Research on Portable Fault Message Analysis Device Based on Mobile Terminals

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Abstract. As the scale of the power grid expands and the complexity of the power grid structure increases, timely acquisition and correct analysis of grid fault information is important for us handling failure and recovering the power supply. When we are facing of complex grid faults, It can help us get accurate assessment of fault nature, fault location result and failure severity. This paper proposes a portable Fault Message Analysis Device based on mobile terminals, which can help field personnel to obtain fault recording information of different sources in different substations, and complete data remote transmission sharing by wireless transmission module. This device can confirm the fault point and judge the correctness of the protection action behavior through differential calculation and analysis of multi-source recording data. It has powerful functions of analysis and communication, which can help improve the level of fault analysis and processing efficiency, reduce the time of fault recovery and improve the reliability of power supply.

1. Introduction

With the continuous increase of the number of substations and the continuous increase of the inspection intensity, the emergency handling of power grid faults requires the inspection personnel to grasp the fault information in a timely, comprehensive and accurate manner.

At present, only the on-site inspection personnel can view the processing methods of fault recording data and protection action information, which can not meet the fast and correct analysis and processing requirements of large-scale multiple faults or conversion faults under complex power grids. \cite{1-2}. Therefore, it is necessary to develop a portable Fault Message Analysis Device for substation, which can realize on-line analysis and management of fault recording data and message information. Portable devices can use wireless network to realize data sharing and relay protection operation and maintenance. The control platform can retrieve the data and analysis results of each portable device in real time \cite{3-4}, to solve the lack of portable fault analysis and information sharing tools at the substation site, resulting in low efficiency of fault handling and slow resource sharing rate, facilitating multiple repair personnel on site. Simultaneously analyze and deal with the fault situation with the remote expert team to improve the efficiency of fault handling \cite{5-7}. At the same time, the portable device has a GPS positioning function, and the position information of the staff can be queried in the relay protection operation and maintenance control platform, so that the maintenance personnel can be properly allocated to improve the repair efficiency. During the troubleshooting process, the maintenance personnel can transmit video...
and image information to the relay protection operation and maintenance control platform to facilitate remote guidance by experts. Therefore, this paper proposes a portable fault-based relay protection operation and maintenance control platform to facilitate remote guidance by experts. Therefore, this paper proposes a portable fault-based portable Fault Message Analysis Device based on mobile terminals, which has powerful analysis and communication functions, which can help the inspection personnel to improve the fault analysis level and processing efficiency, reduce the fault recovery time, and improve the power supply reliability.

2. Overall introduction

The mobile fault-based substation portable Fault Message Analysis Device is mainly composed of hardware system and software system.

The hardware system includes intelligent mobile terminal (PDA), network port acquisition and transmission module, 4G and WIFI wireless communication module, video image acquisition module, GPS positioning module, etc., which can realize the collection of recorded data, on-site graphic data and geographical location information, transmission, sharing.

The software system mainly includes three subsystems: fault recording and message storage subsystem, fault recording and message analysis subsystem, and fault repair remote operation and maintenance subsystem.

The application in the device is different from the ordinary PC-side application. Due to the limitation of the screen size of the device, special design is needed on the information display. The original PC-side program display method cannot be copied, but the human-machine interface should meet the requirements of intuitive and fast, easy to operate features.

3. System design

The portable Fault Message Analysis Device uses a large number of mobile terminals technologies, including intelligent mobile terminals (PDA), 4G wireless transmission, automatic transmission of fault information and analysis data, etc., which can get rid of the failure analysis of traditional on-site information viewing and personnel voice communication. The application of the device can realize the rapid sharing of fault recording, message and protection action information, and the coordinated analysis of voice and video between field personnel and remote expert teams. At the same time, the intelligent mobile terminal logs in through the account and password, and the important information such as the failure analysis result is encrypted and compressed before transmission to ensure the data security during the use process and the transmission process.

3.1. Intelligent mobile terminal

The intelligent mobile terminal platform is based on Android graphics operating system development. It adopts 533MHz high-speed ARM920T processor, 4G large-capacity memory and 2TFlash flash memory. It has powerful online analysis function, and its hardware meets the requirements of big data throughput and fast processing, and can be loaded based on large The management of the capacity list, the message analysis engine, and the waveform analysis engine can implement various functions such as message recording, data analysis, data storage, and data transmission. Taking into account the mobility requirements, it uses ultra-large capacity lithium battery, high-sensitivity anti-jamming GPS antenna and industrial grade 4G and WIFI wireless communication module, which is compact, easy to carry, strong in endurance, easy to expand, IP67 machine dustproof and waterproof.

3.1.1. Data interaction. As an important carrier of the fault recording and packet analysis device, the intelligent mobile terminal can call the fault information file in the fault recorder through the network port acquisition module, and complete the control and operation and maintenance of each device and relay through the 4G and WIFI wireless communication modules. Information interaction and sharing between platforms.

