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DEVELOPMENT OF ELECTRIC FIELD COMMUNICATION DEVICE USING AQUEDUCT

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Abstract. *In 2016, an earthquake with intensity seven on the Japanese scale of one to seven occurred in Kumamoto, Japan. The water pipe burst and water supply will be cut off (water leakage) when an earthquake occurs. We need detect corruption and repairing for quick restoration. We proposed that water leakage detection system used electric field communication. This system used water in water pipe (aqueduct) as a data transmission path and connected outdoor water meter to indoor wireless LAN. In this study, we conducted the experiment using aqueduct 1.2 meters long and we confirmed possible signal received between transmitter to receiver. Aqueduct 1.2 meters long can connect outdoor water meter to indoor. It is suggested that electric field communication using aqueduct is feasible.*
Keywords: Electric field communication, Aqueduct, Disaster recovery

1. **Introduction.** In 2016, an earthquake with intensity seven on the Japanese scale of one to seven occurred in Kumamoto, Japan. The water pipe burst and water supply will be cut off (water leakage) when an earthquake occurs. The difference between number of leakage and number of repair is increased day by day. Waterworks do not carry water to the upper floors of a building because water pressure is in short supply.

The method for specifying fault location of water pipe network in Japan relies on human-wave tactics. When disaster happens, specifying fault location of water pipe network is delayed because of manpower shortage.

In previous research, water leak detection has been studied of water pipe leak detection using a machine learning [1] and development of smart water meter [2,3]. It is necessary to receive method for measured data. For example, data put on radio waves and send to Internet. However, in Japan, radio wave emission is limited by law. In any other way, waterworks patrol the location of smart water meter. It is large effort. We consider to establish communication between water meter to wireless LAN in building and transmit water meter's data to waterworks by way of Internet automatically.

However, water meter is not connected to LAN in building because water meter is often located outside of building and covers metal case. If we want to connect between water meter to LAN in building using wired cable, we must have the wiring work. This matter needs an immediate solution.

We proposed that water leakage detection system used aqueduct electric field communication [4]. It uses aqueduct as the transmission path of the electric signals by electro-quasi-static coupling between aqueduct and communication devices and connects between water meter to LAN in building.

Figure 1 shows this system. This system used water in water pipe (aqueduct) as a data transmission path and connected outdoor water meter to indoor wireless LAN. If Waterworks Bureau will use this system, wiring work is unnecessary and they can be data

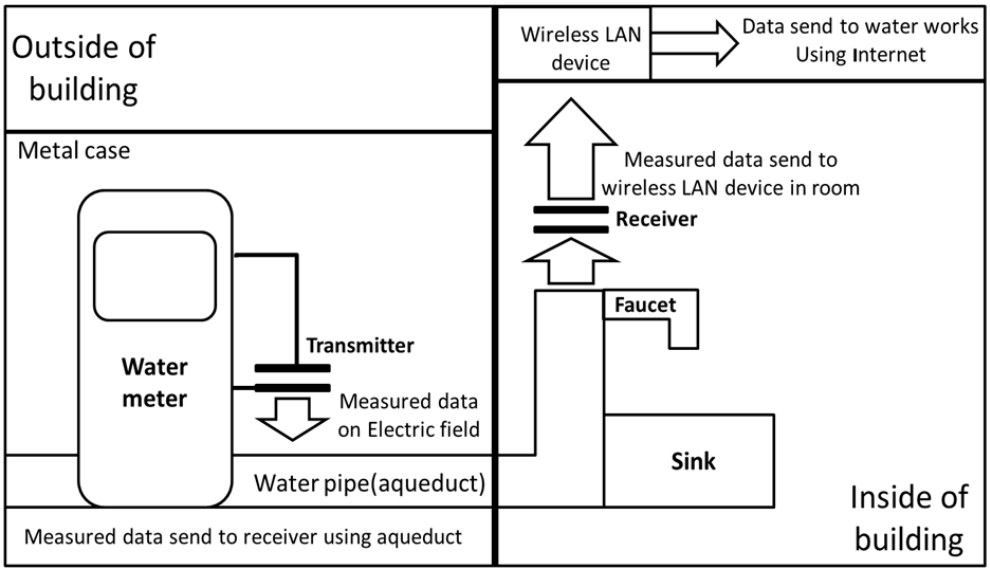

FIGURE 1. Aqueduct electric field communication system

collection without checking water meter directly. In this paper, we investigated feasibility about electric field communication using aqueduct.

2. **Research Questions.** In previous study, aqueduct's transmission characteristics have not been examined in any detail.

In this study, we investigate that electric field communication using aqueduct can send and receive signal. This experiment is in reference to near field intra-body communication [5]. Near field intra-body communication uses human body as the transmission path of the electric signals by electro-quasi-static coupling between human body and communication devices. Human body and aqueduct are similar to electrical properties [6].

