Study Committee D2

Information Systems and Telecommunication

Paper ID_10533

THE LATEST WIRELESS COMMUNICATION TECHNOLOGY INITIATIVES FROM JAPANESE ELECTRIC POWER UTILITIES

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Motivation

- LPWA and private LTE have attracted considerable attention in many areas.
- Japanese electric power utilities are considering the scope to utilize these new wireless communication systems.
- To clarify applicability, LPWA radio wave propagation characteristics and certain application tests of private LTE in electrical power stations are evaluated and described.

An evaluation of LPWA radio wave propagation characteristics

- The LPWA (920 MHz band) is expected to be applied for collecting sensor data from a manhole.
- The propagation pathloss are 10 to 30 dB because of the shielding effects of metallic manhole covers.

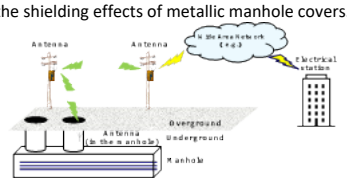

Fig. 1 Application image of wireless communication at a manhole for underground power transmission line facilities.

Application test of private LTE in electric power stations

◆ LTE technology trends

- In recent years, private networks utilizing LTE technology (private LTE) have been spreading.
- In Japan, the 1.9 and 2.5 GHz bands (sXGP and BWA standards respectively) were allocated as frequency bands usable for private LTE.
- However, LTE equipment has been converted into software and a “Software LTE” capable of running on compact PCs has been developed, making it possible to construct private LTEs more economically than before.

◆ Private LTE application tests (BWA standards) in a thermal power plant

- BWA can support both voice (≈100 kbps) and data communication (≥600 kbps) in thermal power plants and is applicable to in-house wireless communication systems covering wide-ranging areas.
- Private LTE is expected to further enhance operation and maintenance using IoT devices such as sensors.

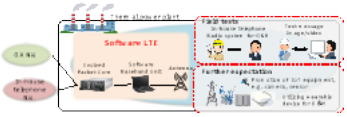

Fig. 2 Application image of a private LTE at a thermal power plant

◆ Efforts to construct a wireless network on the premises of an electric substation in the mountains

- It was confirmed that the radio wave propagation characteristics are consistent with the general model, even at the extra-high voltage substation.
- No electromagnetic impact on the radio wave propagation of sXGP and BWA standards from extra-high voltage substation electrical equipment was detected.

◆ Basic evaluation of Private LTE (sXGP standards) for using wireless communication in a substation

- Measured RSRP and throughput outside the substation within the premises, non line-of-sight to the antenna, given shielding by substation equipment.
- Confirmed communications are mostly available under the substation measuring conditions.

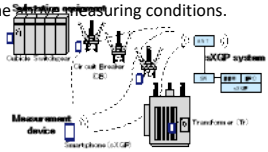

Fig. 3 Measurement image of private LTE (sXGP standards) at the substation

Conclusion

- LPWA radio wave propagation characteristics for collecting sensor data from underground power transmission line facilities are evaluated.
- Three private LTE application tests based on software technology in electrical stations are introduced.

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continued

An evaluation of LPWA radio wave propagation characteristics for collecting sensor data from underground power transmission line facilities

- Measurement setup (Fig. 4 & Table 1)

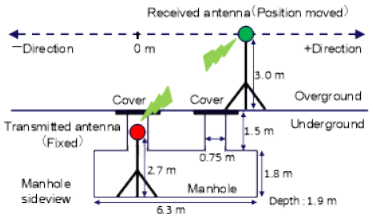

Fig. 4 Image of radio wave propagation measurement

Table 1 Specifications

Radio module	LoRa
Transmitted power	20 mW
Frequency ch.	24 ch (920.6 MHz)
Antenna	Dipole
Polarization	Vertical
Data length	50 bytes
Data transfer rate	21.875 kbps (Bandwidth 500 kHz, Spreading factor 7)
Transmission interval	2 sec
Measurement data	RSSI: Received Signal Strength Indicator
Average	30
Measurement PC	Windows 10, Raspberry Pi

- Measurement result (Fig. 5)

i. In terms of the difference between single and double cover, although negligible at distances of between 2 to 3 m, the RSSI of a single cover is about 10 dB higher when the distance exceeds 3 m.

ii. In terms of the difference between the manhole cover being open and closed, the RSSI is 10 to 30 dB higher when the manhole cover is open.

