Bare Demo of IEEEtran.cls for IEEE Conferences

Thomas Jørgensen
7. semester, Wireless
Communication Systems
Aalborg University
Email: tkjj13@student.aau.dk

Kemal Kapetanovic
7. semester, Wireless
Communication Systems
Aalborg University
Email: kkapet08@student.aau.dk

Mads Gotthardsen
7. semester, Wireless
Communication Systems
Aalborg University
Email: mgotth13@student.aau.dk

***Abstract*—The abstract goes here.**

I. Introduction

In the future it is likely that more and more wireless sensor networks (WSN) will appear. Many of such networks may be placed close to or directly in the ground for instance to monitor traffic flow or home power consumption examples could also include industrial or military uses. In such networks both power efficiency as well as reliability is key. To estimates those a reliable model for the path loss (PL) is needed. When placing the antenna so close to the ground a few problems occur, these problems still needs to be investigated further to effectively estimate the PL. Many of the earliest works only focus on frequencies below 30 MHz [**?**], and states that the complexity increases as frequency increases.

A. Modeller

In terms of calculating the path loss, different path loss propagation models can be applied, to calculate the power received, given different conditions. The Friss transmission equation calculates the power received, given only free space loss, and is given in the following Equation:

$$P_r = P_t G_t G_r (\frac{\lambda}{4\pi d})^2 \tag{1}$$

where P_r is the power received, G_t and G_r are the gains in the transmitting and receiving antenna respectively. While λ is the wavelength of the transmitted signal, d is the distance between the transmitting and receiving antenna. The model given above given in Equation 1 is not the the complete Friss transmission equation, as it indicates perfect polarization, and the the antennas are pointing directly at each other, and perfect matching between the system and antennas. The Friss transmission equation does not take into account the reflected wave. The reflected wave becomes significant as the distance increases between the transmitter and receiver antenna. Therefore another model can be used called, the two-ray-ground-reflection path loss model, and is given as:

$$P_r(d) = \frac{P_t G_t G_r h_t^2 h_r^2}{L \cdot d^4} \tag{2}$$

where $P_r(d)$ is the power received given the distance between the transmitter and receiver antenna, G_t and G_r are the gains in the transmitting and receiving antenna respectively. h_t^2, h_r^2 is the height of the transmitting and receiving antenna respectively. While L is the system loss, and d^4 is the distance between the transmitter and receiver antenna. As the two-ray-ground-reflection path loss model considers two waves,a direct and a reflected wave. Due to this the model predicts oscillations which are caused by the constructive and destructive combination of the two waves, if the following condition is true:

$$d < d_c \tag{3}$$

where d is the distance between the transmitter and receiver antenna, while d_c is called the cross over distance and is given as:

$$d_c = \frac{4\pi \cdot h_t^2 h_r^2}{\lambda} \tag{4}$$

When considering the power received, when placing the antennas at the ground another wave becomes a factor. This wave is called the surface wave, and is given by the following Equation:

$$P_r = P_t G_r G_t \frac{h_0}{d}^4 \tag{5}$$

where P_r is the power received, P_t is the power transmitted from the transmitter, G_r is the gain of the receiver antenna, while G_t is the gain of the transmitter antenna. A combination of the above mentioned models, shall give the power received, with respect to the direct wave, reflected wave and the surface wave this can be expressed as the $ground$ wave and is given in the following equation:

$$P_r = P_0 \left| \frac{E}{E_0} \right|^2 \tag{6}$$

where

$$\frac{E}{E_0} = [\underbrace{1}_{direct} + \underbrace{Re^{j\Delta}}_{reflected} + \underbrace{(1-R)Ae^{j\Delta}}_{surface}] \tag{7}$$

P_0 is the desired path loss model, where if the friis transmission equation is used, the $directwave$ is in use, and therefore the friis transmission equation will be multiplied by 1. While if the two-ray-ground-reflection path loss model it is indicated as P_0, and is multiplied with the $reflectedwave$ factor, where the rest is set as zero.

B. Subsection Heading Here

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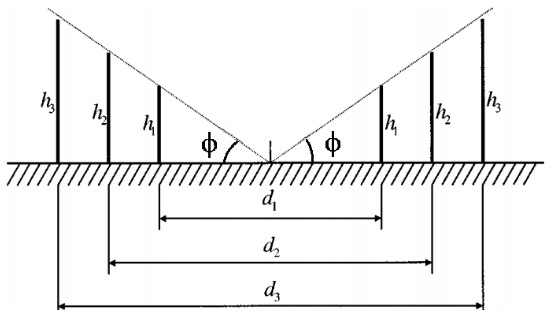

Fig. 1. Test billede

II. Conclusion

The conclusion goes here [**?**].

Acknowledgment

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