

Research of the application of the Low Power Wide Area Network in power grid

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Abstract. Low Power Wide Area Network (LPWAN) technologies developed rapidly in recent years, but these technologies have not make large-scale applications in different application scenarios of power grid. LoRa is a mainstream LPWAN technology. This paper makes a comparison test of the signal coverage of LoRa and other traditional wireless communication technologies in typical signal environment of power grid. Based on the test results, this paper gives an application suggestion of LoRa in power grid services, which can guide the planning and construction of the LPWAN in power grid.

1. Introduction

Low Power Wide Area Network (LPWAN) is an IoT(Internet of Things) technology which developed rapidly in recent years. LPWAN has the characteristics of long coverage distance, low power consumption and low operation and maintenance costs [1]. LPWAN technologies have not made large-scale applications in different application scenarios of power grid. Among several LPWAN technologies which have similar communication performance, LoRa is a mainstream technology using public spectrum resources [2]. This paper will test the signal coverage of LoRa and other wireless communication in typical signal environment of power grid to verify availability of the application of LPWAN in power grid.

2. Scheme of the comparison test

2.1. Test scheme

Traditional wireless communication networks in power grid include 2G/3G/4G public cellular networks rented from the telecom operators, 1800MHz and 230MHz private TD-LTE network[3].

The comparison test in this paper deploys the LoRa gateway equipment and the base station of the 1800MHz private TD-LTE network [4] in the same location. The locations of the base station can be on the roof of the office buildings or transformer substations which are the property of the power grid enterprises. This test selects several typical signal test points which cover the common electric environments where the measurement automation terminals and distribution automation terminals are deployed. This comparison test uses signal testing instrument to test and record the signal strength, packet loss probability and other performance parameters of LoRa, 1800MHz private TD-LTE network and public cellular networks in every signal test point.



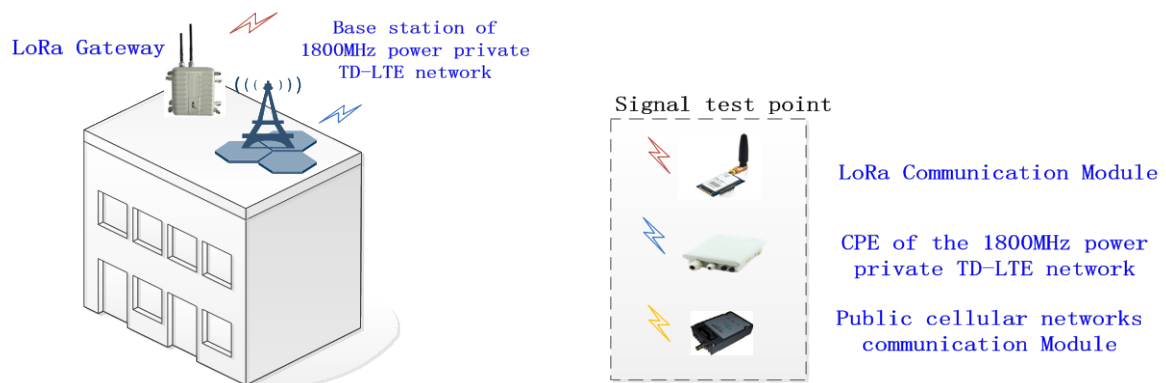


Figure 1. The scheme of the comparison test.

2.2. Specifications of the LoRa equipment in the test

The LoRa equipments in the test include LoRa gateway[5], LoRa communication module and LoRa signal tester.

2.2.1. LoRa gateway. The LoRa gateway can receive the data packets from the LoRa communication modules in its coverage area and forward them to application servers of power grid. The working frequency of the gateway is 470MHz~510MHz and the maximum sensitivity is -140dBm. The gateway has 9 configurable channels(The bandwidth of 8 channels of them is 125kHz, The communication speed of these 8 channels is adaptive and these 8 channels support the spreading factor SF7~SF12. One of the 9 configurable channels is a high-speed channel with 250 kHz /500 kHz bandwidth). The maximum power output of the gateway is 25dBm, in this test the output is configured in 17dBm and the radio central frequency is 476.5MHz. The access message length is 23 bytes and the normal message length is 13 bytes. The frame rate mode is configured into low speed mode. The roof height of the building where the LoRa gateway is deployed is 50 meters and the antenna height of the gateway is 3 meters.



Figure 2. The LoRa gateway in the test.