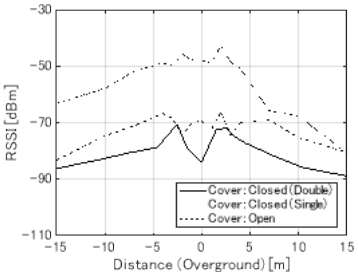

Fig. 5 Measurement result

Application test of private LTE in electrical facilities

◆ LTE technology trends

- The Private LTE standards in Japan (Table 2)

Table 2 Details of sXGP and BWA standards

Item	sXGP standards	BWA standards
Band	1.9 GHz band	2.5 GHz ban
License	None	Needed
Bandwidth	5 MHz	5 / 10 / 20 MHz
Throughput (Theoretical value)	Up: 3 Mbps, Down: 12 Mbps (For 2×2MIMO)	Up: 10 Mbps, Down: 110 Mbps (For 2×2MIMO, 20 MHz)
Communicable distance	50 to 100 m	about 2 km

- Software LTE (Fig. 6)

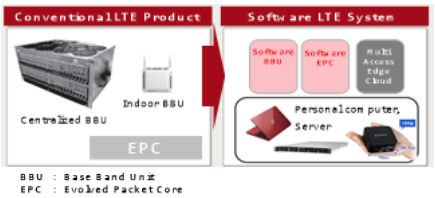

Fig. 6 A conceptual diagram of a conventional LTE product and a software LTE system

◆ Private LTE application tests (BWA standards) in a thermal power plant

- Field tests and results

i. The private LTE was connected to a PBX system and test calls were made between existing in-house telephones (PHS) and private LTE terminals (smartphones), as well as between smartphones. It was confirmed that voice communication was possible without any loss in quality.

ii. An application with a chat function was downloaded to the smartphone and data transmission tests, including messages, images and videos, were conducted. (A video transmission requires a speed of 600 kbps or more)

iii. Radio wave propagation was measured in the buildings and yards of the thermal power plant. It was confirmed that a single base station could cover almost the entire premises (assuming an area of around 24,000 square meters).

As a general rule, transmission is possible when the received power is -120 dBm or more. Since the received power was -120 dBm or more at most measurement points, the scope of the private LTE to cover almost the entire area of the thermal power plant could be confirmed.

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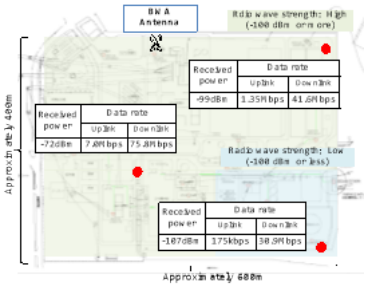

Fig. 7 Measurement of private LTE radio propagation characteristics in a thermal power plant

◆ Efforts to construct a wireless network on the premises of an electric substation in the mountains

- The field tests aimed to confirm the radio wave propagation characteristics and usability of contents via devices.
- The system configuration of the field test is shown in Fig. 8.

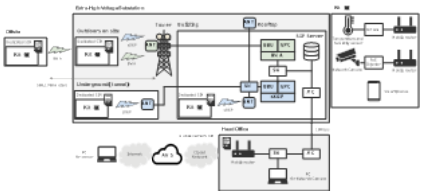

Fig. 8 Configuration of the field test system

- Radio wave strength measurements, throughput (uplink/downlink) measurements, delay time measurements and extension call tests via an SIP server, smartphone and extension applications were carried out at multiple measurement points. Also confirmed was the usability of contents with the network cameras and IoT devices at certain points where the radio wave strength was high and low.
- Regarding extension calls using SIP servers, smartphones and extension applications, it is confirmed that calls can be made promptly, even at points where the radio wave strength is low, provided a value of at least -110 dBm can be obtained.
- As for the visibility of video transmissions via network cameras, it is confirmed that if the radio wave strength is high and a throughput (uplink) of at least 2.0 Mbps can be obtained with a radio wave strength of about -90 dBm, smooth live video transmission is possible, even with a resolution of 1,920 x 1,080 (Full HD) and a frame rate of 30 fps.
- Confirmation over whether sensor information can be transmitted using IoT devices: it is confirmed that the sensor information can be transmitted, even at points where the radio wave strength is low.

◆ Basic evaluation of Private LTE (sXGP standards) for using wireless communication in a substation

- Result of the medium-scale substation (Figs. 9 & 10)
- The downlink throughput was stable, theoretically peaking at 6 Mbps.
- The uplink throughput was lowered near the shield by substation equipment as the distance between the measurement point and antenna increased.
- To ensure stable uplink throughput, antenna placement design is important, e.g. shortening the distance for radio wave propagation between communication devices and antennas by installing multiple antennas.

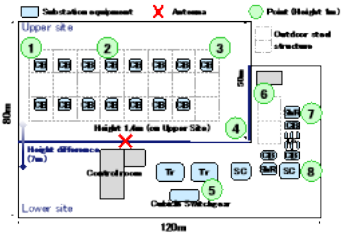

Fig. 9 Measurement points (Medium-scale substation)

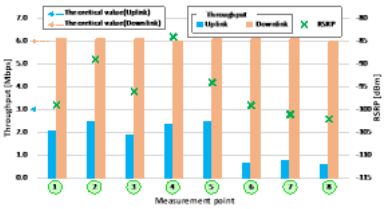

Fig. 10 Result of measurement (Medium-scale substation)