A RESEARCH OF PROTECTION CHARACTERISTICS ANALYSIS METHOD BASED ON FAULT RECORDING DATA

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Traditional software for fault data analysis embedded in fault recorder device is hard to satisfy the requirements of protection characteristic analysis in power systems. Some main algorithms for fault recording data processing are presented, and the software for protection characteristic analysis is also designed in this paper. It can be applied in new protection principle testing and relay checking on site.

1 FOREWORD

The actual operation of relay protection is not only depends on the adopted protective principle, but also closely related to the technology of applied protecting devices. Therefore, the actual protection characteristics and operation behavior has to be analyzed by the actual fault and the material protecting conditions.

Digital fault recorder device real-timely records the change of the relative electrical varieties when fault occur, which provide the strong evidence for operating characteristics analysis of relay protection. On fault checking method, fault analysis accuracy, fault analysis function and subject adaptability of fault analysis, current digital fault recorder devices are very difficult to be completely satisfied with the special requirement of characteristics analysis of relay protection. The paper, hence, discusses how to carry on protecting characteristics analysis, and how to engage in checking and judging the protection operating condition by using fault data that recorded by digital fault recorder device.

2 PRINCIPLE FOR SYSTEM DESIGNING

According to the special request of the behavior analyzing for the digital protection, the software was designed mainly by the following principles:

- Better adaptability for the multi-form recording data;

- Fully considering for the difference between digital fault recorder device and relay protection device in dealing with the input signal, guaranteeing the recording data to analyze basically be the same with the sampled data in protection actually;
- The protection algorithm which be adopted should have fine filtrate wave ability and well treatment ability for the temporary data;
- To analyze the action characteristic combining with the material method of the protecting principle in order to ensure the analysis result be corresponded with reality;
- To offer essential manual intervention interface, for the convenient of the users to carry on essential adjustment on analyzing the course or the calculation parameter;
- To offer diversified output methods of analysis results, for the convenient of analyzing and judging the conclusion for the users.

3 THE LOSS COMPRESSION AND THE DECOMPOSITION OF THE RECORDING DATA

It can save the costs for hardware that using protecting action characteristic analysis the information gathered by the power system fault recorder, fully utilize the present achievements, and share the information resources. The record format of fault recording wave information generally adopts IEEE COMTRADE standard, an intact data structure is written down usually by the head file, the disposes file and datum file to form , the data file is the biggest in 3 kinds of files, its time to convey is very long, the technology of compression and decomposition must be adopted in order to accelerate the transmission of the data. the flow chart of algorithm for the improved loss compression is shown in Fig.1.

4 PROCESSING FOR FAULT RECORDING DATA AND MAIN ALGORITHMS

Fig.1 The flow chart of the loss compression algorithm

4.1 Standardization of fault recording data

The fault recording data files which the analysis software used are composed of header file, configuration file and data file, which are organized in specified format. The analysis software read the recording data based on specified file standard. Format transformation will be done when differences exist between the standard format and the fault recording data from the fault recording equipment.

4.2 Pre-processing of fault recording data

In order to keep consistent to the practical situation of the protection equipments, low-pass filtering must be taken to the fault recording data in the protecting characteristics analysis of fault recording data firstly. In the analysis software, the digital second-order RC low-pass can simulate the leading low-pass.

The transfer function $H(S)$ of the analogue filter should be identified firstly when using digital filter to simulate analogue filter. Then transform the $H(S)$ in continuous time-domain to $H(Z)$ in discrete time-domain and make them with almost the same amplitude frequency characteristics.

4.3 Basic algorithms for fault analyzing

Pre-processed by the leading low-pass filter, the fault recording data can be used for calculating electric parameters based on the structure theories of protection and the analyzing requirements.

4.3.1 Phasor sudden-change amount algorithm

The phasor sudden-change amount algorithm is used to detect the timing of faults. For example, when three continuous sampling points satisfy the in equation below,

the fault can be detected.

$$\|i(k-N) - i(k-2N)\| - \|i(k) - i(k-N)\| \leq k_f I_{dz}$$

N is the sampling number of the cycle for every industry frequently, k_f regulates coefficient for the definite value of the sudden-change amount, I_{dz} starts definite value for sudden-change amount, generally speaking $k_f = 1$; As measuring after shake systematically, k_f value is raised automatically, in order to prevent causing the sudden-change amount algorithm to start by mistake in the course of shaking; Because this algorithm judge fault moment by adopted for cycle of cycle sudden-change amount difference, contribute to preventing the judgment of mistake caused by sampling frequency and system frequency mismatch in the course of shaking.

