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## OPTImizer+® Application Note 1

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### *Incipient Breaker Failure Detection and Remedial Protection & Control Possibilities*

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#### A. ABSTRACT

This Application Note discusses use of the OPTImizer+® Breaker Wear Monitor in protection and control remedial schemes to avoid breaker failure clearing. Clearing for a breaker failure often involves disconnection of buses, which is undesirable from a power delivery perspective. The System Engineer may choose different application possibilities, depending on the importance of the breaker, power apparatus configuration and available protection and control infrastructure.

#### B. BACKGROUND

##### 1. Breaker Failure Defined

A Breaker failure is defined as when a trip request is made to a breaker, and the breaker does not trip within a required time interval. A breaker failure is a serious event, and appropriate contingency protective schemes must be developed to deal with them. These contingency schemes may involve the use of local or remote backup.

##### 2. Local and Remote Backup

- *Local backup* involves using other breakers in the same substation as the failed breaker to isolate and clear the fault that the failed breaker cannot clear.
- *Remote backup* involves using other breakers out of the same substation as the failed breaker to isolate and clear the fault that the failed breaker cannot clear.

##### 3. Causes of Breaker Failure

According to a CIGRE 1988 paper (1), detectable breaker failure causes, which can be monitored on-line, can be placed into four general categories:

- *Contact Wear* – Damage from excessive interrupting duty, which is cumulative. Catastrophic failures have occurred under this circumstance.
- *Dielectric Compromise* – Contaminated oil, worn baffles, nozzle ablation, and other items that cause excessive arc duration. These situations cause a longer clearing time, which may gradually increase to infringement on the breaker failure time.

- *Mechanism Problems* – Mechanical issues such as worn parts, “frozen” linkages, and pneumatic or hydraulic system malfunctions. These problems may either gradually develop (degradation), or suddenly develop from a component failure.
- *Control Circuit Failure* – Shorted coils, open coils, open or shorted circuits. These problems may either develop suddenly, as in a short circuit from wire abrasion or open circuit from termination failure, or gradually, as in insulation breakdown in a coil leading to a short.

## C. ISSUES

### 1. Utility Organization Practices

The detection and mitigation of incipient breaker failures involves multiple disciplines within an electric utility.

- System Protection & Control Engineers concern themselves with creating contingency plans to address what happens after a breaker fails, which is the application of breaker failure schemes and their associated clearing of back-up breakers.
- Substation Operations and Maintenance Engineers concern themselves with attempting to maintain breakers so they function, and then rely on the system to clear for a breaker failure.

### 2. In-Situ Monitoring of Breakers

Breakers may be monitored in-situ (on-line) to provide data from every operation, as well as the status of control circuits. In-situ monitoring, versus periodic monitoring, has application advantages for detection of problems and incipient problems. In-situ monitoring can offer detection of anomalies as they occur, and report these incidences to Operations through SCADA, as well as act as input to protection & control remedial schemes.

The OPTImizer+ is an IED that examines electrical “signatures” from a breaker and can take action based on deviations from normal. The OPTImizer+ examines the symptoms of breaker wear, and can report and alarm the following:

- **Contact Wear** – Cumulative  $I^2T$  is logged on a per phase basis, with an alarm setpoint and danger setpoint available for output relay actuation. An analog output proportional to cumulative  $I^2T$  is also available.
- **Dielectric Compromise** – Arc duration time is examined and an alarm setpoint is available for output relay actuation. In addition, restriking is detected per the ANSI ¼ cycle definition and can be alarmed by output relay actuation.
- **Mechanism Problems** – Mechanism transit time is examined and an alarm setpoint is available for output relay actuation.
- **Control Circuit Failure** – The trip and close circuits are monitored for viability and indeterminate position. An alarm state is available for output relay actuation.

The reporting of this data is available in a table format. This table is downloaded from the OPTImizer+ in a text format using ASCII commands. The OPTImizer+ can be integrated into RS-232 based communication networks.

