Research on "Courts Recognition Technology" for Low-Voltage Electricity

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Abstract. In the process of power operation, due to poor management, the courts of users are inconsistent with the system. The courts identification technology intelligently identifies the correct attribution of users through corresponding technical means, thus solving various problems such as collection and line loss. Based on the research on the current principle of courts identification technology, a courts intelligent recognition model and method based on frequency offset detection is proposed. The method effectively improves the accuracy and timeliness of the courts identification result and greatly reduces the occupation of local communication channel resources.

1. Introduction
In the field of intelligent identification model research, the international community has carried out more in-depth basic theoretical research and industry practice, and made outstanding achievements in the field of Internet of Things technologies such as smart city and intelligent logistics, generating information flow through diversified perceptual recognition technology. The integration of the external physical world and the internal information world has also brought profound influence to the proposal and development of the smart grid concept, and realizes intelligent two-way interaction of the power grid through advanced technology. In the last one kilometer of the low-voltage courts intelligent identification of the power grid, some countries or industry alliances in the world pass the channel selection, channel coding, filtering design, power allocation, modulation and demodulation methods, routing topology algorithms and self-organization of the low-voltage power line carrier communication network. The network technology has carried out certain research and practical application, which has greatly improved the reliability of power line carrier communication technology, and industrialized a series of carrier technology alliances and carrier chip products.

There are many wiring methods for on-site electricity courts. The topology and circuit characteristics of courts are also diverse. Many types of courts have crosstalk problems with adjacent courts, which affects the accuracy of courts file management. To study the courts identification technology, it is necessary to study the current courts characteristics and attribution crosstalk, and to study the existing courts identification technology principles and models, in order to solve the problem, optimize and improve the proposed new technical methods.

2. Analysis of typical domestic electricity courts
To study the courts identification technology, it is necessary to study the characteristics of typical courts and the communication crosstalk of the station. The following is an analysis of the characteristics of various typical domestic electricity courts:
The rural courts: courts environment is relatively independent, the users are evenly distributed, the load is small, and there is basically no communication crosstalk between the courts. The urban and rural junctions courts: courts environment is relatively crowded, the user distribution is irregular, the load is uncertain, the courts crosstalk often occurs, and the messy lines cause signal coupling. High-rise electricity courts: courts environment is excellent, user rules are distributed, load is large, there is courts crosstalk phenomenon, mostly through transformer crosstalk. Isolated small settlements courts: courts environment is isolated, the number of users is very small, the load is small, and communication crosstalk is basically not generated.

There are two main reasons for courts crosstalk: one is that the distance between multiple transformers is close, or that multiple transformers are zero-zero; the other is that the line overlaps and so on, causing power line signal coupling crosstalk. The traditional courts distinguishing technology relies on the success or failure of power line communication or signal attenuation to distinguish physical courts. However, under the above typical courts crosstalk conditions, theoretically different courts will actually crosstalk regardless of the power line signal used. Therefore, in the case of courts that already have communication crosstalk, whether the power line can successfully communicate with courts can be used to distinguish courts. Certain theoretical flaws. The current courts recognition model is introduced below, and a new improved technique is proposed based on the prior art.

3. Current courts identification technology principle

(A). Current pulse model

This model uses the combination of current pulse and carrier modulation signal for courts identification. The composition of the model is as follows: a terminal: power line power supply line; b terminal: low voltage side current pulse injection point of the energy meter end; c terminal: transformer low voltage side current detection point; d terminal: transformer low voltage side carrier modulation signal injection point; Energy meter side carrier modulation signal receiving point.

First, a current pulse signal is emitted at the b-end. After detecting the pulse current at the c-end, the phase of the b-end of the pulse injection point is recognized according to the detected pulse channel, and it is preliminarily determined whether the b-end belongs to the transformer or not. At the same time, the power line carrier signal is sent at the corresponding end of the d terminal. If the e terminal detects the signal, the user belongs to the transformer; if the e terminal does not receive the power line carrier signal, it is necessary to check whether the host receives the pulse current signal, if the pulse current is received. The signal also indicates that the user belongs to the transformer; if the pulse current signal is not received at the e terminal, this indicates that the user does not belong to the transformer.

