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A design of small current grounding line detection device based on MCGS and steady-state signal

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ABSTRACT

In neutral point ineffectively grounding power system, the single-phase-to-earth fault is most likely to occur. Due to the complicated environment when single-phase-to-earth fault occurs, lots of domestic and foreign experts are focus on the related research of related theories and devices. Although varieties of fault line detection theories are emerge endlessly, the results are unsatisfactory. The main reason is that the front channel signal detection, sampling, conversion is inaccurately. For those reason,Combined with zero-sequence admittance method, MCGS (Monitor and Control Generated System) touch screen module, ADAM-4117 data acquisition module, front-end circuit module and power resource module are used to develop a new type of fault line detection device in this paper. By this line detection device,the flaw of previous line detection device can be remedied. And the new device which can improve the degree of accuracy and the efficiency in line detection can make the line detection really play a role. And then the stability and reliability of power system will improve. Before then,the line detection device mainly base on DSP and SCM and utilize the zero-sequence current method. The MCGS software is available for many years. But not develop its advantages in line detection field. This combination is the first time. In addition,zero sequence admittance method has never appeared in the actual line detection device. The accuracy and instantaneity of this device in fault line detection are verified through laboratory and actual transformer substation experiments.

KEYWORDS

Small current grounding system; Zero sequence admittance method; MCGS; Line detection device; ADAM-4117, Steady-state signal.

INTRODUCTION

In neutral point ineffectively grounding power system, the single-phase-to-earth fault often occurs. As this system can keep the line voltage symmetrical and the fault current is small, there is no need to trip immediately. The power system can continue to run for 1-2 hours. However, at this time, phase-voltage will rise to the line-voltage on two healthy phases, which is a serious threat to the insulation of power system. The fault must be detected as soon as possible[1,2].

Since the 80's, the small current grounding line detection devices which based on the microcomputer system and MCU have got further development and application. These devices often utilize the algorithm of comparing amplitude and phase of zero-sequence current, comparing amplitude and phase of a group of line,fuzzy set method and so on. These device often utilize MCU and DSP as a hardware platform. The results of actual experiment show that most of the devices running effect is not good, even some devices exist in name only[3]. Analysis the reason as follows:1, the front channel signal detection, sampling and conversion circuit is inaccurately.2, The algorithms of those devices are too complex, which lead to many algorithmic errors.3,The device's work environment is complicated. Based on the above reasons, this device utilize easy-realization module (MCGS, high-precision signal collection module)as R&D platform and the simple but high-accuracy zero-sequence admittance method as detection algorithm[4,5]. The accuracy and instantaneity of this device in fault line detection are verified through laboratory and actual experiments.

THE DESIGN OF DEVICE

The hardware design of device

The hardware structure diagram as follow:

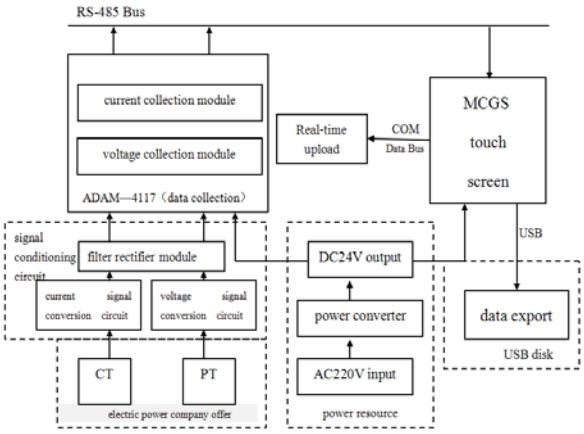

Figure 1 : The hardware structure diagram

The hardware system include: MCGS touchscreen module,ADAM-4117 voltage/current signal acquisition module, Signal conditioning module, the power resource module. The PT/CT of substation collect the zero-sequence voltage and zero-sequence current of power system in real-time. The signal of the secondary side of CT/PT must be use the signal conditioning circuit to adjust to the range of AMAD-4117. In order to make the signal had more faulted characteristic and high-accuracy, the signal after signal conditioning circuit must be pass the commutating and filtering circuitry. The signal flowed from the commutating and filtering circuitry is collected by ADAM-4117. The MCGS touchscreen is connected with ADAM-4117 by RS-485 data line. By the program which already downloaded in MCGS, the MCGS do the analysis about line detection. The results will display on the touch screen. The data can be export by USB flash disk or upload to manager computer.

MCGS touchscreen

The MCGS touchscreen of kunluntongtai company is the core of the hardware system. The interface should be program by the MCGS configuration software running under windows operating system. The program which based on zero-sequence admittance algorithm should be write. The program need to be download into MCGS by data line. The configuration software have advantages of easy-programming, short development period and good man-machine interaction,etc. Line detection results will display on MCGS after program execution. In addition,the USB port in MCGS can transfer the data.