In order to ensure the security of data interaction between each mobile intelligent terminal and the remote relay protection operation and maintenance control platform, the intelligent mobile terminal performs data transmission with the server through the HTTPS transmission protocol. HTTPS is an
HTTP-based SSL-based solution. It is currently a relatively high-security transmission protocol used by PC-side users to access online shopping websites or online banking systems using browsers. HTTPS ensures the legitimacy of the server through the server certificate, thereby preventing users from being spoofed by malicious third parties. The handheld mobile terminal and the remote server use an asymmetric encryption mechanism when using HTTPS for data transmission, and use the public key and the private key to encrypt and decrypt the data sent by both parties, and any third-party malicious eavesdropper caught in it can only watch. After the encrypted content, the original data cannot be decrypted. In order to ensure the legitimacy of the client, each intelligent mobile terminal can also increase the authentication of the client digital certificate when the implementation is implemented. The remote server can only create the legal data certificate stored on the server after confirming that the digital certificate provided by the client is a smart data terminal. Connect, otherwise the client will only get an error message that the connection failed.

3.1.2. Recording Wavelet Display Interface optimization. Mobile smart terminal has many limitations when displaying the oscillography briefing due to the screen size problem. The main problem is that the horizontal screen is too small, resulting in a limited number of columns that can be displayed, and cannot be displayed according to the oscillography briefing format of the PC. All analysis operations, display processes (such as waveform overlay, scaling, editing) need to be done on the graphics system. Therefore, in order to ensure the intuitiveness and ease of use of the maintenance personnel, it is necessary to fully consider the characteristics of the mobile terminal and optimize the display interface as follows.

1) Recording simplification

The recorded files, especially the recorded files generated by the fault recorder, contain a large number of channels, and one fault only involves several of them. Many other channels are not related to the fault, not only for analyzing faults. Help also causes too many channels to be displayed in the failure analysis software, which affects the efficiency of viewing analysis.

The fault recorder file simplifies the simplification of the oscillography file from two angles: by analyzing the condition of each channel, determining whether it is related to the fault related channel, and if not, culling, simplifying the fault recording file by reducing the channel vertically. By analyzing the fault time, only the data of several cycles before and after the fault time are intercepted, other unrelated data is deleted, and the fault recording file is laterally simplified by reducing the recording time.

2) Use flipping instead of scrollbar

The traditional PC-side recording analysis software generally provides a scroll bar for the user to scroll through, but the smart mobile terminal application is inconvenient to use the scroll bar due to the operation mode problem, and the extended view of the page is used. In general, the page is used instead, and according to the user's use. I am used to developing a set of recording programs for mobile applications.

3.2. Fault Recording and Message Storage Subsystem

The fault recording and message storage subsystem reads the original waveform record from the fault recorder in a wired connection or in the form of a wireless connection, or acquires the message data from the packet acquisition subsystem in a wireless transmission manner. And complete the storage, management, remote transmission and conversion of related data.

The system should include: fault recording and message data receiving module, fault recording and message independent storage module, fault recording storage management module, IEC61850/103/104 protocol remote transmission module, COMTRADE data conversion module, message storage management module Sub-modules such as storage management for exception messages.
3.3. Fault Recording and Message Analysis Subsystem

1) The fault recording and packet analysis subsystem includes a fault calculation analysis module, a fault ranging module, an abnormal packet event alarm module, and a message analysis module, and can implement an SV message, a GOOSE message, and an MMS message. Various types of message analysis processing. At the same time, the system has the following basic functions.

2) Depth analysis of standard COMTRADE format file, which can complete auxiliary analysis functions such as voltage, current data RMS, negative sequence component, zero sequence component calculation, harmonic component analysis, impedance trajectory analysis, phasor analysis, etc.

3) The processing and display of abnormal messages can complete the frame loss, the wrong order judgment and the GOOSE message conformity and continuity judgment of the SV message.

4) When the intelligent mobile terminal can be accurately and uniformly used as the standard clock source, the difference between the time of each recorder and the absolute time of the intelligent mobile terminal can be compensated, and the time of the same fault related information from different recorders of different substations can be performed. Synchronization can provide recorded data with absolute time scales, providing basic support for wide-area synchronous data analysis and fault diagnosis based on wide-area fault recording information.

5) According to the different source fault recording data of different substations, the high-precision double-end ranging technology can be used to greatly measure the distance accuracy, and the ranging analysis data is automatically sent to the line inspection personnel to quickly process and isolate the fault points. Provide timely and accurate analysis results for system accident analysis and recovery of power.

6) Common software functions include automatic generation of message analysis results, automatic generation of fault reports, automatic remote transmission of messages and recorded data, and so on.

3.4. Failure Analysis Algorithm

The portable device failure analysis module judges the correctness of the position of one fault point and the behavior of the protection action by differential calculation of the multi-source fault recording data.