The principle is based on the fact that the lower frequency pulse current signal is not easily propagated across the mesa to other lines, and because the transmission distance is relatively long, combined with the characteristics of the power line carrier across the courts attenuation, the two criteria are combined, that is, at least one If the signal is successfully received, the meter is considered to belong to the transformer courts.

(B). Zero-crossing frequency offset detection model

This model mainly identifies courts based on different characteristics of different courts AC operating frequency (50Hz) offset.

The composition of this model is as follows:

a). The target carrier slave node, that is, the target energy meter of the model, can receive multiple master node signals, that is, the case where there is courts crosstalk occurs;

b). Same as the master node of the courts, that is, the concentrator local communication module belonging to the same physical courts as the target slave node;

c). The non-same courts, that is, the concentrator communication modules of non-courts, in this model, refer to the different courts concentrators that can establish communication with the target slaves;
d). The communication link refers to various types of power line carrier communication links between the master and slave nodes, such as narrowband carriers and wideband carriers, including various modulation methods such as PSK, FSK, and OFDM. This model combines the power line carrier zero-crossing transmission carrier communication technology and the AC zero-crossing phase offset statistics. The essence is to use the different load of different stations to cause different AC phase offsets to realize the courts identification.

During the courts power line carrier communication process, the slave node receiving the master node data acquisition command can calculate the time offset between the signal reception time and the AC power phase. A statistical offset can be obtained by excluding the known offset between the three phases. The slave node i can receive a plurality of master node acquisition instructions, wherein the zero-crossing deviation amount is the smallest master node as its home node.

The slave node transmits the phase offset original data of itself and the multiple master nodes to the original home node, and the terminal compares the results to determine whether the slave node is a cross-courts node. If the node is a cross-courts node, a cross-courts event (such as event object 3112 in the 698.45 protocol) is generated for reporting to the primary station.

(C). Voltage curve correlation model
This model uses the voltage characteristics in parallel with the courts node to achieve courts identification by comparing the voltage variation correlation between nodes. The basis is that the main node of the same courts and the slave node change more consistently, and the consistency of the masters and slaves of different courts is weak. The physical courts of the meter are determined by comparing the voltage correlation indicators between the slave nodes and the different master nodes. According to the previous analysis, the longer the value of time it is, the more reliable the recognition result is, but the lower the efficiency, which requires a trade-off between accuracy and efficiency in practical applications.

It is necessary to pay attention to the voltage curve required in the model, and the time point requirement for recording the voltage must be as accurate as possible. Generally, the voltage curve freeze is frozen at the whole point. If the time synchronization error between the meter and the master is small, the time point of the voltage curve can be considered to be strictly corresponding. However, the energy meter does not support freezing the curve data of any density. Some unsupported density needs to be simulated by real-time reading. At this time, the actual acquisition time of the corresponding points of the curve data of different meters is different, which will make the correlation coefficient does not correctly reflect the consistency of the voltage changes between the meters, which in turn affects the results of courts identification. Therefore, the curve acquisition time point is about accurate, and the accuracy of this model will be better.

Furthermore, depending on the nature of the correlation coefficient, if the density of the voltage curve is greater, the accuracy of the recognition is higher. The greater the density of the curve, the more detailed the difference in consistency that can be detected. The more accurate the final model output is, the more accurate the courts are. For example, the 96-point curve is better than the 24-point curve.

Figure 1. Model process diagram
4. Courts intelligent recognition model based on frequency offset detection

It can be seen from the above courts feature analysis that in many mesa structures with possible crosstalk, the frequency offset feature distinguishing method is theoretically applicable to all crosstalk scenarios, which combines the power line carrier zero-crossing transmission carrier communication technology and the method of statistic of zero-crossing phase offset of AC is essentially to realize the courts distinction by utilizing the different load of different courts to cause different phase shift of AC. The focus of the courts differentiation technique is to find features that reflect the essential differences between different courts. The AC operating frequency is 50 Hz, but due to changes in real-time loads, the actual power frequency will always be slightly offset. The load of different courts may not be exactly the same. These different loads will cause different shifts of the power frequency of the respective courts. The degree of difference between these offsets can be used to distinguish courts. Although the power frequency offsets of different measurement points of the same courts are not strictly the same, the difference is much smaller than the offset between different courts. By comparing the different offsets of multiple master nodes, it is theoretically possible to distinguish the physical courts of the measurement points.

