Integration Of Recording Relays Into Disturbance Analysis

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Abstract : The world of power system protection, monitoring and control is quickly changing. Today's powerful microprocessor technologies can provide a capability to do many functions for the power utility needs. New Digital Signal Processor (DSP) Technologies have provided the power to have recording relays become a reality. While this may seem obvious, there are some technical and non technical issues that have also to be resolved .

This paper looks at how the integration of recording relays can be achieved and how this concept can be expanded to meet the challenges of utility personnel with respect to fault and disturbance analysis.

Keywords : recording relays, fault and disturbance analysis, integration of recorder and relaying technologies

Introduction

In the past world of electromechanical protective relays, the only way to monitor and assess their operation was by way of a stand alone fault recorders. These fault recorders sometimes had mechanical methods of providing prefault information by way of rotating drums or through some sort of storage medium such as looped magnetic tapes. While somewhat crude, by today's standards, these early recorders provided much insight into what took place during faults and system disturbances.

As the power of the modern microprocessor evolved in the 1980s, stand alone recorders were able to use the power of digital data processing to provide the analytical engineer with power system voltage and current waveforms that could be analyzed in the electronic medium before being printed on paper. This of course was a tremendous step forward. Power system analytical tools such as fault, stability and electromagnetic transient programs also became more widespread in their development and use. At this time the emergence of microprocessor relays also took place.

What Is Driving Todays Needs For Fault And Disturbance Recording

The operation of a electric power utility today is being driven more and more by issues like deregulation where more has to be achieved with fewer human resources in a shorter time period. To address power system reliability issues, the North American Reliability Council (NERC) has been charged with the responsibility to see that this is achieved. It is not in the scope of this paper to look at the pros and cons of this group, other than to say that there exists some expectations by this group being placed on operators of power utilities to demonstrate knowledge of what their systems look like and what their performance is like during a particular type of fault or system disturbance condition.

Time Frames Associated With The Operation Of A Power System

Various events happen at various time frames. Some of these events can be categorized as follows :

TIME PERIOD	EVENTS	EXAMPLE
microseconds	switching surges	breaker restrikes
milliseconds	harmonics	variable speed drives
cycles	fault clearing	relay and breaker operation
seconds	load flow changes	governor / exciter response
minutes	system stability	reaction to dispatcher actions
hours	load variation	new generation schedules
days	NERC reports	system disturbance
months/years	modelling of systems	fault, load flow and stability

Today's World Of Microelectronics In The Power Utility Field

While it is true that many pieces of equipment are still protected by electromechanical relays, it cannot be denied that the digital world has arrived in the power industry. Processors such as the Digital Signal Processor (DSP) have a tremendous affinity to perform mathematical computations for data processing and performing protective functions. Digital technologies today can provide both a protection as well as a recording function in one box in a robust and technically feasible solution .(See Figure 1) Recording relays have the ability to cover recording time frames from milliseconds to hours with a sampling speed of about 100 samples per cycle.This sampling rate can be averaged down to also cover the power swing time domain.In this way, issues related to harmonics, faults, load flow and stability can be covered. There is no reason to believe that this direction will not continue as station integration of all IEDs produces technically sound and efficient solutions.