In the event of a grid failure, the substation-related active-side fault recorders that provide power to the fault point initiate recording. As shown in the figure, the L1 line, T1H (main transformer), L3 line, and T2H (main transformer) in the 220kV substation 1 and the substation 2 are active branches. The L point of the L5 line is faulty. The fault recorder in station 1 and substation 2 will store the fault occurrence time of the L1 line, the T1 line, the L5 line (station 1 side), the L5 line (station 2 side), the L3 line, and the T2 line. Current and voltage waveforms before and after protection and protection start and action information.

![Figure 1. Analysis example](image-url)

The on-site maintenance personnel can collect and share the above waveforms and information through the portable Fault Message Analysis Device, and synchronize the multi-source fault recording
data by comparing the time difference compensation with the fault mutation amount. According to the system primary equipment wiring diagram, each interval current transformer is used as the unique identification unit, and which units can constitute the differential logic calculation has been programmed into the program and stored in the database. In this example, the combination of each unit that can constitute the differential logic calculation is shown in Table 1. The calculated combination 1 satisfies the differential protection operating condition, and then checks the protection action information and the switch displacement information on both sides of the L5 line, and initially determines that the fault point occurs on the L5 line. At the same time, the adjacent differential logic calculation combination 2-6 is compared, and the differential protection operation condition is not satisfied, and the adjacent active interval main transformer protection and line protection start, the bus differential protection is started, and the corresponding switches are not displaced, and the confirmation can be confirmed. One fault point is on the L5 line, and the protection action on both sides of the line is correct, and the switch has been correctly tripped.

### Table 1. Combination of differential logic calculation.

| Differential logic meter | Composition unit                      |
|--------------------------|---------------------------------------|
| Combination number       | Unit                                  |
| 1 (line differential)    | L5 (station 1 side), L5 (station 2 side) |
| 2 (busbar differential)  | L5 (station 1 side), L1 line, L2 line, T1H (main transformer) |
| 3 (busbar differential)  | L5 (station 2 side), L3 line, L4 line, T2H (main transformer) |
| 4 (main change)          | T1H (high), T1M (middle), T1L (low)   |
| 5 (main change)          | T2H (high), T2M (middle), T2L (low)   |
| 6 (station differential) | L1 line, L2 line, T1H line, L3 line, L4 line, T2H line |

Based on the differential calculation and analysis of multi-source fault recording data, combined with the interval protection action behavior and switch displacement information for fault point confirmation and protection action behavior evaluation. Because the differential protection principle has the action of the fault in the area and the fault outside the zone, the discriminating degree of the braking amount is large, and it is not affected by the system oscillation and the grounding resistance. The convection dead zone fault, multi-point simultaneous fault, system oscillation causes protection. In complex situations such as malfunctions, it is still possible to quickly obtain analytical conclusions and assist on-site maintenance personnel to analyse faults.

### 4. Application scenarios

After the fault occurs, the maintenance personnel carry the portable fault recording and packet analysis device to the site, and take a wired connection through the FTP or HTTP protocol to read the recorded file of the fault recorder and related newspapers. Text.

Through the WIFI wireless function provided by the device, the recorded files, original messages and related graphic data are shared among multiple intelligent terminals in the field.

The operating device handles all types of messages and the COMTRADE standard format. After deep analysis, the waveform file and the abnormal message analysis result are displayed. At the same time, the device relies on the built-in fault analysis algorithm and high-precision ranging function to automatically form a fault analysis report.

In addition, the mobile terminal device also provides a waveform editing calculation tool and a message analysis tool for the user, and provides further technical support for the maintenance personnel to analyze the on-site accident. All analysis operations are performed on the graphics system, which is intuitive, fast and easy to operate.

The device comes with 4G module and GPS module. In the process of fault handling, the maintenance personnel can transmit the information about the location, video and image of the suspected fault point to the relay protection operation and maintenance control platform, which is convenient for the remote expert team to remotely guide.
5. Conclusion
This paper proposes a modern mobile terminals technology combined with multi-source recording data differential analysis algorithm to develop a portable Fault Message Analysis Device for substation inspection. The device makes the coordination of fault analysis possible, makes the fault analysis process more intuitive and convenient, and is beneficial to improve the efficiency of field fault analysis. The main features of the device are as follows:

Intelligentization of fault analysis: Using modern wireless communication technology, advanced mobile terminals, and convenient communication network, the fault analysis is modernized and the degree of intelligence is greatly improved, and the maintenance work is more intelligent and efficient;

Convenience of fault analysis: It adopts more advanced fault analysis algorithm, higher precision ranging algorithm and automatic fault reporting production program than the recording device. All analysis operations are performed on the graphics system, which is intuitive, fast and easy to operate. It makes the maintenance personnel more convenient and convenient for on-site accident analysis.

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