The signal conditioning circuits

The signal conditioning circuits mainly include the commutating and filtering circuit, voltage signal conversion circuit and current signal conversion circuit. The function of these circuits convert the signal coming from the secondary side of CT/PT to the acceptable level of ADAM-4117.

a) Voltage signal conversion circuit: By a little PT (100V/15V), this circuit converts AC57.7V of PT secondary side of substation to an acceptable voltage of ADAM-4117.

b)Current signal conversion circuit:By a resistance conversion circuit,this circuit converts AC20mA of CT secondary side of power supply company to an acceptable current of ADAM-4117.

c)Che commutating and filtering circuit: The commutating and filtering circuit adopts bridge rectifier circuit. It will process the converted voltage/current signal. In order to ADAM-4117 can collect the less-noise or no-noise signal.

ADAM-4117 data acquisition module

The mainly function of this module is collect the signal which already convert to an acceptable level in real-time. RS-485 communication line can transfer the collected signal to MCGS touchscreen. ADAM - 4117 is the core of the voltage and current signal collection. It has many advantages, such as: good anti-interference, good- programmability,widely gathering range, cheap-price,etc.

The real-time-upload module

The computer's RS-232 data export can be used. The function of data real-time-upload will be come true. The RS-232 data line combine computer with MCGS. The 2,3,5 pin of COM1 of computer corresponding to the 3,2,5 pin of COM of MCGS. The touch-screen upload the real-time data and the computer is responsible for receiving

The power resource

The power resource can provide working power resource to MCGS touchscreen module, voltage/current signal acquisition module, signal conditioning module.

Figure 2 : Test the equipment in laboratory

The software design of device

Program by the MCGS configuration software[6] running under windows operating system. The program is based on zero-sequence admittance algorithm. The program flow chart as follow:

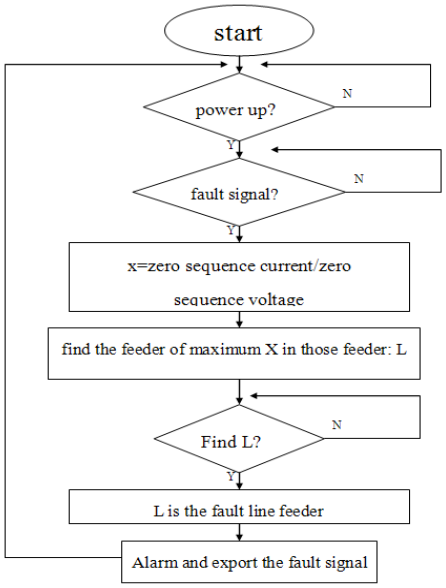

Figure 3 : The program flow chart

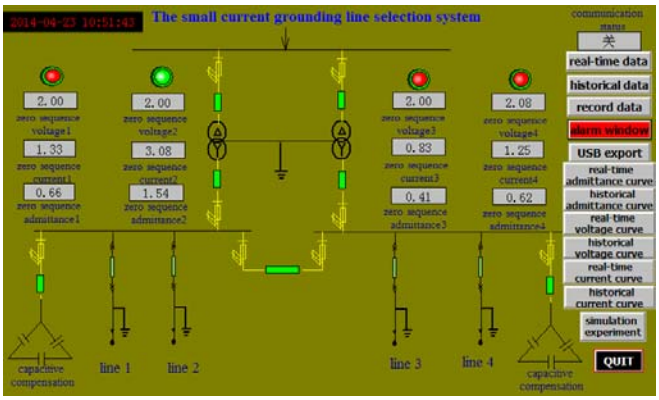

Figure 4 : The main interface of software system

The main interface of program display various of state of feeder in real time,which include real-time zero-sequence admittance, real-time zero-sequence voltage and real-time zero-sequence current of each feeder. The main interface also is an entrance of the other specific interface. This interface contains a 1 1incoming line 4 outgoing line 2 transformer power substation. The main interface also can be designed according to the actual transformer substation.

In addition, The program also include:

a) Real-time data window: This interface real-time display the zero-sequence admittance, real-time zero-sequence voltage,real-time zero-sequence current of each feeder. It realizes the function of real-time monitoring of each feeder.

b) Historical data window: This interface display the historical data of the zero-sequence admittance, real-time zero-sequence voltage,real-time zero-sequence current of each feeder. The data can be view though forward the page. It realizes the function of the data record of each line.

c) Inventory data window: Inventory data show that the inventory data content.

d) The alarm window: This interface is line detection results showing window. When single-phase-to-earth fault occurs, The alarm window will alarm (the green light turn into red light) in real-time. The red light reminds managers a grounding fault is occurring. After computing,the alarm window provide the final results of line detection. In addition, the alarm window also can set the alarm limit. If one feeder's zero-sequence current improve suddenly, The single-phase-to-earth fault may be happened. The user should pay attention to this feeder.

