Research and Analysis on The Identification Technology of User Group Network in Distribution Station Area

Yue Zuo¹, *, Shijie Cui²,³, Qi Zhang¹, Lianyong Zhu¹

¹State Grid Huludao Power Supply Company, Huludao 125000, China;
²University of Chinese Academy of Sciences, Beijing 100049, China
³Shenyang Institute of Automation, Chinese Academy of Sciences, Shenyang 110016, China

*Corresponding author email: yue_zuo@ln.sgcc.com.cn

Abstract. Due to frequent line reconstruction in the distribution station area, the lines between adjacent lines in the distribution station area are messy and the paths are illegible, so that it is difficult for power grid companies to obtain accurate line losses and cannot balance the load planning, which is not conducive to the station area. Local refined management and service levels have been improved. In order to solve this problem, many identification technologies for users in distribution network stations have been proposed. However, traditional identification technologies have problems such as low accuracy and poor detection failure. The most important thing is that it is difficult to demodulate and identify signals. In order to solve this problem, this paper uses an improved differential cross-correlation algorithm to demodulate and identify the signal, and the power communication technology that carries information by artificially generating small distortions of the grid voltage and current. The experimental results prove the feasibility of the method proposed in this paper. Sex and effectiveness.

Keywords: Distribution network station area, user networking, identification technology.

1. Introduction
It will effectively improve the economic operation level of the low-voltage distribution network, make the relationship between the station and the user clearer, so as to improve the accuracy of the user file management of the power supply company, the fineness of the station line loss management, and the clarification of the station load plan. Provide detailed data for future grid upgrades and new energy grid connection. Regarding the distribution network system, the distribution station area is the last "one kilometer" at the end of the distribution network, which directly affects the safe use of electricity for the general public. Therefore, the distribution station area is reliable, safe, intelligent and economical. [1-4] It has great social, economic and engineering significance for the intelligent development of power grids. At present, for the intelligent development of the last mile of the distribution network, the current main focus is on the protection and detection of the operating state of the distribution transformer, and manual inspection is still used to identify the corresponding...
relationship between the distribution transformer and the user. This is unable to obtain fast and accurate identification results, and even the power companies have lag and blind spots in the user management of the distribution station area. Therefore, in view of the shortcomings of using manual methods to identify the distribution station area in the past, an online identification method is adopted, which is more efficient and agile.[5-9] The realization of the identification function of the user network in the distribution station area can effectively improve the operation level of the low-voltage distribution network, and make the relationship between the station area and the user clearer, so that the grid company can more accurately and finely treat the users and the station area line. It can also provide detailed data for future grid transformation and new energy applications.

2. User identification in distribution station area and its key technologies

The main problems in the current distribution station area are the three-phase load imbalance and the difficulty of monitoring the online line loss. The main reason is that the parameters of the distribution transformer collected by the current distribution station area management control system cannot be matched. The user's meter collection is accurately matched, and the station manager cannot use the background to realize real-time statistics on each phase line, and at the same time cannot accurately identify the load borne by each phase line. Therefore, there is a need for an accurate and rapid identification method of distribution stations to improve the terminal management level of power grid enterprises and the service quality of automated distribution network systems, so as to achieve higher and more economic and social benefits.

(A). Definition of user identification in distribution station area

The user identification of the distribution station area mainly means that the power supply companies in various places conduct statistics, identification, and filing of the users and distribution transformers within their jurisdiction through certain technical methods. The main schematic diagram is shown in Figure 1.

