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Prevention of Cascading Failure in Electrical Protection power system of Nuclear Generating Stations

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1. Introduction

Major blackouts are rare events, but their impact can be catastrophic. Cascading failure is the main mechanism of large blackouts, Failures successively weaken the system and make further failures more likely so that a blackout can propagate to disable large portions of the electric power system. Also, hidden failures of a protection system is a permanent defect that will cause a relay or a relay system to incorrectly and inappropriately remove circuit elements as a direct consequence of another switching event.

Hidden failures in equipment occurs randomly and does not lead to any change in the state of the power system so, remains undetected. Although hidden failures can occur in any equipment in the power system, the hidden failures in protective equipment's have attracted very high attention in the recent years. The effects on the power system due to hidden failures can be catastrophic if suddenly happens .

2. Methods and Results

This paper examines the mechanisms of hidden failures of the protection system, their role in major power system disturbances, and concludes with lessons learned from an examination of past system blackouts.

The IEC 61850 standard and digital relays (intelligent electronic Device (IED)) will be selected as a key solution. The advantage of IEC 61850 standard and digital relays not only to be reliable and safe but also are quite easier to handle. In addition, alternative solutions are also considered in this study.

This work still on progress and all the results and benefits from using the IEC 61850 standard and digital relays (intelligent electronic Device (IED)) will be send before conference and it will be shown in conference.

2.1 failures of power systems

Catastrophic failures of power systems cannot be completely avoided because of failures, admittedly low but unavoidable, in all generation power systems. The best that we can do is to reduce the likelihood of the incidences and limit their propagation through cascading phenomena. Catastrophic failures generally occur with an initiating event such as a fault, particularly when the power system is under stress due to scheduled or unscheduled outages of important generators or transmission facilities. the number of catastrophic failures seems to have increased significantly. Certainly, greater attention is paid to such occurrences in the press and by government agencies. A number of new approaches for monitoring, protection and control of the power grid have been developed in recent years and the application of these methods is helping reducing the frequency and severity of catastrophic failures[1].

2.1 Blackout examples

2.1.1 North American blackout of 1965

This blackout is one of the watershed events in the annals of electric power engineering (among other changes, it brought about a move towards computer based Energy Management Systems). During November 1965, the conditions at the Sir Adam Beck #2 substation on the Canadian side of the Niagara Falls area were as shown in Figure 1. There was local generation at the station of about 1000 MW and 500 MW was being transmitted to Canada from the USA on the two transmission lines shown in figure (1).

In those days, it was common practice to use remote breaker failure protection on transmission lines. The five tapped transmission lines to the north were so equipped, and the loadability limit of the breaker failure relays was 375 MW. These relays were set in 1956, nine years before this incident. When the relays were set, the loadability limit was considered secure, as the expected maximum load was much lower. However, over the years, the power flow on the lines had increased steadily and the inappropriate settings of these relays were overlooked.

With 1500 MW flowing on the five lines and, as is usual, the flows not dividing equally and, due to the uncertainty in the relay characteristics at the reach boundary, the loading on one of the lines exceeded the relay setting and the line tripped. Immediately the power now divided among the remaining four lines and, as can be expected, they all tripped. Thus, there was a step change of power flow on the North American system of 3000 MW, which caused a break-up of the entire system. An area approximately 1600 km square was blacked out and it took more than a week to restore power to all the customers affected.[1,2]

A careful study of several blackouts shows that a surprising number of them have some degree of involvement from the over-tripping of protection systems. By itself this is not a condemnation of the way protection systems are designed, installed, or maintained.

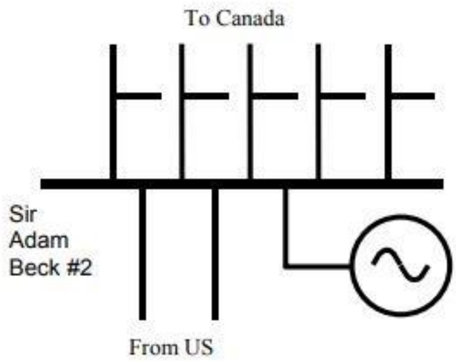

Figure (1):North American Northeast blackout in 1965.