3. **Methodologies.** We did communication experiment between transmitting terminal and receiving terminal. Figure 2 shows the transmitter terminals of electric field communication device using aqueduct. The transmitter terminals are modeled by a pair of parallel plate electrodes made of copper plate. The gap distance between the electrodes is 10 mm. Input voltage is 3 Vp-p and frequency is 5 MHz.

Figure 3 and Figure 4 show the transmission path. Figure 3 shows mixed agar into tap water. Length is 80 cm, width is 7 cm and depth is 3.5 cm. Figure 4 used water in PVC pipe as a transmission path. Input voltage of 5-20 MHz, 5 Vp-p is applied

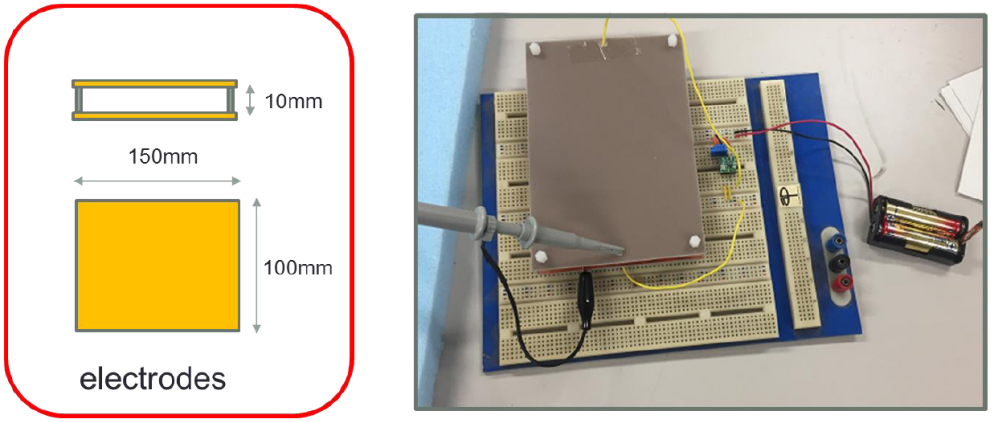

FIGURE 2. Transmitter terminals of electric field communication

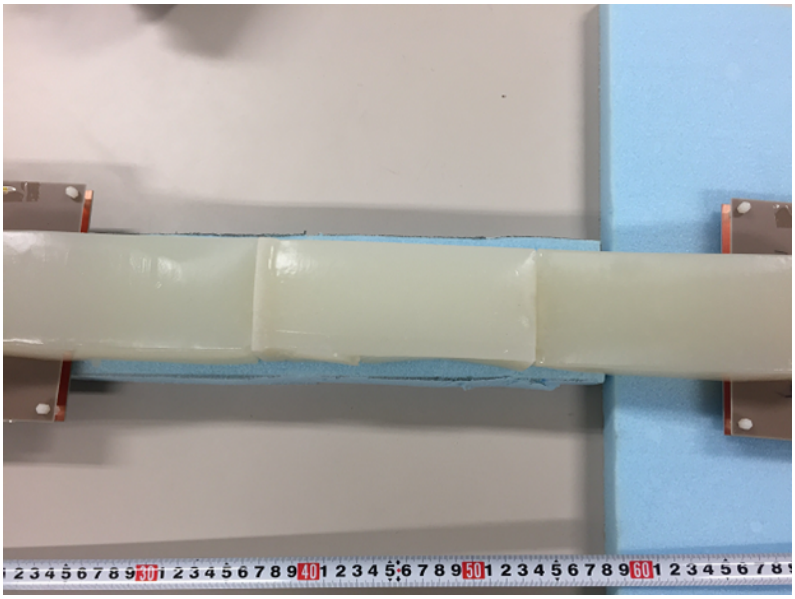

FIGURE 3. Photograph of experimental setup (mixed agar into tap water)

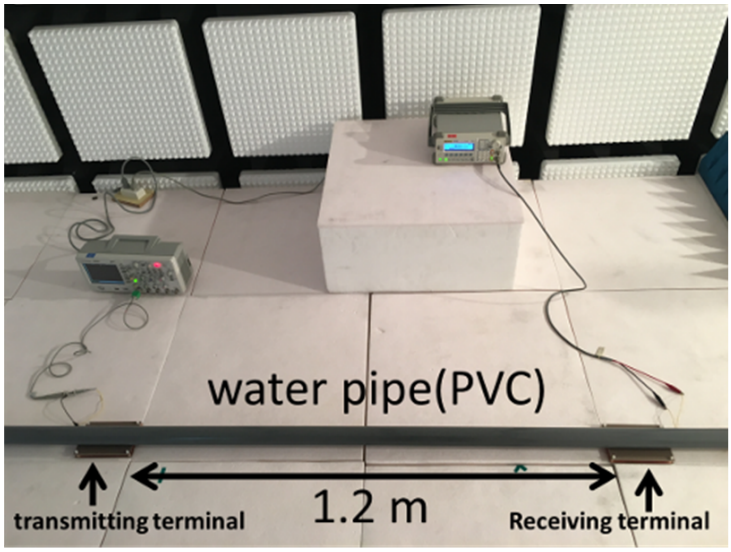

FIGURE 4. Photograph of experimental setup (water in PVC pipe)

