Electronic fence device based on UWB positioning technology

Ting Zhang¹,*

¹School of Electrical and Electronic Engineering, North China Electric Power University, Baoding 071003, Hebei, China

*Corresponding author: 201801001725@ncepu.edu.cn

Abstract. The UWB high-precision positioning in the substation can realize the accurate judgment of indoor switch cabinet aisle spacing, limit the working scope of operators, and form an invisible electronic fence device. By installing positioning tags in the helmets worn by operators, real-time observation of personnel positioning can reduce the incidence of accidents and ensure the safety of electricity use.

Keywords: UWB positioning, electronic fence device, electrical safety

1. Introduction
With the maturing of the deep learning technology, it is widely used in all walks of life, but at the scene of the power grid safety regulation, technology is not closely integrated with the actual business, and the current application of image recognition algorithm is based on the cloud processing. In the case of mass data processing and poor network on the job site, it is unable to effectively identify. Therefore, it is of practical significance to make information collection intensive and supervision efficient.

The electronic fence combines a locating tag with a locating base station, and combined with the background map layout, when workers enter the danger zone set, the buzzer will alarm, at this time if you want to close the current buzzer alarm, can push a button on the tag shell, buzzer alarm is lifted, effectively improve the existing physical fence is not comprehensive, not in time, the defects of no alarm.

2. Electronic fence device based on UWB

2.1. Ultra Wideband technology
The wireless positioning measurement algorithm is to analyze the characteristic parameters of the received radio wave signal, and then calculate the position of the measured object according to the specific algorithm (two-dimensional/three-dimension alcoordinates:Longitude, latitude, altitude), there are three kinds of commonly used indoor wireless location method, respectively is based on the received signal arrival time TOA (time of arrival), based on the signal arrive Angle AOA (arrival of angle), based on the received signal the arrival time difference TDOA (time difference of arrival), the three algorithms under different environment the positioning accuracy of each have advantages and disadvantages. The fusion based on the above positioning algorithms has gradually become a hot spot in the current research. For example, TOA and TDOA algorithms can improve the positioning accuracy.[1]
In this paper, the UWB positioning technology based on TDOA algorithm is selected, which is greatly different from the traditional technology. Information transmission is realized by sending and receiving data with nanosecond or sub-nanosecond very short time. Therefore, it has a long bandwidth, 3.1~ 10.6Hz bandwidth, so compared with the ordinary traditional narrow-band system, it has more penetrating power, so the positioning is more accurate and the system performance is better.

UWB technology can be applied to the tracking, positioning and navigation of stationary or moving objects or people in the room. By providing positioning tags to people, positioning tags can be located and tracked with the time difference between the propagation and arrival of wireless signals from the base station in the area. At the same time, the original data reaching the time difference is transmitted through the network, and the position analysis algorithm is used to calculate the position information of each positioning tag, thus, the precise positioning of personnel is realized. [2]

According to the positioning principle of hyperbola, TDOA distance measurement measures the time difference between the UWB signal at the location to be located and the two receiving devices at the same time, so that we can calculate the distance difference. According to the principle of hyperbola, the distance difference between a point on the hyperbola and two fixed points is fixed, two or more hyperbolic intersection points are used to obtain the specific location of the proxy setting point.[3]

2.2. Electronic fence device
In order to improve the accuracy of positioning, combined with the actual situation of power grid on-site, combine multiple positioning algorithm, we study a kind of more accurate localization algorithm, achieve better positioning precision and effect, substation electronic fence devices using TDOA (principle of arrival time difference), using the UWB technology orientation of measured label relative to the two different radio signal propagation time difference between the base station, the orientation of calculated the label relative to the four groups of base station distance. The UWB-based positioning tag can be mounted in various types of terminal equipment, such as wrist band, chest card and helmet. However, in order to minimize the number of terminals carried by operators and the convenience of
carrying them, we plan to select helmet as the carrier terminal of positioning tag. The device is mainly composed of positioning tag and positioning base station. The positioning label can be integrated into the helmet and combined with the substation layout drawn in the background (the boundary coordinates of each interval and area within the station are drawn on the GIS map) to realize the warning of the interval between accidentally entering the substation.

![Figure 2. Schematic diagram of electronic fence base station](image)

The positioning label is integrated into the helmet to give real-time warning when the operator enters the set danger area to ensure the safety of the worker. Warning prompt mainly includes LED light, buzzer, vibrator three ways. When entering the dangerous area, the buzzer will alarm. If you want to turn off the current buzzer alarm, you can press the button on the label housing. The buzzer alarm is lifted.

![Figure 3. Electrical personnel working in substations](image)

DW1000 chip developed by Deca Wave is adopted, which is compatible with IEEE802.15.4-2011 protocol ultra-wideband wireless transceiver chip, and can be used for object positioning in real-time positioning system, with the accuracy up to 10 cm. Site workers wear a helmet equipped with a positioning module card and enter the site, real-time positioning information can be summarized and sent back to ensure the safety of site workers entering the area. [4]
3. Hardware requirements

3.1. Positioning system module
In order to realize real-time tracking of the location of the operation site, we embedded a positioning system module, whose main features are as follows:

1. Built-in positioning module and antenna, no wiring is required
2. GPS+ Beidou dual mode [5]
3. Positioning accuracy up to 2.5mCEP
4. Update rate up to 20Hz
5. Operating temperature is -40℃~85℃
6. Adopt serial port communication, configuration data can be saved

These features can meet its timely and accurate positioning in the outdoor complex environment, conducive to the background to determine and monitor the location of the operation.

3.2. UWB wireless transceiver module
The electronic fence device uses UWB (ultra-wideband) technology to measure the time difference between the location tag (helmet) and the radio signal propagation between the two different location base stations, so as to obtain the distance difference between the location tag and the four groups of location base stations.

The UWB wireless transceiver module used in this paper is SWM1000, which can achieve high precision (error & LT;10cm) wireless location and wireless ranging functions. SWM1000 module uses
DW1000 wireless transceive chip of Deca wave company and STM32F051 processor built in. It can conveniently realize UWB parameter setting, periodic UWB signal sending, UWB signal receiving and wireless ranging through serial port commands. Its main features are as follows:

1. Designed to comply with FCC (Federal Communications Commission) UWB spectrum standards
2. Comply with IEEE502.15.4 UWB standard
3. Support 3.5ghz rf band
4. Encryption method is AES 128-bit hardware encryption
5. Positioning error of 10cm
6. Transmitting power & LT; 1mW
7. Support high density tag distribution in real-time location

**Figure 6. Core control board prototype drawing**

**Figure 7. Schematic diagram of UWB usage scenario**

### 4. Conclusions

The study of electronic fence takes both hardware and software into consideration, which is applicable to the work of safety supervision in the power grid system of all provinces and cities in China. It can effectively improve the disadvantages of the traditional safety supervision system, such as relying on manual labor, low accuracy and delayed information feedback. Hardware through a variety of smart technology integration, effectively integrating safety process, saves space utilization, also made through the calculation of information collection intensive, can do various aspects of information integration in time, reduce shorten the information transmission link, the software is based on TDOA algorithm to constantly optimize the accuracy and versatility of target detection and enhance its durability, is advantageous to the power grid system security problem of prevention, maintenance and
supervision, the system can satisfy the need of safety process of various aspects, and has higher practical application value and wide application scene at the same time the electronic fence based on UWB hardware, Software can be developed in depth according to the different needs of specific users, so as to be applied in different fields, with large space for development.

![Schematic diagram of electronic fence](image)

**Figure 8.** Schematic diagram of electronic fence

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