(B). The key technology of user identification in distribution station area

The main method for identification of traditional distribution station area is that when electric power inspectors conduct a general survey in the station area, they find the user group corresponding to each phase line of the transformer through the distribution transformer along the live line, and use manual meter reading. Statistical identification of household information and station area information. This manual identification method requires household statistics for each station area, which not only requires a lot of work, but also prone to miss statistics and miscalculate statistics. In order to solve this problem, since the 1980s, the China Electric Power Equipment Management Association and major power companies have conducted discussions and studies on how to realize the identification of the corresponding relationship between distribution transformers and users when the distribution network is working normally. Regarding the correspondence between the distribution station area and the users, the core of the research lies in the information transmission channel between the distribution transformer and the users.
3. Network identification scheme and process of distribution station area

The intelligent power distribution station area management and control system is mainly composed of user layer, cable transmission layer, station area distribution layer, network communication layer and the most important background management layer. The main functions of each layer are as follows. The whole station information monitoring is mainly used for the monitoring of station information, power quality monitoring, and analysis and management of economic operation. The network management layer is mainly the hub of the user layer, the power distribution layer and the background monitoring layer in the station area. This layer is mainly composed of communication methods based on different communication methods, and is mainly responsible for the two-way transmission of the amount of the user layer and the power distribution layer in the station area. The distribution layer of the station area is mainly composed of distribution cabinets and distribution transformers. It mainly includes intelligent power distribution terminals, free compensation cabinets and other equipment for protection and detection of transformers in the station area. The user layer uses the user network identification signal and demodulation unit of the power distribution station area to demodulate the identification signal from the power distribution station area through the power line, thereby completing the identification function of the entire station area.

![Flowchart of User Network Identification in Distribution Station Area](image)

**Figure 2. Flowchart of User Network Identification in Distribution Station Area**

The entire identification flow chart of the entire distribution station area user network is shown in the figure above. The Internet of Things remote control platform sends station area identification instructions to the signal modulation unit. When the signal modulation unit receives the identification instructions, it sends the three-phase distribution transformer in turn the voltage modulation carries the identification data of the phase sequence information and the serial number of the station area. The identification data is transmitted to the signal demodulation unit of the user terminal through the power line, and is processed by the relevant algorithm and demodulated. After the wireless network summarizes the statistics on the remote-control platform, so far, the user network identification of the power distribution is completed.

4. Improved differential cross-correlation algorithm to demodulate and identify signals

Through the above analysis, it can be known that the most critical part of the user network management and control system in the entire station area is the demodulation of the identification signal; the user identification of the distribution station area with the help of power carrier technology has measurement uncertainty and unstable characteristics. An improved differential cross-correlation algorithm is used for demodulation, which is a power communication technology that carries information by artificially generating small distortions of the grid voltage and current near the 50Hz voltage of the power frequency. In the signal demodulation process, the most commonly used signal extraction method is the time-domain difference method, assuming the grid voltage waveform expression is:

\[ u = U \sin(t) + \Delta e(t) + v(t) \]  

(1)
Among them: $U$ is the peak value of the grid voltage; $\Delta e$ is the random interference signal; $v(t)$ is the distorted voltage signal.

Then the voltage of two adjacent waveforms can be expressed as:

$$
\begin{align*}
    u_1 &= U_1 \sin(\omega t) + \Delta e_1(t) + v(t) \\
    u_2 &= U_2 \sin(\omega t) + \Delta e_2(t)
\end{align*}
$$

The difference between $U_1$ and $U_2$ is the sampled signal.

$$
\varepsilon = u_1 - u_2 = (U_1 - U_2)\sin(t)[\Delta e_1(t) - \Delta e_2(t)] + v(t)
$$

When the power grid works normally without large voltage fluctuations, $U_1 \approx U_2$, and because the harmonics and other periodic interferences on the same line change very little in a short time, the noise signal is greatly eliminated after the above-mentioned differential calculation, namely $\Delta e_1(t) - \Delta e_2(t) \approx 0$, so:

$$
\varepsilon = v(t)
$$

However, when the grid voltage fluctuates, the grid voltage waveforms of two adjacent points will have deviations, making $U_1 \neq U_2$. In order to solve the impact of grid voltage fluctuations on data demodulation, the direct difference method can be optimized. As shown in Figure 3.