between the electrodes of transmitting terminal. The distance between terminals is 20-120 mm. We measured induced voltage between the electrodes of receiving terminal. This is the transmitting terminal and this is receiving terminal. Water pipe is located between terminals.

4. **Results.** In Figure 5 vertical line shows the induced voltage on the receiving terminal and the horizontal one distance using mixed agar into tap water. Induced voltage is 0.1 Vp-p on the point of 80 cm. Figure 6 shows the wave form on 50 cm. the results suggested that transmission signal is detectable in this case. Figure 7 shows the comparison between the water in water pipe and air in water pipe. Solid line is water in water pipe. Dotted line is air in water pipe. The vertical line shows the induced voltage on the receiving terminal and the horizontal one frequency. The distance between terminals is 120 mm. Solid line is larger than dotted line. On the 15 MHz, solid line's induced voltage 2.5 times as large as dotted line. In Figure 8 vertical line shows the induced voltage and the horizontal one distance. Frequency is 15 MHz. Induced voltage is 1.1 Vp-p on the 1.2 m.

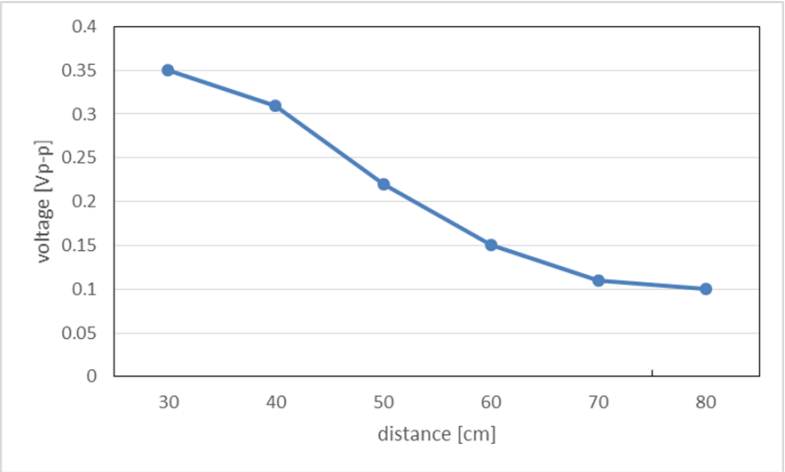

FIGURE 5. Induced voltage on the receiving terminal (mixed agar into tap water)