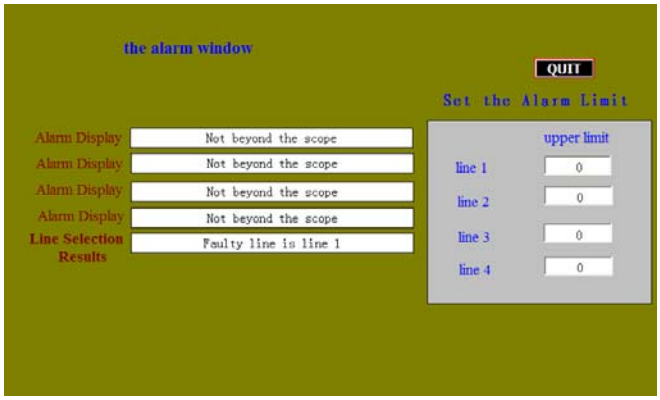

Figure 5 : The alarm interface

e) The curve of the real-time zero-sequence admittance, zero-sequence voltage and zero-sequence current window:The zero-sequence voltage, zero-sequence current and zero-sequence admittance curves of each feeder can can be draw in real-time,which can provide a general trend of each feeder to user.

f) The curve of the historical zero-sequence admittance, zero-sequence voltage and zero-sequence current window:The zero-sequence voltage, zero-sequence current and zero-sequence admittance curves of each feeder can can be draw in historically,which can provide user a general trend of historical fault.

g) The function of USB flash disk export:It can derive the inventory information. USB disk should be insert. The start time and end time of related information should be set. Then press the button of "USB disk export"in the MCGS touchscreen. After 3 seconds,There will be a Excel file in user's USB disk. The user can check this file or draw a carve using these information.

h) The function of real-time upload:The data and curve should be upload to upper computer by the COM1 of computer,which will make the examine of feeder and MCGS easily and convenient.

Figure 6 : The interface of USB flash disk exporting

The design of shell of this device

The shell of this device utilize 2mm cold-rolled sheet to produce. The size of the hole of substation cabinet of substation is 482*178*291. In order to lock in the substation cabinet,the left and right of front-side leave 15.5mm margin. The size of the hole in front-side is 215*152 in order to install the MCGS touchscreen. The rest of parts install in the interior of the shell.

Figure 7 : The overall appearance of the device

LABORATORY TEST

Experimental equipment

The experimental equipment of this test including DG1022/DG1022U signal generator, the device based on MCGS and power resource.

The significance of each channel of signal generator

By DG1022/DG1022U,This experiment simulate the signal of zero-sequence current/zero-sequence voltage of CT/PT secondary-side.

The CH1 channel of DG1022U simulate the zero-sequence current of line 1. The CH2 channel of DG1022U simulate the zero-sequence current of line 2. The CH1 channel of DG1022 simulate the zero-sequence current of line 3.The CH2 channel of DG1022 simulate the zero-sequence voltage of bus.

The signal generator only output voltage signal. In order to collect the current signal,By ADAM-4117,The voltage signal be transfer to the zero-sequence current signal which MCGS need. The CH2 of DG1022 need not conversion,as the bus need voltage signal.

Experimentation

1)The power of signal generator and the line detection device should be plugged in.

2)The parameters of each channels,the period (50Hz)of signal and the voltage value of line 1,line 2,line 3 should be set.,In addition,a fault feeder should be set in these lines.

3)After signal output,The alarm window should be click in the MCGS touchscreen. as there is line detection results.
4) Experimental results:

TABLE 1 : Experimental data and result.

serial number	zero-sequence current(A)	zero-sequence voltage(V)	zero-sequence admittance(S) calculate result	zero-sequence admittance(S) experiment result	anticipated result	experimental result
1	0.0167	2.5	0.00668	0.00724	Line 1	Line 1
	0.0075		0.003	0.00296		
	0.0158		0.00632	0.00633		
2	0.00415	2.5	0.00166	0.00168	Line 2	Line 2
	0.0104		0.00416	0.00434		
	0.00625		0.0025	0.0025		
3	0.005	2.5	0.002	0.002	Line 3	Line 3
	0.0104		0.00417	0.00398		
	0.0208		0.00883	0.0083		

Experiments show that the line of this device selected is same with the fault line we set.

CONCLUSIONS

The experiment of laboratory and actual substation results show that the small current grounding line detection device based on MCGS have a outstanding performance and the function of design already realized. This device has a better value of market. Meanwhile,this device has advantages including:high-integration,low-price,short development period,easy-maintain, good-man-machine interface,simple-to-use,etc.,This device is in a class by itself in line detection device.

CONFLICT OF INTEREST

This article content has no conflict of interest.

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