2005년도 대한전기학회 하계학술대회 논문집 2005. 7. 18 - 20

고장점 탐색 장치를 위한 H/W 설계

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H/W Design for Fault Location System on Underground Power Cable System

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Abstract -Developing fault location system for underground power cable which can detect its fault location exactly require very high speed data acquisition and signal processing capability. We are developing fault location system which is different from conventional fault locator. This fault location system monitor underground power cable by using on-line speed current sensor and if there are an accident, it record its transient signal and calculate fault location by analyzing it. Signals which acquired when power cable fault arise, showed transient characteristics and its frequency band is very high. So, to develop fault location system, we designed special high speed data acquisition and signal processing board.
In this thesis, we describe on data acquisition and signal processing H/W design for fault location system on underground power cable.

1. Introduction

Fault location detection is finding exact fault position of cable when there were any unwanted accidents like short circuit, open circuit, insulation breakdown, etc.
Because of large damage and inference of power cable accident, power authorities want to have exact fault detection method to recover power lines as soon as possible. Various methods have been developed to reduce damage and inference.
But most of fault detection methods have shortcomings. Some have low accuracy, some are difficult to apply because of surrounding environment, some give unwanted damage to healthy neighboring cable and facilities.
Among these fault location methods, pulse echoing method are regarded as most useful ones. This method use time difference between incident and reflected pulse to calculate fault location detection and it has relatively high accuracy because it use short period pulse..

Although it has high accuracy, pulse echoing method has some drawbacks. When we apply this method to low impedance accident, the errorwill be increase. If cable is not open circuit and there are no impedance change, there are no reflected pulse wave, and it is difficult to find fault location. Also high voltage pulse generator is needed for pulse echoing method and it is one of its drawbacks. To make high voltage pulse generator one should pay another money and inserting high voltage to cable can cause another damage to cable and facilities. Its is usually applied to detect fault locationafter accident arise and this way need more time to repair.
Because it is very expensive system, on-line motoring and fault location detection of cable require so big money. And its natured drawbacks mentioned above, power authorities need new methods which can detect fault location exactly and which on-line monitoring is possible.

New methods are under developing which can detect fault location exactly and which on-line monitoring is possible. We are trying to develop low cost, but very exact power line fault location system.
This system usually monitor underground power cable on-line. But if there are an accident, it record its transient signal and we can calculate fault location by analyzing it.

In this thesis, we describe on H/W design for new fault location system which is exact, cheap and on-line monitoring is possible.
In following chapter 2, we will represent on outline of new fault location detection system we are developing. In chapter 3, detailed description on H/W design for fault location detection system and results will be described.

2. outline of New fault location system

We are developingnew fault location system. This new fault location system will provide more flexibility to install and more advantage which is exact, cheap and on-line monitoring is possible.
For the new method, sensors will be installed to the end of cable terminal to detect transient current which will flow through cable when there are an accident. To calculate exact fault location, transient current signal should be recorded and analyzed after accident arouse.
So, a device which can store transient current signal waveform will be installed with sensors to the end of cable. Fault location

detection process is followed to find exact fault position

Figure 1 show the overall system structure. As you can see there are two current sensors and two devices to record transient waveform for one power transmission line.

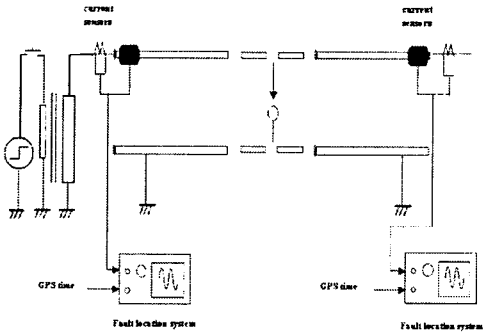

Fig. 1 Fault Location System Structure

We already found that by analyzing recorded fault signal waveform we can calculate exact fault position and distance resolution can be reduced to several meters. Fault location accuracy, distance resolution, can be reduced to adjusting sampling rate.

We calculated relationship between accuracy and sampling rate. Our design goal on accuracy was within 5 meter and we decided to use Rogowski coil as current sensor and we used 100MHz as sampling rate. To develop fault location, we conduct various experiment by using power line fault simulator we developed and we found that Rogowski coil has best as current because of its high frequency characteristics and flexibility of handling.

3. H/W design for fault location system for underground power cable

To design system that should operate with very high speed, we should considered various factors. Sensor, A/D conversion, data fetch and record, detection of fault, signal processing for fault location, etc.

For sensors, we used Rogowski coil as already mentioned to measure fault current. Rogowski coil is very adequate for fault location sensor because it has very high frequency characteristic and it also has flexibility to design. Easy to design and install.

A/D conversion is another problem. Because fault signal has high frequency characteristics, we must use fast A/D converter We choose 100MHz A/D converter to reduce distance resolution within 5 meters. Further more, we wished to develop our fault location system as possible as small size, and this make us to select fast but small sized chip.

Data fetch and record is very important, too. So we used fault detection algorithm and FIFO, programmable logic.

