

An Overview of LTE 230 System in Smart Grid

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Abstract. LTE 230 system developed based on 4G LTE core technology distinguishes out of several specified wireless network for its advantages of wide coverage and low cost considering with the communication requirement for power allocation application in smart grid. The system is able to offer a complete solution for electric power communication for its advantages of a large vesture radius, ability to support vast numbers of users, adaptability for electric power service, high transmission rate and high reliability. Simulation results have proved its coverage ability in dense urban and transmission ability in wideband.

Introduction

The development of smart grid has triggered the increasing requirement for reliable and secure power system. The terminals of the smart grid are widely scattered, making the transmission through fiber impractical due to high cost of material and complex deployment. So the full coverage of amount users will not be realized in spite of its strong transmission ability. Fortunately, the wireless communication technology has been mature to support the transmission service which has been a supplement of wired fiber communication even a dominant one in power system [1]. The construction of wireless specific frequency band (i.e., 230MHz) has attracted more and more attention.

Currently, almost all the grid employs the GPRS, CDMA provided by the telecommunication operators on loan, as a wireless communication method to fulfill the services like collect information and so on. The public wireless network provides the convenience of no requirement for network deployment and maintenance, just a one-off payment to the operators [2]. However, this kind of network always gives the highest priority to publican voice and data service in which way the security, no latency and QoS of power system service cannot be satisfied. It is thus essential to have

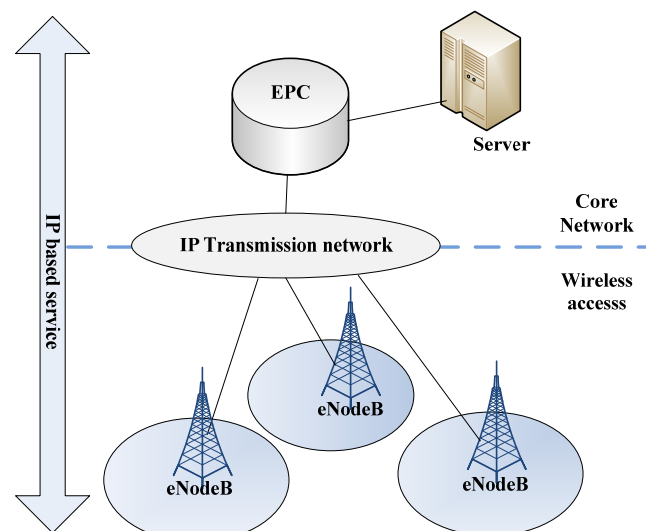


Figure 1 Illustration of the network structure for smart grid based on LTE 230.

a specified wireless network that does not rely on the public wireless network to ensure the requirement for the service in smart grid power system.

LTE 230 transmission system operates on 230MHz band which is exclusive to power system. Figure 1 shows the structure of smart grid based on LTE 230. In this structure, all the power equipment is connected with the eNodeB through LTE technology. All the transmissions between power equipment and eNodeB are IP based and the connections between eNodeBs and core network are also IP based. Such a network structure separates the control plane and the user plane which can simplify the organization of smart grid and decrease the latency of transmission. At the same time, it helps the LTE 230 system provide perfect management for network equipment and the remote communication module, various remote customization and configuration for the customer then can be realized. It has the advantage of long distance coverage benefited from the low frequency property, that reduces the expense in both construction and maintenance than other systems. Furthermore, electric power system has been endowed with 40 authorized frequencies access point on 230 MHz frequency band by the national radio regularity community. Henceforth, LTE 230 occupying the advantage in nature and policy will help achieve the goal for service in electric power system.

Smart grid based on LTE 230

The existing specified wireless communication band concludes LTE 230 system, 230 radio modem and 1800MHz wireless wideband transmission system. The criteria of electric power wireless network technology system selection mainly consider three factors: the single base station coverage radius, the adaption with electric power service and the transmission rate.