4.3.2 Fundamental frequency component algorithm

The commonly used basic algorithm is "full-wave Fourier algorithm", regard sine-cosine function as the function of samples, according to the quadrate characteristic of sine, cosine function, the calculation type of the form that must discrete through deriving, Real part value U_{Rn} , imaginary part value U_{In} are corresponding.

$$u_{Ri} = \frac{2}{N} \sum_{k=0}^{N-1} u(k\Delta t) \cos\left(ik \frac{2\pi}{N}\right)$$

$$u_{Ii} = \frac{2}{N} \sum_{k=0}^{N-1} u(k\Delta t) \sin\left(ik \frac{2\pi}{N}\right)$$

Among them, N is the sampling number in cycle for every fundamental frequently; Δt is the time interval in order to sample, The advantage of this algorithm is when the input signal only includes invariable direct current and whole number harmony except the fundamental component, calculate precision is very high, to other harmonic component, this algorithm have good restrain result too.

4.3.3 Detecting frequency algorithm

Frequency measured by the software, that is confirm frequency according to the time difference between the adjacent zero point of waveform of the voltage. Take wave form of voltage illustrated in Fig. 2 as an example, have v_1 , v_2 and v'_1 , v'_2 crosses the sampled value before and after the zero point for two adjacent cycles respectively, T_s is sampling cycle, the difference time between 0 and v_2 can be approximated to calculate with linear methods.

$$T = T_s (v_2 / (v_1 + v_2)), \quad T' = T_s (v'_2 / (v'_1 + v'_2))$$

Waveform cycle: $T = NT_s - T' + T$, Frequency: $f = 1/T$

4.3.4 Fault types and phase discrimination

Fig.2 Frequency measurement voltage oscillogram

Adopt different protection algorithms according to the difference fault types, there are different implementation methods to ensure the fault phase, in analyzing software, adopt the following algorithms to select fault phase.

(1) Grounding discrimination

The grounding discrimination usually adopts the discretion method that the steady quantity and the fault sudden- change amount combine together.

$$(I_0 \quad 1) \quad (I_0 \quad 2) \quad (U_0 \quad 3)$$

Join the zero sequence voltage as a judgment condition can prevent from short time appears the I_0 to cause the mistake judgment, because of the unbalance of the current transformer transient state procedure, when occur the phase to phase short-circuit.

(2) Single-phase grounding discrimination

The single-phase trouble generally adopts phase electric current sudden- change amount difference to select the phase; the practical single-phase grounding phase selecting adopts the following method:

A phase single-phase grounding $K^{(A)}$

$$(m |\Delta I_b - \Delta I_c| \quad |\Delta I_a - \Delta I_b|) \cap (m |\Delta I_b - \Delta I_c| \quad |\Delta I_c - \Delta I_a|)$$

B phase single-phase grounding $K^{(B)}$

$$(m |\Delta I_c - \Delta I_a| \quad |\Delta I_b - \Delta I_c|) \cap (m |\Delta I_c - \Delta I_a| \quad |\Delta I_a - \Delta I_b|)$$

C phase single-phase grounding $K^{(C)}$

$$(m |\Delta I_a - \Delta I_b| \quad |\Delta I_c - \Delta I_a|) \cap (m |\Delta I_a - \Delta I_b| \quad |\Delta I_b - \Delta I_c|)$$

Under most power system structure situations, m value can be choose according to 4 ~ 8.

(3) Bi-phase grounding short-circuit phase discrimination

That is sure bi-phase grounding short-circuit after grounding short-circuit was confirmed while three single-phase grounding judgment are not tally. In software development, zero sequence voltage and phase voltage are adopted to compare phase and realize the judgment of fault phase.

(4) Three-phase short-circuit discrimination

Can judge whether it is three-phase short-circuit if it is not disgrounding short-circuit, Adopt the short data window to

calculate I_a 、 I_b 、 I_c ,Can confirm it is three-phase short-circuit when the data are greater than the definite value.

(5) Bi-phase short-circuit phase discrimination

Bi-phase short-circuit can be judged after deleting three-phase short-circuit, if it is not disgrounding short-circuit .The outstanding characteristic of bi-phase disgrounding short-circuit is that robust phase current fault component value is far smaller than the fault phase, According to this characteristic, can confirm fault phase.