Furthermore, To record fault signal only, we need to detect fault signal. This is very important key point of our new approach If this is not possible, we should record very high speed signal entirely and it is not possible with limited device's memory. So, we developed fault signal detection algorithm and implemented it by using flexible programmable logic for high speed operation.

Signal processingfor fault location are designed to use wavelet transform. For recorded fault signal, wavelet signal processing technology applied.

To design fault location system which can find fault position accurately, firstly, one must use sensor which has best characteristics. Secondly, one should develop good signal processing technology which can extract signal that are wanted to calculate fault position. Finally, one should design H/W effectively. H/W system should record data fast, should transfer data effectively with external and internal devices, should have high stability and reliability. Furthermore, other factors like small sized, good user I/F, etc. also required.

Considering above mentioned factors, we designed H/W for fault location system.

Fault location system composed of CPU, A/D conversion block, FIFO, FPFA, Memory block, Display unit, and I/F module.

CPU blocks function are recorded waveform signal processing and calculation of fault position, control of system, communication control, interface control, etc. Interface with FPFA, Memory, external I/F, Display unit, it process various event interactively and control overall functionalities.

A/D conversion block's main function is data input conversion. Because fault signal waveform has very high frequency characteristics, its sampling rate also high, 100MHz. We choose 2 channel high speed A/D converter, one for fault signal waveform capture, another one for signal capture trigger. Signal capture trigger input is to detect fault signal only, otherwise we should record every data. It is impossible for system which has limited memory size. So, to record signal when there are fault, we implemented fault signal detection algorithm by using programmable logic. H/W logic input one of A/D conversion channel, signal capture trigger channel, and it decide there are fault, system fetch signal that are stored in FIFO.

To input high speed data, we used high speed FIFO. Used FIFO are very high speed one and its clock rate are up to 166MHz. This FIFO can handle has 16kByte long data and we used this size as moving window.

FPFA module control FIFOand fault signal detection is one of its function. It receive data from FIFO, by using window. And it decide is there any fault arose. If it decide as fault, it request to CPU to transfer data to memory.

I/F module's are composed for selection switches, status display unit, external interface, RS232C, etc. This module's main functions are provision for board test, display of device status, data transfer to external device for test and communication.

Figure 2 shows developed control unit, including CPU, A/D conversion unit, FIFO, and Memory except Display unit.

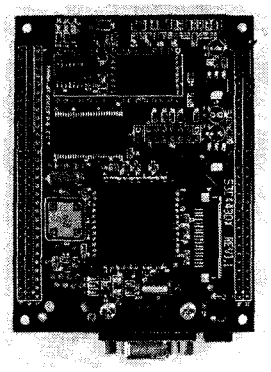

Fig. 2 Control unit for Fault Location System

Display unit are used for display of captured signal and processed signal, and for GUI. Its display resolution is 320X240. We can see easily captured signal and processed waveforms moving forward and backward by using switch buttons, one for forward scrolling , one for backward scolling.

Figure 3 shows developed display unit.

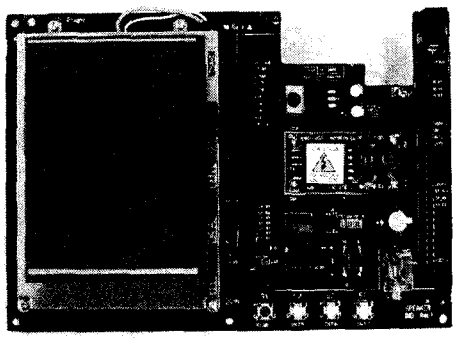

Fig.3 Display unit for Fault Location System

Figure 4 shows integrated fault location system. The waveform showing in figure 5 are signal which captured .
In figure 4, channel 1 signal represent waveform captured for test and channel 2 signal represent trigger signal. We designed triggering mechanism which use reduced sampling rate and less sensitive sensor signal.

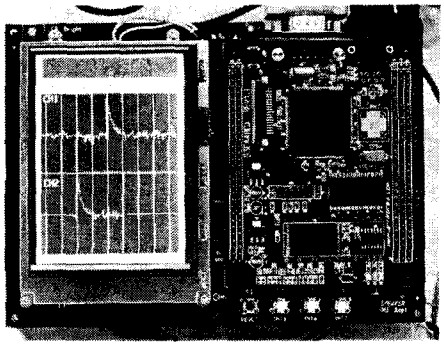

Fig. 4 Developed Fault Location System H/W

4. Conclusion

We are developing fault location system which is different from conventional fault locator. Developing this new fault location system for underground power cable which can detect its fault location exactly require very high speed data acquisition and signal processing capability. This fault location system monitor underground power cable by using on-line high speed current sensor and if there are an accident, it record its transient signal and calculate fault location by analyzing it. Signals which acquired when power cable fault arise, showed transient characteristics and its frequency band is very high. So, to develop new fault location system, we designed special H/W system that is adequate to input and capture high speed and large number of data signal. This H/W system also has signal processing capability. With well designed GUI and interface, developed H/W will be used for test and for more advanced device development.

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