The traditional 230 radio modem has nearly the same coverage ability as LTE 230, but it can only support narrow band data transmission in low data rate, which make it unable to satisfy the wide bandwidth and high data rate requirement. Most wireless communication system operates in high frequency (e.g., 1800MHz) [3]. Despite the strong data transmission ability, it suffers for the weak coverage ability which will cause a high construction cost, and the mediocre ability to integrate the electric power service. All the three factor mentioned previously considered, LTE 230 satisfies application requirements of power industry, has the advantages of wide coverage, broadband transmission ability and in particular it is exclusively developed for the power industry. So LTE 230 is best choice for electric power applications in communication system. The remainder of this paper elaborates the advantages of LTE 230 exclusive for electric power system wireless communication applied in smart grid network in detail.

Coverage of LTE 230

Terminals of electric power allocation service in smart grid are widely scattered. The Use of base stations having wide coverage can not only decrease the number of base stations constrained in the same area, but also reduce the network optimization complexity. The realization of seamless coverage and low emergence of blind area, reduce the probability of hand-off, thus improving the stability and the reliability of communication.

Coverage is an important indicator for wireless communication, which also directly affects the cost including hardware, the rent for base station, engineering installment, power supply and manual maintenance. Thus the coverage is a key factor determines the selection of communication systems.

Simulations are lunched for the coverage ability performances in 230MHz, 400MHz, and 1400MHz using Okumura model, and 1800MHz and 2400MHz using COST 231 model [4].

Okumura model is applicable over distances of 1-100 Km and frequency ranges of 150-1500MHz. The base station heights for these measurements were 30-100 m, the upper end of which is higher than typical base stations today. The empirical path loss formula of Okumura at distance d parameterized by the carrier frequency f_c is given by

$$P_L(d) \text{ dB} = L(f_c, d) + A_{mu}(f_c, d) - G(h_t) - G(h_r) - G_{AREA}$$

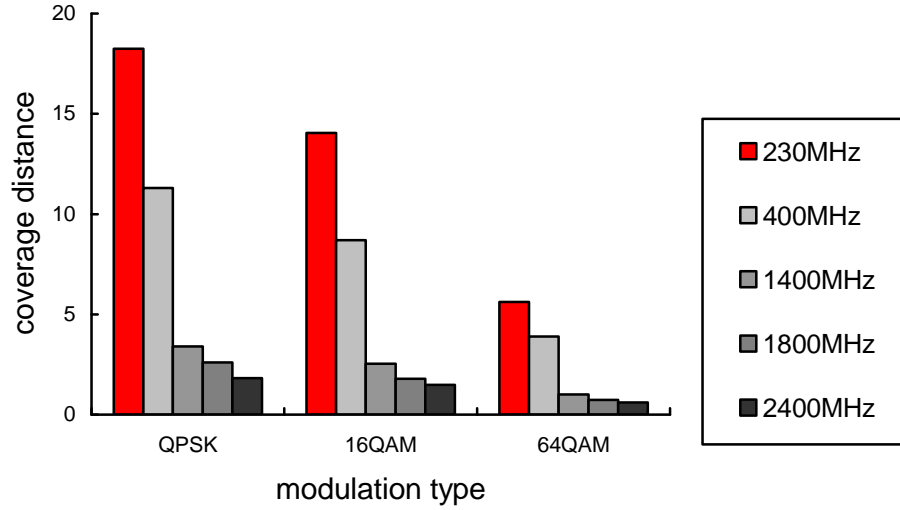


Figure 2 coverage performance

where $L(f_c, d)$ is free space path loss at distance d and carrier frequency f_c , $A_{mu}(f_c, d)$ is the median attenuation in addition to free space path loss across all environments, $G(h_t)$ is the base station antenna height gain factor, $G(h_r)$ is the mobile antenna height gain factor, and G_{AREA} is the gain due to the type of environment. The values of $A_{mu}(f_c, d)$ and G_{AREA} are obtained from Okumura's empirical plots. Okumura derived empirical formulas for $G(h_t)$ and $G(h_r)$ as

$$G(h_t) = 20 \log_{10}(h_t / 200), \quad 30 \text{ m} < h_t < 1000 \text{ m}$$

$$G(h_r) = \begin{cases} 10 \log_{10}(h_r / 3), & h_r < 3 \text{ m} \\ 20 \log_{10}(h_r / 3), & 3 \text{ m} < h_r < 10 \text{ m} \end{cases}$$