The hidden failures of the power systems are of two kinds:

1) The settings of the protection systems are inappropriate for the prevailing system conditions. In most cases, the settings were appropriate when made, however, the system has undergone sufficient changes and the settings have not been revised. Consequently, although the relay functions correctly, in effect it has a hidden failure because of the inappropriate setting.
2) Actual failure in the relay. The failure may be due to a failed component, component wear or to a component that has been damaged by environmental conditions or by incorrect human intervention.

3. Strategies and countermeasures

3.1 improvement measures using IEC 61850 standard

IEC 61850 is gaining popularity in power substation automation and will dominate the future substation automation and protection system design. The development of non-conventional instrument transformers, Merging Unit and wide application of micro-processor relay allow effective implementation of digital protection scheme through Ethernet-based local area network communication.

The secondary circuits in substation are simplified significantly; the massive hardwired cables from primary plant to secondary protection and control system are replaced by the high speed process bus The essential point in the given context is the fact that the station controller will not only communicate with the IEDs connected to the station bus, but also with the CB controllers connected to the process bus. The station controller may send controls to operate the CBs and receive reports about the execution of the commands. To reach the CB controllers, client/server traffic must be exchanged over the process bus, where it will interact with the Sampled Values. as shown in figure (2).[3]

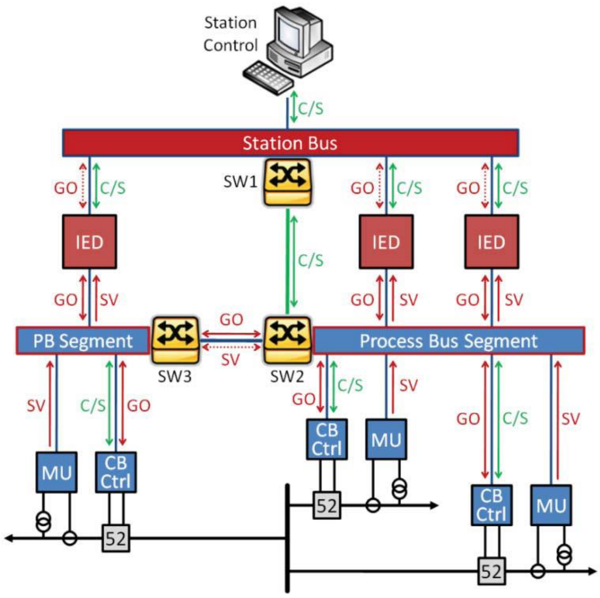

Figure (2): power utility communication network with dedicated station bus and process bus

Protection systems were essentially digital, it is reasonable to expect that different failure modes and different probabilities of hidden failures will occur. Nevertheless, the techniques of analysis developed here are applicable to digital protection systems as well. The advantage of digital protection systems is its ability to monitor itself and determine that it is not functioning correctly and then alarm so that corrective action can be taken immediately.

2.1 Digital protection system

The term "fully digital" power utility protection, automation, and control system targets at an installation that utilizes all kinds of communication defined in IEC 61850, i.e. client/server communication, GOOSE, and Sampled Values [3,4]. The different protocols offered by IEC 61850 can be transmitted over a common communication network for transporting traffic of different kinds from multiple senders to multiple receivers instead of using multiple point-to-point connections [4].

3. Conclusions

Simulation techniques using ETAP SIMULATION PROGRAM, can be useful tools for detecting the effect of applying IEC 61850 standard and digital relays (intelligent electronic Device (IED)) to detect and prevent hidden failures in nuclear power plant generation stations.

The IEC 61850 standard and digital relays (intelligent electronic Device (IED)) will be selected as a key solution. The advantage of IEC 61850 standard and digital relays not only to be reliable and safe but also are quite easier to handle.

The results of this work by using IEC 61850 communication protocol in Nuclear power Generation power system still under progress and results will be sent later this month.

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