Research on Power Wireless Private Network Based on Dual-band Fusion Base Station

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Abstract. Power wireless private network provides fundamental support for developing and fulfilling various power grid related businesses. It becomes more and more crucial to improve the reliability and cut its construction cost. In this paper, the deployment of the fusion base station in the power multi-band wireless communication system was studied and a fusion system for wireless communication working in the dual-band of 230MHz and 1800MHz is proposed based on the characteristics of different types of terminal service and its communication requirements in the smart grid. Corresponding hardware and software for the fusion base station were developed accordingly. Meanwhile, the system was deployed on site in a real-time environment. And comprehensive tests were conducted on relevant technical indicators. Test results show the system works reliably and have met the designed technical requirements, and the system has significant reference for the networking mode of the power wireless private network.

1. Introduction
State Grid Corporation's investment in the smart grid continues to increase, and the power communication access network is gradually entering the stage of large-scale deployment after pilot phase of local areas. In particular, the fourth generation of wireless communication technology (LTE) has gradually become the mainstream technology of smart grid wireless communication networks. The wireless frequency is mainly in the 230MHz band and the 1800MHz band (referred to as LTE230 and LTE1800 in the text) \cite{1}. The test result of pilot networks meet the needs of power applications.

The 230MHz wireless signal has the characteristics of low frequency band, small space loss and strong diffraction capability. A single base station can cover a large area, but has fewer frequency resources, so it is suitable for widely distributed low-rate terminal communication scenarios \cite{1}; 1800MHz wireless has the characteristics of high frequency band and large space loss. The coverage area of single base station is relatively small \cite{2}, but the 1800MHz frequency band is rich in resources and can be applied to high-speed terminal communication requirements. Therefore, high-bandwidth communication services have advantages in local hotspot areas \cite{2}.

Power service applications need to consider 230MHz and 1800MHz network integrated applications, so it is practical and necessary to study the dual-band wireless base station system \cite{3}.

Both the 230MHz wireless private network and the 1800MHz wireless private network have in-depth research and application, but the application research of integrated device fusion of these two frequency bands has not appeared \cite{4}. In the field of operators, there are design and application of
GSM900/DCS1800 dual-band base station test system. The characteristics of wireless frequency space propagation and 230MHz are very different. The implementation concept can provide reference for this paper [5][6].

Based on the research of networking mode of LTE wireless private network in 230MHz frequency band and 1800MHz frequency band, this paper proposes the hardware and software implementation scheme of fused wireless base station, and obtains application verification in the power company experimental network.

2. Cross-band wireless communication system

2.1. Cross-frequency networking requirements
According to the statistics of the State Grid Corporation, it is estimated that the number of business terminals will reach 16.87 million by the end of the “13th Five-Year Plan”. Among them, the single-site communication demand of terminals such as distribution automation and power consumption information collection is relatively small. But these services are widely distributed and are suitable for LTE230 wireless network bearers; However, the single-point communication demand of terminals such as integrated monitoring of power distribution stations, transmission and distribution machine inspections is high and the distribution is concentrated [1], which is more suitable for LTE1800 wireless network bearers. Thus, cross-band networking has practical needs.

2.2. Fusion networking mode
The wireless data transmission and reception of two frequency bands is implemented on the same set of wireless base station platforms, and the system structure of the cross-band fusion networking mode is as follows:

![Figure 1. Networking mode of fusion base stations](image)

According to Figure, the fusion networking implements dual-band wireless signal coverage at 230 MHz and 1800 MHz in the same base station, which simplifies network design and reduces base station construction costs, thereby reducing the complexity of later operation and maintenance.

3. The design of fusion base station
The difficulty of the scheme design is that the converged base station not only receives the air interface messages of 230MHz and 1800MHz, but also comprehensively processes the services of the network to which the two frequencies belong [7]. The design of the converged base station is as follows.

3.1. Overall architecture design
The fusion wireless base station adopts a split base station design and is divided into an eBBU (enhanced Base Process Unit) and an eRRU (enhanced RF unit). The eBBU unit communicates with the eRRU230 and eRRU1800 through the Ir port.

![Design architecture of the fusion base station](image)

From the above design, the cross-band technology implementation is mainly in the eBBU network element, that is, the eBBU processes the air interface messages of the two frequency bands received through the optimized protocol stack to achieve dual-frequency fusion [8].

### 3.2. eBBU hardware implementation

The eBBU hardware logic is composed as shown below.