An Example Of A Recording Relay Infastructure

Overall Relay

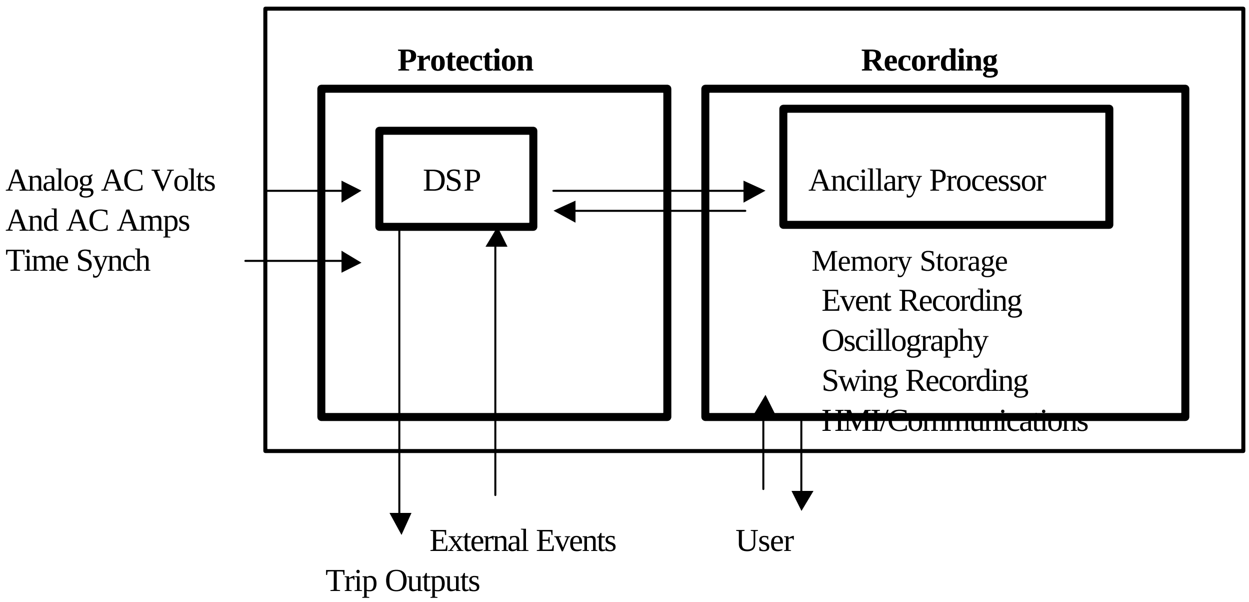


Figure 1

Benefits Of Using Fault Recording Relays

Some of the benefits of use of fault recording relays are :

1. Cost benefits. Minimize external connections and hardware.
2. Voltages and currents captured are the same as those used by the relay itself. Waveforms captured will be the same used by the relay itself.
3. Relay functions that operate are all part of the fault record itself. That is, the events of the fault record can be seen on the same software as the analog volts and amp channels.

4. Relay settings at the time of the fault can be easily attached to the fault record to help produce a more complete database for the fault.

Some Issues Related To Use Of Recording Relays

1. **What happens to recording if the relay fails during the fault ?** This question can be answered with another question, What happens to protection if a relay fails ? Good protective relaying design practices dictate that backup relaying needs to be provided for protection purposes, Should backup recording be such a foreign concept then ? If overlapping zones of protection are used, overlapping zones of recording is certainly available.Figure 2 illustrates an example of a line distance relay covering two busses forward and reverse from its location using more or less conventional relaying logic. Since protection logic can be used to initiate recording, recording can also be initiated for any faults in the six bus area. In addition, protection redundancies at these busses should also provide backup protection and redundant recording.

