Radiation from a 430MHz Antenna in Manhole

1. INTRODUCTION

Modern cities increasingly rely on the infrastructure such as water-supply pipelines, electric power distribution network and communication trunk line network built underground. Monitoring and supervising underground facilities can be made easy if radio access is possible. Perhaps, radio access is desirable from the disaster mitigation point of view. This paper investigates the use of an antenna placed in a manhole to provide the radio access to water pipe sensors. Fields inside and outside of manhole generated by the antenna in manhole are calculated at 430MHz by 3D FITD (Finite Integration Time Domain) simulation. In Section 2, a model of manhole for water pipelines is presented. In Section 3, results of simulation are presented. In Section 4, results of experiment and simulation are compared to support the validity of simulation.

2. MANHOLE MODEL

Model used for the simulation study, a water pipeline manhole containing a rod antenna, is shown in Fig.1.

![Antenna in a water pipe manhole model](image)

Dielectric properties of soil, concrete and asphalt used in simulation are given in Table 1.[1,2]

![Cross-section of antenna used in the present study](image)

Fig.2. Cross-section of antenna used in the present study. La = 15.6cm, Da = 0.6cm, G = 0.5cm, Rd = 16.9cm, Td = 0.3cm. Coordinates of gap = (a, b, c) = (12.5, 0, -35.6) given in cm.

3. SIMULATION

Fields in and around the manhole are computed at 430MHz by the Finite Integration Time Domain method using a commercial 3D simulation software (CST MW Studio V5.1). [3,4] Results are presented in Fig.3, showing a contour plot of E-field (absolute) distribution. Fig.3 indicates that a region of asphalt layer:

![Contour plot of E-field (absolute) snap shot in xz-plane at 430MHz](image)
surrounding the metal top acts as a ring source region for the radiation into the space above ground. Approximately 1.7% of the antenna input power is radiated into the space above ground, according to simulation. Far-field radiation pattern (linear scale) in xz-plane corresponding to Fig.3 is presented in Fig.4.

Fig.4. Far-field radiation pattern (linear scale) in xz-plane at 430MHz. Main lobe direction = 23.0°. Angular width (3dB) = 26.5°. The pattern is expected for the radiation from ring source with D/λ = 1.17, where D = 82cm (metal top diameter) and λ = 69.8cm at 430MHz.

4. EXPERIMENT

A standard water manhole was built in a car parking lot covered with asphalt pavement. A 430MHz transmitter/receiver unit (battery powered) with a rod antenna (L_a = 21cm) and a reflector disk (R_a = 12.5cm) was held in the manhole with the antenna rod in vertical position. The metal top of manhole was closed before starting measurement runs. The z-component of electric field strength was measured using a calibrated standard measuring set comprising measuring receiver (ML522B, Anritsu), standard dipole antenna, and coaxial cable (10m). The receiving dipole antenna was held vertically by a wood support mounted on a wooden carriage, which allowed adjustments of its height and horizontal distance from the centre of manhole top. Results of E-field measurements in two directions (φ = 135°, 180°) are presented in Fig.5 along with the corresponding simulation results. Fig.5 shows that, although the simulation gives higher values than the measurement by about a factor of 2, basic features of E_distribution are quite similar in both simulation and measurement, demonstrating the validity of simulation.

5. CONCLUSION

Use of antenna placed in manhole is investigated. With an input power at 10mW, E-field strength was found to exceed 10mV/m over a wide range of distance from manhole, say, at a height of 3m above ground. It is possible to provide underground facilities with practical radio connection to/from above ground communication network using this technique.

ACKNOWLEDGEMENT

This work was conducted as a part of project, "Restoration Support with Image Processing and Ad Hoc Networking in Disaster," supported by the NICT, Japan, 2000-2005.[5]

REFERENCES