![Hardware design of the fusion base station](image)

The main control module is the core processing module of the eBBU and is responsible for overall system control.

The baseband processing module is the most critical processing unit for dual-band fusion. It completes the processing of the baseband signal, and can simultaneously accept the Ir interface data of the eRRU230 network element and the eBBU1800 network element, and performs decoding and different protocol adaptation processing.

### 3.3. eBBU software implementation

The eBBU software mainly implements the following functions: signaling processing, service processing, and operation and maintenance performance. Meanwhile, the eBBU software also needs to complete some basic module functions, such as the transmission network function including the communication protocol stack function, the synchronization timing function, the middleware operation support function [9]. The hierarchical and modular system architecture is as follows:
Figure 4. Software architecture diagram of the fusion base station

1. Application software layer: The application software layer includes a control plane protocol stack module, a user plane protocol stack module, a baseband processing module, and an operation and maintenance module;

2. Synchronization timing function: The module can provide accurate GPS/Beidou clock and calculation function of the air interface system frame number;

3. Transmission network function: This completes the communication interaction between the internal boards and the network elements;

4. Middleware operation support function: This provides functions for inter-application signaling communication, inter-board signaling communication, timer, resource management, memory management, and shared tasks for upper-layer applications.

On the application layer control plane protocol stack module, user plane protocol stack module, baseband processing module and operation and maintenance module several functional modules, the implementation body of the dual-band fusion software is processed for the 230MHz and 1800MHz protocols.

4. Test verification

In order to verify the results of the dual-band converged wireless base station, we built an experimental network at the power company and tested it for key functions. The test results are in line with expectations, which proves that the research results and application feasibility.

4.1. Key function verification

The experimental environment of the test is located in the office building of the power supply company. At the same time, a set of fused wireless base stations is constructed to realize wireless coverage of 230MHz and 1800MHz, and the wireless coverage and fusion functions of the two frequency bands are tested and verified.

4.1.1. Fusion function

The 230MHz coverage sector and the 1800MHz coverage sector are successfully configured under the fused base station, and the communication terminals of the two frequency bands are successfully accessed in the corresponding sector to confirm the support of the dual-band by the fused base station.

4.1.2. Coverage performance

To verify coverage performance by Drive Test(DT) method, driving with a terminal for field signal strength testing along the road, automatic recording the signal strength and latitude and longitude information through the test software, and define -110dbm to the lowest level that can be accessed.

230MHz test results: the signal coverage is 8km farthest to the east, 8.8km to the south, 10km to the west, and 9km to the north.
1800MHz test results: the east, south, west and north directions have an effect coverage distance of less than 2km, and the farthest is about 4km in the northwest direction. The test result is as follows.

![Figure 5. Test chart for 230MHz signal coverage](image)

![Figure 6. Test chart for 1800MHz signal coverage](image)

4.1.3 Throughput test
The communication terminal is configured according to the authorized frequency resource. The LTE 230 communication terminal has a frequency of 1 MHz, and the LTE 1800 communication terminal has a frequency of 10 MHz, and respectively performs a throughput test. The test result as below:

| Test | RSRP (dbm) | LTE230 Throughput (kbps) | LTE1800 Throughput (kbps) |
|------|------------|--------------------------|---------------------------|
| 1    | -75        | 1530                     | 13730                     |
| 2    | -80        | 1530                     | 13510                     |
| 3    | -85        | 1520                     | 12870                     |
| 4    | -90        | 1490                     | 12220                     |
| 5    | -95        | 1330                     | 12940                     |
| 6    | -100       | 895                      | 7230                      |
| 7    | -105       | 346                      | 3040                      |
| 8    | -110       | 118                      | 1030                      |

4.2 Analysis of test results
(1) The LTE230 wireless signal covers the maximum distance of 10km, and the LTE1800 wireless signal covers the most 4km. The low-band wireless signal is obviously superior to the high frequency band in the coverage distance.

(2) The fusion base station can simultaneously access the LTE230 and LTE1800 communication terminals, and successfully realize the dual-band wireless coverage of 230MHz and 1800MHz, so this scheme is feasible.

(3) The LTE1800 frequency band is rich in resources and is more suitable for local high bandwidth services.

5. Conclusion
Based on the research results of wireless base stations with dual-band fusion, the test network was constructed and tested, and the test results were in line with expectations. By extending the multi-band support function of the base station system, we have realized the cross-band fusion of wireless base stations and provided a wide-narrow integrated communication network, which effectively reduces the cost of network construction and has exemplary significance for the power grid industry and other industries.

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