However, due to the three-phase power supply, there are three phases naturally occurring with courts. When calculating the offset, the influence of phase removal should be considered first, so the node phase information must be known first. In courts without phase information or without phase recognition, the model cannot be practically applied. On the other hand, the offset of the power frequency is a very small amount, and the phase of the offset is also small. It is determined that the courts are easily interfered by the measurement error by one-time comparison. Based on these two aspects, the frequency offset model can be optimized as follows: one is to supplement the phase discrimination function in the model; the other is to reduce the interference caused by the error by the big data analysis method.

First, phase-shift-based clustering analysis is performed on all the slave nodes, and the phase difference of the three-phase intrinsic zero-crossing is eliminated to determine the known offset.

(a). Data preprocessing

The zero-crossing offset of the information received from the node converts the time offset into an angular value. It is mainly based on the parameters of the original hardware acquisition data. First, the original data is converted into time quantity according to these parameters, and then the relationship is converted according to time and angle to obtain the angle quantity, which is convenient for analyzing the phase.

(b). 3-means clustering

The measured phase angles of all measurement points are 3-means clustered on a one-dimensional axis. The initial coordinate points of the three types can be arbitrary, or the standard phase difference of three phases is 0, 2n/3, 4n/3, which is theoretically more efficient. The clustering distance is defined as the standard Euclidean distance, which is the absolute value of the difference between two points on the one-dimensional axis.

(c). Evaluation output

For each slave node, the offset of each receiving time and the zero-crossing point is counted in the zero-crossing communication process, and the ATi data accumulation is accumulated over a period of time, and the phase 3-means clustering result is intersected multiple times to improve the result. Reliability, the phase of the measurement point is finally obtained.

In this way, in the subsequent courts identification, the inherent phase offset caused by the three-phase power supply can be excluded, and then the courts can be distinguished by considering only the offset of the receiving phase and the zero-crossing phase.

During the courts power line carrier communication, the slave node receiving the data acquisition command can calculate the time offset between the signal reception time and the AC phase.

Excluding the known offset between the three phases, the statistical offset ΔTi is the offset from the node: the receiving time Ti relative to the phase of the alternating current. If the slave node is able to receive data acquisition commands from multiple master nodes, {ATi} can be sorted in ascending
order to \{ATis\}, and \{ATis\} corresponds to the statistics of the zero-crossing deviation between nodes i and each master node. The queue, in which the zero-crossing deviation is the smallest, is the master node to which the slave node i belongs.

5. Big data statistical analysis
For the target slave node, the inherent phase offset is excluded based on the above phase identification result, and the calculation result of the zero-crossing deviation ATi with all the communicable master nodes is calculated and converted into the phase angle offset. The master node with the smallest cumulative offset or average offset is the master node of the same courts as the target slave node, thus completing the courts identification.

It is theoretically proved that the application of ATi calculation results for long-term big data accumulation can further improve the accuracy of courts recognition.

The slave node i that receives the data acquisition command can calculate the time offset between the signal reception time and the AC phase. Set a target slave node to correspond to the business scenario of the two master nodes, and draw the statistical analysis result of the courts that it accumulates over a period of time. It can be seen from the results that the discrimination can be basically made in the initial stage, but the offsets of the two main nodes in the initial stage are very turbulent, and it is obvious that there are more random interferences in the initial stage. As time accumulates, the curve approaches a steady state, indicating that the combined use of cumulative data increases the stability of the courts distinction and reduces the impact of incidents.

6. Conclusion
By summarizing and analyzing the current status of the current power supply courts and the current courts identification technology principle, based on the actual needs and pre-existing conditions, and based on the big data analysis method, a power carrier zero-crossing time-transmitted carrier communication technology and AC zero-crossing phase are proposed. The identification method of offset statistics effectively improves the accuracy and timeliness of the courts identification result, and greatly reduces the resource occupation of the local communication channel. By comparing with existing models, it is clarified that this model is a courts recognition model that is more suitable for field applications. The research proposes a new courts recognition technology for collecting terminals and smart meters, using more reliable frequency offset indicators as the basis for identification, accurate identification, and no need to add additional hardware to facilitate application promotion.

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