Overlapping Zones Of Recording For A Line Example

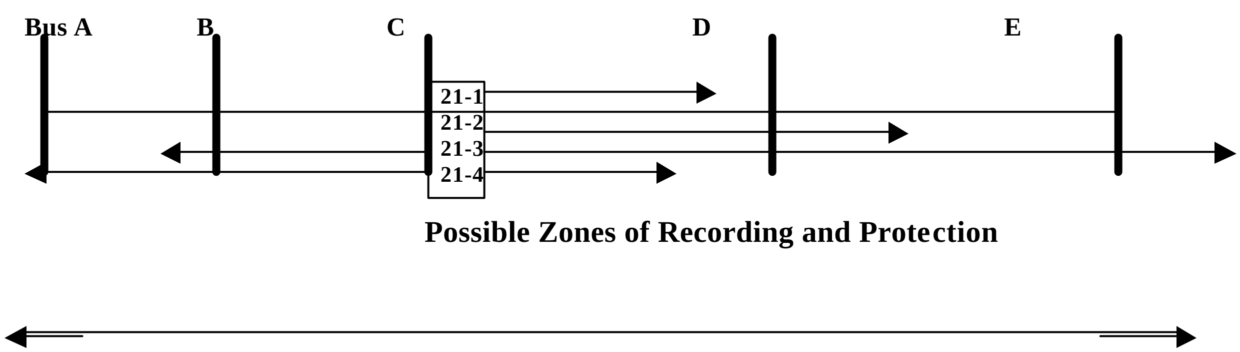


Figure 2

2. **What happens if the relay gets burdened with recording, then slows down its protective function ?** Make no mistake, a recording relay's primary function must be to provide the protection aspect, then recording. Intelligent recording relay design can use one processor such as a DSP to provide protection then hand off recording to another on board processor, thus unaffecting protection for any system condition.
3. **Data rates for relay functions are typically in the range of 4 to 16 samples per cycle.Where can good quality fault recording come from ?** Again, processors such as DSPs can be made to sample analog voltage and current quantities at rates of say 100 samples per cycle then average down this rate as required for relay algorithm needs.Advances in memory technologies has made storage of data in the relays possible.

4. **Time Synchronization ?** Most relays as well as stand alone disturbance fault recorders are able to accept time signals such as IRIG-B to ensure good time resolution between events. Failure to do this with any data collected by any IED can lead to a chicken/ egg situation. Fortunately, IRIG-B is getting better and less costly for station applications.

Other Sources Of Disturbance Data

The presence and ability to collect disturbance data from recording relays is of course not an end all solution. Other sources of data can come from:

1. Stand alone fault and disturbance recorders.
2. SCADA and RTUs.
3. Other relays and IEDs such as meters, controllers and special protection devices.

A Data Management Model

With all the IEDs on a power system in place, the first question one may ask is " Where is the information that I need ? " This may seem to be an obvious answer but past experience shows that either the relevant information is buried in a heap of data or possibly failed to reach its destination for some reason. (Mr. Murphy had a theory on this !) In the building of this model, a healthy component of this theory can be used to make the model better.

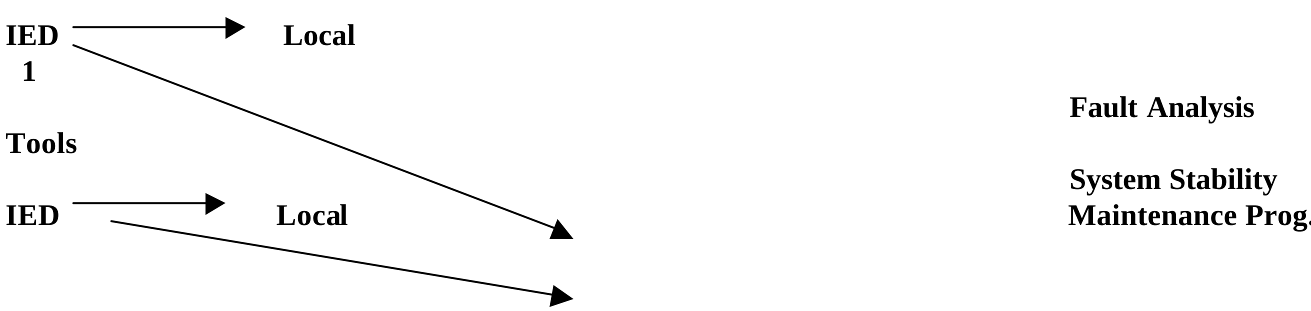
Some of the basic questions that need to be asked in the direction of this model are :

1. Who needs the information ?
2. How soon is the information required ?
3. What type of information is needed for each user ?
4. Where is the information needed ?
5. When is the information needed ?

Other issues that need input in the model are :

1. Where should the data be stored ?
2. What is the fallback position if data is not received ?
3. What can be done with redundant data ?
4. How can data be integrated into a useful form ?
5. What form is the data format ?

One first attempt of a data integration model can be seen in Figure 3. In this model, IEDs in the field collect data then report this data to their own collection systems and/or to a common central station.



