A cable partial discharge on-line monitoring method based on GPS clock wireless synchronization

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Abstract. In recent years, power cables from 10kV to higher voltage level are widely used in cities for power transmission. As the main power transmission cable of power transmission and distribution, the most important parameter of its running state is the insulation condition of the cable, which can usually be reflected by the magnitude of grounding current, serious partial discharge or loss angle. This paper proposes a cable partial discharge on-line monitoring method based on GPS clock wireless synchronization (CPD-GPS), through introducing GPS clock wireless synchronization, CPD-GPS can collect data timely and accurately. Experiments show, our method can effectively realized the cable fault monitoring and has very important application value for the safe and stable operation of power grid.

1. Introduction

In recent years, power cables from 10kV to higher voltage level are widely used in cities for power transmission [1]. With the rapid development of modern cities and the continuous increase of residential and industrial electricity consumption, the cable length is increasing, and the cable operation and maintenance work is facing great pressure [2]. At present, the management of high-voltage cables by most domestic power enterprises is still in the stage of post-fault maintenance [3,4]. Regular inspection and inspection methods are adopted for the operation of high-voltage cables, which not only consumes manpower and material resources, but also makes it difficult to observe the fault points with naked eyes, so the inspection effect cannot be guaranteed. In addition, it takes a long time to determine the fault point and arrange the line maintenance and troubleshooting in a short time, which results in poor customer service quality [5].

As the main power transmission cable of power transmission and distribution, the most important parameter of its running state is the insulation condition of the cable, which can usually be reflected by the magnitude of grounding current, serious partial discharge or loss angle [6,7]. Power cable partial discharge situation are the most effective operation of cable monitoring means, but it's also difficult to realize monitoring method, because cable partial discharge are no obvious external representation, and the beginning is very weak, deteriorating, until suddenly cable deflagration accident [8,9]. In addition, the cable partial discharge occurrence rule is not very obvious, all kinds of noise interference in the cable operation field, corona discharge of adjacent equipment, flashover discharge, lightning strike, wireless communication carrier, switching power supply will cause serious interference to the detection and resolution of partial discharge signal [10].

To address above problems, this paper propose a cable partial discharge on-line monitoring method based on GPS clock wireless synchronization (CPD-GPS), through introduce GPS clock wireless synchronization, CPD-GPS can collect data timely and accurately. Experiments show, our method can
effective realize the cable fault monitoring and has very important application value for the safe and stable operation of power grid.

2. Methodology

2.1. Construction of partial discharge collector

Partial discharge collector construction bureau partial discharge collector CJ, the CT head of the device to take electricity from the high-voltage cable bus is an energy-collecting transformer with an inner diameter of 60mm, which can charge the super energy storage capacitor or battery through the rectifier. The structure of the device is shown in Fig. 1:

The partial discharge pulse generated by the cable propagates along the cable body and shielding layer. CJMachine generates alternating electromagnetic fields around the wire for this high-frequency pulse. This electromagnetic field can be picked up around the roche coil of the wire, and the corresponding electrical pulse can be induced. After preamplification, it can be sent to the AD converter for digitization. In order to facilitate practical installation, the CJ sensor is made into a clamp-like structure, which can be conveniently installed under the condition of continuous cable power.

2.2. Collection of data

The partial discharge collector is installed on the cable, which synchronizes according to the clock recovered from GPS, and the background centralized monitoring host sends the synchronous acquisition instruction to the partial discharge collector. After receiving the instruction, the partial discharge collector starts to synchronously sample the local signal detected by the partial discharge sensor. The data collected are preprocessed.

And the processed data will be wirelessly uploaded to the pd concentration monitoring host. The partial discharge monitoring application software on the partial discharge centralized monitoring host analyzes the data uploaded from the partial discharge collector, and analyzes the partial discharge time series data on the whole monitored loop (A, B, C three phases). Hand in hand relay is used to monitor the partial discharge information, and the data of the intermediate partial discharge collector is matched with the data of two adjacent collectors. All data is stored chronologically in the value table FD.

2.3. Integration and collection data in server

Connect the CJ to the server host. The server host is connected to multiple CJ, and CJ serves as the slave of the host. For pairing purposes, host and slave, respectively. The partial discharge collectors of the host and slave are respectively recovered from the GPS receiving terminal. The synchronization precision can reach the order of 25ns. The architecture of the whole system is shown in Figure 2:
According to the acquisition instructions from the centralized monitoring host in the background, the collected data is timestamped on the hardware to ensure that the transmitted data can achieve the "alignment" accuracy of nanosecond in time. The data of FD is output by IRIG-B code, which is internally output by BCD code, and output once per second with 100 pulses. The output time information is: seconds, minutes, hours, and dates. B code signals generally have four forms: TTL level mode, RS422 level mode, RS232 level mode and modulation signal (AM). All coded output lists are stored in the BCDList.

2.4. Early warning
K-means clustering was carried out on BCDList to obtain multiple clustering clusters. For each cluster, time information is output in a serial data stream. In addition, in the receiving process, the time spent in information processing will also affect the time accuracy. Therefore, it is mainly used to mark events with time and establish the regression neural network model BNet based on cluster. Based on BNet, the partial discharge of cable is predicted. If the predicted result exceeds the threshold value T, it indicates that the cable has a fault and gives an alarm.

3. Experiment and system implementation
The method proposed in this study uses MATLAB language to realize all algorithms, and the system's interaction interface is based on QT. Build the power cable partial discharge on-line monitoring platform application software should have the function of wireless data transmission, to receive the data collector through a large number of calculations, partial discharge time domain waveform, frequency domain waveform is given, discharge, reflecting the discharge times (N) - discharge (Q), the electrician frequency phase (Φ) three PRPD spectrum diagram, put the power of the relationship between the location information of spectra (N, L, Q, L spectra), historical record and query in capacity, discharge severity information such as alarm. These analysis results need to be stored in the database and displayed in the QT development interface. The platform should have open business interface, which can be integrated with the existing integrated monitoring system, substation integrated automation system or cable integrated monitoring system reserved communication interface, so as to realize data integration and business expansion. The monitoring software has friendly interface and convenient operation, which can display various data returned by each sensor in real time, control specific equipment, and analyze and process the obtained data. Real-time display of dynamic and static images. It has the functions of dynamic analysis, correlation chart and curve display for all kinds of analog and digital quantities needed for cable operation. It can well meet the users' requirements for video, image, real-time data and other parameters. Platform should have interface
alarm, voice notification, SMS alarm function. The cable prediction results of the platform output are shown in the figure below:

![Figure 3. The platform output.](image)

As shown in the figure, good prediction results are obtained through this platform.

4. Conclusion
In view of the problems faced by existing technologies, this paper proposes an online monitoring method for partial discharge of power cable based on high frequency roche coil partial discharge pulse pickup technology, high speed sampling technology, high speed modern wavelet data processing technology and GPS-based nanosecond wireless clock synchronization technology. This patent can be used to quickly and accurately extract the cable electrical pulse signal information, and identify the key partial discharge information based on GPS clock synchronization signal to realize effective cable fault monitoring, which has very important application value for the safe and stable operation of power grid.

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