cs.york.ac.uk/ ~ fisher / mkfilter by inserting a sampling frequency parameter, cut-off frequency (corner frequency) and filter order.

Penentuaan order filter is done by comparing the value of RMSE (Root Mean Square Error) of the data obtained from the displacement response of each filter of order 1 to order 10. Filter with the best performance were selected.

The test results of the filter order on the x-axis movement sensor as far as 30 cm is shown in Figure 7.

Figure 7. RMSE value for each order

RMSE of the graph can be concluded that the order of 10 gives the best performance so chosen order of 10.

Recursion equations for order Bessel filter 10 is as follows (4).

With a and b are coefficients recursion to value each - each as follows:

b0 = 1

b1 = 10 a1 = -0.0217

b2 = 45 a2 = 0.3013

b3 = 120 a3 = -1.8999

a4 b4 = 210 = 7.1766

a5 b5 = 252 = -17.9970

a6 b6 = 210 = 31.3335

b7 = 120 a7 = -38.3927

b8 = 45 a8 = 32.7257

B9 = 10 a9 = -18.5945

b10 = 1 a10 = 6.3684

Comparison of data before and after filtered acceleration shown by Figure 8. Looks striking difference between the data before the data is filtered after filtered.

Figure 8. Comparison of data before filtered acceleration (a) with the following filter (b)

D. Communications Unit

Communication unit utilizing Xbee Pro Series RF module 1. Module is set in API mode with the data frame format that is used as follows:

1st byte = 0x7E

2nd byte = 0x00

3rd byte = 0x12

4th byte = 0x81

5th byte = MSB address

6th byte = LSB address

7th byte = RSSI

8th byte = 0x00

9th byte = hours

10th byte = min

11th byte = second

12th byte = date

13th byte = month

14th byte = year

15th byte = flag Dx

16th byte = Dx

17th byte = flag Dy

18th byte = Dy

19th byte = Flag Dz

20th byte = Dz

21st byte = 0x00

byte to-22 = checksum

Timing of data delivery is governed by utilizing DS1307 RTC unit. Data transmission is set at an interval of 5 seconds.

IV. TESTING SYSTEM

A. Accelerometer Testing

TABLE 1. TESTING OF EACH AXIS Accelerometer

Distance (cm) X Y Z

Error Measured Measured Measured Runtime Error

Error average - average 1.96 1.88 1.76

Table 2. Cross axis effect on each axis movement

Distance (cm) shift in X shift in Y shift in Z

TABLE 1 shows the results of the testing movement on each axis. Error average - average obtained is equal to 1.96 cm on the movement in the X axis, 1.88 cm on the movement in the Y axis and 1.76 cm on the movement in the Z axis

TABLE 2 shows the value of cross-axis effect that occurs due to the movement on one axis. Highest value of cross-axis effect is 6.91 cm.

B. Testing the RSSI (Signal recieve stength)

For the RSSI testing done by two methods: Testing the RSSI on the condition of Line Of Sight (LOS) and RSSI testing on berpenghalang field. To test LOS done on the beach Widarapayung Binangun Cilacap district. As for the testing performed berpenghalang Widarapayung coastal area which is a coconut plantation area with shrubs and bushes at the base of the soil.

LOS test results shown in Figure 9, the data collection is done every 20 m from 20 m to 500 m.

Tests performed on berpenghalang area at each 10 m from 10 m to 140 m. The test results shown in Figure 10.

Figure 9. RSSI graph on the module on the relationship LOS

Picture 10. RSSI graph on field berpenghalang

C. Testing Power Consumption

On the measurement of power supply used in the form of 2 pieces cell Lithium Polymer battery with a voltage of each - each with a 3.6 V 2600 mAh capacity and in series so that the overall power supply voltage is 7.2 V.

Measurements performed on modules that are running the program the router and sends the data through the RF module to the gateway with the data transmission interval 5 seconds.

The results of the measurements are shown in Table 3 below.

TABLE 3. CURRENT CONSUMPTION MEASUREMENT

Flow Unit

Controller (Arduino) 20 mA

RF (Xbee Pro) 62 mA

RTC (DS1307) 2 mA

Accelerometer (H48C) 1 mA

Total current 85 mA

With a current total of 85 mA and operating voltage is 7.2 V, so the module power consumption is 612 mW. With a battery capacity of 2600 mAh battery should ideally be able to supply modules for 30.5 hours but in fact may vary.

If using a battery as a power supply module, the battery capacity will determine the length of time the module work. So as to make the module work longer hours can be done in several ways such as adding battery capacity, minimizing the controllers work, as well as extend the time lag data transmission.

V. CONCLUSIONS AND RECOMMENDATIONS

A. Conclusion

Accelerometer can be used to perform the measurement of data transfer that can be applied to measure the movement of soil material. Data from the accelerometer, there are still a lot of noise so that the necessary filtering of data.

After using a Bessel filter order of 10, average error - the average measurement of 1.96 cm for the x-axis, y-axis to 1.88 cm and 1.76 cm for the z-axis.

In testing the data communication in LOS conditions, the module can still mlakukan RF communication at a distance of only 500 m was already weakened RSSI value to -97 dBm.

B. Suggestion

The use of accelerometers for measuring dynamic acceleration acceleration values ​​that are still affected by gravity so that the necessary ambahan pecepatan sensor tilt sensor to provide this correction can be done by adding a gyro.