After being processed by the linear link, the two adjacent voltage difference waveforms can be represented by formula (5).

$$
\bar{\varepsilon} = (U_1 - U_2)[\sin(\omega t) - \frac{t_1 - t}{t_1 - t_0}\sin(\omega t_0)] + [\Delta e_1(t) - \Delta e_2(t)] + v(t)
$$

Among them, $(U_1 - U_2)[\sin(\omega t) - \frac{t_1 - t}{t_1 - t_0}\sin(\omega t_0)]$ is the component produced by the fluctuation of the grid voltage; the component produced by the modulation signal is $v(t)$; $[\Delta e_1(t) - \Delta e_2(t)]$ is the
component produced by random noise. And let $\varphi = \omega t$, the ratio of amplitude components in the voltage sampling before and after the processing of the grid voltage fluctuation is:

$$\frac{e_1 - (U1 - U2)}{e_1} = \sqrt{1 - \left(\frac{\sin(\varphi)}{\pi - \varphi_0}\right)^2 + \pi - \arccos\left(\frac{\sin(\varphi)}{\pi - \varphi_0}\right) \cdot \left(-\frac{\sin(\varphi)}{\pi - \varphi_0}\right)}$$

$$= \frac{\sin(\varphi) + \arccos\left(\frac{\sin(\varphi)}{\pi - \varphi_0}\right) \cdot \left(-\frac{\sin(\varphi)}{\pi - \varphi_0}\right)}{\sqrt{1 - \left(\frac{\sin(\varphi)}{\pi - \varphi_0}\right)^2}}$$

(6)

Where $\varphi_0$ is the angle radian, when voltage sampling is performed 30° before the zero-crossing point, $\varphi_0 = \frac{5\pi}{6}$, and the amplitude component ratio in grid voltage sampling is 0.03, which can eliminate the influence of grid voltage fluctuation on voltage sampling.

5. Conclusions
Aiming at the shortcomings of using manual methods for identification in power distribution stations in the past, this article adopts an online identification method, and for the most important thing, it is difficult to demodulate and identify signals, the article uses an improved differential cross-correlation algorithm for demodulation. The identification signal, the power communication technology that carries information by artificially generating small distortions of the grid voltage and current. This method is more efficient and agile, which is beneficial to improve the reliability of user network identification in the distribution station area, and it can also enable low-voltage distribution. The operation level of the power grid can be effectively improved, making the relationship between stations and users clearer, so that power grid companies can manage users and station line losses more accurately and finely, and it can also be used for future grid transformation and new energy applications. Provide detailed data.

Acknowledgements
This paper is funded by the Science and Technology Project of State Grid Liaoning Electric Power Company Ltd (2020YF-40), Research on rapid fault location and accurate report of power failure information in distribution station area.

References
[1] Research station area synchronization line loss abnormal data governance and methods [J]. Liu Bo. Communication World. 2017(21)
[2] Typical model of smart distribution station area [J]. Xie Guangzhi, Dong Huaqiang, Jiang Guorui, Du Kai, Gao Jing. Rural electrification. 2017(04)
[3] Research on the impact of unbalanced three-phase load of distribution transformer on the operation of distribution network [J]. Wang Xue, Niu Haitao. Electronic production. 2017(06)
[4] Research on the transmission characteristics and signal detection of TWACS signals in the station [J]. Gao Bo, Ma Wenjing. Electric Power Information and Communication Technology. 2017(02)
[5] Exploring the electricity sales side [J]. Liu Liang. China Electric Power Enterprise Management. 2016(13)
[6] On-line line loss classification management and intelligent anomaly analysis design in
distribution station area [J]. Li Xinjia, Kong Yueping, Zou Yunfeng, Deng Sulan. Power
demand side management. 2016(02)

[7] The impact of the new round of power reform on the distribution network planning of power
grid enterprises and countermeasures [J]. Shen Hongyu, Chen Jin, Gui Sanrong, Tan Jian,
Wang Zhe, Li Yang. Electric Power Construction. 2016(03)

[8] Rural power grid intelligent power distribution station area integrated solution [J]. Sun Jianhua,
Zhu Feng, Tan Shanshan. Electrical Technology. 2014 (S1)

[9] The State Grid Corporation of China released the 2014 version of the new technology catalog
and the key to promote the new technology catalog [J]. Electric Power System Automation.
2014 (18)