COST 231 model is

$$P_{L,urban}(d) \text{ dB} = 46.3 + 33.9 \log_{10}(f_c) - 13.82 \log_{10}(h_t) - a(h_r) + (44.9 - 6.55 \log_{10}(h_t)) \log_{10}(d) + C_M$$

where $a(h_r)$ is the same correction factor as before and C_M is 0 dB for medium sized cities and suburbs, and 3 dB for metropolitan areas. This model is restricted to the following range of parameters: $1.5 \text{ GHz} < f_c < 2 \text{ GHz}$, $30 \text{ m} < h_t < 200 \text{ m}$, $1 \text{ m} < h_r < 10 \text{ m}$, and $1 \text{ Km} < d < 20 \text{ Km}$.

The results are shown in Figure 2, from which we can observe that communication on 230MHz has the best coverage, exceeding about 15 km than the traditional 1800MHz band in QPSK modulation type.

Transmission rate of LTE 230

Electric power communication is a typical uplink oriented asymmetric service, so we focus on the uplink simulation. We use different modulation types (e.g., QPSK, 16QAM and 64QAM) operated on the 40 authorized frequencies points [5]. The result is plotted in Figure 3 ranging from 0 dB to 20 dB and the peak transmission rate is stored in TABLE 1. We can see that the maximum throughput capacity existing in 64QAM reaches 25Mbps under the conventional receiver operating SNR region (from -7 dB to 19.5 dB) that is covered by the modulation and coding scheme (MCS) in the current release of LTE specifications.

Summary

LTE 230 wireless communication equipped with advanced technology is dedicated to satisfy the demand of power allocation service with the advantage of wide coverage and low cost. The simulation results verified its coverage ability in dense urban and strong transmission ability applied

in electric power system. With the increase of the number of electric power services and the related terminals, a more versatile and intelligent power grid construction scale will gradually be established.

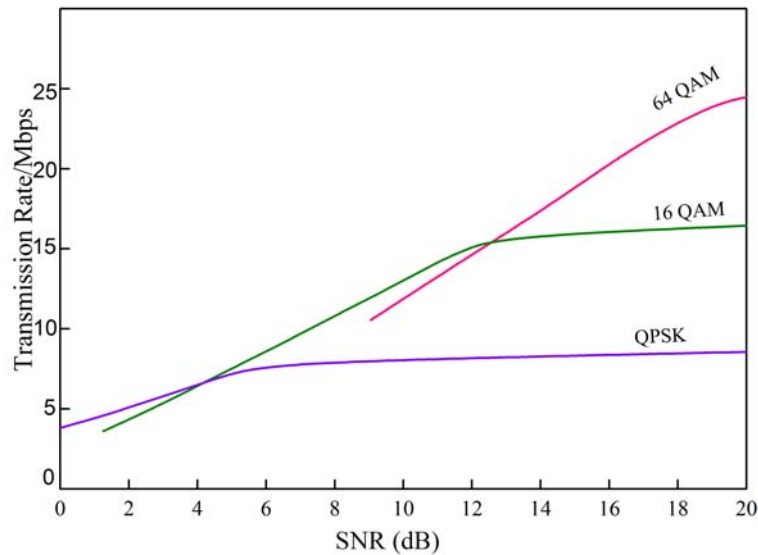


Figure 3 transmission rate at different SNR

TABLE 1 Transmission Rate

| Modulation | QPSK | 16QAM | 64QAM |
|------------------------|------|-------|-------|
| Transmission rate/Mbps | 7.2 | 14.7 | 24.3 |

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