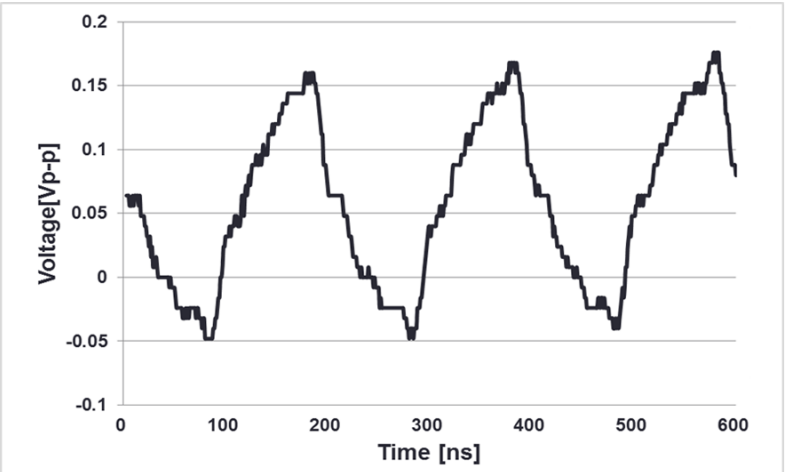

FIGURE 6. Wave form on 50 cm

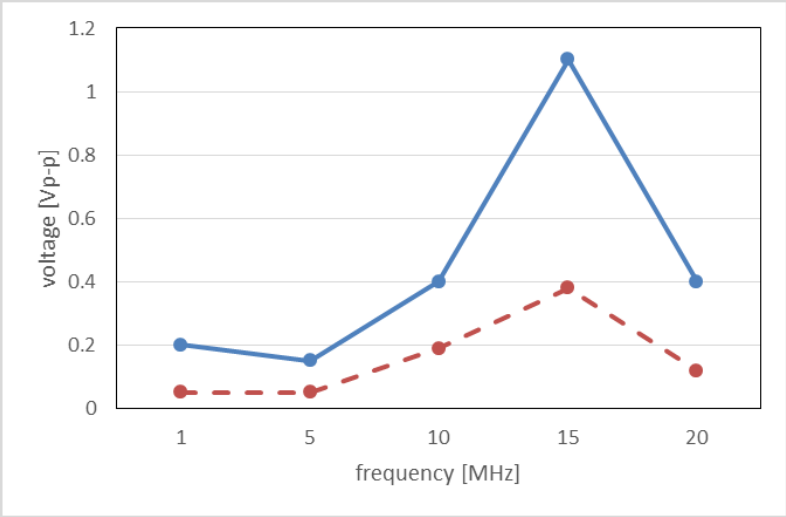

FIGURE 7. Comparison of induced voltage between water and air in PVC pipe (Distance: 120 mm)

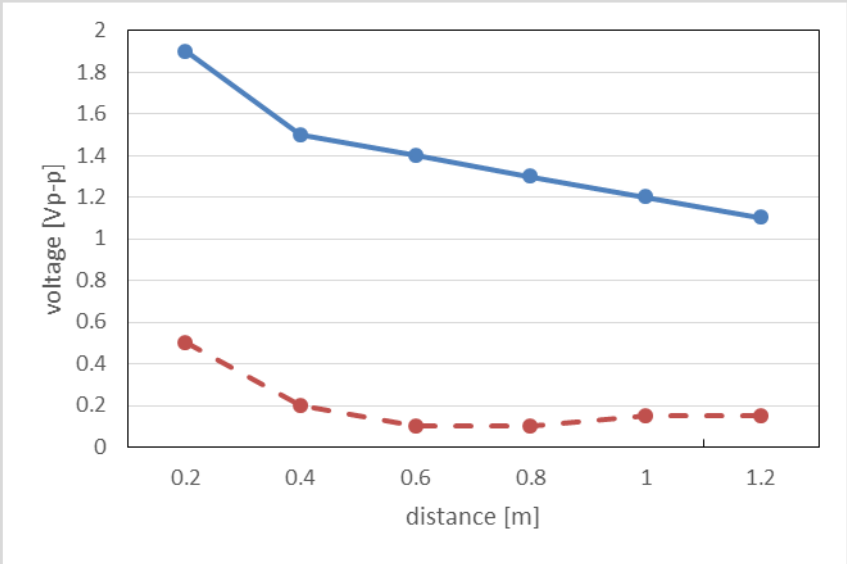

FIGURE 8. Comparison induced voltage between water and air in PVC pipe (Frequency: 15 MHz)

Figure 7 and Figure 8 suggest that receiving terminal's induced voltage using aqueduct is larger than air in water pipe and we can receive signal at 1.2 m long and induced voltage depending on the frequency. If we used to carry frequency 15 MHz, we can receive induced voltage 1.1 Vp-p at the point of 1.2 m on the aqueduct. Water pipe 1.2 m long can connect between water meter at outside to wireless LAN device at inside. It is suggested that we can establish communication path between water meter to wireless LAN in building and water leakage detection system using aqueduct electric field communication is feasible.

5. **Conclusion.** We investigated feasibility about electric field communication using aqueduct. We conducted the experiment using aqueduct 1.2 meters long and we confirmed possible signal received between transmitter to receiver. The aqueduct 1.2 meters long can connect outdoor water meter to indoor. It is suggested that we can establish communication path between water meter to wireless LAN in building and water leakage detection system using aqueduct electric field communication is feasible.

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REFERENCES

[1] T. Mizuno, H. Miyakawa, S. Meguro and J. Akahani, Study of water pipe leak detection using a machine learning, *Proc. of the IEICE General Conference, Communications (2)*, 2016 (in Japanese).
[2] S.-C. Hsia et al., Remote monitoring and smart sensing for water meter system and leakage detection, *IET Wireless Sensor Systems*, vol.2, no.4, pp.402-408, 2012.
[3] B. Zhang and J. Liu, A kind of design schema of wireless smart water meter reading system based on Zigbee technology, *International Conference on E-Product E-Service and E-Entertainment (ICEEE)*, 2010.
[4] Y. Yoshino and T. Taketa, Pre-experiment of development for water leakage detection system used electric field communication, *Proc. of the IEICE General Conference, Communications (1)*, 2017 (in Japanese).
[5] T. G. Zimmerman, *Personal Area Networks (PAN): Near-Field Intra-Body Communication*, Master Thesis, MIT Media Laboratory, 1995.
[6] S. Gabriel, R. W. Lau and C. Gabriel, The dielectric properties of biological tissues: III. Parametric models for the dielectric spectrumof tissues, *Physics in Medicine and Biology*, vol.41, pp.2271-2293, 1996.