The Effect of Bush Growth on Radio Wave Propagation in 920-MHz Band

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***Abstract* – The change of the radio wave propagation loss in 920-MHz band was examined as bushes in a farm grew higher. Received Signal Strength Indicator (RSSI) was measured as a function of the distance between the transmitting antenna (Tx) and the receiving antenna (Rx) in a 50 x 50 m mulberry field. Tx and Rx were placed at a height of 1.5 m. Moreover, the horizontal and vertical polarizations were measured. The results revealed that the path loss increased in both horizontal and vertical polarizations as bushes grew up and that the horizontal polarization could be less affected by bushes than the vertical polarization.**

***Index Terms* — Radio wave propagation, path loss, 920-MHz, wireless sensor network, bushes**

I. INTRODUCTION

Recently, studies on precision agriculture introducing IT have been performed widely by gathering Big Data obtained in a farm [1]-[5]. At present, crops are produced on the basis of human skills and experiences, so the know-how cannot be handed down easily. In this situation, however, we expect a solution of this problem if IT is introduced into agriculture.

Wireless sensors are set in a farm to introduce IT into agriculture. For example, they measure the amount of sunlight, temperature, moisture of soil and so on. Since it is troublesome to connect such sensor nodes with cables, wireless systems are suggested.

Various studies have been performed to design wireless sensor networks in a farm. If a lot of wireless sensor nodes are used, cost of their batteries should be cut down by reducing energy consumption of each node [5]. Calculating a link budget precisely helps design wireless sensor networks so that the transmission power of each wireless sensor node be minimized. In this paper, the path loss in a farm is gathered, and we focus on making it fundamental data to calculate a link budget. There are many cases reported in which path-loss prediction models are used. However, the short-distance path loss is not examined when plants are growing up and jamming the radio wave propagation. So, in this study we measured the distance characteristics of Received Signal Strength Indicator (RSSI) in a farm in 920-MHz band. 920-MHz band has the following advantages compared with 2-GHz band :

- Large diffraction capability
- Less interference
- Reducing the transmission power

We carried out the measurement in a mulberry field. The height of the bushes was from 0.92 to 2.19 m. The transmitting antenna (Tx) and the receiving antenna (Rx) were placed at a height of 1.5 m. RSSI was measured in the horizontal and vertical polarization.

II. FIELD AND MODULES OF MEASUREMENT

A. Wireless module to measure RSSI

As the wireless module to measure RSSI, we have used MH920-Node, which is compliant with the IEEE802.15.4 (MAC layer) , IEEE 802.15.4g (PHY layer) , and ARIB STD-T108. This module uses 922.3 - 928.1 MHz as the frequency band, and has a transmission output of 20 mW. The communication speed is 100 kbps and the modulation method is GFSK. Moreover, we use sleeve antennas for 920-MHz, which have a length of 195 mm, and a gain of 2.44 dBi.

B. Field of radio propagation

We measured the distance characteristics of RSSI in the mulberry field, as shown in Fig. 1.

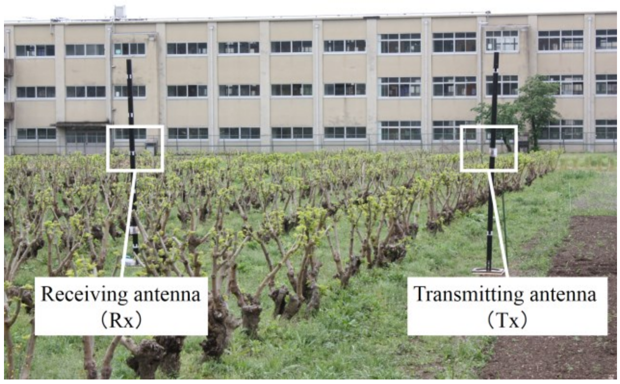
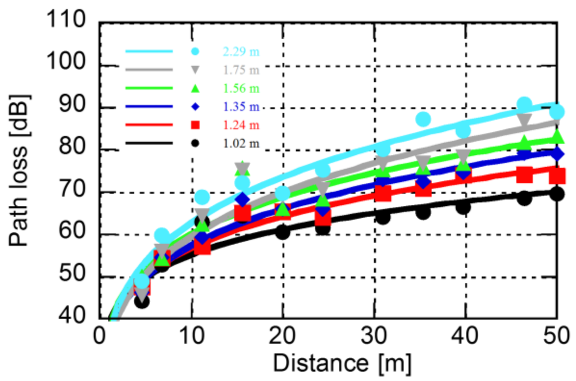


Fig. 1 Mulberry field to measure RSSI.

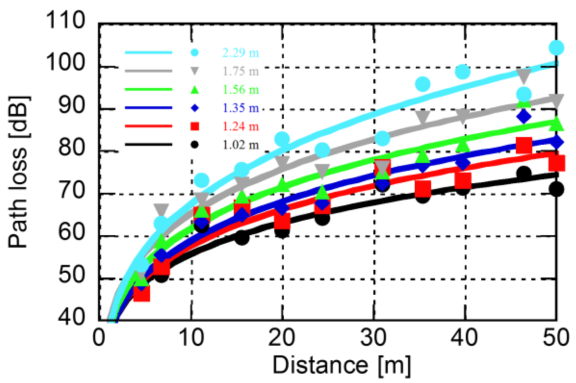
The width, length, and height of a ridge were 1.0, 50.0, and 0.1 m, respectively. Each ridge was at intervals of 2.2 m, and each mulberry was planted at intervals of about 0.5 m. We measured RSSI in the horizontal and vertical polarization when the distance between Tx and Rx was 4.6, 6.8, 11.2, 15.6, 20.0, 24.4, 31.0, 35.4, 39.8, 46.4, and 50.0 m, respectively. Tx and Rx were placed so that the straight line connecting the two antennas be vertical for the ridges. Moreover, they were placed at a height of 1.5 m.

III. MEASUREMENT

In the field and the measuring setup as described in Section 2, we measured RSSI when bushes were growing up and the height of them was changing. The height of the mulberry bushes was 1.02, 1.24, 1.35, 1.56, 1.75, and 2.29 m. We measured RSSI values ten times at each measurement point, and we used the mean value of them. Figure 2 shows the path loss calculated from the antenna gains of Tx and Rx, cable loss, and the RSSI we measured. Figure 2 (a) and (b) represent the path loss of the horizontal polarization and that of the vertical polarization, respectively. Moreover, fitted curves by power approximation corresponding to each height of the bushes are described in Fig. 2 through the method of least squares.



(a) Horizontal polarization



(b) Vertical polarization

Fig. 2 Path loss in 920-MHz band in the event of bush growth.

It is read from Fig. 2 that the path loss increased as bushes grew up. Comparing the power approximate curves in Fig. 2 (a) with those in Fig. 2 (b), it is found that the path loss of the vertical polarization is larger than that of the horizontal polarization at each height of the bushes. Therefore, the result reveals that the horizontal polarization can be less affected by bushes than the vertical polarization.

IV. CONCLUSION

In this paper, the radio wave propagation loss in 920-MHz band in a farm was examined in the horizontal and vertical polarization when bushes were growing up. The results revealed that the path loss increased as bushes grew up, and that the horizontal polarization could be less affected by bushes than the vertical polarization. These data would be useful for the evaluation of link budgets to design wireless networks in a farm.

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