2.2.2. LoRa module. The LoRa communication modules can acquire the data packets from different service terminals of power grid and send them to the LoRa gateways. The LoRa module supports LoRaWAN Class-A/C protocol. The radio frequency of the LoRa module is set to 476.1MHz, 476.5MHz, 478.2MHz, and 478.8MHz, and the bandwidth is 125 kHz. The spreading factor of the LoRa module is set to SF12 (the maximum sensitivity is -140dBm at SF=12) and the encoding rate is set to 4/5.



Figure 3. The LoRa module in the test.

2.2.3. LoRa signal tester. The LoRa signal tester can test uplink data packet loss rate, downlink data packet loss rate, and the signal quality (RSSI and SNR) of the gateway sending packets.



Figure 4. The LoRa signal tester in this test.

2.2.4 Test points selection. This test selects 4 typical signal test points which cover the common electric environments where the measurement automation terminals and distribution automation terminals installed. The photos of the environments of these 4 test points are showed in Figure 5.

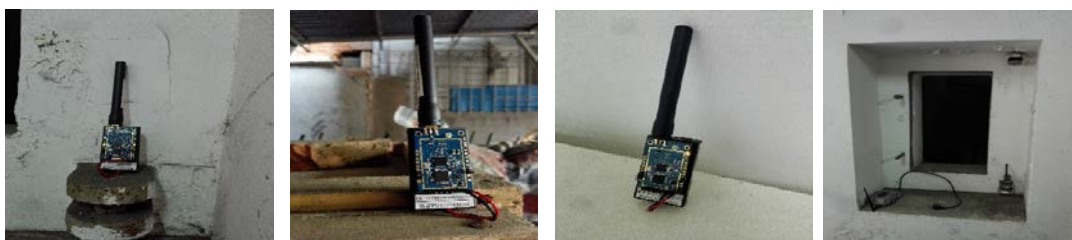


Figure 5. The environments of 4 test points.

3. Test results

3.1. Test results of LoRa

Table 1 shows the receiving sensitivity of LoRa in different spreading factors and bandwidths from the experimental data. In different environments, the test results of the LoRa in 4 test points are shown in Table 2. The results prove that In 4 test points with building sheltering, the LoRa network can make normal communication.

Table 1. Receiving sensitivity of LoRa in different spreading factors and bandwidths.

Bandwidth (kHz)	125	125	125	250	250	250	500	500	500
Spreading factor	7	10	12	7	10	12	7	10	12
Receiving sensitivity (dBm)	-125	-133	-140	-122	-130	-135	-118	-125	-130

Table 2. Test results of LoRa in 4 test points.

Test position	Frequency point	Bandwidth	Encoding rate	Test environment	Packet loss rate	Signal strength(dBm)	Communication status
Test point 1	476.5	125kHz	4/5	Park in the Negative first floor	1.05%	-102	Normal
Test point 2	476.1	125kHz	4/5	First floor indoor	0%	-81	Normal
Test point 3	478.2	125kHz	4/5	First floor indoor	0.00%	-86	Normal
Test point 4	478.8	125kHz	4/5	Park in the Negative first floor	3.44%	-108	Normal

3.2. Signal strength test results of the other wireless technologies

The signal strength test results of the other wireless technologies include 1800MHz private TD-LTE network, public cellular networks rented from China Mobile, China Telecom and China Unicom. The test results are showed in Table 3.

Table 3. Signal strength test results of the other wireless technologies.

Test position	RSRP of 1.8GHz private wireless network	China Mobile 4G	China Telecom 4G	China Unicom 2G	China Mobile 2G
Test point 1	No signal	-115dBm	-86dBm	Medium	Weak
Test point 2	-103dBm	-83dBm	-67dBm	Strong	Strong
Test point 3	-123dBm	-87dBm	-73dBm	Strong	Strong
Test point 4	-120dBm	-98dBm	-107dBm	Weak	Strong

The test results show that 1800MHz private TD-LTE network has worse performance in signal receiving in building sheltered electric environment. The construction of the indoor distribution systems of telecom operators can effectively improve the signal coverage of the public cellular networks in some test points. But in some sheltered electric environment without indoor distribution

systems, the signal of the public cellular networks is weak, so the dedicated private wireless network for power grid is necessary to solve the weak signal coverage of the telecom operators in some areas.

4. Conclusion

The comparison test results show that LoRa network has excellent signal coverage performance than traditional wireless networks used in power grid. Considering that the signal coverage of the indoor distribution systems of the telecom operators cannot cover some building sheltered electric environments, the power grid enterprises can apply LoRa network or other LPWAN with similar communication performance as the communication channel for low-bitrate M2M power grid services.

References

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