### 3. Bridging the Gap Between Operations and System Protection & Control

While Operations and System Protection & Control tasks may be different, in-situ monitoring of breakers can provide usable information for both concerns. The information obtained from monitoring may be ascertained by alarm relay actuation, analog signals and digital communications.

- *Operations* would use the information to enact reliability centered maintenance (RCM) programs that use data analysis as a means of determining maintenance schedules. They would also use the information to employ just-in-time (JIT) maintenance techniques that would dispatch maintenance as soon as a sufficient degradation or failure is detected.
- *System Protection & Control* would use the information to enact remedial protection and control schemes. The possibilities for remedial schemes depend on the breaker, the surrounding switchgear, topology of the substation, and existing protection & control infrastructure.

## D. APPLICATIONS

Several options are available to the utility for remedial action. They range from simple alarming to Operations for an inspection, to proactively implementing schemes.

- **Minimize breaker failure time** for back-up tripping in the event of a trip request to a breaker in an alarm condition. This would be applicable to low voltage (13.8kV) generator breakers feeding a GSU, feeding high voltage breakers in a high voltage substation. Automatic reclosing would not be an issue here; so accelerating the breaker failure timer to the high voltage breakers might avoid stress on the system components and aid stability margin if the 13.8kV breaker were to fail. This could be accomplished on a local basis, or remotely by SCADA.
- **Isolate a breaker** by automatic control where a failure is suspected to occur. This would be applicable in situations where other breakers can take the power flow, such as ring-bus or breaker and one-half schemes, where the incidence of bus fault is unlikely, but a bus-clearing breaker failure operation is to be avoided if possible. This would be accomplished on a local basis.
- **Prevent tripping and reclosing of a breaker** where a failure is expected to occur. This would be the case in distribution and sub-transmission feeders where the bus breaker could trip and reclose for a fault on a feeder. This would prevent a breaker failure and undesirable subsequent bus lockout. This type of strategy has been applied by digital relays for "breaker saving" purposes when an instantaneous high set element is used to block a breaker whose fault interrupting duty would be exceeded by a particular high level of fault. The same logic may be applied to incipient breaker failures, avoiding possible damage and maximizing stability. This would be accomplished on a local basis.

## E. CONCLUSIONS

In-situ breaker monitoring provides the ability to employ remedial protection & control schemes to detect incipient breaker failures, and avert breaker failure clearing. The results of a breaker failure involve backup breaker operation, which can result in widespread outages. Employing remedial protection & control schemes for incipient breaker failure offers utilities a way to improve power delivery by predicting incipient breaker failures, and avoiding breaker failure clearing. The suspected breaker may then be examined, refurbished if necessary, and placed back into service.

### **Keywords:**

*Breaker failure* - A breaker failure occurs when a breaker receives a trip command, and does not trip within an allotted time interval. A breaker is considered to fail when this time limit is exceeded regardless whether the clearing was from a fault, SCADA or manual command.

*Incipient fault* - An incipient fault is a fault that will occur with the next operation(s) of a device (circuit breaker). Detection of an incipient fault allows the enacting of remedial schemes.

*In-situ* - Continual measurement of a process by a sensor in the process stream. This differs from periodic measurement, which does not continually record and evaluate data.

*Protection* - Protection of the bulk power system employs high-speed relays and other intelligent electronic devices to clear faults in the fastest time possible, isolating only the affected parts of the system, with maximum security.

*Remedial Scheme* - A scheme enacted to avert a failure or correct a problem.

*SCADA* - System Control and Data Acquisition. When employed on the wire side of a utility, this system is used to switch, dispatch, control efficiency and report status of the bulk power system. It normally does not include high-speed system protection functions, although it may interface to the protective system.

### **Reference:**

Methodology for Monitoring the Condition of High Voltage Circuit Breakers, CIGRE 1988; Barkan, Deni, McCabe, Reckleff, Scherer, Woodward