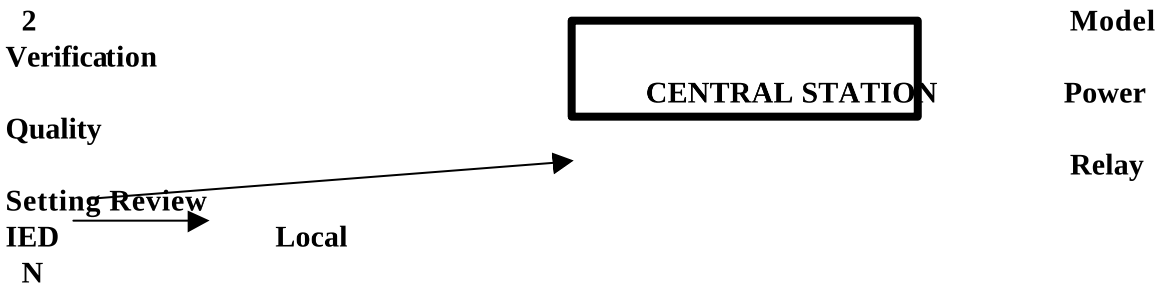


Figure 3

The data from the various IEDs may be sent in the same or in different formats.In order to place the data into the Central Station in a meaningful fashion, this data needs to be converted to a standard format such as the same Comtrade format . Once this is done, various tasks can be performed on this data. Appropriate data can be absorbed into the various tasks by different data processors. For example, Fault Analysis can be performed either by a artificial neural network or by a combination of human and software interactions. The results of this activity can either go off to other areas or can be put back into another part of the Central Station database.

In some cases, such as say need for fault location, the information may be required more quickly than can be provided through the Central Station information route. In these cases, the data from the relays can be provided locally and through connection with systems such as SCADA to provide the information to the right people at the right time. This does not preclude the possibility of also sending information such as fault information to the Central Station for further analysis of for statistical value.

Central Station Format

In order to provide enough flexibility in being able to use the data collected by the Central Station, it must be structured to allow this to take place readily. One possibility for the Central Station is presented in Figure 4.

Possible Central Station Makeup

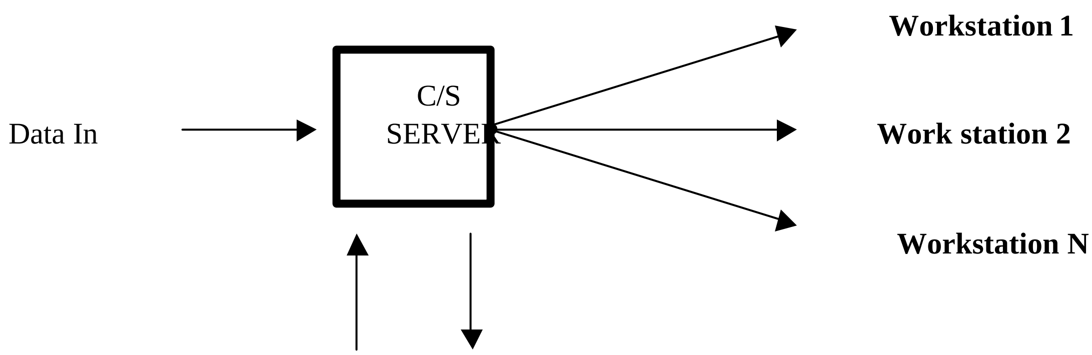


Figure 4

This model of a Central Station allows the data collected from IEDs to be distributed to various user workstations where data can be analyzed or used by other software programs. This model also goes some distance in addressing issues such as backup storage of data. In all the models for common use of data, time synchronization and the ability to generate standard forms of data using standards such as Comtrade to normalize the information is important. If this cannot be achieved, then the user will be forced to use several central station programs that may be very difficult to correlate to a given fault or disturbance. This unfortunately still happens today for too many disturbances.

Concluding Remarks

As the need to know on power systems expands and becomes more and more important, any and all sources of fault and disturbance data will be sought and used by the power system analysts and system operators. All information available for a particular disturbance will therefore be actively used. For all faults and disturbances it is guaranteed that one form of protective relay or another will be involved and assessed. The ability of a recording relay to provide information about the power system during these disturbances can certainly help in the analysis process.