5 REALIZATION OF THE PROTECTION MOVEMENT CHARACTERISTIC ANALYSE

The software adopts VC as the developing instrument, regard Windows as the application system platform, takes realization of the figure user's interface as the focal point, have set up perfect methods to deal with the mistakes, has unusually avoided unusual operating and system halted phenomenon, enable analyzing personnel can be under the good human-computer interaction interface, realize the data entry, calculation analysis and results show, data processing and graphical display are fast, there are many kinds of outputs ways;

After the software run, user can choose recording data files to be analyzed in appointed file directory according to the need .For meet different protection characteristic analyze, software set up the file of disposition about parameter, so that users set up relevant parameters according to the need, dispose the parameter include the coefficient of proportion of the passage mainly, selecting phase definite value, the definite value of detection to the timing of faults, parameter of the leading digital filter and open or off choosing etc.

After read and pretreatment the recording data , the software judge the fault time automatically. After judgment, graphic will show presentation change wave form of electrical variables around the fault time automatically, so that users can judge according to the showing of the wave form whether the fault time is correct or not.

Once the fault time is checked out , the software will differentiate the fault type according to the electric current、 voltage of the circuit, and show result; The software has offered some typical relay protection device types for users to choose, including quadrangle impedance relay protection devices and round impedance relay protection devices of direction, etc; Users can choose relay protection device types needed to analyze through the “relay” menu, provide relevant definite value.

The software has offered many kinds of multi-form analysis results, include mainly: Wave form, phase

sequence amount, harmonic wave, frequency, measure impedance orbit analysis and switch amount shift order.

5.1 Display of wave form

Among the "sample" menu, can look over the electric current, voltage wave form of input data about A、B、C three phases and zero sequence. can choose to show on the axle at one time of analogue amount of No. 4 wantonly, analyze the phase relation between every phase or different electric amount; analyze electric amount detail wave form and amplitude change in trouble point and switch movement point.

5.2 Harmonic wave analysis

Harmonic wave analysis is improved in the algorithm, have strengthened the treatment ability of the attenuation a periodic component, not only can calculate every harmonic component more accurately, but also can calculate out the amplitude and attenuation time constant of the attenuation a periodic component.

5.3 lay of phase

Can look over the electric current, voltage phase value and changing orbit on different moment by clicking "phasor" menu, the amplitude and phase can be calculated of wanton moment A、B、C three-phase fundamental frequency voltage or current, the amplitude and phase of positive phase sequence, negative sequence, zero sequence also can be calculated. The function calculating of the phasor is very flexible, to letting an electric amount signal analyzed, give full play to the advantage in data processing of the computer, and economize a large amount of calculation time for personnel on site.

5.4 Display the orbit of measure impedance

Can look over the changing orbit of measure impedance and impedance value of the every moment during trouble by clicking "impedance" menu, meanwhile show the real part, imaginary part and amplitude and phase of corresponding measurement impedance, it is very helpful to judge the protection operation behavior which is based on impedance principle on site. In order to understand the operation behavior during trouble of impedance relay, the operation characteristic of the relays selected will be shown on the impedance level, it also shows the impedance orbit at the same time.

5.5 Check-up the operation behavior of relays

In the software, there are many different operation characteristics of relays which is to be check-up, carry on

check-up with the relay through "relay" menu, and compare relative relay movement characteristics with fault phasor and impedance orbit analyzed, then got the operation situation and the operation time of the relay, in order to check up it on site.

This software can be used for testing the new-type relay protection principle, only need to increase the movement characteristic of protecting principle newly in the relay menu, adopt the fault phasor and changing orbit based on operating site, then test new-type protecting principle.

6 CONCLUSION

This system has been steadily operated since it began to run at Tianding 220kv Substation of Changsha Electrical Bureau in November 2003. The system can make analysts realize data input, counting analysis and result show in the good man-machine interface, and possesses the basic analysis function involving relay protection operation analysis. The system contributes to further recognition of protecting actual operation characteristics and improvement of protection characteristics, provides powerful tools to analyze the accidents at operating site, and also can be applied to new protection principle testing and relay checkup on site. Thus the system helps to improve the accurate ratio of relay protection operation and would be widely applied.

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